Fraunhofer
PORTUGAL

ASSOCIAÇÃO FRAUNHOFER PORTUGAL RESEARCH

ANNUAL REPORT 2017

PERSONAL | CONNECTED | INTELLIGENT SOLUTIONS

Associação Fraunhofer Portugal Research

Research of Practical Utility lies at the heart of all activities developed by Fraunhofer Portugal.

Founded in 2008 – as a result of the long-term Portuguese-German collaboration in Science and Technology – Associação Fraunhofer Portugal Research focuses on companies as customers and partners to promote innovative product development by delivering applied research results in an international context.

Adopting the well tested – and undisputedly successful – model operated in Germany by Fraunhofer-Gesellschaft, Associação Fraunhofer Portugal Research supports economic development and social well-being by contributing to the population's quality of life.

Currently, Associação Fraunhofer Portugal Research (Fraunhofer Portugal) owns and operates the Fraunhofer Portugal Research Center for Assistive Information and Communication Solutions (FhP-AICOS) – a partnership between Fraunhofer-Gesellschaft and the University of Porto – focusing on Ambient Assisted Living (AAL) and Information and Communication Technologies for Development (ICT4D).

Acknowledged by the Portuguese Government as an 'Entity of Public Interest', Associação Fraunhofer Portugal Research was named after Joseph von Fraunhofer (1787-1826), the illustrious Munich researcher, inventor and entrepreneur.

A investigação de utilidade prática está no centro de todas as atividades desenvolvidas pela Fraunhofer Portugal.

Fundada em 2008 – e resultando de uma colaboração de longo prazo em Ciência e Tecnologia entre Portugal e a Alemanha – a Associação Fraunhofer Portugal Research mantém um enfoque nas empresas como parceiros, promovendo e desenvolvendo atividades de investigação aplicada num contexto internacional.

Adotando o bem-sucedido modelo de negócio operado na Alemanha pela Fraunhofer-Gesellschaft, a Associação Fraunhofer Portugal Research apoia o desenvolvimento económico e promove o bem-estar social, ao contribuir para a melhoria da qualidade de vida das populações.

Neste momento, a Associação Fraunhofer Portugal Research (Fraunhofer Portugal) detém e opera o Fraunhofer Portugal Research Center for Assistive Information and Communication Solutions (FhP-AICOS) – uma parceria entre a Fraunhofer-Gesellschaft e a Universidade do Porto – dedicada às áreas de "Ambient Assisted Living" (AAL) e de Tecnologias de Informação e Comunicação para o Desenvolvimento (ICT4D).

Reconhecida pelo Estado Português como Pessoa Coletiva de Utilidade Pública, a Associação tem o nome do famoso cientista, inventor e empreendedor Joseph von Fraunhofer (1787-1826), originário de Munique, Alemanha.

ANNUAL REPORT 2017

Fraunhofer Portugal: A change for the better!

Change is part of the evolutional process of all organizations, and 2017 was inevitably marked by the change of the top leadership of Fraunhofer Portugal. After 9 years of dedication and commitment, which resulted in the creation of a prosperous applied research centre of Fraunhofer in Portugal, Prof. Doctor Dirk Elias decided to embrace an offer from a multinational company to lead an external R&D department. Immediately after his announcement, a new recruitment process was launched to find the person that would lead the future of Fraunhofer Portugal and FhP-AICOS, the first semester being a period specially focused on the selection of the new director.

The selection process was highly competitive and it involved candidates from all over the world. After a rigorous evaluation, the candidate that revealed the best competences to lead Fraunhofer Portugal was a well-known face of the organization, a previous senior scientist that had assumed important roles during the last years of the development of the organization. Her name, Liliana Ferreira, a talented senior scientist that was able to prove that with hard work, dedication, commitment and enthusiasm it is possible to make a difference and achieve extraordinary results!

The initial appointment as Director of FhP-AICOS was in September 2017, but, by the end of the year, changes in Fraunhofer Portugal's vision were already evident. Hopefully excellent results will be achieved with the new course that the organization is now embracing, the team being totally focused in further developing the prestige and competitiveness of Fraunhofer Portugal nationally and internationally.

The year of 2017 was also prosperous in terms of new projects and business development. In total, revenue from projects increased to 1.7M€, representing the highest volume of external revenues ever achieved by FhP-AICOS. The team has also grown to 79 collaborators, this being the highest number of positions in FhP-AICOS of the last years. A significant part of the revenue growth was related to new contracts that extend to 2018, which provide the sustainability and composure that is necessary to look to the future and implement changes in a positive and propitious environment.

In terms of the operational achievements, the total OPEX increased 2% to 2.768K€[1] and CAPEX expenditures increased 3% to 387K€. Both combined represent a total Business Volume in 2017 of 3.155K€, which represents a growth of 2% when compared with the previous years.

[1]   *The OPEX considered for the normal operation of FhP-AICOS excludes the costs of recruitment of the Director.*

The performance indicators of FhP-AICOS also revealed a significant positive development during 2017, increasing 9% to a value of 62%, which is in line with the outcomes achieved in the past. Despite the positive evolution, and the good performance of the organization, reality shows that the dependency of funding from national programmes is still affecting significantly the performance of FhP-AICOS. In 2016 the delay in the announcement of a project being evaluated by CCDR-N affected the expected national revenues at year end, and in 2017 a similar scenario occurred, this time with six project proposals of industry projects, in co-promotion, that are being evaluated by ANI and which affected the expected industry revenues of 2017. The reasons behind these delays are various, but unfortunately, and even if different, these are factors that the organization cannot control, the only solution to minimize the impact of these delays being the reduction of the dependency of this type of projects/funding.

At the scientific level, in 2017 significant achievements were accomplished. One of them was the grant of two new patents related to the Precise Indoor Location technologies that the research team of FhP-AICOS has been developing in the last years. This achievement represents an important milestone for the organization, not only because it evidences the scientific quality of the technologies that are being developed in the organization, but also because it will certainly create new business opportunities to licence Intellectual Property originally developed by FhP-AICOS.

Also relevant are the negotiations that started in 2017 for the creation of a new applied research centre of Fraunhofer in Portugal. The first conversation on this topic started back in 2016, and in 2017 an important meeting was held in Dresden with the visit of a Portuguese delegation to Fraunhofer IKTS which involved the presence of the Portuguese Minister of Science, High Education and Technology, Prof. Doctor Manuel Heitor. The outcomes were very positive and currently a strong initiative is in development to define the operational plans and the details of the creation of an applied research centre that will research topics related to precision agriculture and water management.

Finally, and looking at the perspectives for 2018, FhP-AICOS was able to secure a significant volume of contracts in 2017 that lead to a strong Backlog of projects to be developed in 2018, specially in what concerns with national and EU research activities. This allows the organization to be more focused in the acquisition of industry projects, which remains the biggest challenge of the organization, although some important external projects that are currently financing internal research will be completed until the end of 2018.

Pedro Almeida
Acting Director

FhP-AICOS has a proven track record in the field of technology-enabled innovation. We deliver superior innovation based on knowledgeable end-user insights. For almost a decade, FhP-AICOS has been working to extend the reach of the information and knowledge society and enhance the life of specific groups, such as seniors and populations in remote regions or developing countries. But there are more opportunities ahead. The digital transformation continues to accelerate in all sectors of life and business. FhP-AICOS competences in developing intelligent technology for users which fall out of mainstream audiences, while looking at the potential of larger markets, can bring greater value.

In the last quarter of 2017, we started to reshape the competencies offered to our clients and partners into three main pillars: Personal, Connected and Intelligent solutions. This transformation comes together with the identification of new topics for the application of these competencies and a new focus on improving the way we do business, create intellectual property and unlock our full potential so that we can be more agile, validate our business ideas with the markets and understand the full value of innovation.

Collaboration is key to success. The relation with the University of Porto is an example of a relevant cooperation that needs to be nurtured, but is not the only one. In 2018, we will use our team of highly qualified researchers, namely in the area of artificial intelligence, to foster a culture of cross-pollination to reach customers and establish relationships with local ecosystems.

The commitment is to continue the success path of FhP-AICOS in becoming a leading R&D partner for industry. We will increase the quantity and quality of our scientific outputs, and the value brought to science, economy, and the community while ensuring the continuation of the creation of Remarkable Technology, Easy to Use.

Liliana Ferreira
Director

Fraunhofer Portugal: Uma mudança para melhor!

A mudança faz parte do processo evolutivo de todas as organizações, e o ano de 2017 ficou inevitavelmente marcado pela mudança da liderança da Fraunhofer Portugal. Após 9 anos de dedicação e empenho, que resultou na criação de um próspero centro de investigação aplicada da Fraunhofer em Portugal, o Prof. Doutor Dirk Elias decidiu aceitar o desafio de uma empresa multinacional para liderar um departamento externo de I&D. Logo após a sua comunicação, um novo processo de recrutamento foi lançado com o intuito de encontrar a pessoa que viria liderar o futuro da Fraunhofer Portugal e do FhP-AICOS, sendo o primeiro semestre um período especialmente focado na seleção de um novo diretor.

O processo de seleção foi muito disputado, envolvendo candidatos de todo o mundo. Após uma avaliação rigorosa, o candidato que revelou as melhores competências para liderar a Fraunhofer Portugal, era um rosto já bem conhecido da organização. Liliana Ferreira, uma cientista sénior que anteriormente desempenhou um papel relevante no desenvolvimento da organização ao longo dos últimos anos, tinha já dado provas da sua competência e mostrou que, com trabalho árduo, dedicação, empenho e entusiasmo, é possível marcar a diferença e conseguir resultados extraordinários.

A nomeação como Diretora do FhP-AICOS foi em setembro de 2017, mas, no final do ano as mudanças na visão da Fraunhofer Portugal eram já evidentes. Esperamos alcançar a excelência nos resultados com o novo rumo tomado agora pela organização, uma vez que a equipa está também totalmente focada no desenvolvimento da Fraunhofer Portugal, quer a nível nacional, quer internacional.

O ano de 2017 foi também bem-sucedido em termos de novos projetos e desenvolvimento de negócio. No total, a receita de projetos aumentou para 1,7M€, representando o maior volume de receitas externas já alcançado pelo FhP-AICOS. A equipa atingiu também os 79 colaboradores, sendo este o maior número de cargos ocupados nos últimos anos no FhP-AICOS. Uma parte importante do crescimento da receita está relacionado com novos contratos que se estendem até 2018, os quais proporcionam a sustentabilidade e a tranquilidade necessárias para encarar o futuro e concretizar mudanças num ambiente positivo e propício.

Em termos de realizações operacionais, o OPEX total aumentou 2% para 2.768K€[1] e os gastos com CAPEX aumentaram 3% para 387K€. Em conjunto representam um volume de negócio total, em 2017, de 3.155K€, o que representa um crescimento de 2% quando comparado com o ano anterior.

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1   *Os gastos operacionais considerados para a operação do FhP-AICOS excluem os gastos com o recrutamento do Diretor.*

Os indicadores de desempenho do FhP-AICOS também revelaram um desenvolvimento positivo durante 2017, aumentando de 9% para 62%, o que está em linha com os resultados obtidos no passado. Apesar da evolução positiva e do bom desempenho da organização, a realidade mostra que a dependência do financiamento dos programas nacionais continua a afetar num modo significativo o desempenho do FhP-AICOS. Em 2016 o atraso no anúncio de um projeto avaliado pela CCDR-N afetou as receitas nacionais esperadas no final do ano, e em 2017 ocorreu um cenário semelhante, desta vez com seis propostas de projetos indústria em co-promoção, que estão a ser avaliados pela ANI e que afetaram as receitas de indústria esperadas em 2017. As razões por trás destes atrasos são múltiplas, mas, infelizmente, e mesmo que diferentes, são fatores que a organização não consegue controlar, sendo a única solução para minimizar o impacto desses atrasos, a redução da dependência deste tipo de projetos/financiamento.

Na área científica, em 2017 foram alcançados feitos significativos. Um deles foi a concessão de duas novas patentes relacionadas com as tecnologias *Precise Indoor Location* que a equipa de investigação do FhP-AICOS tem estado a desenvolver nos últimos anos. Esta conquista representa um marco importante para a organização, não só porque evidencia a qualidade científica das tecnologias que estão a ser desenvolvidas pela organização, mas também porque certamente criará novas oportunidades de negócio para licenciar Propriedade Intelectual originalmente desenvolvida pelo FhP-AICOS.

Também relevantes são as negociações iniciadas em 2017 para a criação de um novo centro de investigação aplicada da Fraunhofer em Portugal. A primeira abordagem sobre este tema teve início em 2016 e, em 2017, realizou-se uma importante reunião em Dresden com a visita de uma delegação portuguesa à Fraunhofer IKTS, que contou com a presença do Ministro Português da Ciência, Tecnologia e Ensino Superior, Prof. Doutor Manuel Heitor. Os resultados foram muito positivos e atualmente está em curso uma iniciativa para definir os planos operacionais e os detalhes da criação de um centro de investigação aplicada em áreas relacionadas com a agricultura de precisão e a gestão hídrica.

Por último, e olhando para as perspetivas para 2018, o FhP-AICOS conseguiu garantir um volume significativo de contratos em 2017 que levam a um forte Backlog de projetos a serem desenvolvidos em 2018, especialmente no que diz respeito a atividades de investigação a nível nacional e da UE. Isto permite que a organização esteja mais focada na aquisição de projetos para a indústria, que continua a ser o seu maior desafio, embora alguns projetos externos importantes, que financiam atualmente a investigação interna, estejam concluídos até o final de 2018.
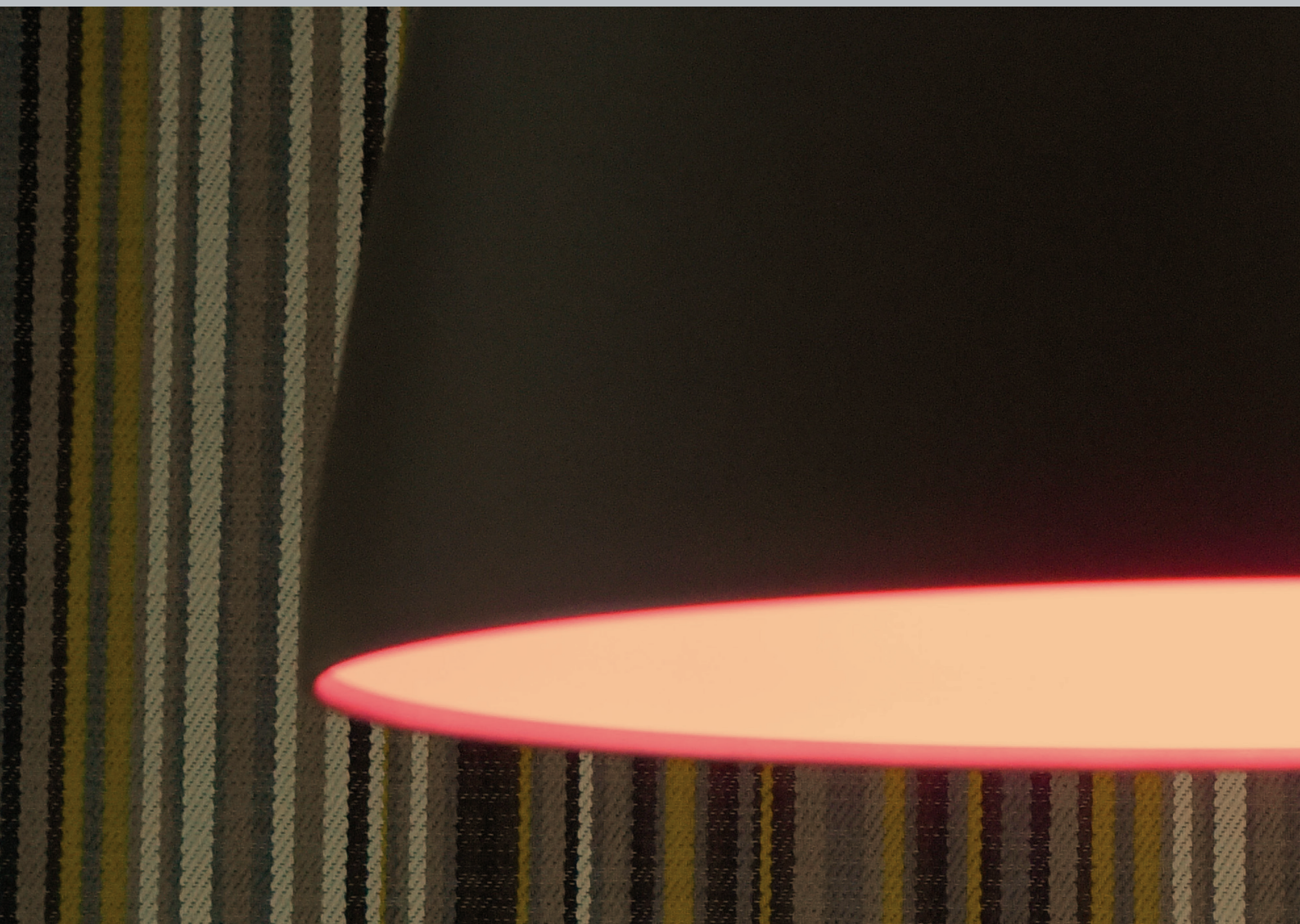
Pedro Almeida
Diretor Interino

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O FhP-AICOS tem um historial comprovado no campo da inovação e capacidade tecnológica. Oferecemos inovação superior com base no conhecimento do utilizador e nas suas perspetivas. Durante quase uma década, o FhP-AICOS tem trabalhado para difundir o alcance da sociedade da informação e do conhecimento, e melhorar a qualidade de vida de grupos específicos, tais como os idosos e as populações em regiões remotas ou de países em desenvolvimento. Mas há mais oportunidades a explorar. A transformação digital continua a acelerar em todos os setores da vida e da economia e a aplicação das competências do FhP-AICOS no desenvolvimento de tecnologia inteligente para utilizadores não convencionais pode trazer grande valor, também em mercados de maior dimensão.

No último trimestre de 2017, iniciámos a reestruturação das competências oferecidas aos nossos clientes e parceiros redefinindo-as em três pilares principais: Pessoas, Conectividade e Inteligência. Esta transformação aparece ligada com a identificação de novos tópicos de aplicação para essas competências, bem como, um novo objectivo: o de melhorar a forma como fazemos negócio, como criamos propriedade intelectual e desbloqueamos todo o nosso potencial de modo a sermos mais ágeis, a garantir a validação das nossas ideias com os mercados e compreender o valor da inovação.

A colaboração é a chave do sucesso. A relação com a Universidade do Porto é um exemplo de cooperação relevante que precisa de ser estimulada, mas não é o único caso. Em 2018, usaremos a nossa equipa de investigadores altamente qualificados, nomeadamente na área da inteligência artificial, para promover uma cultura de polinização cruzada, alcançar clientes e estabelecer relações duradouras com os ecossistemas locais.

O compromisso é continuar o caminho de sucesso do FhP-AICOS tornando-o num parceiro líder de I&D para a indústria. Simultaneamente, aumentaremos a quantidade e qualidade dos nossos resultados científicos, e o valor que criamos para a ciência, economia e comunidade, enquanto garantimos a continuidade do desenvolvimento de "*Remarkable Technology, Easy to Use*".

Liliana Ferreira
Diretora

REPORT OF THE
EXECUTIVE BOARD

GOVERNANCE & MANAGEMENT

OVERVIEW OF FRAUNHOFER PORTUGAL

MANAGEMENT REPORT 2017

GOVERNANCE & MANAGEMENT

GOVERNANCE STRUCTURE
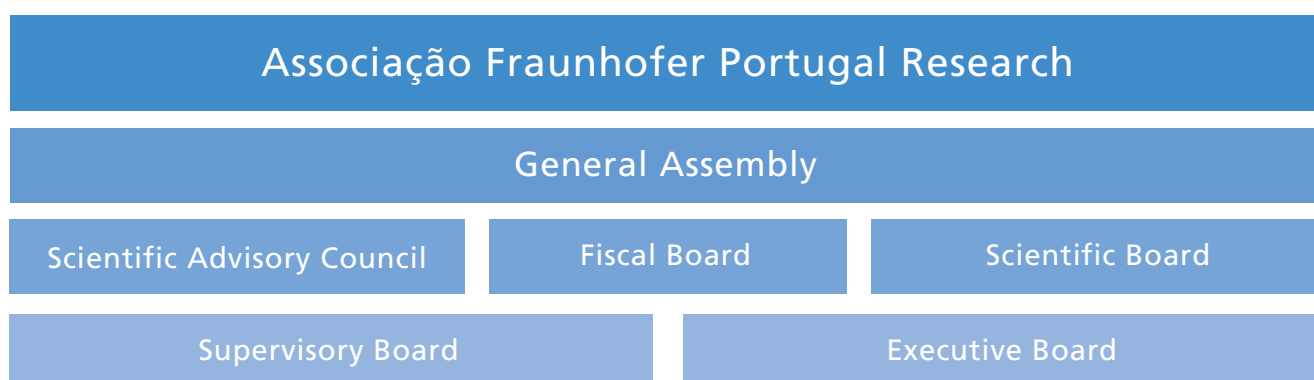
Associação Fraunhofer Portugal Research

General Assembly

Scientific Advisory Council	Fiscal Board	Scientific Board

Supervisory Board	Executive Board

We seek to follow the best practices in every area of the Association's governance by reflecting such practices in our organization, principles and transparency.

The Associative Structure of Fraunhofer Portugal clearly distributes functions, duties and responsibilities among its board members.

Management

Fraunhofer Portugal management is a shared responsibility of both the Supervisory Board (with broad assessment powers) and the Executive Board (responsible for daily management and current management actions).

SUPERVISORY BOARD

President
Georg Rosenfeld
Member of the Executive Board
Fraunhofer-Gesellschaft

Vice-President
João Paulo Oliveira
Member of the Executive Board
The Navigator Company

Member
Manfred Hauswirth
Member of the Executive Board
Fraunhofer FOKUS

Member
Paulo Simões
Member of the Executive Board
Sonae SR, SGPS, SA

Member
Steffen Schudt-Pialat
Member of the Executive Board
Volkswagen Autoeuropa

EXECUTIVE BOARD

Liliana Ferreira 1
President of the
Executive Board
(*since November 2017*)

With an academic and professional career focused on research in the areas of Health Informatics, Human Language Technologies and Artificial Intelligence, Liliana Ferreira holds a PhD in Informatics Engineering and a MSc in Electronics and Telecommunication Engineering, by the University of Aveiro, complemented with a strong research background developed in several industry and R&D organizations across europe (Portugal, Germany and the Netherlands).

Functional Assignments: General Administration, R&D Planning, Business Development, Facilities.

Pedro Almeida 2
Acting Director
(*until October 2017*)
Executive Board Member
(*presently*)

With a professional career that started with R&D activities through to the full innovation cycle with the creation of a spin-off of a prestigious University in Portugal, Pedro Almeida holds a MSc in Electronics and Telecommunications Engineering by the University of Aveiro, and holds a post-graduation in Advanced Management for Executives also from the same university.

Functional Assignments: Business Development, Planning & Control, Accountancy & Finances, Human Resources, Legal, Facilities.

Berthold Butscher 3
Executive Board Member

With a career highly oriented towards R&D, both in industry and in R&D institutions, Berthold Butscher holds a Dipl. Ing. in Electrotechnical and Computer Engineering from the University of Applied Sciences of Konstanz and from the Technical University of Berlin.

Functional Assignments: R&D Planning Support.

OVERVIEW OF FRAUNHOFER PORTUGAL

Vision

A Driving Force in Innovation

Fraunhofer Portugal proposes a radical change regarding technological innovation in collaboration with scientific institutions in Portugal, and aims at creating scientific knowledge capable of generating added value for its clients and partners, exploring technology innovations oriented towards economic growth, social well-being and the improvement of the quality of life of its end-users.

Mission

Research of Practical Utility

Fraunhofer Portugal promotes applied research of direct utility to private and public institutions and of broad benefit to society, by managing and coordinating the cooperation of its research centres with:

- Other Research Institutions – such as universities and other relevant Portuguese or non-Portuguese research institutions, as well as Fraunhofer Institutes and other research centres integrated in the Fraunhofer-Gesellschaft knowledge network;

- Industry Partners – clearly perceived and understood as our main customer group, we are developing partnerships and cooperation agreements with private and public enterprises, as well as participating in business associations;

- Supporting Partners – Government Institutions and other Institutional partners.
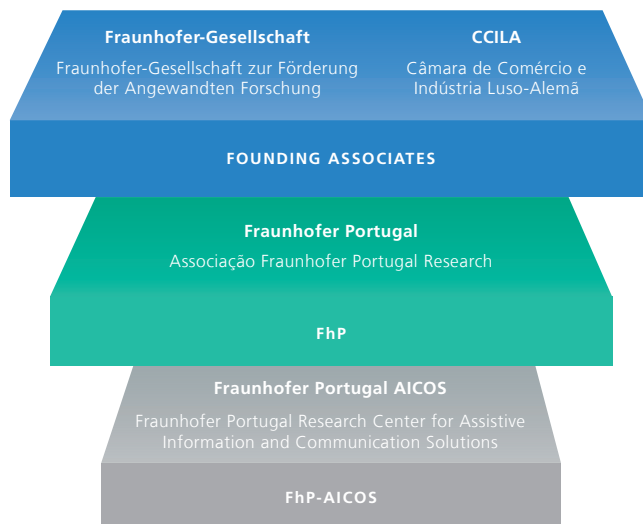
Funding Model

Fraunhofer-Gesellschaft and the Portuguese Foundation for Science and Technology (FCT) agreed on a tripartite funding model similar to the one used by Fraunhofer-Gesellschaft.

At Fraunhofer Portugal, our scientists and engineers work with a budget financed by external revenue (projects and licensing) and institutional funding provided by FCT and Fraunhofer-Gesellschaft.

The base line for this type of funding determines that it will be granted in progressively smaller amounts over the initial years, encouraging the implementation of an efficient business model mainly financed by external revenue.

External revenue should be guaranteed through research projects, development projects, contracts signed with third parties within Fraunhofer Portugal's fields of activity, intellectual property rights and licensing of the commercial optimization of products and services resulting from Fraunhofer Portugal's R&D results.

Fraunhofer-Gesellschaft
Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung

CCILA
Câmara de Comércio e Indústria Luso-Alemã

FOUNDING ASSOCIATES

Fraunhofer Portugal
Associação Fraunhofer Portugal Research

FhP

Fraunhofer Portugal AICOS
Fraunhofer Portugal Research Center for Assistive Information and Communication Solutions

FhP-AICOS

Fraunhofer-Gesellschaft

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains 72 institutes and research units. The majority of the more than 25.000 staff are qualified scientists and engineers, who work with an annual research budget of 2.3 billion euros. Of this sum, almost 2 billion euros is generated through contract research. Around 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Around 30 percent is contributed by the German federal and state governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to re-inforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.

German-Portuguese Chamber for Industry and Commerce (CCILA)

With over 1.000 associates in Portugal and Germany, the objective of the Chamber is to enhance and promote the economic relationships between the two countries.

Associação Fraunhofer Portugal Research

Founded in 2008 – within the framework of a long-term Portuguese-German collaboration in Science and Technology – Associação Fraunhofer Portugal Research (Fraunhofer Portugal) promotes applied research that drives and encourages economic development and serves the wider well-being of society. The Association's services are sought out by customers and contractual partners in industry, the service sector and public administration.

Currently, Fraunhofer Portugal owns and operates the Fraunhofer Portugal Research Centre for Assistive Information and Communication Solutions (FhP-AICOS) – a partnership between Fraunhofer-Gesellschaft, Fraunhofer Portugal and the University of Porto – focusing on Ambient Assisted Living (AAL) and Information and Communication Technologies for Development (ICT4D).

Fraunhofer Portugal's development strategy accommodates the option to establish additional research units whenever a sustained demand for R&D services applied to a specific area of scientific knowledge is detected in the market.

Services

Fraunhofer Portugal's Research Services, rendered through the research institutions it operates, provides three different types of collaboration to industrial customers, also provided within public funded project participations:

   – R&D Contract;
   – R&D Consulting;
   – Living Labs.

Fraunhofer Portugal is committed to building a reputation of excellence within different service dimensions such as knowledge, credibility, professionalism, creativity, flexibility, response time and cost.

Fraunhofer Portugal AICOS

Fraunhofer Portugal Research Centre for Assistive Information and Communication Solutions (FhP-AICOS)

Incorporated as a partnership between Fraunhofer-Gesellschaft and the University of Porto and focusing its activity on Ambient Assisted Living (AAL) and Information and Communication Technologies for Development (ICT4D), FhP-AICOS is the first research institution operated by Fraunhofer Portugal.

Extending the Reach of the Information and Knowledge Society

FhP-AICOS aims to enhance people's living standards by offering intuitive and useful technology solutions, capable of facilitating their access to the Information and Communication Technologies, and in this way assisting in the integration of an increasingly larger sector of the population in the Information and Knowledge Society.

Remarkable Technology, Easy to Use

FhP-AICOS' mission is to generate Remarkable Technology, Easy to Use. This means offering specialised competences centred on the improvement of end-user experience and usability of applications, generating applied research solutions capable of contributing to the market success of our client's products and services.

Collaboration plays an essential role in enabling the research centre to fulfil its mission. Therefore, FhP-AICOS strongly promotes and consolidates partnerships and cooperation with key players and decision makers in its strategic research areas, namely:

– *Association européenne pour la maladie de Parkinson* (Belgium): charitable organisation that brings together several national Parkinson organisations from Europe. Collectively, these organizations have more than 250.000 members in 36 countries and advocate for the rights and needs of more than 1.2 million people with Parkinson's and their families;

– *Associação de Reguladores de Comunicações e Telecomunicações da Comunidade dos Países de Língua Portuguesa* (Portugal): a private law association that promotes information sharing and exchange of experiences between communication's regulators of the Portuguese speaking countries (Angola, Brazil, Cape Verde, Equatorial Guinea, Guinea-Bissau, Mozambique, Portugal, São Tomé e Príncipe and Timor-Leste) towards the sector's improvement and market growth;

– *Centro de Investigação e Tecnologias Agroambientais e Biológicas* (Portugal): focused on the agro-food and forestry systems, it is composed of a multidisciplinary team with expertise in fundamental sciences such as Biology and Chemistry, fostering agronomists, forestry engineers and ecologists, with scientific experts in the fields of Mathematics, Physicsand Technological Engineering, and engineers, who applie they work in the areas of: Ecointegrity; Sustainable Agro-food Chains and Biosystems Engineering;

– *Centro de Reabilitação Profissional de Gaia* (Portugal): an association focused on the rehabilitation of people affected by accidents or diseases, which also assists young people with disabilities in their transition from school into an active life;

– *Centro Tecnológico das Indústrias Têxteis e do Vestuário de Portugal* (Portugal): a private non-profit Technological Institute which provides technological support and services to companies acting in the textile and clothing business. Being present in Europe, Africa, Asia and South America, the organization's activities are focused in: Product Design & Development; Prototyping; Testing and Applied R&D oriented to innovative applications;

– *Charité – Universitätsmedizin Berlin* (Germany): with more than 300 years old, it is one of the largest university hospitals in Europe. At the university, approximately 3.700 doctors and scientists heal, do research and teach at the top international level. More than half of the German Nobel Prize winners in Medicine and Physiology come from the Charité, among them are Emil von Behring, Robert Koch and Paul Ehrlich;

– *Deutsche Sporthochschule Köln* (Germany): the only university in Germany dedicated exclusively to the field of sport and exercise science, which is studied in detail at 21 institutes, four affiliate institutes and nine academic centres;

– *Eidgenössische Technische Hochschule Zürich – Departement Gesundheitswissenschaften und Technologie* (Switzerland): leading international academic institution at the cutting edge of health sciences and technology, aims to create the foundations for sustaining and improving the quality of life for people into old age, by accelerating the transfer of knowledge and technology in clinics, industry and society, and educate a new generation of students at the interface of science and technology;

– *Escola Superior de Tecnologia da Saúde de Coimbra* (Portugal): a centre of creation, transmission and dissemination of science, technology and culture, it holds as its mission the intervention and development at the levels of graduate and postgraduate education and research in health sciences and related areas, as well as the service to community and cooperation with national and international organizations in common interest activities and society in general;

– *Eurecat – Centre Tecnològic de Catalunya* (Spain): is the major Technology Centre of Catalonia aiming its services at all business sectors but especially at seven key strategic areas: Food; Energy & Resources; Industrial Systems; Design-based Industries; Industries related to Sustainable Mobility; Health Industries and Cultural, Experience-based Industries;

– *Faculdade de Economia da Universidade do Porto* (Portugal): with a long and prestigious history in the teaching of Economics and Management in Portugal, it is considered the best Portuguese University according to most international rankings;

– *Faculdade de Engenharia da Universidade do Porto* (Portugal): a top-level faculty that awards degrees in several engineering fields, such as: Computer Engineering; Mechanical Engineering; Chemical Engineering; etc.;

– *Faculdade de Medicina da Universidade do Porto* (Portugal): well renowned faculty that promotes teaching and provides scientific research of excellence and medical support activities to the community;

– *Fraunhofer FOKUS* (Germany): Fraunhofer Institute, based in Berlin, operates closely in related scientific fields, in this way pooling expertise in interdisciplinary collaborative projects as well as facilitating FhP-AICOS' seamless integration with Fraunhofer-Gesellschaft in different institutional aspects;

– *Fraunhofer IDMT* (Germany): Fraunhofer Institute focused on developing cutting-edge solutions in the digital media domain, consistently designed to meet user requirements and expectations;

– *Health Cluster Portugal* (Portugal): organization which focuses on the promotion and implementation of initiatives and activities leading to the creation of an innovative and technology-based national cluster;

– *Instituto de Biomecánica de Valencia* (Spain): is a technological centre that studies the behaviour of the human body and its interaction with products, environments and services, aiming to improve competitiveness among the business sector, by promoting people's well-being through the combination of knowledge in areas such as: Biomechanics; Ergonomics & Emotional Engineering, and its application to diverse sectors;

– *Instituto Nacional das Comunicações de Moçambique* (Mozambique): is the national authority responsible for regulating and supervising the communications sector (postal and telecommunications), as well as the management of the spectrum of radio frequencies, being responsible for granting licenses to communication services and monitoring the compliance with the legislation;

– *Instituto Nacional de Saúde Dr. Ricardo Jorge* (Portugal): public organization of the Ministry of Health, endowed with scientific, technical, administrative, financial and property of its own, that plays a triple role as State Laboratory in the Health Sector, National Reference Laboratory and National Health Observatory;

– *Instituto Universitário de Lisboa* (Portugal): a public university that pursues teaching, research and community service activities, in areas such as: Business; Sociology; Public Policy; Social Sciences; Technology and Architecture;

– *Istituto Superiore Mario Boella sulle Tecnologie dell'Informazione e delle Telecomunicazioni* (Italy): is a research and innovation centre operating in the Information and Communication Technologies domain, playing an active role in devising innovative solutions on research areas such as: Advanced Computing; Mobile Solutions and Pervasive Technologies (Internet of Things);

– *KempenLIFE* (Netherlands): a cooperative established by and for older citizens living in the rural Kempen area, Netherlands. It aims to organise new services for comfort, welfare and care, making use of ICT and broadband internet, and collaborating with hospitals and care organisations in the field of eHealth to increase independent living and quality of life for its members;

– *Loughborough University* (United Kingdom): a UK top 15 University with an international reputation for excellence in teaching, research and sport, producing research that matters, with strong links with industry, commerce and the professions, in areas such as: Computer Science; Mechanical, Electrical & Manufacturing Engineering; Aeronautical & Automotive Engineering, Sport, Exercise & Health Sciences, etc.;

– *Nelson Mandela Metropolitan University* (South Africa): a dynamic African university offering professional and vocational training for leadership in generating cutting-edge knowledge for a sustainable future, specialised in the scientific fields of: Health, Engineering, Business & Economics, Arts and Law;

– *Parque de Ciência e Tecnologia da Universidade do Porto* (Portugal): official Science and Technology Park of the University of Porto that fosters the creation of technology-based companies and the establishment of national and international private R&D centres, supporting an effective knowledge and technology transfer between academia and the market;

– *Santa Casa da Misericórdia de Lisboa* (Portugal): is the Portuguese largest private organization that pursues in a humanitarian way, objectives of social action, provision of health care, education and culture, and the promotion of the quality of life, particularly for the benefit of those in greater need of protection, with a special focus in the development of social work in the areas of: Childhood; Youth; Family & Community and Elderly people;

– *Seniornett Norge* (Norway): a non-governmental organization working for the inclusion of elderly people in the 'e-'world (PC, Internet, social media, etc.), in cooperation with the Norwegian Government, Microsoft (Gates Foundation), several non-profit organizations and telecom companies. It has established 200 training centres all over Norway where senior citizens can go for training, meet peers, ask questions and socialize;

– *Seoul National University* (Republic of Korea): one of the world's top 50 institutions, aims at creating a vibrant intellectual community where students and scholars join together in building the future, by committing to diversifying its student body and faculty, fostering global exchange, and promoting path-breaking research in all fields of knowledge;

– *Tohoku University – Institute of Development, Aging and Cancer* (Japan): is a Usage /Research Centre for Smart-Aging Research affiliated with Japanese universities that promote aging sciences and aims to clarify basic mechanisms of aging, as well as to control age-related diseases, such as dementia and intractable cancers;

– *Universidade de Trás-os-Montes e Alto Douro* (Portugal): a recognized reference in the Portuguese university system, focuses on high quality Teaching, Research and Community Outreach, striving to be a Centre of Excellence for lifelong learning and for the creation, transmission and dissemination of culture, science and technology, in area such as: Agricultural & Veterinary Sciences; Human & Social Sciences; Science & Technology and Sciences & Environment;

– *Universidade do Porto* (Portugal): our primary and distinguished university partner offering access to university know-how and infrastructures, as well as privileged contact with students interested in enrolling in advanced training at FhP-AICOS. We have closer cooperation with some of its faculties, namely the ones described above;

– *Universidade Eduardo Mondlane* (Mozambique): the oldest and largest university in Mozambique which focuses on producing and disseminating scientific knowledge, as well as promoting innovation through research, educating generations to face challenges to benefit society's development, namely in the scientific fields of: Biology; Agronomy; Engineering; Human Sciences and Linguistics;

– *Università degli Studi di Torino* (Italy): one of the most ancient and prestigious Italian universities, aims at promoting culture and producing research, innovation, training and employment, by covering several fields of knowledge. Its Medical Diagnostic; Biosensor and Nanotechnologies research centres are amongst the best ones in Italy;

– *Universitat Politècnica de Catalunya* (Spain): a public institution dedicated to higher education and research, specialised in the fields of: Engineering; Architecture and Science;

– *Universität Siegen* (Germany): a modern, high-profile university with an international orientation guided by the central principle 'creating a humane future', by offering a variety of degree programmes in areas such as: Science & Technology; Economics; Education, Architecture; Arts and Humanities;
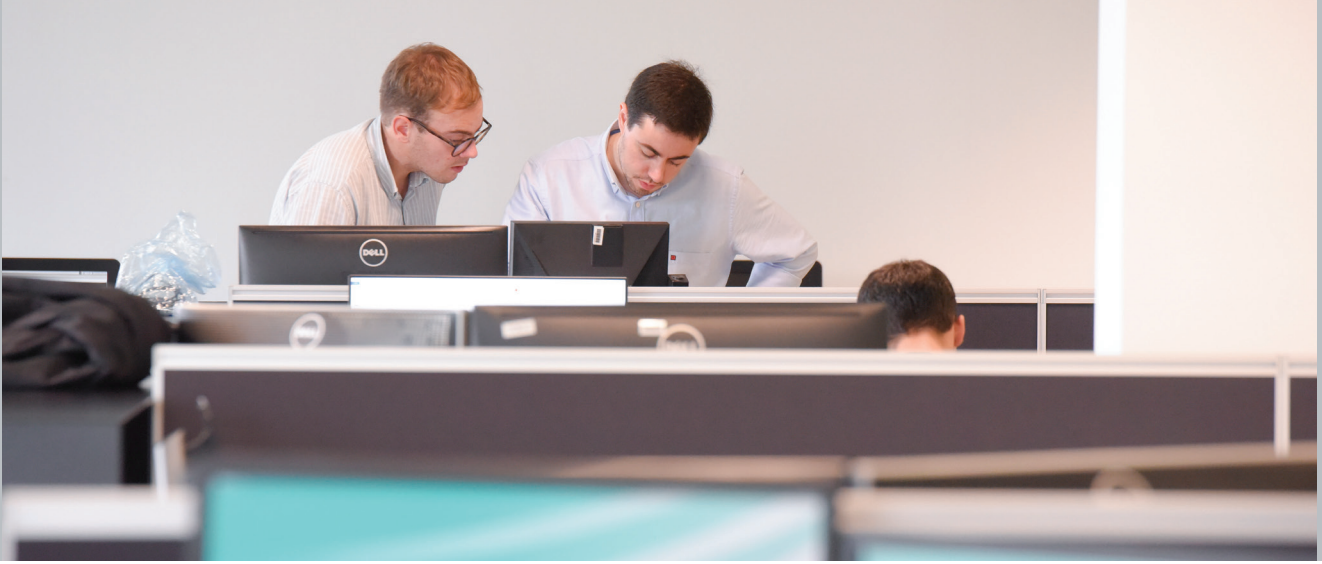
– *University of Limerick* (Ireland): distinctive, pioneering and connected university that undertakes world-class research and delivers innovative teaching in the fields of: Health Sciences; Science & Engineering; Arts; Humanities; Social Sciences; Business and Education;

– *University of the Sunshine Coast* (Australia): is one of Australia's newest and fastest growing universities, offering more than 100 undergraduate and postgraduate study programmes in Business and Information Technology; Communication and Design; Education; Health; Humanities and Social Sciences; and Science and Engineering.

Strategic Research Agenda

FhP-AICOS constitutes a new approach to Information and Communication Technologies through Fraunhofer-Gesellschaft and contributes to the creation and development of competences in activities of great relevance for the future, addressing two main business fields: Ambient Assisted Living (AAL) and the emerging field of Information and Communication Technologies for Development (ICT4D).

– AAL includes methods, concepts, (electronic) systems, devices and services that are providing unobtrusive support for daily life, based on the context and the situation of the assisted person. The technologies applied for AAL are user-centric, i.e. oriented towards the needs and capabilities of the actual user. They are also integrated into the immediate personal environment of the user. Consequently, the technology is adapted to the user rather than the other way around. In order to share relevant information between systems and services, technologies for AAL should ideally be based on modular and interoperable concepts.

FhP-AICOS intends to mainly address the needs of the ageing population, to reduce innovation barriers of forthcoming promising markets, but also to lower future social security and healthcare costs. This goal can be achieved through the use of intelligent products and the provision of remote services, including care services that extend the period during which senior citizens can live in their home environment. The services envisioned and developed by Fraunhofer will increase the individual's autonomy and assist them in carrying out their daily activities.

– ICT4D is a general term which refers to the application of Information and Communication Technologies (ICT) within the field of socioeconomic development or international development. ICT4D focuses on the direct application of information technology approaches to contribute to poverty reduction and to reduce the digital divide.

FhP-AICOS currently intends to focus its ICT4D activities on the African continent, with special emphasis on Mozambique and Angola. The primary target user group will be ICT users in rural and developing areas, and the objective is to provide solutions for mobile device services and applications which meet the local users' demands, contributing to a more positive user experience which, in many cases, may be their first contact with ICT.

Among the significant diversity of topics related to AAL and ICT4D, FhP-AICOS focuses on a reduced set of business sub-fields that our customers consider relevant and that are directly related to our core competences.

In the AAL business field, FhP-AICOS currently covers the following sub-fields:

– Fall and Activity Monitoring;

– Chronic Diseases and Well-Being Management;

– Assistive Environments.

With regards to the emerging ICT4D business field, one sub-field has currently been defined:

-   ICT4D on Mobile Devices.

Additionally, FhP-AICOS supports the creation of scientific knowledge capital in three key areas that define the Center's core competences developed to date:

-   Human-Computer Interaction (HCI): focusing on User & Social Experience, Mobile & Future Devices and Evaluation & Usability;

-   Information Processing (IP): focusing on Content Retrieval, Context Awareness, and Multimodal Information Fusion;

-   Autonomic Computing (AC): focusing on Remote Management, Control and Configuration.

MANAGEMENT REPORT 2017

Summary of Key Figures

	2017	2018 (Budget)
Total Budget	3.155.836 €	3.791.000 €
Staff Costs	2.167.088 €	2.740.000 €
Non Personnel Costs	601.133 €	776.000 €
Industry Revenues	540.185 €	850.000 €
Public Revenues & Others	1.168.465 €	1.250.000 €
Base Funding	1.446.495 €	1.689.853 €
FTE (Full Time Equivalent)	58,6	62

Economic and Political Background

– Recovery of the Portuguese economy, with an GDP increase of 2,7%.

– Signature of cooperation protocol with ANI and Ministry of Economy for the implementation of 'Programa Interface'.

– First high-level meetings for the creation of a new applied research centre of Fraunhofer in Portugal.

According to the National Institute of Statistics, Portugal, the economic activity in 2017 had an increase of 2,7%. This value confirms the initial projections of Banco de Portugal, the current estimations of this entity being that the profile for the upcoming years will maintain a growth profile, although with a slower pace compared with the last year (2,3%, 1,9% and 1,7% in 2018, 2019 and 2020 respectively).

When comparing the GDP with the level seen prior to the economic financial crisis, current projections reveal a positive variation of approximately 4% until 2020, demonstrating the positive moment that the Portuguese economy is experiencing nowadays. At a macro level, the GDP growth in Portugal will be close to the euro area average over the period 2018-2020. Furthermore, in the next years the Portuguese economy will benefit from a favourable external environment, as the current economic expansion cycle extends to all euro area countries, where Portugal's main trading partners are located. Outside the euro area, a sustained expansion in activity and trade is expected. Projections for exports are also positive, as they maintain a robust growth explained by developments in external demand and continued gains in market share. In 2020, exports are projected to reach more that 68% of the value achieved in 2008.

The political background in the year of 2017 was also positive, the current government being steady and with a strong emphasis in the creation of programs to stimulate the relation between applied research organizations and industry. One example of these initiatives is the 'Programa Interface', a governmental initiative that aims to enhance Portuguese products through innovation, increased productivity, value creation and the incorporation of technology into the productive processes of national companies. It is aimed at accelerating the transfer of technology from universities to companies, enhancing the certification of products, increasing the competitiveness of the Portuguese economy and companies in the national and international markets. Fraunhofer Portugal signed the cooperation protocol with the National Innovation Agency (ANI) and the Ministry of Economy, related to the implementation of 'Programa Interface', on the 23rd of February 2017.

In June 2017, a delegation of Fraunhofer Portugal was invited by the Minister of Science, Technology and Higher Education, Prof. Doutor Manuel Heitor, to participate in a high level meeting in Dresden, with Fraunhofer IKTS, related to the creation of a European initiative associated to Precision Agriculture. Besides FhP-AICOS, the Portuguese committee also included representatives of Universidade de Trás-os-Montes e Alto Douro, Universidade de Évora and the National Institute for Agrarian and Veterinarian Research (INIAV). This first initiative was the basis for the creation of a larger cooperation agreement that launched the basis for the creation of an additional research centre in Portugal, being expected to address applied research topics of precision agriculture and water management. The exact terms of the operational developments of this new centre are being currently designed and naturally new developments will occur during 2018.

Business Evolution

- Significant growth in performance levels (+9%) with Rho at 62%.

- National and EU projects acquisition ensures excellent position to maintain growth in 2019.

- Delay in PT2020 co-promotion projects affected planned industry revenues.

Business Development

In 2017 Fraunhofer Portugal achieved an important growth in the performance levels when compared with the previous year. This achievement is partially due to the result of a significant effort of projects acquisitions that started at the beginning of the year, the total volume of contracted projects in 2017 being circa 2M€.

Regarding National projects, one of the projects granted for funding was MDevNet. This project aims to increase the technology and knowledge transfer activities of Fraunhofer Portugal, contributing to the increase of the capacity to license its technologies and to generate more revenues from the industry. Within this project a set of actions were defined jointly with other four research centres in Portugal: i3S – Institute of Research and Innovation in Health of the University of Porto, CINTESIS – Center for Research in Health Technologies and Information Systems, IPO – Portuguese Institute of Oncology and CICECO – Aveiro Institute of Materials, aimed to facilitate the transfer of knowledge, related to technology based medical devices, between the research laboratories and the industry in order to maximize its economic value and maximize its impact in society.

2017 also brought positive news for the Collective Transfer FhP project. Almost one year after the submission of the proposal, Fraunhofer Portugal received the positive notification of funding for this project. The investments plan was reviewed in the beginning of May and the final budget was approved by the funding agency until the end of the month. The start date defined for the project was November 2016 and the project duration was defined as 24 months, ending therefore in October 2018. The funding attributed to the project will be used to develop two types of activities: initiatives related to interaction and scientific knowledge transfer, including an improved version of the competition 'Fraunhofer Portugal Challenge', a new initiative called the 'Fraunhofer Collective Transfer Day' and dissemination actions of new knowledge and technology generated within the FhP-AICOS' R&D activities, involving sectorial actions of experimentation and construction of pilot projects for demonstration of the use of technologies in the areas of Ambient Assisted Living (AAL) and ICT for Development (ICT4D).

In the third quarter of 2017, Fraunhofer Portugal received the results of the evaluation of the Mobilizer projects proposals. Out of four project proposals that were submitted in 2016, only one proposal was approved, TexBoost. The goal of this project is to develop, among other results, an innovative and intelligent surf suit for adverse environments. This suit will be used to guarantee user's protection and to monitor the surfer's performance during specific surfing sessions. It will integrate wearable devices, such as a smartphone and a panic button, which will be used to gather and analyse sensor data, detecting several performance related metrics and also emergency events.

In terms of the current National projects, in the DeM – Deus ex-Machina project FhP-AICOS faced some delays during 2017 related to the contracts of external R&D consulting entities. Meanwhile these problems were surpassed and the project was able to proceed as initially planned, with four organizations currently being sub-contracted by FhP-AICOS to develop specific parts of the project, namely Fraunhofer FIT, Fraunhofer IZFP, the University Eduardo Mondlane of Mozambique and the University Nelson Mandela of South Africa.

In term of EU projects, during 2017 nine proposals were submitted to different funding programs. These proposals included different topics, most of them related to health, well-being and IoT technologies adapted to Active and Healthy Ageing scenarios. Three of these project proposals were submitted to the Active and Assisted Living Programme (AAL Programme). The call of 2017 was focused on proposals based on 'AAL packages/Integrated solutions', aiming to fund packages integrating different solutions based on ICT to support active, healthy and independent living of older adults. As FhP-AICOS has an extensive experience in this topic, and a strong network of contacts which includes European SMEs, these proposals include the participation of existing clients, namely Gociety and Dividat, and other private entities that have the potential to become Industry clients.

At the operational level, the ACP Street Libraries project ended in January. A final payment request was submitted to the funding agency and the final auditing of the project was concluded with success. Although some of the indicators initially planned were not achieved, the funding agency has been informed in due time of the deviations versus the original planning and the final outcome is line with the revised plan approved by the ACP programme.

The Clockwork project finally started its normal activity and a kick-off meeting took place in FhP-AICOS during the first quarter of 2017. Due to the delays associated to the consortium problems the project plan had to be revised, the duration of the project being reduced to 18 months.

Regarding Industry projects, in 2017 Dividat, a Swiss company that coordinates the AAP JP project Active@Home, contracted the project StepDetector, which aims to detect steps with high accuracy using inertial sensors. Despite being a small project, it recognizes the scientific and technical competences of FhP-AICOS in developing applications based on the analysis of the human movement.

In September 2017, Fraunhofer Portugal received a positive notification of the individual R&D PT2020 project that was submitted by the company F3M in September 2016. Although with seven months of delay from the expected date for the announcement of the proposals' evaluation, the outcome was positive and the contractual process was concluded in 2017 to start the implementation of the project.

At the operational level, the project SV4DMZ, which was contracted by the National Telecommunication Regulator of Mozambique, INCM, by the end of 2016, suffered from several unrecoverable delays in the administrative procedures. Due to these delays, the schedule for the implementation of the project was adjusted and a significant part of the work to be developed was postponed to 2018.

Still related to Industry projects, during the second quarter of 2017, the scientific team of FhP-AICOS was highly engaged in the preparation of six project proposals for PT2020

Co-promotion R&D projects, which involved the participation of companies from the North and Centre regions of Portugal. The topics addressed in these proposals range from IoT, Precision Indoor Location and Precision Farming to Health, Well-being and Nutrition, the entities involved in the development of these new technological being frameworks large companies, SMEs and other R&D organizations, mainly in the North region.

Unfortunately, and contrary to the initial expectations, the evaluation process of these proposals is suffering from a significant delay. The deadline communicated by the funding agency in the call was that the results would be announced until the beginning of October 2017, but at the time we are writing this report, no information has been received from the funding agency.
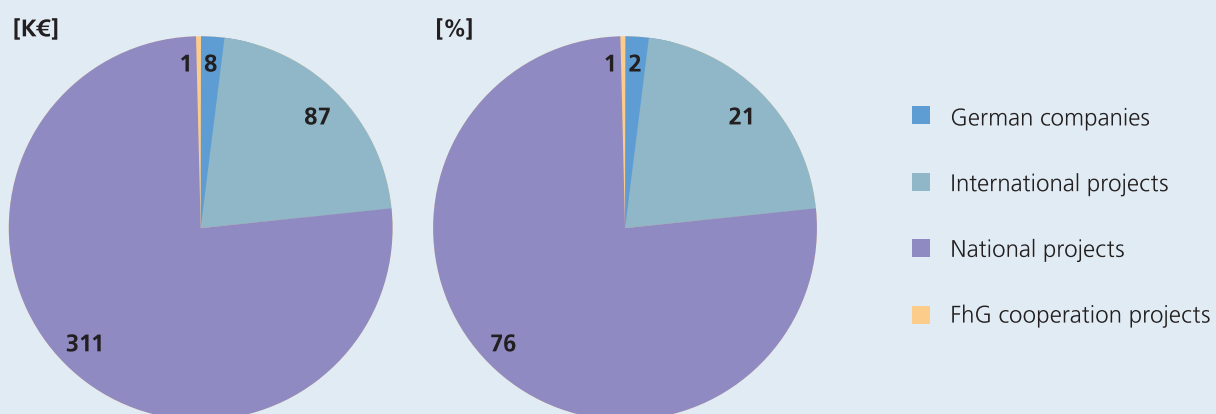
During the third quarter of 2017, the scientific team of FhP-AICOS submitted two project proposals, associated to the PT2020 programme: one for the creation of R&D Innovation nucleus in co-promotion with Inovamais, Increase Time and NorteExcel 2020 (three organizations of the North region that are involved in initiatives associated to Active and Assisted Living) and an individual project promoted by SAKPROJECT International SA, a company that manufactures shin guards and accessories for football players, both amateur and professional. The goal of the first project is to explore jointly innovative concepts, such as the Internet of Things (IoT), Big Data, Human Computer Interaction and the integration of diverse sensors, to unobtrusively capture information from everyday life with the goal to create Active and Assisted Living technologies. In addition, it is expected to increase and strengthen the competencies of the R&D teams of the

partners of this project in these thematic areas, as well as to ensure the alignment of the technological developments with the requirements of medical device certification. In terms of the objectives of the second project, in this case FhP-AICOS will be subcontracted to develop a prototype of a set of shin guards equipped with motion sensors.

Another important key performance indicators (KPI) of FhP-AICOS activity is related to the involvement of German and Portuguese partners, either as contractors or partners, in the scientific projects of the organization. During the period of 2010-2017 we were able to generate 3,77M€ of revenues in projects that involve German partners and 5,98M€ of revenues in projects that involve Portuguese partners, which reveals our continuous and strong commitment to work together with German and Portuguese institutions and, in this way, to contribute towards strengthening the economic relationship between Portugal and Germany.

In 2017, we generated revenues of 87K€ with German institutions in international projects, 311K€ in national projects that include the participation of three Fraunhofer Institutes: Fraunhofer FOKUS, Fraunhofer IDMT and Fraunhofer IZFP and 8K€ in projects for German Companies. In terms of revenues that involve Portuguese partners, in 2017 we generated 377K€ of revenues in projects that involve Portuguese companies, 481K€ of revenues in national R&D projects and 313K€ of revenues in international R&D projects that involve other Portuguese organizations.

Revenues Involving German Partners 2017

[K€]

1 | 8

87

311

[%]

1 | 2

21

76

■ German companies

■ International projects

■ National projects

■ FhG cooperation projects

Revenues Involving Portuguese Partners 2017

[K€]

1

377

481

313

[%]

1

32

41

26

■ Portuguese companies

■ International projects

■ National projects

■ FhG cooperation projects
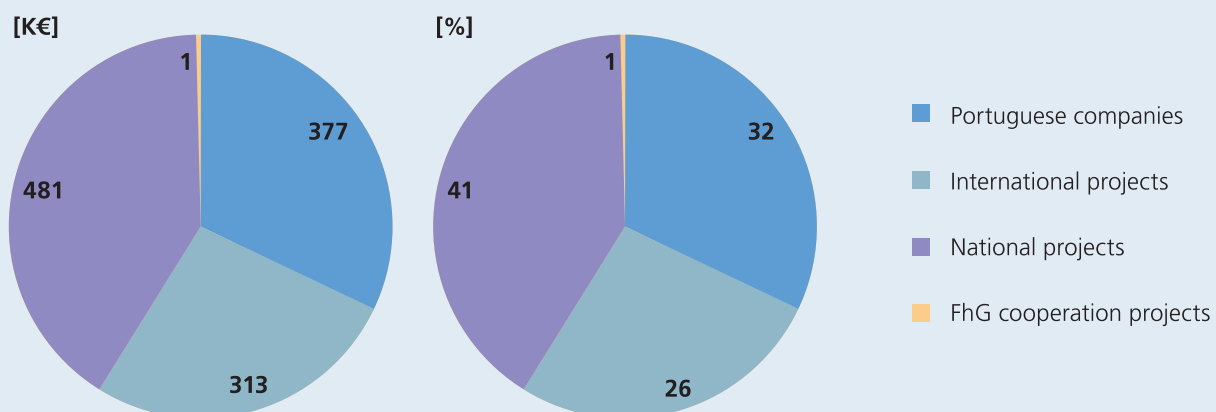
Scientific Results & Corporate Development

- First initiatives of Knowledge and Technology transfer.

- Two new patents granted.

- Liliana Ferreira appointed as FhP-AICOS director.

In terms of the scientific results, the year of 2017 was particularly fruitful, and in the next sections we describe some of the accomplishments that the scientific team was able to attain. Actually there would be much more successful outcomes to share with Fraunhofer Portugal's stakeholders, but the topics selected for this report are the ones that particularly marked the development of FhP-AICOS.

The first result to highlight is related to ACP Street Libraries – Culture for All, a project that was created to preserve and to promote, digitally, the local culture of Africa, Caribbean and Pacific – ACP countries. This project was coordinated by FhP-AICOS and developed in four countries: Ghana, Liberia, Cameroon and Mozambique. The results of the project, which had a direct impact in 20.000 children, were presented in the headquarters of Fraunhofer Portugal, in Porto and the closing event was attended by the international partners of the project.

Regarding the project Sustainable Villages for Development – SV4D, in 2017 FhP-AICOS started the deployment of a solution to provide Internet access in rural areas of three developing countries, Cape Verde, Mozambique and São Tomé and Príncipe, aiming to improve the quality of life of

the communities and to reduce the Digital Divide. A team of FHP-AICOS scientists completed a series of site surveys on the Zambézia province, North region of Mozambique, Lobata district, São Tomé and Príncipe, and Cidade Velha, Cape Verde, with the goal to install pilot projects in these regions. This last location, Cidade Velha, is an UNESCO World Heritage Centre, being the first European colonial town to be built in the tropics, and marks a decisive step in European expansion at the end of the 15th century towards Africa and the Atlantic area, which has a symbolic relation to the SV4D project and the expansion of FhP-AICOS' initiatives towards Africa.

2017 was also the year when FhP-AICOS started to develop several Scientific and Technological Knowledge Transfer initiatives. These actions promote the results of applied research projects and the contribution of this research to the development of society. Different sessions of dissemination of knowledge transfer were organized during 2017 in Portugal and in Africa, namely in Cape Verde, Mozambique and São Tomé and Príncipe, where the concept and technology related to the Sustainable Villages for Development (SV4D) project were presented.

During the last years FhP-AICOS has been developing a solution for the evaluation of fall risk factors on a daily basis, the Fall Risk App, and during 2017 a study was conducted by the Faculty of Health Care of Zuyd University to validate its application, developed in partnership with the Dutch company Gociety. The aim of the validation study was to compare the evaluation of fall risk made by the developed application and three standard fall risk assessment tests: Tinetti Performance Oriented Mobility Assessment (POMA), Timed Up and Go (TUG) and Functional Reach (FR). The Faculty of Health Care

of Zuyd University conducted the validation of the project, with a total of 65 subjects (mean age was 65.7 ± 6.5 years old). In a group of 29 males and 36 females, 31 used walking aid and 24 have fallen last year. All the participants carried, during two weeks, a smartphone inside the pocket or fixed in the belt. The mean fall risk score calculated by the application during that time showed good correlation with the standard tests: the correlation with the correlation with POMA and FR tests is moderate and with the TUG test is strong.

Another important achievement in 2017 was the validation of the ShopView solution, which uses state of the art image processing technology, together with a semi-automatic device, to compare shelf layout and product placement plans (planograms) with actual in-store product displays, thus detecting wrong product location and out-of-stock situations. Following the public demonstration of the ShopView2Market project in Portugal, the solution was successfully tested during an international demonstration at SPAR Austria. With over 12.000 stores in over 40 countries, SPAR is one of the largest food retailers worldwide. Michael Pecher, Head of Branch Coordination at SPAR Austria and member of their Innovation Board, referred at the end of the demonstration that "the prototype works and can help solve a business challenge for retailers, thus helping serve our customers better".

FhP-AICOS received in 2017 an important award in a contest called RESOLVE, which is promoted by i3S – Instituto de Investigação e Inovação em Saúde: research institute on cancer, host response interaction, neurobiology and neurological disorders. RESOLVE is a consistent and effective ignition program to promote seed projects and start-ups in the health sector, boosting the translation of innovative ideas into business ventures and value creation. The technology that FhP-AICOS presented in this competition concerns with the design and implementation of a framework of risk triage of skin cancer, which uses a new generation of mobile devices in its architecture to capture the images. This technological framework automatically pre-process and segments mobile-acquired skin moles images, as well as perform image registration and extraction of significant features for risk assessment and melanoma pre-diagnosis purposes. In some preliminary contacts with the Shared Services of the Ministry of Health (SPMS), this entity, which concentrates most of the developments and support to technologies used in the National Health System, revealed a strong interest to implement a pilot initiative with this technology.

During the second quarter of 2017 FhP-AICOS received the notification of another important accomplishment, the grant of two patents associated to a Global Calibration system for Precise Indoor Location: 'Mobile Portable Device and Position Determination', European patent EP2999973B1, and 'Mobile Potable Device and Positioning', US patent US9797984B2. This significant achievement will allow our team to further develop the technological components associated to this topic and to reinforce our competitiveness in this scientific area.

In terms of the results achieved in the scientific domain, the following table provides a summary of FhP-AICOS' activities with an important impact:

Scientific Activities	
Papers	16
Master's Thesis	14
Book Chapters	3
Patents Granted	2

At the corporate level, 2017 is inevitably marked as a period of significant changes in the organization. After the announcement of Prof. Doctor Dirk Elias, in October 2016, a series of administrative processes were initiated internally to ensure a smooth transition in the management of the organization. Within this context, an interim position was created for the figure FhP-AICOS' director, and Pedro Almeida assumed the functions of Acting Director of Fraunhofer Portugal until a new person was selected for the position of Director.

The recruitment process for the new Director for FhP-AICOS evolved as planned during the first semester of 2017 and the new Director of FhP-AICOS was formally appointed in September. Actually, the person selected to assume this high profile functions and responsibilities is well-known among Fraunhofer Portugal's team, as it was a former collaborator that had an important role in our organization, having assumed the positions of Senior Scientist and President of the Scientific Board. Her name, Liliana Ferreira, was received with

great enthusiasm by all the team, having Fraunhofer Portugal now the opportunity to strengthen its position as one of the top applied research organization in Europe. The fact that Liliana Ferreira knows very well the competences, strengths and weaknesses of Fraunhofer Portugal gives a high level of confidence that the future of FhP-AICOS will be prosperous.

A not so positive event to be reported in 2017 was an incident in the Lisbon office that conditioned the use of our laboratories. Unfortunately a fire occurred in one of the offices due to a problem with an air conditioning equipment and the smoke and residues affected all the space. Due to the type of particles released during the fire, a special cleaning was necessary that lasted until the end of the first semester of 2017. After the cleaning a series of tests were conducted to ensure that the work environment was safe and the operation come back to normal.

In February Fraunhofer Portugal signed a protocol with the Ministry of Economy, through the Portuguese National Innovation Agency (ANI), for the contribution on the INTERFACE Programme creation. One of the purposes of the INTERFACE Programme is to develop dynamic interactions between scientific and technological entities, promoting scientific and technological knowledge transfer for companies and for society. The innovation process is only possible with the improvement of technological infrastructures and with the strengthening of financial and human resources, which allows to increase investigation and development (I&D) cooperation networks, to appreciate the knowledge, to create products, services and companies based on science and technology.

FhP-AICOS signed also a protocol with the Lobata District Council, a district located in São Tomé and Príncipe. The official ceremony occurred on October 24th, with the presence of the Mayor of the Lobata District Council, Policarpo Freitas.

This cooperation protocol lays the foundation for a partnership which aims to pool and dedicate efforts to research and development in the Information and Communication Technologies (ICT) area, as well as to improve and facilitate the services of the District Council.

The agreement sets in motion several Research and Development projects. It also aims to kick start joint programs, with the purpose of contributing to the growth of the District, in the areas of Information and Communication Technologies. It also contemplates the sharing of experiences, scientific knowledge and studies regarding the technical management of Council services, and the training of the institution's technicians.

Business Performance

–   Total Business Volume of 3,2M€.

–   Total Project Revenues above 1,7M€.

–   Global performance of the organization of 62%.

In 2017, FhP-AICOS recovered from the glitch of the previous year and registered the best result ever of its Business Volume, above 1,7M€, and a global performance in line with its best achievements of the last years, 62%. As explained in the previous sections, the delays in the administrative processes related to the evaluation of PT2020 project proposals are still affecting the operation of the organization, this being the external factor that unfortunately continues to affect the performance of the organization.

By the end of the year, the total Business Volume was circa 3,2M€, representing an increase of 2% compared with the previous year.

The total project revenues surpassed 1,7M€, representing an increase of 18% when compared with the previous year. National project revenues increased 91%, industry projects revenues decreased 16%, and EU project revenues increased 1%.

As a result of the combination of the above results, FhP-AICOS global KPI, which measures the volume of revenues over the total operational costs has increased 9%. The total operational costs increased 1%, which in combination with the increase of external revenues, resulted in a global performance (total external revenues / total operational costs) of 62%.

Total Business Volume (cash basis) 2014–2017 [€]
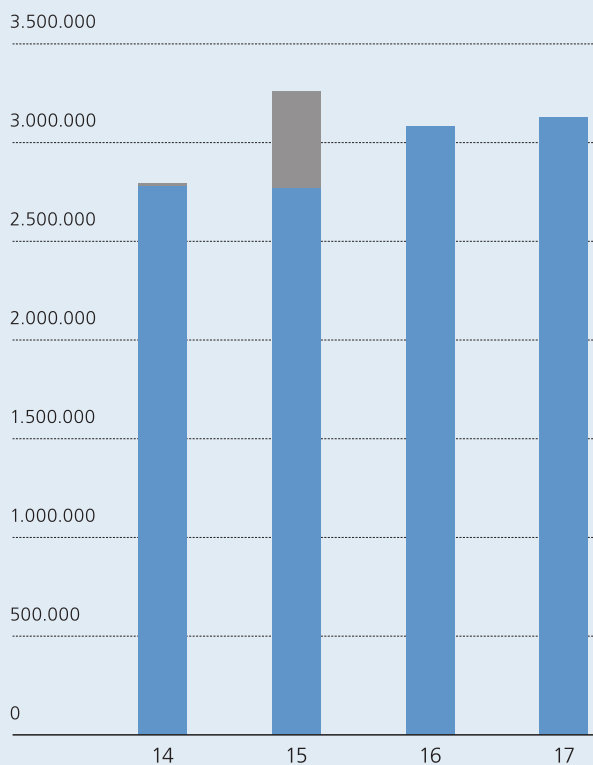
	2014	2015	2016	2017
⬜	10.000 €	474.668 €	-862 €	0 €
🟦	2.781.572 €	2.792.212 €	3.108.540 €	3.155.836 €

⬜ Major Infrastructure Capital Expenditure

🟦 Contract Research
(Total Expenses and Research Capital Expenditure)

Contract Research

– Staff costs on similar levels of the previous year.

– Non-staff costs consistent with current costs distribution.

– Increase in CAPEX related to investment planned for 2017.

Personnel expenses for contract research increased 3%, and represented 78% of our total operational cost in the financial year of 2017. This is in line with the costs of the last year, although the current remuneration model for FhP-AICOS' director implies that part of the cost is recognized as personnel costs.

Non-personnel costs decreased by 5%, which is in line with the expenditures of the last years.

Capital expenditure with R&D contract research rose by 3% when compared with 2016. This evolution is in line with the plan approved in the budget for 2017 that included an extensive list of scientific equipment's to be acquired during the year.

FhP-AICOS increased its revenues by 18% vs. 2016. Since 2011, our compound annual growth rate[2] is 22.09%, which are very good results considering the economic adjustment period experienced in Portugal since 2011.

Our Industrial revenue decreased 16% vs. 2016. This is a result of the delay in the evaluation of six PT2020 industry project proposals. When compared with our Operational Revenues, Industry revenues now account for 32%.

2 *Compound annual growth rate (CAGR) is a geometric average growth rate over a period of several years.*

Contract Research Revenue Evolution 2014–2017 [€]
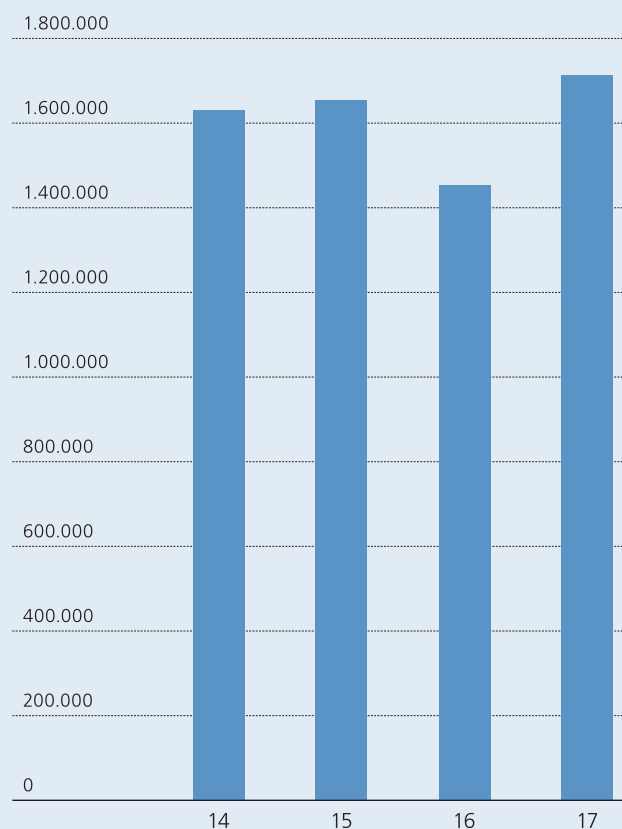
	2014	2015	2016	2017
	1.626.224 €	1.651.855 €	1.444.386 €	1.709.342 €

■ Contract Research

Revenue from national projects increased to 91% when compared to the last year. This increase is explained by the two Knowledge and Technology transfer projects that were contracted in 2017.

Revenue from EU-funded research projects decreased their share to 23% in our Operational Revenues. Despite the reduction in the relative share compared with the total revenues, the absolute value of EU revenues increased in 2017.

Employees

– Peak of 89 collaborators in February.

– Increase of FTE in 5,93%.

– Increase of 5% of female Scientists.

Fraunhofer Portugal's success and Human Resources policy is based on the respect for human values, merit, pro-activity, observance of the law, and on knowing how to reach the goals we propose, in order to build a motivated team united towards innovation.

During 2017, we were able to increase our regular staff Full Time Equivalent (FTE) in 5,93%, and this is proof that Fraunhofer Portugal is able to captivate and retain talents (61% vs. 57% in 2016).

Headcount Evolution 2014 – 2017

Year	Scientific, technical and administrative personnel
2014	82
2015	74
2016	75
2017	80
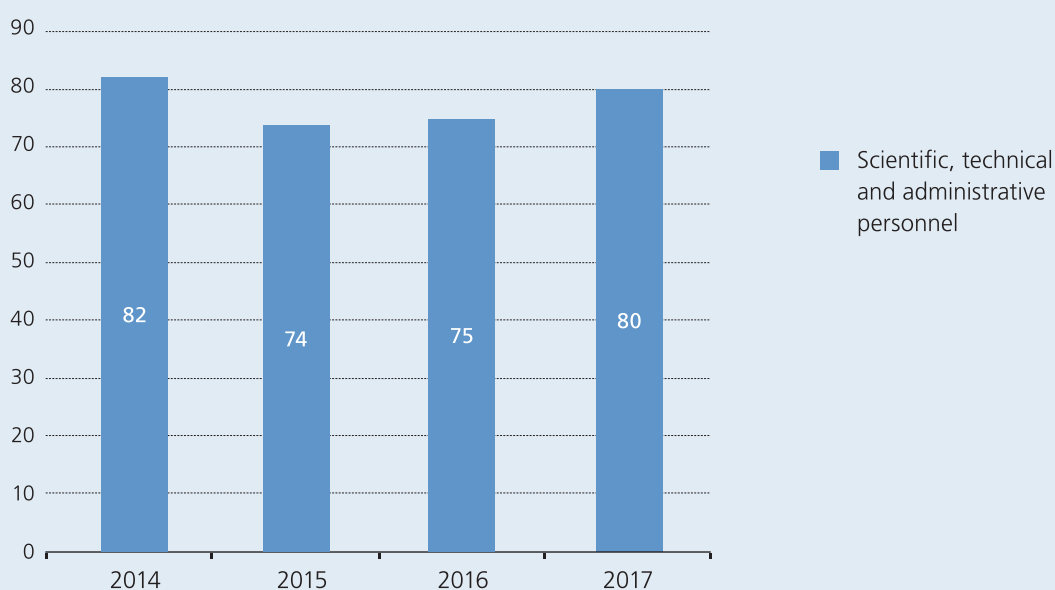
As in previous years, Fraunhofer Portugal had a peak of collaborators during the months in which the thesis students were welcomed, reflected in February of 2017 with a head-count of 89 people.

During 2017, Fraunhofer Portugal was able to maintain the team on the average of 83 collaborators and closed the year with a total headcount of 80 collaborators. We run a highly qualified team, as 98% of our staff members have a university degree, 59% are MSc and 9% have a PhD degree.

Also, during 2017, 29 collaborators joined Fraunhofer Portugal, 17 under work contract and 12 grant holders, and it is noteworthy that from the 17 celebrated employment contracts 11 are the result of grants that we have attributed.

2017 was also, and for the first time, a Welcome Back year for three former employees that had left Fraunhofer in the last years, and we closed the year predicting the integration of one more former collaborator in January of 2018.

Along the year of 2017, some collaborators left Fraunhofer Portugal, 26% less than in 2016. The main reason behind these changes was, once again, better work contracts offered by the industry sector to our previous employees. This is a result of the training and technical skills acquired at FhP-AICOS and, once again, proves that we are accomplishing our mission to increase the innovation pace of the Portuguese Economy by contributing to the qualification of highly skilled individuals that are of interest to the industry.

Regarding Human Resources activity, and following our vision to motivate the team and promote merit and pro-activity of all collaborators, in the second semester of 2017 we proudly an-nounced the winner of the 2017 Entry Level Excellence Award, awarded to a young researcher that achieved outstanding results in the previous years: David Ribeiro.

Outlook and Strategic Development

Portugal's economic recovery gathered pace in 2017 and innovation has been identified by the Portuguese government as the basis for rising prosperity. Portugal seeks to accelerate innovation in its commercial life to raise the productivity of its economy. The Portuguese start-up ecosystem doubled in 2017 the European average growth rate. The entrepreneurial mindset is finding its way through and taking place on the international routes.

For FhP-AICOS, this means new opportunities and an improved environment for increasing business results. The recent align-ment between the FCT, Fraunhofer-Gesellschaft and Fraunhofer Portugal to extend the partnership between Fraunhofer and Portugal with the creation of a new research centre focused on the topics of smart agriculture and water management, is an outcome of such environment. This new centre will bring together related activities at the Institute for Ceramic Technologies and Systems (IKTS) in Saxony and Thuringia (Germany) with the Portuguese research excellence and a broader spectrum of climate zones. FhP-AICOS competencies in information technology and emerging communications, namely our know-how in intelligent systems, artificial intelligence, networks and user-centred design, are expected to contribute significantly to the activities of this new initiative and also help to boost FhP-AICOS related business.

Also, the positive evolution of the conversations with the Dutch company Gociety regarding the FhP-AICOS born GoLiveClip, give positive indications for the successful continuation of busi-ness with this customer. FhP-AICOS competencies supported the creation of a robust and market-ready consumer product that will improve the quality of life of its end-users. GoLiveClip is the first device of its kind, as it combines activity monitoring, an alarm button, a fall risk analyser and a fall detector in a device specially designed having in mind the health and safety of the general population and seniors.

The commercial launch of this product on November 2017 after an agreement with the Dutch healthcare insurer Zilveren Kruis to bring GoLiveClip to their insured population, allows the continuation of the successful relationship between FhP-AICOS and Gociety. These positive indications are reflected in the negotiations already taking place for new related projects in 2018. The positive trend of wearables in healthcare, reflected in the predicted value of 110 million fitness devices to be sold in 2018, also provides positive indications regarding the success of this product and the possibility of obtaining revenues from the licensing of GoLiveClip in the coming years.

Also, the promising results obtained in the IoTIP project, together with our partner Amkor Technology Portugal SA, are creating relevant opportunities for selling and accelerating the market entry of this innovative solution. IoTIP is a development platform for wearables and IoT based on a wafer-level modular architecture, which also includes a set of software tools that help developers to build new wearable and IoT solutions based on this architecture.

In fact, and as already indicated in the editorial section, the year of 2017 was a game-changing year for FhP-AICOS. The latest months of 2017 launched the definition of a new strategy and the identification of new ways for productive cooperation between FhP-AICOS and its clients and partners.

For almost a decade, FhP-AICOS has been working to extend the reach of the Information and Knowledge society and enhance the life of specific groups, such as seniors and populations in remote regions or developing countries, by offering them intuitive and useful technology solutions. But there are more opportunities ahead. Digitalization in all spheres of life and all sectors of our economy continue to accelerate, and FhP-AICOS competences in developing intelligent technology for users which fall out of mainstream audiences due to particular needs can bring greater value.

In the last quarter of 2017, we started to reshape the competencies offered to our clients and partners into three pillars: Personal, Connected and Intelligent solutions. This transformation comes together with the identification of new topics for the application for these competencies: as Health and Wellbeing, Industrial Production, Precision Agriculture and Sustainable Communities.

Placing people at the center of our design process creates the unique conditions for the best possible match between technology and user needs. We apply research and development methods from engineering, design and social sciences to solve problems impacting people not yet fully served by mainstream technology while looking at the potential to create innovative solutions for larger markets.

This strategy is closely linked with the definition of a portfolio of R&D services that can be provided to our customers and a stronger connection to the University of Porto to ensure the increase of our scientific critical mass.

The availability of a team of highly qualified researchers in the identified areas and the fostered culture of cross-pollination, also with other institutes and industry partners, allows FhP-AICOS to focus and strengthen its core competencies, extend its market position in Portugal and Europe, and brings additional confidence on the success of this path.

The conclusion and application of the strategy is expected to be reflected in quantity and quality of our scientific outputs, in the value brought to science, economy, and community, and, consequently, in our business results.

Liliana Ferreira
Director

Perspetivas e Desenvolvimento Estratégico

A recuperação económica acelerou em 2017. A inovação foi considerada pelo Governo Português como essencial para a prosperidade, que continua a apostar na inovação como base para o aumento da produtividade económica. O ecossistema das "Start Up" portuguesas cresceu o dobro da média europeia e a mentalidade empresarial nacional tem-se tornado uma realidade, obtendo crescente reconhecimento nas rotas internacionais

Para o FhP-AICOS, este ambiente traduz-se em novas opor-tunidades de negócio e potencial para melhores resultados. O recente acordo entre a FCT, a Fraunhofer-Gesellschaft e a Frau-nhofer Portugal para ampliar a parceria entre a Fraunhofer e Portugal através da criação de um novo centro de investigação focado nos temas da agricultura de precisão e gestão hídrica, é um resultado significativo desta envolvência. Este novo centro reúne as atividades relacionadas do instituto alemão Fraunhofer Institute for Ceramic Technologies and Systems (Fraunhofer IKTS) na Saxónia e na Turíngia (Alemanha) com a investigação nacional de excelência e um espetro mais amplo de zonas climáticas. As competências do FhP-AICOS em tecnologias da informação e comunicações emergentes, nomeadamente o nosso conhecimento em sistemas inteligentes, inteligência artificial, redes de comunicação e *design* centrado no utilizador, têm o potencial de contribuir de um modo significativo para as atividades desta nova iniciativa, bem como impulsionar as nossas oportunidades de negócio relacionadas.

A evolução positiva das conversações com a empresa holandesa Gociety relativamente ao GoLiveClip, desenvolvido pelo FhP-AICOS, fornece também um indicador positivo para a continuidade das já bem-sucedidas negociações com este cliente. As competências do FhP-AICOS garantiram já a criação de um produto robusto e pronto a ser comercializado que melhorará a qualidade de vida dos seus utilizadores. O GoLiveClip é o primeiro dispositivo do género, uma vez que

combina monitorização de atividade, um botão de alarme, um avaliador do risco de queda e um detetor de quedas, tudo num dispositivo especialmente concebido para garantir a saúde e a segurança da população sénior.

O lançamento comercial deste produto em novembro de 2017, após um acordo com a seguradora de saúde holandesa *Zilveren Kruis* que permitiu levar o GoLiveClip até à sua população segu-rada, permite a continuidade da boa relação entre o FhP-AICOS e a Gociety. Estes indicadores positivos refletem-se nas atuais negociações para novos projetos em 2018. A tendência positiva que se identifica atualmente na tecnologia *wearable* para os cuidados de saúde, refletida no valor previsto de venda de 110 milhões de dispositivos de *fitness* em 2018, é também um indicador positivo para o sucesso deste produto e para potenciais resultados oriundos do licenciamento do GoLiveClip nos próximos anos.

Também os resultados promissores obtidos no projeto IoTIP, em conjunto com o nosso parceiro Amkor Technology Portugal SA, estão a criar oportunidades relevantes para a aceleração da entrada no mercado desta solução inovadora. O IoTIP é uma plataforma de desenvolvimento para *wearables* e para IoT (*Internet of Things*), baseada numa arquitetura modular construída ao nível da *wafer*, que inclui também um conjunto de ferramentas de *software* que facilitam o desenvolvimento de novas soluções baseadas nesta arquitetura. A tecnologia tem reunido o interesse de diversos parceiros e clientes nacionais e internacionais.

De facto, e como já indicado na secção editorial, o ano de 2017 foi um ano de mudança para o FhP-AICOS. Os últimos meses de 2017 iniciaram a definição de uma nova estratégia e de novas formas de cooperação entre o FhP-AICOS e os seus clientes e parceiros.

Durante quase uma década, o FhP-AICOS trabalhou para alargar o acesso da sociedade da informação e do conhecimento e melhorar a qualidade de vida de grupos específicos, como os seniores e as populações em regiões remotas ou de países em desenvolvimento, oferecendo-lhes soluções tecnológicas intuitivas e úteis. Mas há mais oportunidades a explorar. A digitalização continua a acelerar, em todos os aspetos da vida e em todos os setores da nossa economia. As competências do FhP-AICOS no desenvolvimento de tecnologia inteligente para utilizadores não convencionais podem trazer grandes oportunidades.

No último trimestre de 2017, começamos a estruturar as competências oferecidas aos nossos clientes e parceiros em três pilares: Pessoas, Conetividade e Inteligência. Essa transformação está ligada à identificação de novos tópicos para aplicação destas competências: saúde e bem-estar, produção industrial, agricultura de precisão e comunidades sustentáveis.

Colocar as pessoas no centro do processo de *design* cria condições únicas para atingirmos a melhor combinação possível entre a tecnologia e as necessidades dos utilizadores. No FhP-AICOS, aplicamos métodos de investigação e desenvolvimento em engenharia, *design* e ciências sociais para resolver problemas que afetam a vida das pessoas ainda não totalmente abrangidas pela corrente tecnológica. Ao mesmo tempo, avaliamos o potencial que existe na aplicação destas soluções inovadoras em mercados mais abrangentes.

Esta estratégia está intimamente ligada com definição de um novo portfólio de serviços de I&D a serem fornecidos aos nossos clientes e com uma ligação mais forte com a Universidade do Porto que garanta o aumento da nossa massa crítica científica.

A disponibilidade de uma equipa de investigadores altamente qualificados nas áreas identificadas e a cultura fomentada de polinização cruzada, também com outros institutos e com parceiros industriais, permite que o FhP-AICOS atinja e fortaleça as suas competências essenciais, bem como a posição de mercado em Portugal e na Europa.

Espera-se que a conclusão e a aplicação da estratégia se reflita na quantidade e qualidade dos nossos resultados científicos, no valor trazido à ciência, educação, economia e à comunidade e, consequentemente, o aumento dos nossos resultados de negócio.

Liliana Ferreira
Diretora

REVIEW OF FRAUNHOFER PORTUGAL RESEARCH

STRATEGIC RESEARCH AGENDA

PROJECTS AND RESULTS 2017

STRATEGIC RESEARCH AGENDA

AS FRAUNHOFER PORTUGAL CURRENTLY ONLY OPERATES ONE RESEARCH CENTER, NAMELY FRAUNHOFER PORTUGAL AICOS (FHP-AICOS), ITS STRATEGIC RESEARCH AGENDA IS DICTATED BY FHP-AICOS' INTERESTS AND ACTIVITIES.

Business Fields

FhP-AICOS addresses two main business fields: Ambient Assisted Living (AAL) and the emerging field of Information and Communication Technologies for Development (ICT4D).

Ambient Assisted Living

Ambient Assisted Living (AAL) includes methods, concepts, (electronic) systems, devices and services that are providing unobtrusive support for daily life, based on the context and the situation of the assisted person. The technologies applied for AAL are user-centric, i.e. oriented towards the needs and capabilities of the actual user. They are also integrated into the immediate personal environment of the user. As a consequence, the technology is adapting to the user rather than the other way around. In order to share relevant information between systems and services, technologies for AAL should ideally be based on modular and interoperable concepts.

A main driver for the development of AAL technologies is the increasing number of ageing population and the inversion of the demographic pyramid that is occurring in developed countries. AAL technologies can be instrumental in tackling the massively increasing cost of healthcare and social security. Another driver is the rising number of single person households together with rising expectations towards the quality of life. AAL technologies also cater towards the increasing demand of safe and comfortable living environments, as well as the increasing demand for communication and stronger social interaction with others.

FhP-AICOS intends to mainly address the needs of the ageing population, not only to reduce innovation barriers of forthcoming promising markets, but also to lower future social security costs. This can be achieved through the use of intelligent products and the provision of remote services, including care services that allow the time senior citizens can live in their home environment to be extended, while guaranteeing adequate comfort, safety and quality of life. These services will increase their autonomy and assist them in carrying out day-to-day activities.

The research and development of Ambient Assisted Living solutions by FhP-AICOS aims at a primary target user group – the Ageing and Elderly – with the purpose of:

- Extending the time people are able to live in their preferred environment by increasing their autonomy, self-confidence and mobility;

- Maintaining health and functional capability of elderly individuals;

- Promoting a better and healthier lifestyle for individuals at risk;

- Enhancing security and safety, to prevent social isolation and to help maintain the multifunctional network around the individual;

- Supporting caretakers, families and care giving organizations;

- Increasing the efficiency and productivity of resources used in ageing societies.

Information and Communication Technologies for Development

Information and Communication Technologies for Development (ICT4D) is a general term used to refer to the application of Information and Communication Technologies (ICT) within the field of socioeconomic development or international development. ICT4D focuses on directly applying information technology approaches to reduce the digital divide and therefore contribute to poverty reduction in developing countries.

FhP-AICOS intends to focus its ICT4D activities on the African continent, specifically on Mozambique and Angola. The primary target user group will be ICT users in rural and developing areas, and the objective is to provide solutions for mobile device services and applications matching the local users' demands and contributing to a more positive user experience which, in many cases, may be their first contact with ICT.

One of the most dominant differences between ICT usage in industrial and developing countries is the type of devices and technologies used when interacting with ICT. In industrial countries, interaction with ICT is made primarily via PCs, while in developing countries the mobile phone has taken over the role of primary device of access and interaction with ICT.

Mobile devices, like smart(er)-phones and Mobile Internet Devices will continue to play a dominant role in developing countries in terms of growing widespread usage. In developed countries, the same tendency occurs, although the current use of PCs potentially slows down this trend when compared to developing countries.

Business Sub-Fields

Due to the large amount of topics related to both fields, and our comparably small R&D team, we have chosen to focus on fewer subfields that our customers consider relevant and which, over the first period of operation, we were capable of creating, taking into account our core competences which clearly differentiate us from our competitors.

In the AAL business field we currently cover the following subfields:

Fall and Activity Monitoring

For frail and elderly individuals, falling can have serious conse-quences including injury, psychological damage, limitations on mobility and reduced quality of life. Technology addresses this issue following two different perspectives: providing a better emergency response after a fall has occurred and allowing for detection and prevention of falls, through continuous mon-itoring of senior adult activity. Despite the market potential, current technological solutions are cumbersome and are not inclusive, focusing only on formal caregivers, they present cost obstacles and are, in general, hard to handle and maintain. FhP-AICOS' approach to fall prevention, detection and activity monitoring focuses on the development of solutions for smartphones which have several clear advantages: cost effectiveness, user friendliness and inherently manageable.

Chronic Diseases and Well-Being Management

Along with an ageing population comes the higher incidence of different chronic diseases. In high-income countries, chronic diseases are the greatest cause of early death and disability and also a major source of costs for social security systems. FhP-AICOS partners with relevant entities (companies, health care providers, public entities, etc.) in an attempt to help society improve the services for chronic disease management, by creating valid prototypes and contributing to the standardization effort through several different existing solutions, or solutions which are yet to come.

Assistive Environments

As the world's population is ageing, there is a growing need to support independent living conditions for elderly individuals. Assistive environments incorporate the latest pervasive and ubiquitous technologies and provide a viable alternative to traditional assistive living solutions. One of the aims is to enhance the user comfort. Comfort can be an essential or fundamental benefit for people with disabilities or elderly individuals. Environments equipped with these solutions are able to compensate some disabilities of the senior users by simplifying daily routines and reducing the elderly individual's dependency on other people by taking advantage of the functionality of the environment by themselves, reinforcing their independence and personal freedom and allowing them to remain in their usual surroundings for longer time. FhP-AICOS' approach is to simulate assistive environments as closely as possible by taking advantage of its Living Lab and to create applications that enable the consolidation of this vision.

With regard to the emerging ICT4D business field, one subfield has currently been defined:

ICT4D on Mobile Devices

The above mentioned subfield consists of mobile ICT solutions jointly developed with African partners for user groups in rural and developing areas in order to enhance the living standards of those groups. In the beginning, the solutions will target four application areas which were identified as the most market relevant in the next years: agricultural production chains (mAgriculture), micro-enterprises (ICT for Very Small Enterprises), mobile health (mHealth) and mobile Government (mGovernment).

Core Competences

FhP-AICOS' core competences are strongly related to the demands of our customers in the above described business fields. Some competences have been specifically created based on the request of a specific customer, but the vast majority is related to our prediction of a future demand from the side of our customers. In order to gain competences, we are using internal projects that will ideally lead to existing results and competences when a customer requires them. In this case, we can successfully transfer an internal project into an external industry project. In other cases, we are able to convince customers with results from internal projects that do not yet completely match the requirements of our competence to achieve the desired result on time and with high quality. Thus, the selection process for internal projects is very important, as any competence that we create and which is not used afterwards within a reasonable time needs to be considered as holding academic value only and as an investment without return.

To date, FhP-AICOS has developed the following core competences:

Human-Computer Interaction (HCI)

At FhP-AICOS, designing products and services that are adapted to our specific target audiences and which meet their needs is a main goal to be addressed. The HCI team is responsible for performing user research, designing solutions according to its results and iterating them through evaluations with both experts and final users. As such, the group is expected to ensure the significance and usability of any solution developed at the institute. The research performed within the HCI core competence is focused on the following subfields:

– User & Social Experience, associated with research on users' characteristics as well as their environments and context. It provides the knowledge required to create meaningful solutions that meet users' demands;

– Mobile & Future Devices, a research field that includes the discovery of new technologies with the goal of enhancing users' interaction with current and novel systems;

– Evaluation & Usability, focuses on evaluating the extent to which developed solutions fit users' expectations. It includes systematic evaluation tests with both HCI professionals and end-users.

Information Processing (IP)

This core competence has originated from the demands imposed by our business fields and provides us with the capability to generate algorithms to solve the problems that arise in our projects. Advances in information and communication technology have triggered an exponential growth in the amount of data available. IP scientific area is related to the methods developed to cope with these vast amounts of information ranging from simple sensor events, over natural language to complex multimedia content. The IP core competence has been divided, according to our main activities, into three main subfields:

– Content Retrieval, a research field concerned with the search of information within multiple contexts. It is mainly related to the development of algorithms to extract and process the data retrieved from the different sources available;

– Context Awareness, focuses on the development of ubiquitous solutions that use unconventional sensor data and combine it with environmental context information, such as the users' location or even meteorological and other geographical information;

– Multimodal Information Fusion, concerned with the combination of the information retrieved by different sources. It is mainly applied in FhP-AICOS to fuse the information retrieved by different sensors in order to replace external sensors by software for smartphones.

Autonomic Computing (AC)

FhP-AICOS aims to create solutions adapted to people's needs and competences. However, the variety of communication technologies, Operating Systems and networked devices creates complexity in the daily life of non-technical people. The AC core competence addresses the aforementioned complexity by proposing solutions capable of adapting to time changing conditions while hiding the intrinsic complexity from the non-technical people. Moreover, due to the specific requirements of FhP-AICOS business fields, there was the need to focus on one specific AC subfield:

– Remote Management, Control and Configuration, a research field consisting of reusing and extending remote management protocols and service discovery standards as well as implementing modular and adaptive software architectures. It is mainly applied at FhP-AICOS to cope with the lack of interoperability between devices and applications and the reduced remote management capabilities in AAL and ICT4D.
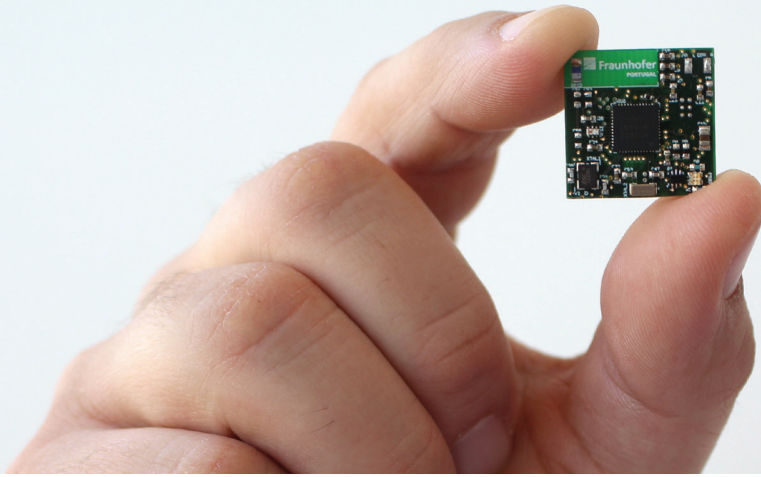
As a consequence of the work we carried out in the business subfield 'Fall and Activity Monitoring' related to the very interesting achievements regarding the related competences in 'Multimodal Information Fusion', we decided to increase our activities in order to prepare for the predicted market demand through the creation of a Fall Competence Center (FCC). The FCC concentrates our efforts and extends the scope to go beyond the current focus on fall detection and fall risk prediction to the two additional application fields of falls in extreme sports and incident detection for security and safety personnel. Likewise, we extended our activities in the emerging business field ICT4D through the creation of the ICT4D Competence Center (ICT4DCC), which concentrates all the competences required to develop and assess solutions for mobile devices in the application fields of mAgriculture, mHealth, mGovernment and ICT for Very Small Enterprises (business solutions for the growing micro-enterprises in developing countries). It also allows us to form an international team with guests from Africa and Europe that have the potential to create a joint melting pot for the related activities of Fraunhofer in Germany.

PROJECTS AND RESULTS 2017

EXTERNAL PROJECTS

In accordance with the Fraunhofer Business Model, two thirds of Fraunhofer Portugal's income should be generated by external projects which can have one of two formats: Industry Contract Research, i.e. projects having industry partners as clients, or Government Contract Research, i.e. projects resulting from the participation in national and EU publicly funded programmes. This section describes the external projects that are being developed at FhP-AICOS.

ACP Street Libraries – Culture for all

Description: The main objective of the ACP Street Library project is to contribute to the development of culture in ACP (African, Caribbean and Pacific Group of States) countries mainly by promoting the creation of new Street Libraries and the modernization of existing ones. The partners involved in the project also plan to develop a set of activities related to the ACP Cultural sector promotion and consolidation mainly by encouraging the preservation of local cultures that are currently only transmitted in oral format.

There are four specific objectives associated to the project implementation, namely:

– Increase the number of ACP Street Libraries;

– Increase the number of books available for oral reading in ACP Street Libraries;

– Improve existing databases of ACP countries local culture;

– Improve ACP countries discussion and cooperation platforms.

The key stakeholders of the project will be actual and future cultural entrepreneurs, who will benefit from the project or promote and disseminate their artistic work; NGO (Non-Governmental Organizations) and private and public institutions, who will benefit from the project by building the necessary capacity to create new Street Libraries and cultural projects; universities and research centres, who will benefit from the new project results by promoting technology transfer to the local students, local partners and international ACP members; and finally, the local population, children and young people of ACP countries, who will have access to more cultural resources and who will be able to preserve their local legends and histories for the future generations. All the actions developed in the project will comply with user centred design methodologies, the end-users always being directly involved in all the project activities.

Outcome: This project aims at the creation of a set of actions, services and features supported on mobile technologies, that will allow actual and future cultural entrepreneurs, NGO and private and public institutions, to leverage Street Libraries in ACP Countries, developing this cultural action at regional, national and international levels as well as maximize its impact on local populations, especially in children and young people.

Partners: FhP-AICOS (coordinator) (Portugal); ASRAD – Appui Solidaire Pour Le Renforcement De L'aide Au Developpement (France); Microsoft Portugal MLDC– Microsoft Language Development Center (Portugal); VPWA – Volunteer Partnerships for West Africa (Ghana); YCWL – Youth Crime Watch of Liberia (Liberia).

Active@Home – Social ExerGaming, Dancing and Tai Chi for Wellbeing and Fall Prevention [1]

Description: This project aims at developing a holistic solution, focusing on physical, cognitive and social aspects, to promote physical activity at home and foster fall prevention, based on typical exergames, dance and Tai Chi.

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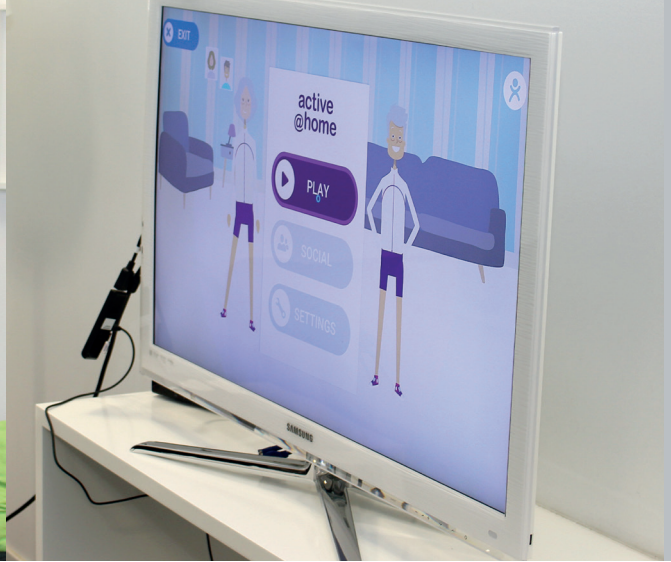
The solution features a home entertainment system that incorporates Tai Chi-based strength training, dance-based balance training and cognitive training explicitly targeted to attentional and executive functions. Exercises are monitored using wearable motion sensors placed on both arms (wrists) and legs (ankles) and are guided by user-friendly virtual characters.

The game runs on a High-Definition Multimedia Interface (HDMI) dongle that is plugged into the TV. All interaction with the game is made resorting to wearable motion sensors, which are worn on the body using a slap-band mechanism. The solution is also supported by a backend which enables all game session data to be stored and further analysed.

By incorporating theoretical background from movement sciences, neuropsychology and arts of game design, the technology-based training game is specifically adapted to the constraints and needs of elderly people and in particular to be used in home-based settings. It is designed towards high usability as well as joyful and entertaining experiences to be motivating. Besides integrating interactive social features, the game adds the possibility of sharing community events, which nourishes social interaction and integration that will further help people living in their homes.

Outcome: A multicomponent interactive game for motor-cognitive training will be developed, focusing on physical, cognitive and social aspects, to promote physical activity at home and foster fall prevention. Game design principles and background from movement sciences will be incorporated in view to obtaining an effective intervention combined with joyful and entertaining experiences. Twenty independently living older adults will participate in extended field trials in Switzerland, the Netherlands and Portugal.

Partners: Dividat GmbH (coordinator) (Switzerland); Comfort Keepers Portugal – Conforto em Casa Lda (Portugal); ETH Zürich – Eidgenössische Technische Hochschule Zürich | Departement Gesundheitswissenschaften und Technologie (Switzerland); KBO-PCOB (Netherlands); MIRALab SARL (Switzerland).

Clockwork – Smart System for the Management and Control of Shift Workers' Circadian Rhythms

Description: The main goal of the Clockwork project is to support the self-care of middle-aged to older shift workers. Particularly, the solution will target shift workers working in healthcare institutions, who are greatly affected by chrono-disruption, which can lead to health issues, long absences or early retirement.

This objective will be achieved by enabling workers to self-monitor relevant parameters and use light interventions that can help them regulating their sleep cycles. Shift workers will wear a Smart badge to track sleep intervals, physical activity, and light exposure; and will use the Clockwork Box for monitoring noise, temperature, and light conditions of their environment. Collected data will be presented to shift workers in a smartphone application, to enable self-reflection about their work and lifestyle, and to sleep and occupational health specialists, to detect early issues on the health of workers before they become problematic. The project will also integrate a Smart Lamp, able to perform bright and dim light interventions, for increasing alertness or triggering sleep.

Outcome: The project will develop a system for shift workers to self-reflect about their activities and intervene using light, and another one for sleep and occupational health specialists to monitor the health of shift workers. Feasibility trials will hint at the several impacts of using the system in everyday activities.

Partners: FhP-AICOS (coordinator) (Portugal); Ab.Acus Srl (Italy); BCB – Informática y Control SL (Spain); Grado Zero Espace Srl (Italy); Grupo Jose de Mello (Portugal); KOHS PIMEX – Kviecien Occupational Health Solutions (Austria); RK Tech Ltd (Hungary).

CordonGris – Making Sense of Data to Promote Effortless Healthy Eating Habits and Autonomy for Older People 2

Description: One major cause of older adults' frailty in many countries is malnutrition. A study from January 2015 reported that one in every six seniors reaching the emergency room are malnourished (Pereira, Bulik, Weaver, Holland, & Platts-Mills, 2015) and those at risk of malnutrition are estimated to be as much as two thirds. Malnutrition can have serious consequences on one's health and independence. Being unable to follow a healthy diet will most likely lead older adults into a vicious cycle: functional decline leads to malnutrition and malnutrition leads to further decline.

The project will create a system to gather and manage all the data that is relevant for the recommendation of a healthy diet, coming from different sources: sensors for activity monitoring, user reported data, country-specific food databases, retailers' information, producers' information, service providers' information. By making sense of all the data, the central intelligent system can generate recommendations that range from meals to physical activity or other healthy behaviours and prompt people to adopt a healthier lifestyle against malnutrition. With its intelligent treatment of the data, along with the recommendations, the project will provide the conditions for the 'flat-rate food' concept to become a reality.

The project is born out of previous knowledge from the different partners and it is designed to build on a strong contribution from field implementations in the three countries participating in it: Portugal (Research and development (R&D) + food supplier + end-user), United Kingdom (food supplier + end-user) and the Netherlands (independent end-user).

Because food can take various forms, our idea is also to acknowledge and work with these different ways of consuming food, e.g. retailers, food producers, pre-prepared food or the well-known concept of meals-on-wheels.

Outcome: To develop a convenient system that leverages the potential of the Internet of Things to guarantee longer living at home by tackling malnutrition. We will do this by:

–   Helping older adults manage their groceries shopping;

–   Leveraging the power of local communities to assist each other in food related aspects;

–   Providing intelligent and healthy food and meal recommendations to older adults based on health characteristics, lifestyle, culture, resources, availability, local production and season;

–   Creating a comprehensive system that brings together the needs of consumers, retailers and food producers;

–   Proving the concept of 'flat-rate food' on field trials.

Partners: FhP-AICOS (coordinator) (Portugal); Can Cook CIC (United Kingdom); Red Ninja Ltd (United Kingdom); SCML – Santa Casa da Misericórdia de Lisboa (Portugal); Sonae Modelo Continente SA (Portugal); Unie KBO – Unie van Katholieke Bonden van Ouderen (Netherlands).

CTFhP – Collective Transfer FhP

Description: Since the beginning of its implementation in 2008, the Associação Fraunhofer Portugal Research has developed a number of Scientific and Technological Knowledge Transfer initiatives in order to promote the results of their applied research projects, and simultaneously promote the importance and the contribution of this research to the development of society in general.
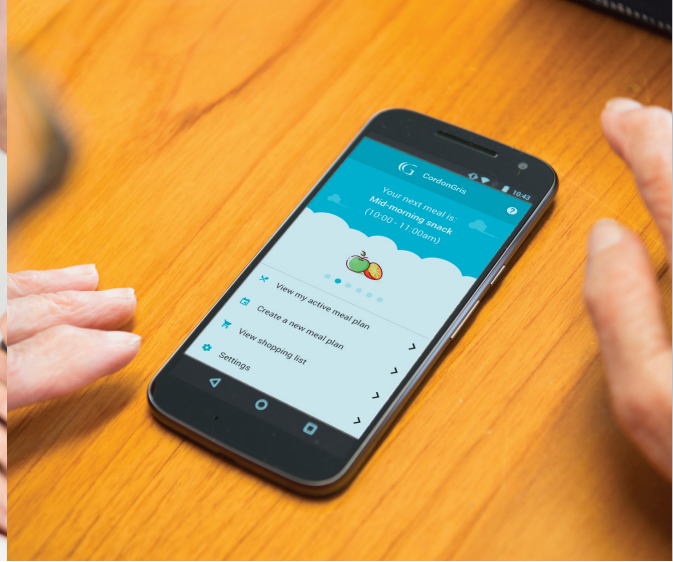
This project presents a set of actions in the field of dissemination and diffusion of new knowledge and technologies generated in R&D and actions in the field of experimentation and effective demonstration of this knowledge in real environments, intending to make a significant contribution to overcome barriers to their assimilation and application by the industry and also to demonstrate a model of good practice in technology transfer applicable to other entities of the Portuguese system of Research and Innovation (R&I). The project is focused on the following three types of activities:

– Initiatives related to interaction and scientific knowledge transfer between students, researchers and private entities including network activities and both national and international promotion, with the completion of the idea contest 'Fraunhofer Portugal Challenge' and a new initiative called the 'Fraunhofer Collective Transfer Day';

– Dissemination actions with dissemination of new knowledge and technology generated within the R&D activities of the FhP-AICOS, located in Porto, for the national and international business community, including exhibitions, forums, conferences and networking events;

– Sectorial actions of experimentation and demon-stration, involving demonstrative pilot projects in the areas of Information and Communication Technologies for Development (ICT4D), and also in the area of Ambient Assisted Living (AAL).

Outcome:

– Knowledge Transfer Initiatives (Fraunhofer Portugal Challenge and Fraunhofer Collective Transfer Day);

– Dissemination of Pilot Projects related to ICT4D;

– Dissemination of Pilot Projects related to AAL.

Partners: There are no Partners in this Project.

DeM – Deus ex Machina

Description: When thought of at a distance, many of today's societal challenges stem from waste, inadequate use of resources, lack of integrated solutions and effort replication. All of these are leading not only to citizens being unable to maintain their living standards, but most importantly, to what some academics call defuturing.

Facing this challenge, societies demand more from less for more, seemingly unsolvable, but which appears to be the point in ancient Greek drama, when such an impenetrable problem is suddenly disentangled by a new element coming onto the play: the 'Deus ex Machina'.

Societies are striving for these new elements towards efficiency gains mediated by a symbiotic relationship of humans with technology. We need elements such as these, which are able to deal with complex problems and, at the same time, be transparent to the users, as 'companions' who assist in difficult, unknown or just prosaic tasks.

We have devised a clear project to begin tackling these challenges. It consists of two research lines, one being built on top of the other. The first one will research and create building blocks – from tangible to intangible elements –, while the second will put these building blocks at the service of pressing societal needs in European and African countries.

The first research line (EITCC – Eyes of the Internet of Things Competence Centre) will concentrate on the aspects to

understand the environment, the user, his/her context and actions, and is serving as a technological base to all target domains in the other research line (C3 – Companion Competence Centre). Using the tools emerging from the EITCC, C3, the second research line, will study relevant societal challenges within scientific domains in relation to humans in order to design 'companions', which are non-intrusive, assistive tools for everyday life.

Outcome: Four work packages build the EITCC:

– Sensing and acting: bringing novel sensing mechanisms and actuation by accessing existing devices and developing new Internet of Things (IoT) sensing sources;

– Local information fusion: research on data aggregation algorithms to create refined and contextual information obtained in multiple local sensing devices;

– Remote information fusion and big data analytics in the cloud: implement information fusion from multiple distributed sensors, historical and contextual data to provide higher level abstraction data to C3;

– Networks for ICT4D: development of solutions for ad-hoc broadband networks for remote locations in developing countries.

C3 will study relevant societal challenges within six domains:

– Mind and behaviour: researching human interaction with computers, with a particular focus on human dignity, ethics, perception, cognition, communication and cultural aspects;

– Health: researching solutions for patient empowerment, reducing burden in public health care and streamlining the path to full digitally supported electronic health;

– Nutrition: understanding what people eat, why they eat it, and how healthier and more sustainable behaviours could be encouraged towards gains in health and reduction of food waste;

– Agriculture: considering applications suitable to developed and developing regions towards sustainability and efficiency gains by introducing precision agriculture;

– Activity monitoring: understanding users, their activities, context and behaviour, and providing tailored recommendations and tools that will be useful for tackling the challenges of coping with ageing and health conditions, preventing diseases by keeping an active and healthy lifestyle, improving the performance of sports athletes and increasing public safety and security;

– Community tools and social inclusion: developing inclusive tools, which make use of crowdsourcing and data mining concepts, focused on citizen empowerment, participatory monitoring, urban service delivery, and social equity.

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Partners: FhP-AICOS (coordinator) (Portugal); 2C2T – Centro de Ciência e Tecnologia Têxtil (Portugal); Centro ALGORITMI (Portugal); CIDESD – Centro de Investigação em Desporto, Saúde e Desenvolvimento Humano (Portugal); CINTESIS – Centro de Investigação em Tecnologias e Serviços de Saúde (Portugal); CITAB – Centro de Investigação e Tecnologias Agroambientais e Biológicas (Portugal); CPUP – Centro de Psicologia da Universidade do Porto (Portugal).

FallSensing – Technological Solution for Fall Risk Screening and Falls Prevention 3

Description: Falls are one of the most common health problems in the elderly population, representing more than 50% of the hospitalizations due to lesions in this age group. Falls are also considered one of the main causes for loss of independence and institutionalization.

Falls have a multifactorial origin, however most of the fall risk factors are amendable by implementing falls prevention programmes based on improving strength and balance and modifying behaviours. Even though, fall risk screenings and the implementation of such falls prevention programmes are rarely part of the elder's routine.

In this project the creation of the FallSensing system is proposed. This system will enable the evaluation of multiple fall risk factors and the implementation of fall prevention exercise plans, while providing feedback during the execution of the exercises. The data collected during fall risk evaluations or performance of falls prevention exercises are stored in a medical record platform, so that the healthcare professionals and caregivers may follow the evolution of the user and define personalized exercise plans. These personalized exercise plans may also be automatically recommended by the system promoting a continuous adaptation of the intervention plans to the evolution of the user.

FallSensing system is intended to create a new technological solution to enable screening and monitoring of the risk of falling and the implementation of falls prevention programmes in the elderly population. The system will be simple, adapted to different use cases, transportable and with low operation costs, so that everyone in risk of falling may have the possibility to reduce this risk and prevent falls.

Outcome: The main outcome will be a fall risk screening and falls prevention solution based on technology.

The technology will be deployed and validated by ESTeSC physiotherapists in different settings: clinics, nursing homes, municipalities and local health facilities.

ARS Centro, the network Ageing@Coimbra and Municipality of Nordeste from Azores endorsed the project.

For FhP-AICOS it's an opportunity to transfer the knowledge and solutions created in the FCC to the market.

Partners: Sensing Future Technologies Lda (coordinator) (Portugal); ESTeSC – Escola Superior de Tecnologia da Saúde de Coimbra (Portugal).

INNOVASmartInnovation – RD&I Partners

Description: The core business of the Portuguese company InCorporate (Linkintense) is the development of software tools for management support, such as Innovation Management Systems and Business Process Management Systems. Research, Development and Innovation (RD&I) Partners is a project of InCorporate to improve and extend their Innovation & RD&I Management System which integrates their current product portfolio and is already in use by some R&D institutions.

Within the Innovation Management Support Tools, InCorporate has developed a module to manage the workflow of ideas generation, validation and implementation (project management) and a first version of the module for innovation partners' integration.

This project will be dedicated to the development of an integrated and improved innovation management system capable of supporting the following processes:

- Idea generation and implementation;

- Innovation strategic partners' integration;

- Knowledge management and technological surveillance;

- Open innovation / crowdsourcing.

Outcome: Integrated and optimized innovation management software solution.

Partner: Linkintense SA | InCorporate (coordinator) (Portugal).

IoTiP – Internet of Things in Package: Wafer Level Modular Architecture for Internet of Things 4

Description: Over the last few years we have seen the integration of sensor technology, processing power and radio connectivity in the objects that surround us in our daily life, corresponding to the emerging Internet of Things (IoT). Despite the increasing number of smart devices there are still some challenges that have a negative impact in the sustainability and dissemination of the IoT. One of the most concerning challenges is the time and costs associated with hardware development. Having this in mind, IoTiP addresses these problems by presenting a development platform that will contribute for the spread of the IoT concept. IoTiP's platform combines hardware, firmware and software components to build a development ecosystem for the IoT. This will contribute to the simplification and speeding-up of the development of new IoT solutions, thus contributing for a more advanced technology addressing new markets and requirements.

Furthermore, IoTiP also addresses technical related issues, such as miniaturization, reduction of energy consumption, integration with other systems or the access to higher levels of information.

The proposed ecosystem is built on the top of a new System-in-Package (SiP) that embeds sensing, processing, energy management and radio communications. This chip provides a physical interface to enable a modular architecture for adding new features that can be of practical use in a huge variety of applications. Moreover, IoTiP's ecosystem also provides a hardware abstraction layer that allows developers to seamlessly interact with the SiP and its features in order to reduce even further the development cycle. A web platform to provide the specifications, documentation and examples to develop solutions based on IoTiP's ecosystem is also being developed in the scope of the project.
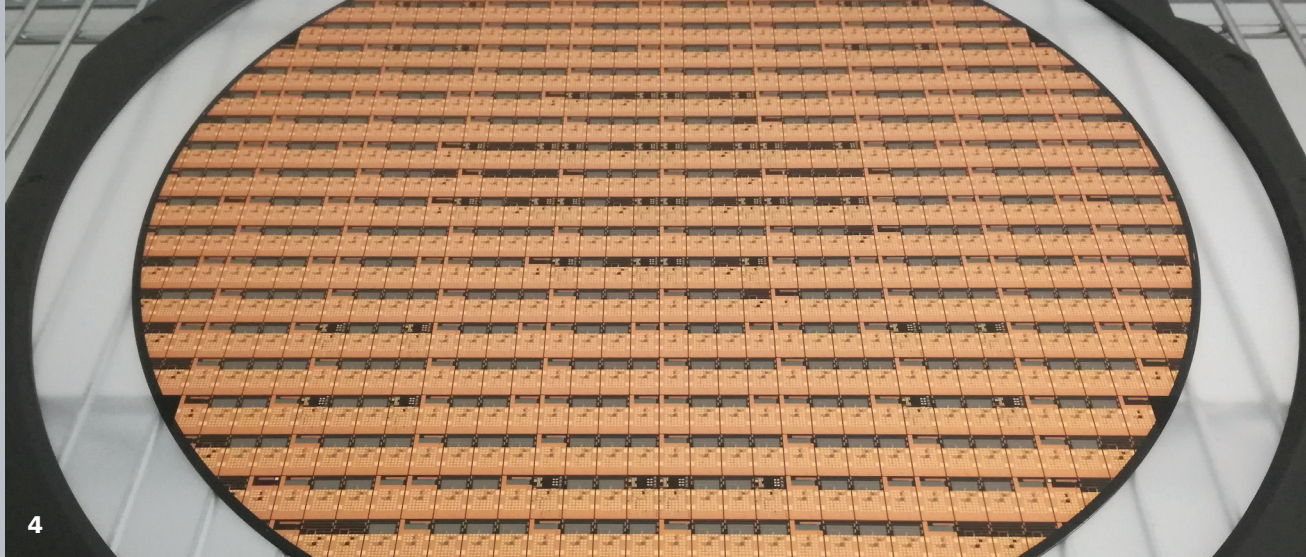
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Not only is the project goal to offer a development platform that stimulates the creation of new IoT solutions, but also to enable former low-tech industries, such as footwear or textile industries, to embed technology in their solutions yielding a differentiated product.

Outcome: Development ecosystem for the Internet of Things that includes:

– A novel miniaturized and modular SiP architecture;

– An abstraction layer featuring seamless access to hardware core functions and optimized algorithms for information extraction;

– A web portal to present the ecosystem, features, documentation and examples;

– An example application developed based on IoTiP's ecosystem to demonstrate its potential and main advantages.

Partner: ATEP – Amkor Technology Portugal SA (coordinator) (Portugal).

MASPARK – Characterizing Freezing of Gait in Parkinson's Disease

Description: Gait impairments often hinder the mobility of people living with Parkinson's Disease. Even though effective therapeutic options exist, with time, progression of the condition is likely to restrict their effect. Auditory cueing has been used as an alternative to improve the gait of people living with Parkinson's, however, existing solutions present limitations that prevent their use in everyday life.

This project is developing a mobile and automated system that detects issues in the gait and that stimulates gait using rhythmic cues. The developed system uses a wearable sensor, a smartphone, and a Bluetooth headset, that can be tailored to the patient's specific gait characteristics.

The evaluation of the system will be performed in laboratory, to measure the impact of the system in the gait, as well as in patient's home, to assess usability and acceptance of the system.

Outcome: A system that detects anomalies in the gait and that triggers auditory cueing. An initial evaluation of technology acceptance will also be performed.

Partners: Centro Médico Teknon (coordinator) (Spain); UPC – Universitat Politècnica de Catalunya (Spain).

MDevNet – National Network of Knowledge Transfer on Medical Devices

Description: FhP-AICOS has so far invested largely in the research and development of technology and know-how in the fields of Chronic Diseases and Well-being Management, and Fall and Activity Monitoring, in line with the current societal and economic challenges of population ageing and related health issues.

Particularly in the areas of Fall Activity Monitoring and Detection, Physical Activity Monitoring and Management of Chronic Diseases, which are related to technology based medical devices, FhP-AICOS has developed a number of key technologies such as the Diabetic Retinopathy Detection, Melanoma Risk Assessment or Fall Detection and Risk Assessment Algorithms, among others. These are critical assets that hold a significant potential to enable further cooperation with the industry and

create economic value. However, bridging the gap between R&D results and the market, particularly in the technology based medical devices market, is a key challenge – a difficulty that is shared by all national R&D Organizations.

This is a Knowledge Transfer project aiming to strengthen FhP-AICOS' ability to license its technology and to generate more revenues from the industry. It defines a set of actions aimed at facilitating the transfer of knowledge, related to technology based medical devices, between the research laboratories and the industry in order to maximize its economic value and its impact in society.

These actions include the creation of a national network of Knowledge Transfer in the area of technology based medical devices which aims to promote interaction and knowledge transfer; includes incremental technological improvements and demonstration of the new technology transfer approach, and also on promoting dissemination activities of the research results, the development of pilot projects with industry stakeholders and the MDevNet network activities.

Outcome: A number of inter-organizational activities will take place to support knowledge transfer:

– Creation of a Knowledge Transfer Network aimed to facilitate the cooperation between its members, allowing to clarify the requirements, regulations and other relevant information regarding the certification process of technology based medical devices;

– Collaborations with new partners (national and international);

– Increased capacity to generate new projects with the industry, including licensing agreements and research contracts;

– Technology refinement and validation from three pilot projects with Health Industry stakeholders;

– Dissemination and demonstration of the R&D results to the relevant industry sector and creation of new networking opportunities;

– Workshops with industry stakeholders to enable two-way communication between the R&D and Industry organizations, in order to collect feedback from the market on the R&D Results and their potential improvement.

Partners: There are no Partners in this Project.

MobileDRS – Mobile Diabetic Retinopathy Screening 5

Description: DiabeticRetinopathyScreening is a project with the Portuguese company First Solutions – Sistemas de Informação SA with the goal of developing and validating a mobile solution for the risk assessment of diabetic retinopathy by image processing. The project will be focused on the screening of preliminary diabetic retinopathy.

Outcome: Mobile-based Risk Assessment of Diabetic Retinopathy by Image Processing (EyeFundusScope prototype) integrated with retinopathy screening solution of FIRST's SiiMA Rastreios.

Cooperation in the validation study to test and incorporate the mobile solution in field trials.

Partner: First Solutions – Sistemas de Informação SA (coordinator) (Portugal).
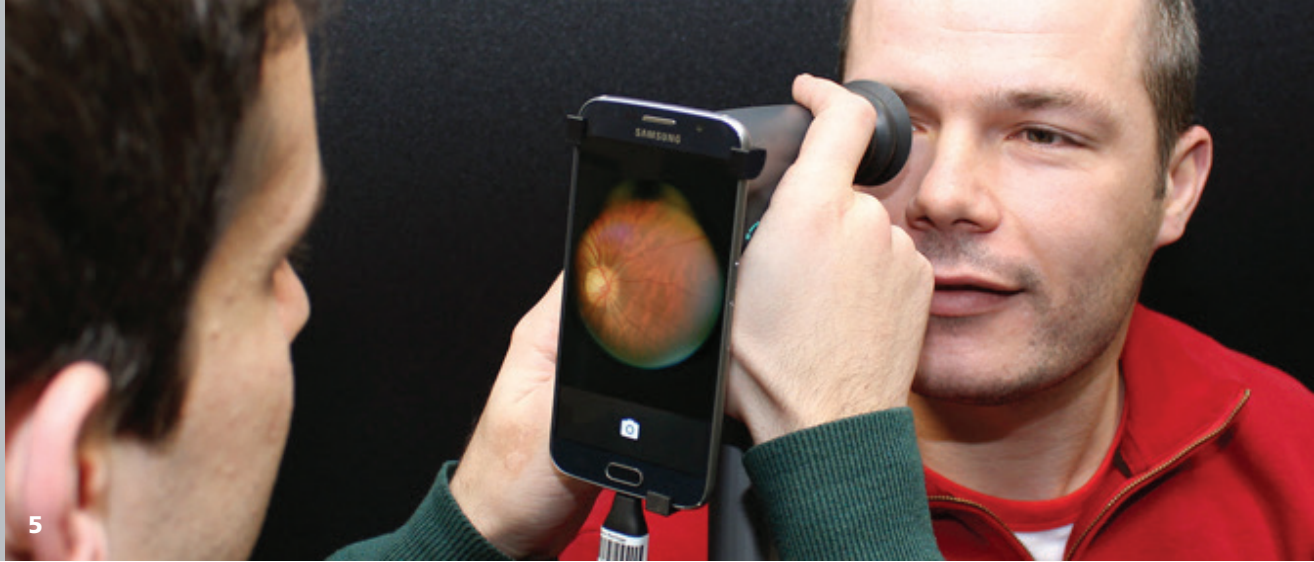
MpDs – Medical Pre-diagnostic System

Description: MpDS is a project with the Portuguese company F3M,which has over 3.000 clients in the Social Economy sector, where some of these clients provide health care services to people outside of the large urban centres.

Skin cancer affects one in every seven people throughout their lives, with 10% of those being of the malignant type which is responsible for more than 90% of skin cancer deaths. On the other hand, and more generically, skin ulcer patients typically are admitted for longer and readmitted more often than average, drawing considerable resources from the National Health Service. The great majority of this cost and suffering can, however, be avoided if detected early in these pathologies' development. To detect these, and also in a great number of other clinical contexts, microscopes with up to 1.000x magnification are necessary, but those are expensive and require specialized personnel to operate, which leads to only few health units being able to provide these services.

The challenge of MpDS project is to build a mobile solution that addresses the various needs of collecting and processing medical images in order to support diagnostic in several clinical contexts, namely: a) analysis of skin moles and ulcers and b) analysis of blood samples. The solution aims, therefore, to collect macroscopic, dermatoscopic and microscopic images of the identified pathologies, and do so with a high performance in terms of reliability and differentiation, through the coupling to a smartphone of various optical magnification peripherals. This innovative solution will be composed by a number of integrated modules and systems, along with algorithms of image processing and supervised machine learning running locally in the smartphone and in the cloud.

Outcome:

–   Integration of mobile-based solution for skin cancer risk assessment algorithm (developed in SMARTSKINS);

–   Improvement and integration of image acquisition modules for skin moles and blood samples;

–   Development of image acquisition module for skin ulcers.

Partner: F3M Information Systems SA (coordinator) (Portugal).

My-AHA – My Active and Healthy Ageing

Description: The project proposes a holistic view of interrelated frailties: cognitive decline, physical frailty, depression and anxiety, social isolation and poor sleep quality, which are a major burden to older adults and social and health care systems. Early detection and intervention are crucial in sustaining Active and Healthy Ageing (AHA) and slowing or reversing further decline.

The main aim of My-AHA is to reduce frailty risk by improving physical activity and cognitive function, psychological state, social resources, nutrition, sleep and overall well-being. It will empower older citizens to better manage their own health, resulting in healthcare cost savings. My-AHA will use state-of-the-art analytical concepts to provide new ways of health monitoring and disease prevention through individualized profiling and personalized recommendations, feedback and support.

An Information and Communication Technologies based (ICT-based) platform will detect defined risks in the frailty domains early and accurately via non-stigmatising embedded sensors and data readily available in the daily living environment of older adults. When risk is detected, My-AHA will provide targeted ICT-based interventions with a scientific evidence base of efficacy, including vetted offerings from established providers of medical and AHA support. These interventions will follow an integrated approach to motivate users to participate in exercise, cognitively stimulating games and social networking to achieve long-term behavioural change, sustained by continued end user engagement with My-AHA.

The proposed platform will provide numerous incentives to engage diverse stakeholders, constituting a sustainable ecosystem with empowered end users and reliable standardised interfaces for solutions providers, which will be ready for larger scale deployment at project end. The ultimate aim is to deliver significant innovation in the area of AHA by cooperation with European health care organizations, Small or Medium-sized Enterprise (SME), Non-Governmental Organization (NGO), etc.

Outcome: Development of an innovative ICT-based platform to detect subtle changes in physical, cognitive and social domains that indicate an increased risk of subsequent vicious cycle of disability and diseases, including dementia, depression, frailty and falls. The ICT-platform will continuously monitor individuals' risk profile including their lifestyles with cognitive, physical and social capabilities. This information will be used to determine individuals' risk profiles and to provide personalized intervention strategies for sustainable use.

The ultimate purpose of My-AHA is to contribute to the slow-down of cognitive and physical decline and, possibly, delay the onset of associated end-stage diseases through empowering citizens to manage their own health by improved health literacy.

Partners: UNITO – Università degli Studi di Torino (coordinator) (Italy); Deutsche Sporthochschule Köln (Germany); GESMED – Gestió Socio Sanitaria al Mediterrani SL (Spain); IBV – Instituto de Biomecánica de Valencia (Spain); Institut für experimentelle Psychophysiologie GmbH (Germany); IP Health Solutions BV (Netherlands); ISMB – Istituto Superiore Mario Boella sulle Tecnologie dell'Informazione e delle Telecomunicazioni (Italy); JIN CO Ltd (Japan); Johanniter Österreich Ausbildung und Forschung gemeinnützige GmbH (Austria); Kaasa solution GmbH (Germany); Loughborough University (United Kingdom); SNU – Seoul National University (Republic of Korea,); Tohoku University – National University Corporation (Japan); Universität Siegen (Germany); USC – University of the Sunshine Coast (Australia).

Physio@Home – My Rehabilitation Suite at Home 6

Description: The efficacy of physical rehabilitation depends on the correct and systematic execution of specific exercises. However, the number of sessions is usually low as compared with the potential of recovery of the patient, due to time and cost limitations. To speed up rehabilitation, patients are prescribed exercises at home, however, health professionals don't have the necessary tools that are able to monitor the movements of patients and offer them feedback, outside the clinic environment.

The goal of this project is to develop a solution that can be used at home, in complement to the sessions performed at the clinic, using smartphones or tablets and wearables containing Electromyography (EMG) and inertial sensors, which track the execution of exercises and give biofeedback to the user. The solution will be modular, mobile, low-cost, and easy to use, with interactive games and biofeedback that help the exercise execution and promote users' adherence.

The smartphone or tablet will display intuitive games that will guide the user through the execution of the exercises and

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provide biofeedback. The performance metrics collected about the exercises during the games will be stored and made available to the physiotherapist through a web portal, to support their work at the clinic.

The gamification of rehabilitation exercises and their deployment in ubiquitous and pervasive devices, such as smartphones or tablets in combination with wearables for movement monitoring, will enable a more engaging complement to physiotherapy sessions and ensure the correct execution of the exercises at home. This project also aims to improve the efficiency and cost-efficacy of rehabilitation processes, by complementing the sessions at the clinic with the execution of some exercises at home.

Outcome: A rehabilitation suite that can be taken home in order to improve the users' motivation and adherence to complementary sessions of physiotherapy at home by using exercise video games (exergames) and wearables. The project will result in a new product for the Portuguese company Plux, extending their PhysioPlux system – that is currently only used at clinical facilities – to the person's home.

Partner: PLUX – Wireless Biosignals SA (coordinator) (Portugal).

ShopView2Market – Automated Solution to Validate Shelf Layouts in Stores 7

Description: ShopView leverages computer-vision technology for retailers that want to gain a competitive edge in product placement auditing. The solution relies in a drivable platform equipped with a high speed flash synced with multiple digital cameras, aided by a light softener, a laptop and a couple of sensors to:

– Photograph shelves – controlling reflections and minimizing blur in high-resolution;

– Recognize the positioning of real products – via information and image processing algorithms;

– Evaluate product placement – validating against target planograms;

– Reporting errors to store manager in aisles covered by the Buggy's imaging system.

Other features include:

– Layout management of multiple stores;

– Map of aisles in floorplan;

– Panoramic full-length views;

– Label detection;

– European Article Number (EAN) decoding;

– Multiple-camera matching.

The former ShopView project has finished having its R&D objectives accomplished. Although it is capable of doing the job with a considerable degree of reliability, some challenges and limitations were identified through the execution of the project: Automatic Integration, Usability, Auditing features should be completed with Correction features – to be able to act upon the information created by ShopView, e.g. for re-stocking, rearranging and optimizing shelf product placement.

FhP-AICOS proposed to address the identified issues in ShopView, and complete the validation of the solution throughout a long-term pilot, with demonstrators all over the world: the ShopView2Market.

Outcome: ShopView2Market solution validated with high (seven) Technology Readiness Level, with enough maturity for product roadmap and commercial use, which means:

– Demonstrations without critical failures in operational environment;

– Easy installation and configuration;

– Fully integration with retailer business model;

– Functionalities adapted to user expectations.

Partners: WeDo Consulting – Sistemas de Informação SA (co-ordinator) (Portugal); Sonae Modelo Continente SA (Portugal).

SmartBEAT – Smart System for the Management of Heart Failure in Older Adults 8

Description: The increasing number of patients with Heart Failure is overloading the public healthcare systems. In Portugal there are 360.000 individuals with Heart Failure and worldwide this figure reaches 63 million. The global costs associated with this pathology is estimated to be 88,4 billion euros, in which 86% is attributed to high-income countries that constitute only 18% of the global population. Furthermore, 60% of this amount is related to direct medical costs, especially hospitalizations in which more than half of those are of patients aged over 75. Maximizing therapeutic adherence is currently considered one of the most important aspects of a successful management of chronic disease, and remote patient monitoring has the potential of answering such challenging requirements.

The SmartBEAT project aims to address the needs of senior Heart Failure patients and their formal and informal caregivers by offering an integrated solution to leverage patient self-care through autonomous condition monitoring and real-time feedback to their caregivers. Using SmartBEAT, it is possible to improve disease outcomes and enhance the quality of life of senior Heart Failure patients. This objective will be achieved through the acquisition of user's physiological data and a smartphone application integrated with a Monitoring Engine and a Caregivers Gateway for data analysis, management and reporting.

Outcome: SmartBEAT proposes to develop a system that allows for Heart Failure outpatients to remotely and autonomously monitor and manage their condition. The solution aims at early identifying hemodynamic imbalances inherent to episodes of acute decompensated Heart Failure, so carers can act accordingly by changing the therapeutic plan, redirect the patient to an early appointment or suggest an urgent hospital admission.

SmartBEAT is a simple and inexpensive follow-up solution for Heart Failure older adults which allows to optimize the quality of care, reduce costs, reduce the number of hospital admissions and, ultimately, improve the prognosis and reduce mortality in this population.

Partners: FhP-AICOS (coordinator) (Portugal); CHSJ – Centro Hospitalar São João (Portugal); FMUP – Faculdade de Medicina da Universidade do Porto (Portugal); KempenLIFE (Nether-lands); LifeOnKey Inc (Netherlands); Remedus BVBA (Belgium); Seniornett Norge (Norway); SGE – Stichting Gezondheid-scentra Eindhoven (Netherlands); Smart Homes – Nationaal Kenniscentrum voor Domotica & Slim Wonen (Netherlands); Verhaert – New Products & Services NV (Belgium); Vigisense SA (Switzerland).

SV4DMZ – 'Praças Digitais' Mocuba and Alto Molocue 9

Description: The National Communications Institute of Mozambique (INCM) wants to promote universal access to broadband communications and Information and Communication Technologies (ICT) to the citizens of Mozambique, and therefore to mitigate the effect of digital divide in the provinces throughout the country. Upon this need, INCM aims to deploy 'Praças Digitais' in different districts, which will allow locals to explore the digital world and further develop the access of the population to ICT. Moreover, these deployments target at building different sustainable villages, which not only will connect those who once were unconnected, but also will provide sustainable access to internet users by introducing new business models that promote the improvement of new economic opportunities based on ICT.

Outcome: First pilot project related to SV4D – Sustainable Villages for Development.

Partners: FhP-AICOS (coordinator) (Portugal); ARCTEL-CPLP – Associação de Reguladores de Comunicações e Telecomunicações da Comunidade dos Países de Língua Portuguesa (Portugal); FSAU – Fundo do Serviço de Acesso Universal (Mozambique); INCM – Instituto Nacional das Comunicações de Moçambique (Mozambique).

TexBoost – Less Commodities more Specialties

Description: TexBoost is a mobilizer project ('*Projecto Mobilizador*'). The aim of this type of projects is to mobilize a complete industry sector to advance in its specific core business(es), through innovation. FhP-AICOS will participate in a specific subproject with a company like Damel and a research centre specialized in textiles (CITEVE), with whom we had contacts in past, to bring innovative concepts to a surfing suit.

The developments consist in an intelligent dry suit for surfing in adverse environments, with several ground-breaking characteristics, such as protection, comfort and the monitoring of the athlete's physical performance. The parameters will help the athletes to be more aware of his surfing quality and execution perfection, which are important factors in any professional or amateur sport. The monitoring system will also contain an alarm / help request button for emergency situations.

FhP-AICOS will contribute with its know-how in the area of human activity recognition and will be responsible for all the localization, signal processing and communication components. Regarding textile developments, Damel as a company, will focus on developing technical clothing, confining and producing the surfing suit. CITEVE will contribute with its vast knowledge in the technologies and processes of cutting, sewing, sealing and will perform laboratory tests related to the quality and normative process.

Outcome:

- Innovative Surf Suit including analysis of the surfing performance and emergency events detection;

- Extension and improvement of the movement analysis algorithms to a water sport;

- Technology transference of SmartSurf project's results to the market.

Partners: Damel – Confecção de Vestuário Lda (coordinator) (Portugal); CITEVE – Centro Tecnológico das Indústrias Têxteis e do Vestuário de Portugal (Portugal).

INTERNAL PROJECTS

In order to foster core competence building and to enhance our team's experience, we frequently assess ideas and launch internal project initiatives.

DEMalariaScope – Digital Analysis of Malaria Infected Blood Smears via Mobile Devices 10
(Associated with the DeM – Deus ex Machina)

Description: The MalariaScope solution consists on a mobile-based solution that can provide an effective pre-diagnosis of malaria to be used in medically underserved areas. It is intend to use the new generation of smartphones in the system architecture, which exhibit significant improvements in terms of image acquisition and image processing and that are becoming widespread worldwide, even in developing countries. Moreover, this project aims to create a magnification gadget that can be connected to the smartphone and provide the necessary magnification capability. Thus, the project is divided into three main components:

- The µSmartScope (optical magnification component);

- The image processing and analysis component;

- The smartphone application component.

The main goal of the DEMalariaScope is to contribute to the EITCC and simultaneously improve the MalariaScope solution. For the EITCC, this project will create components for local image processing and information fusion, as well as explore new approaches for machine-learning and cloud computing. These outcomes will then be used to improve the MalariaScope solution and other C3 companions based on image processing (e.g. EyeFundusScope).

Specifically for MalariaScope, the aim is to increase the robustness of the optical magnification prototype and performance of the image processing modules in terms of classification and computational time. Moreover, the final MalariaScope solution will be considered as an output of the C3 in the area of health and well-being.

Outcome:
- µSmartScope: fully automated 3D-printed smartphone microscope with motorized stage;

- Computer vision modules for: (1) the automatic determination of parasite density on thick blood smear images; and (2) the automatic identification of the species and life-cycle stage of the detected parasites on thin blood smears;

- Android application: to be used on the field by technical personnel without specialized knowledge in malaria diagnosis;

- Web interface: to be used remotely by microscopy specialists in malaria diagnosis for supervision of the automated results.

Partners: INSA – Instituto Nacional de Saúde Dr. Ricardo Jorge (Portugal); SWISS-TPH – Swiss Tropical and Public Health Institute (Swiss); TUHN – Toronto University Health Network (Canada).
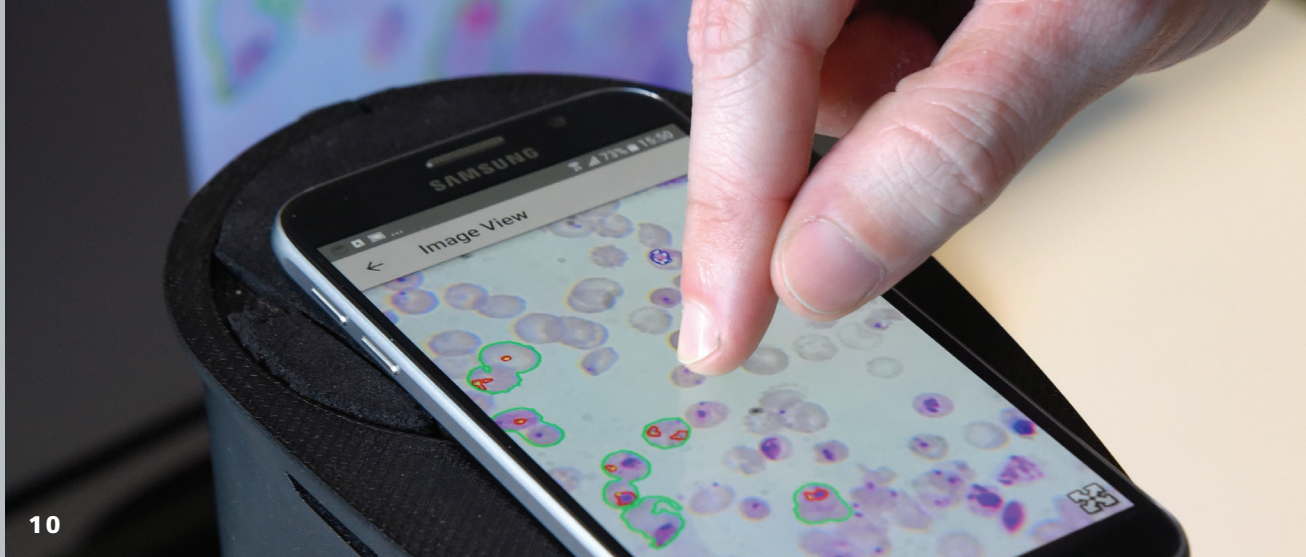
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DEMBACCHUS – Boosting Agriculture with a Companion for Connecting Healthy Plants, Users and Sensors
(Associated with the DeM – Deus ex Machina)

Description: Boosting Agriculture with a Companion for Connecting Healthy Plants, Users and Sensors (BACCHUS) is a subproject of DEM – Symbiotic technology for societal efficiency gains.

Sustainable Precision Agriculture is a farming activity that associates viable technology to standard agriculture methodologies. Boosting productivity, reducing waste and improving agro-food quality requires intelligent, environmental and knowledge-based decision making systems, as precision tools that deliver quick solutions to act on over-fertilization, climate change and chemical-charged soils.

Image processing and computer vision techniques will have a major input from the soft computing area, namely advanced neural computing and machine learning, as a way to incorporate uncertainty in the associated support systems. Algorithms of background analysis will be developed for early detection of stress conditions in crops, digesting the risk factors and producing individual advices on diseases and pests.

The different stakeholders need to be able to get the right information at the right time and place. Mobile technologies have the potential to play a major role in the improvement of these recommendation systems.

We envision the BACCHUS solution to be of interest for winemaking companies, towards connecting the producers, farmers and retailers through systems for managing the full supply chain using big data and cloud services from the EITCC.

A Farming Education module will provide the best practices and actuation methods to allow the farmer to be connected to a broader community, sharing experiences and making use of the common knowledge. The highly visual representation of information and easy interaction with the end-users will be crucial for a true companion in agriculture. The use of mobile technologies brings together this wider perspective of the agriculture within the economic, social and institutional environment, making the development of specialized tools a differentiator factor to foster the productivity and performance of individual farmers.

For cost-optimized farming with healthy crops and correct growth on time, meteorological data in combination with actual physical parameters of the current status of the crops, as the leaf moisture, must be evaluated and combined. Water stress evaluation, which is gaining renewed importance in climate changing scenarios, is one of the challenges that the north area of Portugal is facing. The information provided by non-destructive techniques, as hyperspectral imaging, will be fused with other types of sensors to evaluate water stress. Driven by the high value of the crop, precision viticulture will be focused on grape quality and yield maps, both of great importance during harvest to avoid mixing grapes of different potential wine qualities.

This project will also include prototype validation in real scenarios of hydroponics, green houses and open fields.

Outcome: BACCHUS will be a mobile companion for crop monitoring and farming education by using recommendation tools and will include the following features:

– Agriculture companions to control and predict the productivity;

– Real time monitoring to allow an efficient and timely actuation;

– Storage of historical information and learning from past experience will allow to detect behaviour patterns and to provide intelligent recommendations or alerts.

Partners: CITAB – Centro de Investigação e Tecnologias Agroambientais e Biológicas (Portugal); UTAD – Universidade de Trás-os-Montes e Alto Douro (Portugal).

DEMComm4Dev – Comm4Dev 11
(Associated with the DeM – Deus ex Machina)

Description: Development of solutions for ad-hoc broadband networks for remote locations in developing countries.

Provisioning of broadband access to regions with lower population density and, consequently, with no (or with poor quality) broadband installations. The ever same problem for these areas is the cost per user which is too high to deploy a fibre infrastructure or conventional mobile broadband networks (4G). The ad-hoc planned networks are self-managing and are very energy efficient in order to make use of renewable sources to power them. They are also suitable to get deployed in rural areas in industrial countries with limited connectivity in agriculture scenarios.

This project aims to develop a software framework that exposes a Delay Tolerant Network (DTN) architecture based on Android smartphones, by enhancing the results obtained from PostboxWeb, and to develop lean integration strategies to connect existing mobile networks from commercial operators to interface with the low cost ad-hoc networks described.

Outcome:

– Prototypes for network infrastructure and software framework for disruptive scenarios;

– Report on field tests with prototypes of low-cost/low-power and reliable wireless technology in uncovered areas;

– Bluetooth Mesh integration to final prototypes of network infrastructure for disruptive scenarios.

Partners: Core Network Dynamics GmbH (Germany); Fraunhofer FOKUS (Germany).

DEMCommunity – Community Tools
(Associated with the DeM – Deus ex Machina)

Description: Community tools aim to integrate both formal and informal approaches to citizen engagement, focusing on the link between the use of new technologies, digital education and social inclusion, particularly for disadvantage and vulnerable groups, either in Europe or Sub-Saharan Africa. The goal of DEMCommunity is the development of inclusive tools, focused on citizen empowerment, participatory monitoring, urban service delivery, and social equity.

This project will provide core competences that will support the activities under the scope of the C3 research line. The tasks considered in this project are directly related to the study and development of solutions that can be used by citizens either in European and African contexts, improving their lifestyles and taking advantage of Information and Communication Technologies (ICT) to improve daily activities. Among these tasks are considered the continuous evolution of some existing projects (e.g. IZIDoc and OurMoz) and tasks related to the adaptation of some apps to be used in different contexts (e.g. PostboxWeb).

This project also intends to take advantage of our partnership with UEM – Eduardo Mondlane University from Maputo, Mozambique. This partnership provides a real testing
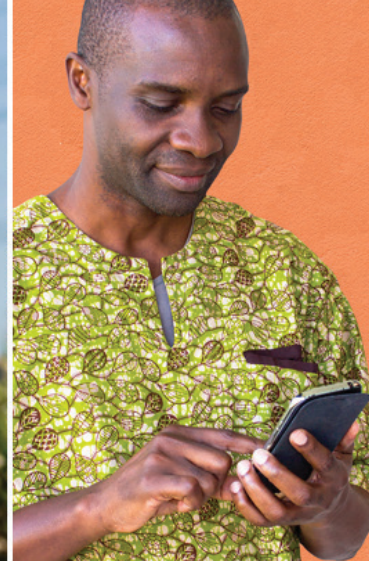
environment, extremely useful for field tests, providing information about the usability and feasibility of our products in real environments.

Outcome:

– Develop a platform to simplify administrative procedures between citizens and public services by mediating process management and improving efficiency of service delivery;

– Develop a crowdsourcing platform for easy information exchange among citizens, creating open and inclusive communication and data collection channels between the community, decision-makers and institutions or public services;

– Develop tools and methodologies that make platforms available and functional for every citizen, focusing on usability issues, reaching vulnerable or poorly represented citizens, and bridging the digital divide.

Partner: CIUEM – Centro de Informática da Universidade Eduardo Mondlane (Mozambique).

DEMDataRepository – Repository for Datasets Storage, Management and Visualization
(Associated with the DeM – Deus ex Machina)

Description: In the context of the DeM – Deus ex Machina, the objective of this project is to develop tools and Application Programming Interface (APIs) for the management, visualization and storage of datasets in a centralized cloud infrastructure.

This research line has a strong focus on the development of algorithms to process Internet of Things (IoT) sensor data and therefore a solution to support the collection, storage, access and visualization of all data becomes a valuable asset. This solution aims to be the foundation that will support the development and validation of signal processing and machine learning algorithms which rely on samples associated with ground truth.

Besides supporting the development process, other outputs will be produced that can be reused by other projects:

– A data model that is able to represent data from very different sensors (inertial, temperature, imaging, etc.) may become the standard to represent data across all projects which will increase the compatibility and reusability of all algorithms;

– Communication protocols will be researched to find the most suitable to efficiently and securely communicate data of this nature;

– A flexible visualization tool will support the data analysis process both in development and production environments.

Outcome:

– Central Cloud based Repository for Datasets of sensor data to centrally store the sensor datasets from all projects;

– Services to store sensor data in the central repository;

– Services to read sensor data stored in the central repository;

– Security mechanisms to ensure authentication and access authorization to the services;

– Standard representation of sensor data to be used in all projects – maximize interoperability between components.

Partners: There are no Partners in this Project.

DEMEyeFS – EyeFundusScope 12
(Associated with the DeM – Deus ex Machina)

Description: The main goal of DEMEyeFS is to allow a non-expert assessment of diabetic retinopathy with the aim of enhancing the proximity of screening programs to the population, by:

– Helping collect images of the retina with low-cost equipment that can be widely available, oppositely to the retinograph (gold standard but 30 times more expensive);

– Automatically detecting microaneurysms and other relevant structures with a smartphone-based solution to recommend forwarding relevant cases to a reading centre in a central hospital.

Outcome:

– Improvements in the construction of a prototype to improve the Field-of-View and image quality even without drug-induced pupil dilation;

– Local and Remote Decision-Support System for Diabetic Retinopathy;

– Segmentation methods for real-time segmentation of mobile-acquired images.

Partners: There are no Partners in this Project.

DEMind – Mind and Behaviour
(Associated with the DeM – Deus ex Machina)

Description: Regardless of the application domain, human-computer interaction is central to the development of companions within project C3. Therefore, this project is designed to conduct research on fundamental principles of human-computer interaction which can support the developments to be made at service and application levels for the companions. Examples of studies to fit under DEMind are: ethics, attention, perception, memory, iconography, language or multitasking.

Outcome: This project informs the design of the companions, by studying the everyday practices of prospective users, such as patients with Parkinson's Disease or people with food allergies; as well as evaluating how participants use the companions, such as serious games used in day care centres.

Partners: There are no Partners in this Project.

DEMLOC – Location Awareness Platform 13
(Associated with the DeM – Deus ex Machina)

Description: The location based services market is forecast to generate over €40.000 million by 2019. Given our interest in including location awareness in some of our current projects, and its potential for future companions, it is very appealing to focus our efforts in this field applied on a single robust platform. DEMLoc will shape a group of experts in finding and tracking people, animals or objects, aiming to minimize tasks replication in the localisation field internally, thus optimising efficiency and delivery times.

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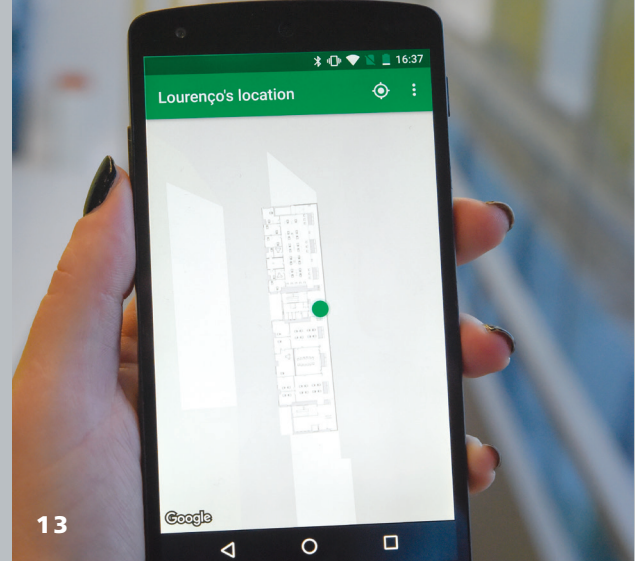
The idea is to create a software library that estimates the most accurate positioning information the available data can provide, which may, subsequently, be extended to appropriately match each companion's needs. Using this information, health care professionals can track patients, equipment and supplies inside hospitals; retailers can use analytics to improve their stores management; regular people can find their way to safety during emergency situations; and an endless stream of other benefits.

Data to be used by this platform can come from a myriad of sources which include inertial and positioning sensors and Wi-Fi, Bluetooth, GSM and GPS radios, either from a single device or a fusion of multiple sources. Even contextual information, like learning a user's schedule and habits, can be used to infer location.

Outcome:

–	Software library that estimates the most accurate positioning information possible;

–	Separate software libraries for each positioning module;

–	Basic demonstration software for each developed module, helping companions to integrate the corresponding features.

Partners: There are no Partners in this Project.

DEMNutritionHF – DEM NutritionHF
(Associated with the DeM – Deus ex Machina)

Description: When professionals recommend a nutritional plan to their clients, they need to be aware of several factors which influence, or are influenced by, their recommendations. This project will use FhP-AICOS' experience on the development of nutritional recommendation systems and explore the use case of patients with Heart Failure.

A nutritional companion for adults with Heart Failure will be developed:

–	Loads information from Portuguese nutritional database;

–	Provides a nutritional plan added/created by a health professionals, taking into consideration the nutritional limitations of the disease;

–	Verifies the nutritional plan compliance;

–	Provides educational tips for the patients.

Outcome: Recommendation system for Heart Failure patients.

Partner: CINTESIS – Center for Research in Health Technologies and Information Systems.

DEMSmartCompanion – Smart Companion 14
(Associated with the DeM – Deus ex Machina)

Description: Google Fit was a software framework allowing app developers and hardware makers to record, log and display health-related data with as little coding as possible. Google Fit is made up of three APIs: Sensors, Recording and History. These APIs are the Google-prescribed standards for getting data from physical sensors to apps and interfaces that want to use it. The official list of data types covers activity times and types, calories burned, pedalling rate, wheel speed, distance covered, heart rate, height, weight, power generated in a workout, steps taken and elevation.

Apple Health, worked in the same direction, by concentrating the data from all those fitness apps and wearable companion apps on the iPhone and attempting to put the data in one place. Apple's official list of default data types is more comprehensive. It covers gender, sleep patterns, blood type, workout duration and intensity, body temperature, heart rate, blood alcohol level, blood glucose, diet, cycling activity, walking activity and more, even how many times a person has fallen.

Since in Android most of the health data types provided by Apple health, like sleep patterns, blood type, heart rate, blood glucose, are not available, we think that Smart Companion could provide this API in order to concentrate in the launcher a set of default data types (e.g. medication, chronicle diseases, caregiver contact, gender, weight, height, age, walking activity, etc.). As so, third party applications or companions can access this data types and used them. Moreover, these applications could also insert data into this content provider.

Additionally, continuous improvements to Smart Companion are planned, including usability testing and UI re-designs,

development of an initial tutorial and set-up integrated with a contacts migration tool.

Outcome:

– Smart Companion User profile and data content provider;

– Provide Smart Companion data to third-party apps (e.g. medication that user is taking, or physical activity);

– Usability improvements and new tutorial with simplified contacts migration.

Partners: There are no Partners in this Project.

DEMSmartMoves – Continuous Accelerometry Monitoring of Fall Risk and Real Falls
(Associated with the DeM – Deus ex Machina)

Description: The main goal of the DEMSmartMoves is to contribute to the DEM EITCC and C3 with the following Work Packages:

– EITCC Sensing and actuating – First and second prototypes of data processing algorithms. Development of fall detection and activity monitoring algorithms that are independent of in-body sensor location. Extraction of metrics such as the time, speed, amplitude, symmetry of movements, or the usual sequence / patterns of activities. Computation and validation of continuous metrics of physical activity, such as number of steps, activity/inactivity periods, variability of gait, among others, and their combination in a physical risk of falling index. The level of association

between this index and the falls occurrence frequency will be determined. The Falls Detection algorithm will be improved and validated against other studies using the FARSEEING Real Falls Database. The combination of metrics in a risk of falling index will be validated by association with the falls occurrence frequency;

– C3 Activity monitoring – Prototype of companion for daily living activities monitoring. Development of interfaces of the companion for continuous fall risk assessment and recommendations for falls prevention;

– EITCC Local information fusion – First prototype of inertial sensor fusion algorithms. Development of a tool for easily training a classifier suitable for arm gestures recognition, and then deploying it in an Android. Since the arm has a great number of degrees of freedom and wrist movements and gestures are very diverse, the inertial sensor signals obtained from free daily living conditions in this position are expected to be very noisy. Therefore gesture recognition problems are not trivial and should be addressed using classifiers that are able to take into account both sequences of sub-gesture motions and model inter-gesture sequential dependencies, for example higher order Hidden Markov Models. In order to achieve high recognition accuracy, other levels of information, such as location and time of the day could also be added in a higher level classification layer. This module will then be used in activity monitoring companions, in particular for rehabilitation and physical activity monitoring and in nutrition companions, for reporting of food and beverages intake;

– C3 Activity monitoring – Prototype of companions for physical activity monitoring. Development of interfaces of the companion for recognition and characterization of movements for physical activity and rehabilitation.

Outcome: The main outcomes of this project are:

– Algorithms and interfaces for continuous fall risk monitoring;

– Algorithms for recognition and characterization of specific arm movements and gestures;

– Interfaces to apply these algorithms in the scope of rehabilitation and physiotherapy movements;

– In addition, the DeM deliverables referred will be produced.

Partners: There are no Partners in this Project.

DEMSports – Monitor User's Daily Activity and Define Workout Program
(Associated with the DeM – Deus ex Machina)

Description: The size of the ageing population has been increasing over the last years, leading to a search for solutions that can improve the quality of life of the elderlies. One of the main means of action is focused on their physical activity. A non-sedentary life can help in disease prevention and disability reduction, leading to an independent living with quality. Moreover, the practice of physical exercise can decrease fall risks and its consequences. Furthermore, it is desirable that the solutions can be accessed by anyone, with a low inherent cost. The Boccia game is a good way to promote physical activity

to the elderly, due to its simplicity and easy adaptability to the physical limitations of the elderly. Following this trend, this project presents iBoccia, a novel framework to monitor elderly while playing Boccia game, through wearable sensors: Mio Fuse band and Pandlet (inertial sensor), and a non-wearable device – Kinect camera. Several performance metrics are expected to be measured during the gameplay. Using the Pandlet we calculate wrist rotation angles and force applied during ball throw, using the Kinect we recognize facial expressions and from the Mio Fuse band we retrieve heart rate.

Outcome:

– For the elderly it can be seen as a way to monitor the game through the suggestion of performance improvement of some of the movements;

– For formal caregivers besides the playful aspect, it may be interesting for them to realize what kind of movements were made during the game, access the affective state of the patient and to detect physical or cognitive declines by analysing the data collected.

Partners: Centro ALGORITMI (Portugal); CIDESD – Centro de Investigação em Desporto, Saúde e Desenvolvimento Humano (Portugal).

DEMThings – Sensing Things
(Associated with the DeM – Deus ex Machina)

Description: Combining data from multiple sources is mandatory to understand how humans behave and how we relate with the 'things' that surround us on our everyday life. By extracting and combining information from the data collected by multiple sources it is possible to get more meaningful information.

Combined information can then be used to understand the context where a user is inserted, in order to enhance its experience and to provide a personalized and most helpful service to fulfil a specific task. Combining multiple sources of data can also be used to extract information related to trends (in agricultural environments for instance) and even to anticipate future behaviours.

In order to merge multiple sources of sensor data there are several challenges that need to be tackled, time synchronization being one of the most relevant issues. Additionally, the tools used to visualize combined data and extracted information need also to be adapted to ensure that it can be easily perceived.

The main purpose of this project is to develop the necessary mechanisms to synchronize and compress the data collected from multiple sources (e.g. several inertial sensors placed around the human body, such as smartphones, watches, Pandlets).

These developments aim to ensure that data acquisition and transmission process are the most accurate and efficient, by maintaining data integrity and reducing power consumption.

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Moreover, this project aims to create an intuitive visualization tool based on a dashboard that can be configured to display different types of data or information and combine them.

Outcome: The developments under the scope of this project will directly contribute for EITCC's Sensing and acting, Local processing and fusion and Remote fusing and big data analytics in the cloud.

Moreover this project aims to:

– Explore data compression mechanisms to reduce the amount of data being transmitted through the network;

– Develop mechanisms to optimize Bluetooth Smart bandwidth;

– Develop a cross-platform features library and establish guidelines for algorithm implementation in cross-platform languages.

Related to EITCC Information fusion from complimentary sensors, EITCC Inertial sensor fusion and EITCC Information fusion from sensors of the same kind, this project aims to:

– Explore and implement synchronization mechanisms to allow data collection from multiple sources;

– Develop algorithms to automatically segment multi-modal repetitive time series data and characterize each repetition in amplitude and temporal domains.

Related to EITCC Models and algorithms for big data aggregation, this project aims to:

– Develop a simple methodology to facilitate the process of finding information hidden on times series;

– Develop new query mechanisms based on synthetic approaches in order to facilitate queries on time series.

Related to EITCC Models and algorithms for big data aggregation, this project aims to:

– Develop a dashboard to represent time sequences that can be dynamically reconfigured based on data type.

The results of this project should result in independent blocks to ensure that they can be reused by other projects developed under the scope of DeM.

Partner: Centro ALGORITMI (Portugal).

PIL – Precise Indoor Location 15

Description: Indoor location systems are an important enabling technology for applications such as indoor navigation, public safety and security management, ambient intelligence, as well as providing huge potential around advertisement and retail businesses.

Because of the lack of reliable Global Positioning System (GPS) signals inside buildings, the so-called Pedestrian Navigation Systems (PNS) have emerged as a solution for the indoor positioning unsolved problem. These systems rely on dead reckoning algorithms based on fused data provided by an Inertial Measurement Unit (IMU).

Since smartphones embrace always-on and sensor fusion was already a topic studied at FhP-AICOS, under the scope of project FCC, using these devices as IMU seemed to be the obvious solution to achieve a highly accurate indoor location system at very low cost.

Dead reckoning based on the fused data provided by IMU on the smartphones can then be used to evaluate one's current position by using a previously determined position. Since dead reckoning is subject to cumulative errors, navigational aids are needed in order to give accurate information on position. This aided information can be gathered from environment measurements, such as magnetic field fluctuations and Radio Frequency (RF) readings.

The main purpose of this project is to develop a solution relying on a novel human motion tracking algorithm combined with fused positioning mechanism that probes for opportunistic reference technologies to determine a user's current location.

Moreover, the system operates in common smartphones and no dedicated infrastructure is required to be installed in the building, which guarantees the easy spread and scalability of the solution.

Outcome: Provide a commercial grade indoor location solution that does not require any kind of infrastructure to be deployed for indoor positioning purposes.

Partners: There are no Partners in this Project.

SkinLesionsRS – Referral Solution for Skin Lesions 16

Description: Internal project to support FhP-AICOS' participation in the RESOLVE programme, with the scientific results from projects: Melanoma Detection, SMARTSKINS and SAL.

RESOLVE aims to 'support the progress of knowledge from the laboratory bench to the point where it provides the basis of a commercially successful business'. The programme supports cataloguing the necessary data to improve the melanoma risk analysis algorithm and perform its calibration.

The services expected to best improve the chances for licensing of the technology are:

– Cataloguing the images we already have (~430) by two additional dermatology specialists;

– Calibrating the specificity and sensitivity of the algorithm based on the dermatology specialists' feedback.

This project also reserves some effort to use the tools from the RESOLVE program focused on facilitating communication with the stakeholders of this technology and identifying potential licensors.

Outcome:

– Validated knowledge of the performance characteristics most suitable in the real world usage scenario (by the specialists);

– Already existing images of skin moles catalogued by two additional specialists;

– Identification of potential new licensors.

Partner: i3S – Instituto de Investigação e Inovação em Saúde (Portugal).

UserNetwork2017 – COLABORAR initiative - The Network for Seniors, the Network of Seniors 17

Description: COLABORAR is a user network that supports research through recruiting older adults potentially interested in taking part in FhP-AICOS' external and internal research studies about technology. This is possible by the establishment of formal relationships with organizations such as day-care/living centres, senior universities, healthcare institutions and municipalities, through cooperation protocols. Furthermore, COLABORAR offers guidance to new researchers and students about good practices on working with seniors and facilitates the interaction of researchers with older adults. COLABORAR also ensures the compliance with research ethics procedures.

The goals for 2017 were:

– Increase the number of partner institutions and users;

– Offer training and support to researchers and students;

– Disseminate the project and its good practices;

– Conduct research on COLABORAR volunteers' motivational and use of technology profiles.

Outcome: This project will:

– Provide ready access of users to researchers as needed for their work across projects;

– Collect background information on users;

– Promote and disseminate the project;

– Disseminate the results of the research on users' profiles regarding use of technology.

Currently, COLABORAR aggregates over 50 partner institutions, including senior universities, adult day-care centres, living centres and healthcare institutions. So far, it has supported over 2.500 user research and testing activities.

Partners: There are no Partners in this Project. A tecnologia tem reunido o interesse de diversos parceiros e clientes nacionais e internacionais.

INCUBATING PROJECTS

The scientific and business activities of FhP-AICOS are driven by the performance related funding model operated by Fraunhofer–Gesellschaft, which means that FhP-AICOS' research work is oriented toward concrete applications and results. In pursue of this objective we have submitted several proposals for projects to be developed in a near future.

AdHeart – Engage with Your Heart: Improving Therapeutic Adherence with a Telemonitoring System for Chronic Heart Failure Patients

Description: The AdHeart project is a Heart Failure (HF) non-invasive telemonitoring study, implemented by the University of Porto and FhP-AICOS, aiming to analyse the effectiveness of technological and behavioural strategies implemented with a Heart Failure telemonitoring system on patient's therapeutic adherence, technological acceptance, as well as on physical and psychological outcomes and quality of life. With a single blinded parallel randomized clinical trial design, this study comprises two groups: an experimental group of HF patients using a telemonitoring system for 12 months beyond the standard care, and a control group only under standard care. All the subjects are adults living in the northern region of Portugal and followed in four hospital settings. At the end of the trial, this study aims to contribute to the development of better practises for the implementation of telemonitoring in HF patients.

Outcome: Primary outcomes concern to variables directly associated with therapeutic adherence and technological acceptance, namely HF self-care, technological acceptance, self-efficacy, coping styles and health literacy. These variables will be collected in pre and post-test assessment as well as in 6 months monitoring assessment.

Secondary outcomes refer to the physical and psychological conditions of the patients that inform about his/her health condition and well-being. This includes:

– Physical (medical variables regarding HF, comorbidities and risk factors);

– Nutritional status (body composition, food ingestion);

– Psychological state (cognitive function, psychopathology).

As well as other outcomes that encompass both dimensions (e.g. frailty, sexual function, quality of life), to evaluate the effect of the intervention on these outcomes.

Partners: FMUP – Faculdade de Medicina da Universidade do Porto (coordinator) (Portugal); CPUP – Centro de Psicologia da Universidade do Porto (Portugal); FCNAUP – Faculdade de Ciências da Nutrição e Alimentação da Universidade do Porto (Portugal).

AltDel – AltDel Smartphone Application

Description: The project AltDel proposes to enable early detection of cognitive decline using an accessible device: the smartphone. Smartphones are carried around by most people most of the time, and have the capability to record a wealth of data through built-in unobtrusive sensing devices. Some of this data is relevant for the detection of cognitive decline.

This project proposal will test and validate a system to monitor and flag cognitive decline via unobtrusive behavioural assessment of measures such as: gait (i.e. walking) speed and sleep activity (via accelerometers), which have been associated with cognitive functioning. This aim will be achieved through a multicentre randomised clinical trial with elders recruited from

different day-care centres in the Lisbon region. These persons will be monitored in a longitudinal design that will look for differences in the behavioural indicators between persons with different levels of cognitive functioning and between the baseline and follow-ups. We expect that both walking and sleep will be compromised in people with worse cognitive status, and that decreases in cognitive functioning from baseline to follow-up be accompanied by significant changes in these behavioural measures.

Outcome: System that can track smartphone use parameters, and by this way, contribute to studies investigating cognitive decline. A side effect of this project will be to pilot the Smart Companion system with further participants.

Partner: ULHT – Universidade Lusófona de Humanidades e Tecnologias (coordinator) (Portugal).

CAPISCEV2 – CAPISCE Industry

Description: The CAPISCE Project aims at introducing technological innovation into the production chain of active inputs mainly used in the Pharmochemical industry, a sector that is very relevant in Brazil.

This is to be achieved by means of an Android application that will help the farmers throughout the extractivism process, as well as interact with the farmer's cooperative and respective technicians. Additionally, the application shall allow farmers to keep track of their earnings, in a game-like manner, as they advance with the Jaborandi tree leaves gathering.

The web application will serve the farmer's cooperative gathering information about the evolution of the work carried out by the farmers on the field. Through this web application, the farmer's cooperative will receive messages from:

–   The farmers as they request for help during the preparation of the land and during the Jaborandi tree growth cycle;

–   From sensors on the field that keep track of the Jaborandi tree crops (e.g., humidity levels, temperature, etc.).

This web application is also a tool where clients can get to know the different farmers currently growing Jaborandi tree, keep track of their investments, and interact with specific farmers and the farmer's cooperative.

Outcome:

–   Inclusive Android application for farmers;

–   Web application to help the cooperative manage the farms and crops;

–   Web application for investors;

–   Communication and sensor network to allow data exchange and tracking of the crops.

Partner: Bio Earth Lda (coordinator) (Portugal).

CLARE – Computer-Aided Cervical Cancer Screening

Description: Cervical cancer is a largely preventable disease, but worldwide it is one of the leading causes of cancer death in women, with most deaths occurring in low to middle income countries. Screening tests such as the conventional Pap smear or Liquid-based Cytology (LBC) have been responsible for a 50% decrease in cervical cancer deaths.

This project aims to create a novel framework that can be used as a Decision Support System (DSS) for the screening of cervical cancer. The proposed solution aims to couple Colposcopy and LBC diagnosis methods to computer vision and machine-learning approaches, in order to create a DSS system that can be easily integrated in the conventional clinical flow of cervical cancer screening.

Outcome: Develop a solution that can be effectively used for cervical cancer screening. This solution will be based on FhP-AICOS background knowledge (e.g. MalariaScope) and is intended to be easily integrated in the conventional clinical flow.

Partner: INESC TEC – Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência (coordinator) (Portugal).

EWomenSoilFertilizerC – Empowering Women by a Soil Fertilizer Companion

Description: Smartphones have become a useful tool in agriculture because their mobility matches the nature of farming, the cost of the device is highly accessible, and their computing power allows a variety of practical applications to be created. Smartphones are also equipped with various types of physical sensors which make them a promising tool to assist diverse farming tasks. Presently, the most commonly used sensors are Global Positioning System (GPS) and cameras but other sensors can provide advanced agricultural solutions.

Among the technologies invented in the past few decades, smartphones have gained large market shares among various user sectors due to their usefulness, ease-of-use, and affordability. The number of new smartphone users continues to grow. One factor that enhances the smartphones' ability to assist users to perform various tasks is the numerous built-in sensors (e.g., positioning sensors, motion sensors, cameras, GPS, microphones). Many industries have adopted

smartphones to facilitate their work, such as health care and education.

Inexpensive smartphones equipped with various sensors are opening new opportunities for rural farmers who previously had limited access to up-to-date agricultural information (e.g., market, weather, and crop disease news) and assistance from agricultural experts and government extension workers. Farmers in large-scale farms, who already adopt assistance from other information technologies, can now utilize smartphone-based sensors to increase productivity and facilitate various tasks throughout the farming cycle.

Dedicated devices (e.g., a Soil Plant Analysis Development (SPAD) meter for leaf chlorophyll assessment, a Li-3100 for Leaf Area Index (LAI) measurement, and a spectroscopy for studying soil structure and components) have been useful in agriculture but might be difficult to access for rural farmers who do not have access to the product providers or insufficient funds to purchase the devices. However, some of the tasks that the dedicated devices perform can be replicated on smartphones with built-in sensors. This provides an easy alternative for farmers who already own smartphones, allowing easy download of applications, and their respective use.

Farming refers to a series of agricultural processes which involve various day-to-day activities on the field, for example, sowing, weeding, fertilizing, and making related agricultural decisions. Farming activities are focused on how to grow plants, kill weeds/pests, identify and correct plant diseases, apply fertilizers, and estimate growth/yield of crops. Recent advances in smartphone application development and an increasing availability of smartphones allow for some of these agricultural challenges to be addressed and guided. For example, farmers may calculate proper amounts of fertilizers for crop fields upon analysing colour of crop leaves with some help from smartphone applications.

A handful of tasks which are performed in the field, that is, seeding, weeding, fertilizing, and watering, may seemingly be repetitive, mundane, and labour-intensive. These tasks usually require precursory decision-making steps prior to the actual activities in order for the farming cycle to be effective. Knowledge such as how to identify crop diseases, the diseases' exhibition locations on crops, and their prevention and cure can save farmers' time and costs in the practice of farming.

One key idea of new practices in agriculture is the use of technology to measure or monitor field and crop conditions in order for farmers to make informed decisions in various parts of their farming process. Sensors for continuous and automatic measurements of different field values are one of the main success factors for precision agriculture.

Outcome: The main outcome for FhP-AICOS will be the reinforcement of our Information and Communication Technologies for Development (ICT4D) solutions and image processing regarding mAgriculture.

The following are three examples of Smart Soil Fertilizer Companion potential applications for farming:

–   Fertilizer Calculator: applying fertilizer is an important farming activity with a potential to greatly affect farm productivity. Decisions on which chemicals to apply and their crop-specific appropriate quantities need to be made by farmers. A mobile application to assist farmers with the calculations as well as amounts can, not only save money but also improve the yields dimension;

–   Soil Study: soil is another major component in farming which has a great impact on the success of agriculture. Farmers equipped with soil data gain an advantage in farming, including in precision agriculture. There are a number of smartphone

applications in the literature that utilized smartphone sensors in studying soil for agricultural purpose. In some studies, mobile phones are used as soil colour sensors. Soil colour information was read from images taken by built-in digital cameras on smartphones and processed using image processing techniques;

–   Disease Detection and Diagnosis: smartphone applications under this subcategory are dedicated to disease detection/diagnosis in farms when utilizing sensors on smartphones.

Partners: TU/e – Technische Universiteit Eindhoven (coordinator) (Netherlands); NMMU – Nelson Mandela Metropolitan University (South Africa).

EyesOnTraps – Smart Learning Trap and Vineyard Health Monitoring

Description: Portuguese company GeoDouro is interested in developing a new module for its clients, which would allow them to monitor the plant health, using image processing technics. The concept involves obtaining the images from 'traps' currently used in the field to capture insects, or directly from a smartphone camera, and developing an algorithm to identify the harmful species.

Outcome:

–   Image recognition algorithm to detect plagues in agricultural setting;

–   Mobile application prototype to acquire the images;

–   New plant health monitoring module to integrate into GeoDouro's Precise Agriculture Monitoring platform.

Partners: GeoDouro – Consultoria e Topografia Lda (coordinator) (Portugal); ADVID – Associação para o Desenvolvimento da Viticultura Duriense (Portugal).

FCTMusicAndMovement – Music, Groove and Body-movement

Description: Little is still known about how music induces movement and how it influences the organization of movement in time and space. This aspect is particularly relevant to people with Parkinson's Disease (PD), who are usually affected by several gait-related problems, including shortened steps, bradykinesia, Freezing of Gait (FOG) and festination. While a number of pharmacological solutions help to manage the symptoms of PD, some gait-related problems appear resistant to such treatments and, over time, movement-related disturbances turn out to be the most incapacitating symptoms of the disease. However, several cueing strategies can be applied being capable of modifying movements' speed and amplitude, as well as reducing and shortening the occurrence of episodic gait disturbances, such as FOG episodes.

In this project, both music and movement-related aspects will be simultaneously explored. For this purpose, music groove and, in particular, complexity and syncopation of music (as well as familiarity with songs and personal preferences) will be evaluated against three main aspects:

– The willingness to move;

– The spontaneous synchronization of movement with musical beats;

– The quality of walking.

An experimental study will be therefore conducted with 50 non-seniors, 50 seniors and 50 people with PD. The quality of walking will be evaluated using a reference lab system based on cameras for gait analysis. Simultaneously, data from inertial sensors (Pandlets or smartphones) will be collected, not only to validate existing algorithms for gait analysis, but also to introduce other gait-related parameters capable of evaluating the quality of synchronization with music and the overall quality of walking. Aspects such as sensibility to rhythm and pleasure in groove music will be tested using Electroencephalogram (EEG).

Main activities of the project:

– Development of an innovative algorithm for the automatic evaluation of music groove, in particular, to evaluate aspects such as complexity and syncopation of music;

– Studying syncopation (and other music-related aspects) against willingness to move, synchronization with music and quality of walking;

– Development of algorithms capable of evaluating quality of movement when walking to different music stimuli based on inertial sensor data.

Outcome: This project will mainly contribute to a deeper understanding of how music and its properties can affect body movement, which is particularly relevant to people with Parkinson's Disease, but also finds applications in rehabilitation (music therapy) or physical performance optimization in sports. An innovative algorithm to automatically extract a score indicative of its ability to induce and improve movement will be developed. Moreover, an algorithm to evaluate movement and Parkinson's-related disorders will be developed and validated (using smartphones or Pandlets), being capable of evaluating movement in real-time in ambulatory conditions.

Partner: FPCEUP – Faculdade de Psicologia e Ciências da Educação da Universidade do Porto (coordinator) (Portugal).

GARMIO – Indoor Localisation for Mobile Networks in GPS-denied Environments

Description: Planning and optimizing cell towers locations and actuation are tasks that currently rely on limited and, thus, not very representative information, acquired by cumbersome processes that require driving around cities registering signal variations. Data collected this way is not representative because it only corresponds to locations where vehicles are allowed to operate, excluding the inside of buildings, parks, and other large areas.

GARMIO is directed towards researching and developing a web-based solution to be provided to mobile communications operators, destined to locate and characterize mobile devices users with high accuracy, both indoors and outdoors, without requiring GPS data.

Since most of our time is generally spent indoors, carefully understanding the penetration of mobile telephony signals throughout the interior of large buildings (particularly in regions like underground parking or elevators) has great potential of helping mobile operators providing better services for their customers, reducing operational costs.

Modern smartphones have access to a multitude of sensors that can help estimate their users' location and behaviour, both indoors and outdoors. This information can, then, be used to annotate mobile telephony signals with much higher granularity than current processes, associating coordinates and activities to signal strength indicators. Furthermore, using machine learning techniques, this estimation performance will improve over time, increasing positioning accuracy and reducing the amount of required data. Ultimately, at least some of these detections may be performed server side, using

only mobile signal data registered in radio cell towers.

Outcome:

– Web-based software for visualizing generated data;

– Software library to be integrated in telecommunications operators own mobile applications.

Partner: Celfinet – Consultoria em Telecomunicações Lda (coordinator) (Portugal).

GRAMPCITY – Moving Smartly Towards Accessible & Inclusive Urban Environments for Our Elders

Description: This project, which will bring together teams of researchers from various disciplinary fields (geography, urban planning, gerontology and social psychology, sociology and public health), aims to respond to one of today's biggest challenges: aging populations in urban areas.

The main objective of GRAMPCITY is to contribute to the broader discussion of 'age-friendly environments', with a particular focus on the issue of mobility and accessibility to resources. This objective implies assessing the ease with which the elderly move in space and access resources and opportunities.

Outcome: The participation of project COLABORAR and the HCI team of FhP-AICOS in studies of usability of applications and user research.

Partner: IGOT – Instituto de Geografia e Ordenamento do Território (coordinator) (Portugal).

HealthPoints – School Platform for Health and Well-being

Description: The prevalence of childhood overweight and obesity has become epidemic in the past decades. According to a 2015 World Health Organization report, 42 million children below five years old were found to be overweight or obese, and, if the current trend continues, it will very likely reach to 70 million by 2025. The fundamental causes behind these alarming numbers are low levels of physical activity and poor nutrition based on cheap and empty-calorie foods, high in fat, salt and added-sugars. Since food habits acquired during childhood persist through adulthood, it is compulsory to create environments where physical activity and healthy choices of food are encouraged.

To tackle these issues, the HealthPoints project proposal aims to develop an integrated platform which will bring together students, teachers, school nutritionists, legal guardians and school administrative boards. The platform is planned to reutilize the current system (Kiosk + Radio Frequency Identification (RFID) card + web portal), already available in many schools to monitor students' movements on campus and acquire/manage several school services, and complement it with the following functionalities:

– Nutrition: provide nutritional information on food and meals offered inside the school campus and monitor food consumption. Additionally, the use of infographic panels and gamification techniques, will be used to promote healthy life style habits, and provide awareness on healthy eating habits and practise of physical activity;

– Anthropometry: monitor the evolution of the child's anthropometric data and combine it with the amount of daily activity to consequently prevent risks.

The diversified information collected will also provide indicators of social, organizational, scientific/academic, and political value, as well as consolidate and encourage the activity of promotion agencies at schools and new target audiences (national and international).

Outcome:

– Adaptation of activity monitoring to children context;

– Nutrition knowledge to extend for other projects;

– Gamification platform to improve adherence.

Partner: Micro I/O – Serviços de Electrónica Lda (coordinator) (Portugal).

iHPFarming – Intelligent and High Performance Farming

Description: The iHPFarming project proposal aims to create a technological infrastructure for automated management of agricultural production, allowing an increase in the production and the quality of the product. This project proposal intends to, not only create an innovative solution integrating sensing and actuation systems, but at the same time, optimize communication and data transfer systems, enabling the application of decision support systems to possess automatic learning capabilities, and their use in different environments. This will guarantee an automation of different processes associated with the system, according to the needs identified in the crops under analysis.

The creation of this technological infrastructure and its associated web platform presents itself as a response to current needs in different areas of agriculture, relative to the meticulous, intelligent and automatic monitoring of different environmental and soil aspects that influence productivity, growth and quality of different agricultural products in

different geographic locations. The iHPFarming proposes the development and optimization of different technologies, in the field of sensorization, actuation, data transfer via wireless networks and, finally, decision support methodologies based on evolving algorithms that work as an autonomous actuation system.

It is intended, therefore, that the developed solution will create a dynamic and positive impact on the production capabilities of the partners, alongside with the promotion of economic growth, through the creation of new business opportunities. In order to tackle the presented challenges, a consortium composed by two companies and three entities of the R&I system (two technology centres and one university) was established, creating a balance and complementarity of know-how, in order to insure the success of this project proposal.

Outcome:

- A Data Storage platform for big monitoring applications;

- A Data Mining and machine learning component for agriculture applications, more precisely for lemon grass and mint;

- A user centre web and mobile interface for agriculture applications;

- An image processing component for agriculture applications, more precisely for lemon grass and mint.

Partners: Eurico Ferreira SA – Proef Engineering (coordinator) (Portugal); CeNTITVC – Centro de Nanotecnologia e Materiais Técnicos, Funcionais e Inteligentes (Portugal); ERVITAL – Plantas Aromáticas e Medicinais Lda (Portugal); UTAD – Universidade de Trás-os-Montes e Alto Douro (Portugal).

IODA – Internet of Things to Improve Quality of Life of Older Adults

Description: The ageing of the population is strongly associated with the deterioration of their quality of life and well-being, social isolation, functional dependence, difficulties of locomotion, unfavourable emotional state, and progressive decrease of physical activity. In this way, it is urgent to find solutions to promote an active, healthy, and inclusive ageing.

There is a broad consensus on the adoption of emerging health technology systems capable of delivering quality services in health and wellness promotion, functional capacity, and independent living. The creation of intelligent environments provides a relevant opportunity in this field, since they allow the detection of environmental and health parameters and provide real-time feedback. These technologies become even more relevant if we consider that the elderly population, the target public of this project proposal, presents difficulties in using smartphones or any other type of wearable devices in a continuous way.

A fundamental aspect in this context is the exploration of innovative concepts such as the Internet of Things (IoT), Big Data, Human Computer Interaction and the integration of diverse sensors, to unobtrusively capture information from everyday life with the goal to create Ambient Assisted Living (AAL) solutions. This makes it possible to automatically recognize behavioural changes and detect health anomalies in the elderly.

Outcome: FhP-AICOS will be mainly enhancing its Bluetooth mesh network, by:

- Considering the hypothesis of making possible the usage of several GoLive Clips on the same network;

– Adding other types of node to the network, i.e., nodes with sensing and processing capabilities besides the 'relaying' (enabling, for instance, including means of room level indoor localization).

FhP-AICOS will also take advantage of its Living Lab and will use it throughout the execution of the project, extending its features and enlarging its usage possibilities.

Partners: Inovamais – Serviços de Consultadoria em Inovação Tecnológica Lda (coordinator) (Portugal); Increase Time SA (Portugal); Nortexcel 2020 (Portugal).

LIFANA – Life-long Food and Nutrition Assistance Package

Description: Many elderly users suffer from nutritional problems that can cause a number of complications such as weakened immune systems and chronic health conditions, like diabetes type 2, high blood pressure, cardiovascular diseases, stroke or even osteoporosis, to name a few. Through appropriate adjustments in their diets, the burdens of established diseases as well as the risks of developing further conditions can be diminished. The objective of this project is to create a software package to support healthy nutrition through all phases of ageing, from active seniors to elderly users in need of care.

FhP-AICOS' main task is to develop a meal planning component, which recommends meals for a whole week based on the user's personal profile. This may include general preferences, such as culture, taste, and budget, but more importantly, nutritional and diet recommendations. The meal planning will be provided by an automated recommender system considering criteria and rules provided by health care professionals such as allergists and nutritionists. The goal will be to include dishes that are nutritionally appropriate on

their own and that the user likes (or are similar to the dishes the user is known to like). In addition, we will strive for the appropriateness of the whole menu (nutrient balance, calorie content, diversity).

Depending on the individual abilities and situation of the user, the meal planning component will further support:

– Shopping tasks for self-cooking;

– Ordering of ready-made meals.

Outcome: To develop a convenient system that leverages the potential of the Internet of Things (IoT) to guarantee longer living at home by tackling malnutrition.

FhP-AICOS will do this by:

– Providing intelligent and healthy food and meal recommendations to older adults based on health characteristics, lifestyle, culture, resources, availability, local production and season;

– Helping older adults manage their groceries shopping;

– Leveraging the power of local communities to assist each other in food related aspects;

– Creating a comprehensive system that brings together the needs of consumers, retailers and food producers.

Partners: LIST – Luxembourg Institute of Science and Technology (coordinator) (Luxembourg); cereneo Schweiz AG (Switzerland); Gociety BV (Netherlands); LIH – Luxembourg Institute of Health (Luxembourg); SCMP – Santa Casa da

Misericórdia do Porto (Portugal); Sonae Modelo Continente SA (Portugal); Unie KBO – Unie van Katholieke Bonden van Ouderen (Netherlands).

PervasiveFalls – Pervasive Approach for Fall Detection and Fall Risk Assessment

Description: This project aims to create a new approach for continuous assessment of fall risk factors and detection of falls. The envisioned solution is mostly oriented to the real-life context, therefore, it relies on the analysis of movement data collected passively by smartphone inertial sensors, while a person uses the device. The long-term longitudinal fall risk monitoring, with a minimum of 30 persons, will be set up in collaboration with COLABORAR user network, and will serve as a basis for the development of a novel, individually adjusted, risk analysis approach. Adaptive learning mechanisms will be applied to process the data against standard clinical procedures. This project will count on the large experience of FhP-AICOS in fall detection and fall risk assessment, supported by the knowledge experience of INESC TEC in machine learning. Besides answering to a societal challenge, this project foresees a potential contribution to the fundamental research applied to time series.

Outcome:

– Improved fall detection algorithm;

– Real-life validated pervasive fall risk assessment approach.

Partners: FhP-AICOS (coordinator) (Portugal); INESC TEC – Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência (Portugal).

SGSSAK – Shin Guard Sensing

Description: Today we live embraced by technology. We value to know, monitor and gather as much information as we desire in order to improve, optimize and record our daily activities.

The Portuguese company SAK, leading experts in making custom shin guards for professional football players, has the need to be on a constant search for innovation to fulfil their exigent clients. Taking advantage of their close relation with professional football players and teams, they realize that most of the players use sensors to monitor their game skills, as so, they need to employ complementary accessories to use the sensors during practice or effective games. Benefiting from FhP-AICOS competences, SAK aims to develop a solution to apply the same sensors on an item which is already massively used, turning the sensors ubiquitous in the shin guards.

By applying the ecosystem already developed under the scope of project IoTiP, which includes motion sensors and a toolbox application, the SGSSAK project aims to create a custom demonstrator for SAK. Also, a usable prototype of the shin guards will be assembled in order to produce a proof of concept that is appealing for commercial purposes.

Outcome:

– Further explore the use of IoTiP's ecosystem in new scenarios;

– Contribute to the achievement of the objectives defined within the scope of the project DEMSports.

Partner: SAKPROJECT International SA (coordinator) (Portugal).

VITAAL – Using Walking Speed Assessment for Personalised Interventions on Geriatric Giants

Description: In the older population, reduced usual or preferred walking speed is strongly associated with increased risk for disability, cognitive impairment, falls, and all-cause mortality. Walking speed was therefore proposed as a simple geriatric assessment to identify older adults with increased mortality risk and was suggested to be 'the sixth vital sign'. The increase in all-cause mortality risk in relation to slow walking speed is mostly associated with increased cardiovascular mortality risk. Moreover, reduced walking speed is predictive of community functioning and is an issue for older adults attempting to maintain their mobility and safety as pedestrians in urban areas. Previous research has shown that high dual-task costs for different gait parameters, including stride time, stride velocity and stride length at fast walking speed, are associated with poorer divided attention performance and some of the Geriatric Giants (immobility, instability, incontinence, impaired intellect/memory). The VITAAL project will use walking speed as a simple geriatric assessment to identify training needs of older adults and use this measure as a vital sign. Based on the preferred walking speed and additional assessments of walking variability, individualized interventions will be formulated in the shape of interactive games that can be played at home.

Outcome: An integrated solution to target the impairments related to the Geriatric Giants (immobility, instability, incontinence, impaired intellect/memory). This solution will be based on the Active@Home prototype, expanded with interventions for cognitive-motor training, pelvic floor muscle training and dynapenia.

A low cost home-based gait analysis tool will also be developed, which can then be independently commercially exploited.

Partners: Dividat AG (coordinator) (Switzerland); ETH Zürich – Eidgenössische Technische Hochschule Zürich | Departement Gesundheitswissenschaften und Technologie (Switzerland); KU Leuven Research & Development (Belgium); Physio SPArtos GmbH (Switzerland); ProCare BV (Belgium); Université de Montreal – Canadian Research Chair in Urogynecological Health in Aging (Canada).

XAISense – Explainable Artificial Intelligence for Human Sensing

Description: The Explained Artificial Intelligence clinical decision based on human sensing information – XAISense project, aims to develop new methodologies with the goal to produce transparency and reporting mechanisms to explain the output of the clinical inference methods. The explanation methods provide clarity to the decisions proposed to the end user/patient and to the clinician that need to validate and promote to the patient the output of the decision systems. These explanation mechanisms support an improvement loop by enabling the developer of clinical decision support systems to adjust and control the machine learning algorithms.

The work is based on use cases where both time series data and decision mechanism have already been developed, both by LIBPhys-UNL and FhP-AICOS. The use cases comprise three main areas of interest: activity monitoring; clinical decision analysis; and continuous electrocardiogram monitoring.

Currently, the decision systems are opaque and do not provide a clear evidence of the decision flow. The European Community regulation is recently promoting the right to explanation and the right to be forgotten on the General Data Protection Regulation and the Artificial Intelligence (AI) researchers listed the 23 Asilomar AI principles. The list of Asilomar principles contains two elements which focus on failure transparency and judicial transparency, calling for mechanisms to audit AI systems.

The XAISense project aims to develop a decision layer, an explanation kernel and a reporting system. The base decision layer will use standard machine learning techniques; the explanation kernel will interpret the decision and identify the decision mechanics. The reporting and annotation will be the interface to the user providing the explanation of what the kernel identified. This will contain four levels of explanation of incremental complexity:

- Explain via structure – shape and motif detection in time series;

- Explain via data – feature selection and data importance analysis;

- Explain via linear decision – linear classifiers and decision trees boundaries analysis;

- Explain via network – detecting structure on deep neural architectures.

The project is based in an evaluation of the societal challenges that machine learning is imposing to the clinical decision, where the ethical context will be analysed as the relation to specific uses cases defining the correct method for validating the explanation capabilities of a system.

The major contribution for the Biomedical Engineering area will be the capability of explaining clinical decision based on different machine learning techniques, and the advanced training of human resources to deal with this challenging interdisciplinary automated clinical decision area, by bringing together biomedical engineers, health care professionals and medical devices industry. The project integrates the research teams on biosignals from LIBPhys-UNL with the research teams from FhP-AICOS. As external partners a Portuguese medical device company promotes the realization of industry PhDs in the context of the project, and the Zurich University Hospital supports with use cases.

Outcome: The main outcome of this project consist of building novel competencies in the current workflow of the FhP-AICOS ML methodologies. Explainable AI is a hot research topic and should deliver valuable new methods for debugging the currently black-box ML approaches and present more informative autonomous recommendation systems. This effort will ultimately result in use cases applied for the areas of active ageing and clinical scenarios.

Partner: LibPhys-UNL – Laboratory for Instrumentation, Biomedical Engineering and Radiation Physics (coordinator) (Portugal).

ACADEMIC ACTIVITIES

Regarding academic activities, it is worth highlighting that the Director of FhP-AICOS is an invited Professor at the Faculty of Engineering of the University of Porto and FhP-AICOS is responsible for proposing a set of topics for Master of Science (MSc) theses. The MSc students join FhP-AICOS team to work on applied research projects and also in their own thesis. The topics proposed for theses are aligned with the Strategic Research Agenda defined by the Scientific Board of FhP-AICOS.

CMosquitoII – Companion Drones for Retail 18

Description: Over the last years, the increasing technological advances in Unmanned Aerial Vehicles (UAV) allowed to expand the concept and applicability of those systems[1]. UAV are now suitable to be used in a wide range of applications such as Search and Rescue, Surveillance, Aerial Photography and Agriculture. Among the possible applications, autonomous flight in indoor and confined spaces is a challenging scientific topic that is suitable to deliver new insights for ubiquitous user/context monitoring[2].

In order to operate in tightly constrained environments, there has been a rapid increase of interest in scaling down the size of platforms to develop Nano aerial vehicles[3]. This interest allowed to extend the UAV applicability to Ambient Assisted Living (AAL) scenarios, where the vehicle can monitor human actions and their behaviour, while 'listening' the environment and understanding the context where the user is inserted in.

This project aims to provide the technological infrastructure that is needed to build a solution applied to the Retail Environment. Namely, providing the technological infrastructure means by integrating different modules (e.g. drone, communications, camera, sensors), and developing a route manager and an obstacle avoidance module that allows the drone to fly between previously known landing spots, such as Qi™ charging pads. The route manager is a simplified version of a flight control system, that allows to control the drone with high-level commands (e.g. 'move X meters to the Y direction', 'hold position', etc.).

Outcome: The main purpose of this project is to provide the technological solution for an autonomous drone that can be applied in several contexts, such as our activities in AAL (e.g. a surveillance drone) or in the retail environment (e.g. an Out-of-Stock drone).

Partner: FEUP – Faculdade de Engenharia da Universidade do Porto (Portugal).

DActivPR – Daily Activity Patterns Recognition

Description: FhP-AICOS has been working in the field of monitoring physical activity and activity related metrics, and already has a solution for Activity Level and Fall Risk monitoring integrated in the Smart Companion environment. However, few or no efforts have been made in analysing the data that is generated while users carry the monitoring application. By understanding the users' behaviour patterns, we can better suggest appropriate intervention strategies and personalized recommendations.

1 Clarke, Roger. 'Understanding the drone epidemic.' Computer Law & Security Review 30.3 (2014): 230-246.

2 Floreano, Dario, and Robert J. Wood. 'Science, technology and the future of small autonomous drones.' Nature 521.7553 (2015): 460-466.

3 Lehnert, Christopher, and Peter Corke. 'μAV-Design and implementation of an open source micro quadrotor.' Proceedings of Australasian Conference on Robotics and Automation. 2013.

The inertial sensor data that is received by the application is processed and stored in a backend server. This data comprises physical activities, postures recognition and related metrics such as walking, running, sitting, standing and resting time, number of sit-to-stand transitions, gait inter-stride variability, walking speed, number of steps, energy expenditure, distance travelled and number of falls along the day. Among activity data, information from GPS location and points of interested visited by the users are also available. For the purpose of this project, it is expected to retrieve all the useful information from the user's database and to develop appropriate algorithms for activity patterns recognition based on hourly, daily and weekly records. For each epoch, different findings and analysis should be performed.

In order to accomplish the objectives of this project, it is necessary to develop methods for data representation, data visualization and relevant outcome identification by analysing major trends and patterns in daily routines for each user. Moreover, data from similar users can be crossed to find group patterns and to infer disruptions in daily activity and early signs of physical and cognitive decline. Whenever it is relevant, meaningful recommendations should arise from the data analysis, as for example, when a user has a sedentary behaviour and poor social life, suggestions of outdoor physical activities and social events are useful when crossed with the user's location.

Outcome: Daily activities and prevention of decline: The progress of physical, behavioural and cognitive parameters will be studied in the context of daily activities. The knowledge gathered will be used to detect functional ability decline and automatically define interventions tailored for each person.

Outcome for project DeM – Deus ex Machina (research line C3 – Companion Competence Centre). Possible outcome for project GoLivePhone, integrated with Activity Level and Fall Risk Applications.

Partner: FEUP – Faculdade de Engenharia da Universidade do Porto (Portugal).

EyesOnFarm – Eyes on Farm

Description: Nowadays, precision agriculture gives the farmer the opportunity to optimize the output and minimize operational costs of his farms. By using sophisticated technology (sensing and actuation devices), the farmer can access different sets of parameters and manage all stages of production, based on real-time information.

However, the interaction between farmers – low or non-technical users – and devices that gather a large amount of data, demands design techniques and technologies in order to understand actions, context and profile of a specific user, providing the best possible experience and efficiently helping in decision-making activities.

The goal of this project is to take advantage of previous work from project Hydroponic Farming and contribute to project DeM – Deus ex Machina, namely:

–   Mind and Behaviour: understanding farmers needs and technology acceptances through user research and analysis;

–   Agriculture: crop monitoring, field tests and experiments: where low-fidelity prototypes will explore new methods of visualization and interaction. Using the data gathered from sensors, information will be effectively represented, helping farmers to make the best decisions in their farming activities.

Outcome:

– Low-fidelity prototypes;

– Report about tests with low-fidelity prototypes;

– Mobile frontend components for Farmer Computer Interaction and future projects.

Partner: FEUP – Faculdade de Engenharia da Universidade do Porto (Portugal).

FOGSensor4PD – Real-time Detection of FOG Episodes in Patients with Parkinson's Disease

Description: Freezing of Gait (FOG) is a common motor symptom in Parkinson's Disease (PD). It was defined by Nieuwboer and Giladi as 'an episodic inability (lasting seconds) to generate effective stepping in the absence of any known cause other than Parkinsonism or high-level gait disorders'[4]. FOG is typically associated with advanced stages of the disease and frequently leads to the occurrence of falls and injuries. It can occur during the initiation of the first step, or during walking (e.g. walking through narrow spaces, reaching destinations or passing through doorways). The episodes are typically brief (one to two seconds), but can also last more seconds[5]. Due to the daily, unpredictable and frequent occurrence of FOG events, they can drastically degrade the quality of life in patients with advanced PD.

A common strategy used to support functional gait is the use of Rhythmic Auditory Stimulation (RAS). However, the effect of RAS may wear off over time so permanent stimulation, in addition to not being comfortable during daily life conditions, is not efficient and therefore not advised. The detection of FOG episodes in real time allows assistive/cueing devices to actuate at the right time, but a minimum latency is required in the detection to support this functionality. While RAS upon detection helps to shorten the duration of FOG episodes, it cannot avoid them due to the latency of the detection. Some studies suggested that a pre-FOG transition period can typically be observed, which opens new research questions related to pre-FOG detection and pre-emptive RAS delivery[6,7].

This project aims at the development of a system capable of detecting FOG episodes with a low latency, using inertial sensors placed at distinct positions, including the ear. It also aims at exploring the detection of pre-FOG periods with a view to developing RAS preventive strategies.

Outcome: This project focus on the development of new mechanisms to detect and predict FOG episodes in Parkinson's Disease using inertial sensor data. Multiple sensor locations will be explored in view to comparing the performance of the algorithms when different body positions are considered. The FOG detection algorithm will need to operate in real-time, being capable of predicting an event (pre-FOG detection) or detecting it with a minimum latency. A proof-of-concept will be implemented and evaluated with real patients using the Inertial Measurement Unit (IMU) on the ear.

Partner: FEUP – Faculdade de Engenharia da Universidade do Porto (Portugal).

4 *Nieuwboer A., Giladi N. Understanding and treating freezing of gait in Parkinsonism, proposed working definition, and setting the stage. Mov. Disord. 2008, 23:1639–1640.*

5 *Coste, C. et al., Detection of freezing of gait in Parkinson Disease: Preliminary Results, Sensors (Basel). 2014, 14:4, pp. 6819-6827.*

6 *Mazilu, S., et al., Feature Learning for Detection and Prediction of Freezing of Gait in Parkinson's Disease, International Workshop on Machine Learning and Data Mining in Pattern Recognition, 2013, pp. 144-158.*

7 *Palmerini, L. et al., Identification of characteristic motor patterns preceding freezing of gait in Parkinson's disease using wearable sensors, Front. Neurol. 2017.*

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inMOTION – Motion Compatibility and Adaptive Filtering for Indoor Localization

Description: Location-based services for mobile devices are a recent and growing area of interest, particularly in indoor environments. Several indoor localization solutions relying on smartphones and inertial sensing-based motion tracking algorithms are currently emerging. However, despite being attractive, these types of solutions still present some challenges, including, heading drift, step length estimation errors, missed steps, inaccurate evaluation of unpredictable motion patterns, and consequently, cumulative errors and long-term inaccuracy.

Often, forward filtering-based methods are applied to mitigate some of these problems. However, unless environmental reference technologies are used (e.g. magnetic and WiFi signals), errors will be accumulating over time, without the possibility to recover/re-calibrate.

However, due to the intrinsic characteristics of human walking patterns (e.g. smoothness, continuity, target-oriented) and because of metric, topological and semantic constraints (path continuity and compatibility) imposed by indoor maps, human walking movements are highly structured and can be described using a relatively small vocabulary of motions (e.g. turning, walking ascent, elevator, opening doors, etc.). Using this knowledge, more effective map matching algorithms can be applied, which can then be used to compensate errors, auto adapt, and learn motion parameters and recover from unpredictable motion patterns.

The aim of this project is therefore to develop a set of adaptive strategies for motion self-learning, based on forward-backward correction mechanisms, capable of improving steps detection, step length and heading estimation robustness. Moreover, through the application of trajectory matching algorithms, and based on the constraints imposed by indoor maps and motion compatibility, the developed system must be able to automatically re-calibrate in case the position is lost and recover the user's recent path history.

Outcome: A new indoor localization mechanism was developed, relying solely on the use of inertial sensor data acquired from two wearable sensors placed on the feet and building map information. The solution features step detection and quantification, combined with drift-correction mechanisms based on zero velocity updates and a Gaussian-based (foot) fusion process. The solution also features map matching and self-recovering methodologies for indoor localization. The system provided an average error of 1.37m over 23 trials with five different subjects and a maximum error of 2.77m.

Partner: FEUP – Faculdade de Engenharia da Universidade do Porto (Portugal).

KneeRecovery – Rehabilitation Exercises for Knee Recovery at Home 19

Description: Osteoarthritis is a progressive musculoskeletal disorder characterized by gradual loss of articular cartilage. It is the most common cause of long-term disability for people over 65, due to the aging process that reduces the ability of the cartilaginous tissue to withstand loads and stresses.

Total Knee Replacement (TKR) is a commonly performed surgical procedure indicated for patients affected by severe knee osteoarthritis, which consists in replacing the damaged knee joint with an artificial knee implant. After surgery, rehabilitation, with an emphasis on physiotherapy and exercise, is widely promoted and is essential to improve the chances for long-term success. There are several exercises indicated to optimize the rehabilitation process, including range-of-motion exercises, progressive muscle-strengthening exercises, body awareness and balance training, and activity-specific training to patient's specific needs.

This project focused on investigating and implementing several rehabilitation exercises indicated for patients that underwent a TKR, using inertial sensors.

Outcome: The main outcome of this project was the development of a solution to complement the rehabilitation process after a TKR, at home, using inertial sensors.

Partner: FEUP – Faculdade de Engenharia da Universidade do Porto (Portugal).

Listen2MySound – Contextual Information Based on Pervasive Speech Analysis 20

Description: Over the last years, the increasing ubiquity of smartphone devices allowed to completely redraw their traditional concept and applicability. The increasing advances on technology allowed integrating a multitude of different sensors, capable to 'sense' the world that surrounds the users and their actions, allowing to perform a continuous Human Activity Recognition (HAR). This topic has become of high interest for medical applications. On the one hand, patients with chronic diseases are required to follow pre-defined exercises as part of their long-term treatments. On the other hand, the evolution of social interactions promoted the interest and need for 'self-measurement'[8].

Traditionally, Human Activity Recognition (HAR) uses a first layer of information based on inertial data which proved to be a valuable asset. However, common available architectures can be improved, if additional sensing mechanisms are introduced to sense the context where the user is inserted[9,10].

This project introduced a new layer of information using pervasive sound analysis from the built-in smartphone's microphones. Sound is everywhere on daily life and certain actions and environments create well-defined fingerprints which can help to increase today's HAR architectures performance[11]. Examples of such actions include the sound promoted by closing/opening doors, walking outdoors/indoors and walking on stairs, which help to locate user and help to identify his activity; the sounds of Human speech, which may eventually address social behaviours; the absence of sound, which may help to assure correct circadian rhythms are being followed. Ultimately, an earlier identification of continuous exposure to high intensity noises, which constitute a potential health hazard, may also prevent potential ear diseases.

This project focused on the development of a framework for HAR and Indoor Location using the sound perceived through the device's microphone, which can enhance the current system's performance, based on their actions and context.

Outcome: This project allowed using the sound as a new information layer for Human Activity Recognition and Indoor Location. The idea was not to consider the use of sound per si as a standalone information layer, but rather to complement the current frameworks in order to increase the overall algorithm's performance. Moreover, this project will allow the study of a new source of information which may bring new applications for FhP-AICOS projects.

Partner: FCT NOVA – Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa (Portugal).

8   Lara, O. D., & Labrador, M. A. (2013). A survey on human activity recognition using wearable sensors. IEEE Communications Surveys & Tutorials, 15(3), 1192-1209.

9   Chen, G., & Kotz, D. (2000). A survey of context-aware mobile computing research (Vol. 1, No. 2.1, pp. 2-1). Technical Report TR2000-381, Dept. of Computer Science, Dartmouth College.

10   Fogarty, J., Au, C., & Hudson, S. E. (2006, October). Sensing from the basement: a feasibility study of unobtrusive and low-cost home activity recognition. In Proceedings of the 19th annual ACM symposium on User interface software and technology (pp. 91-100). ACM.

LocRec – Location Aware Product Recommendations

Description: Nowadays, a typical retail chain store carries an inventory of thousands of products, and usually the customer needs to cover a large area to find all the products he/she needs, because of this, grocery shopping can be a very time consuming and tedious task.

Enter the idea of a shopping companion application to aid customers with their shopping trips, and as a result, improve their overall quality of life.

This project aims to develop a smartphone application that uses product recommendations in order to prebuild a list of items to shop, according to the customer's personal taste. Also, the application knowns when certain products might be needed, by 'looking' into the customer's recurrent buying patterns, recommending these products at the right time.

Even more, the application is able to provide indoor navigation through the store's aisles, to aid the customer to find his way through the store in an efficient manner, giving him a feeling of accomplishment.

Leveraging FhP-AICOS' previous experience and know-how in the areas of precise indoor location and product recommendation, these two techniques can be combined into an innovative solution that helps customers in their shopping trips.

11 *Maurer, U., Smailagic, A., Siewiorek, D. P., & Deisher, M. (2006, April). Activity recognition and monitoring using multiple sensors on different body positions. In International Workshop on Wearable and Implantable Body Sensor Networks (BSN'06) (pp. 4-pp). IEEE.*

Outcome:

– Backend server, with associated web services, which delivers product recommendations and possible indoor routes generated from the customers' previous buys;

– Web frontend for demonstration purposes which allows for recommendations and indoor routing visualization on a store's floor plan.

Partner: FEUP – Faculdade de Engenharia da Universidade do Porto (Portugal).

mDRAssessment – Implementation and Evaluation of a Mobile Decision-Support System for Diabetic Retinopathy

Description: Diabetic Retinopathy is a progressive and major complication of Diabetes mellitus type I and type II, as the blood vessels of the retina are damaged over the time. Many Diabetic patients (35%) suffer from this condition that causes blindness. At an early stage, Diabetic Retinopathy can be treated with medications and/or surgery. But when the diagnosis is at a more advanced stage, the disease is irreversible. As Diabetic Retinopathy evolves asymptomatically, it is necessary having a program that enables the early detection in all patients with Diabetes. However, a 2015 report reveals that nearly a half of the Diabetic patients never went for an ophthalmologic examination. Considering the prevalence of Diabetes (13% in the Portuguese population aged 20-79 years) and its estimated increase in the next years in all countries worldwide, Diabetes Retinopathy is an emergent problem, even considered by some as a Public Health issue.

A mobile-based solution that can provide an effective pre-diagnosis of all patients in a regular medical appointment, instead of an expensive and complex screening program, appears very

promising in the context of health care services. However, new technologies, particularly those aimed at the diagnosis or pre-diagnosis, must be largely validated with the determination of its accuracy and impact, in order to inform the decision-making process. Considering the previous development of the EyeFundusScope prototypes, this project proposes an additional study that applies a comprehensive set of validation tests, in the context of clinical assessment, to a sample of Diabetic patients.

Outcome:

- – Provide novel data on prototype testing;

- – Generate evidence on the integration of diagnostic tests with a mobile-based solution in the context of clinical settings;

- – Generate evidence to inform future decision making in Health Systems.

Partner: FMUP – Faculdade de Medicina da Universidade do Porto (Porto).

MEDICARE – Measuring Impedance in Congestive Failure Patients

Description: Measurement of thoracic impedance is becoming increasingly available in the clinical setting as a tool for assessing hemodynamic and volume status in patients with Heart Failure. The two major categories of impedance assessment are the band electrode method and the implanted device lead method. Base Thoracic impedance is a sensitive measurement, indicating fluid retention in Heart Failure patients, as early as 12 days before symptom development or weight gain.

With this in mind, an electronic system was developed, built around Pandlets (a platform created by FhP-AICOS that measure human behaviour and environmental context). This system is composed by a block responsible for generating a current to be injected, and another block to acquire the signal. A power circuit was also developed allowing the system to be supplied by a simple rechargeable battery. The smartphone uses Bluetooth Low Energy to communicate with the device. To start the measurement procedure and estimate the thoracic impedance, an Android application was also created.

The main objective for this project is to continue the development of the mobile system that monitors patients Base Thoracic impedance, and validate, in clinical environment, the achieved results.

Outcome: Develop a mobile system to monitor patients' base Thoracic impedance, integrated with the following project: Smart Companion, SmartBEAT and DeM.

Partner: FEUP – Faculdade de Engenharia da Universidade do Porto (Portugal).

ML4Malaria – Statistical Comparison of Different Machine-Learning Approaches for Malaria Parasites Detection in Microscopic Images

Description: Malaria is a leading cause of death and disease in many developing countries[12]. In 2015, there were an estimated 214 million cases of malaria, which caused approximately 438.000 deaths. Around 90% of malaria cases occurred in Africa, where the lack of access to malaria diagnosis is largely due to a shortage of expertise. Thus, the importance to develop new tools that facilitate the rapid and easy diagnosis

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12 *World Health Organization ¡World Malaria Report. 2015. URL: www. who.int/malaria/publications/world-malaria-report-2015.*

of malaria for areas with limited access to healthcare services, cannot be overstated[13].

Image processing for malaria diagnosis can bring several advantages, like potentially reduce the dependence of manual microscopic examination, which is an exhaustive and time consuming activity, simultaneously requiring a considerable expertise of the laboratory technician. Most of the related works found on literature for malaria parasites detection in microscopic images are based on instance-based classifiers (e.g. Support Vector Machine, Naive Bayes, Decision Trees)[14], usually with no statistical comparison that supports the selection of a particular classifier.

The goal of this project is to perform a statistical comparison of different machine learning approaches for malaria parasites detection in microscopic images, and find the approach that ensures the best performance. Beyond the conventionally used classifiers, new classification approaches should also be explored, like Deep Learning Algorithms and Fuzzy Logics. Moreover, multi-classifier approaches should also be explored, i.e. combining different classifiers in order to find the machine learning approach with the best performance for malaria parasites detection in microscopic images.

Outcome: The goal of this project is to perform a statistical comparison of different machine learning approaches for malaria parasites detection in microscopic images. Furthermore, the project will experiment/implement a wide variety of machine learning classifiers and feature selection algorithms, with the main goal of finding the machine learning approach

that ensures the best performance for malaria parasites detection in microscopic images.

Partner: FEUP – Faculdade de Engenharia da Universidade do Porto (Portugal).

mSkinColorCalib – Computer Vision-based System for Colour Calibration of Mobile-acquired Skin Lesion Images 21

Description: Images captured with different mobile phones have different colours due to different camera specifications and/or illumination conditions. For medical applications like skin lesion image acquisition, the correct representation of colours is a crucial requirement for the specialist visual analysis. Thus, robust colour calibration of mobile-acquired images for skin lesion analysis can greatly improve its quality for risk assessment purposes.

The first step to calibrate colour consists in performing colour characterization, by computing the relationship between the Red, Green and Blue (RGB) values given by the device and colour space, which depend only on the reflectance properties of the observed objects and the illumination. Usually a device-independent colour space is used, such as CIEXYZ or CIELab (models for colour definition). Only afterwards is it possible to perform colour calibration in the acquired image according to the computed characterization coefficients.

Outcome: The goal of this project was to develop a computer vision-based system for color calibration of mobile-acquired skin lesion images

Partner: UC – Universidade de Coimbra (Portugal).

13 *Rosado, L., Correia da Costa, J.M., Elias, D., S Cardoso, J.. Automated Detection of Malaria Parasites on Thick Blood Smears via Mobile Devices. Procedia Computer Science 2016;90:138-144.*
14 *Rosado, L., Correia da Costa, J.M., Elias, D., S Cardoso, J.. A review of automatic malaria parasites detection and segmentation in microscopic images. Anti-Infective Agents 2016;14(1):11–22.*

rePlano – Reversing ShopView Analysis for Planogram Creation 22

Description: The project ShopView leverages computer-vision technology for automatic planogram compliance checking. Compliance checking is then performed by comparing the detected product placement with the pre-specified planogram. However, this approach requires planograms which are often unavailable for some retailers (a planogram is a tool that retailers use to assist in the merchandising.) Furthermore, product placement is important in retail to maximize sales and minimize wasted space. The aim of this project is to accurately capture the true layout of shelf conditions by ShopView, to interpret and draw a visual diagram for a possible planogram.

Outcome: Automatic Planogram Extraction – new feature for ShopView solution.

Partner: FEUP – Faculdade de Engenharia da Universidade do Porto (Portugal).

SCDash – Smart Companion Dashboard App

Description: Smart Companion (SC) is an Android launcher that was specially designed to address seniors' goals and needs. It aims to be a permanently available companion to support seniors in their daily activities, and bring them closer to their relatives or caregivers. In order to accomplish this task, SC includes a set of applications that range from simple calls and messages to more complex ones such as fall risk calculation, activity monitoring and fall detection. All the applications developed for SC gather a relevant amount of data that can aid its user on their daily activities. Nevertheless, this can only be achieved if data is treated and showed to the user using a simple and meaningful way.

Currently, information collected by SC is spread across several applications, that the user needs to open and browse. Combining information collected from different applications could also result in new conclusions that are relevant to the user.

The goal of this project is to study how the information collected by SC applications can be displayed to the user in an easy, simple, centralized and dashboard-like way, through an application, a widget or other appropriate solution. This includes analysing the smartphone data, conduct research with the users to understand which information is more relevant to them and how it should be displayed, develop low to high fidelity prototypes of the User Interface (UI), and iteratively test the solution.

The outcome of this project is an Android application or widget, where the user can, at a glance, get the most important information available at SC.

Outcome: The outcome of this project is a new application to be integrated in the Smart Companion system. This application should aggregate different information to be displayed in a simple and easy to read way for the user. This application can also be potentially included in GoLivePhone in the future.

Partner: FEUP – Faculdade de Engenharia da Universidade do Porto (Portugal).

ScreeningEFSOptics – Optical Design of a Retinal Image Acquisition Device for Mobile Diabetic Retinopathy Assessment

Description: The eye retina is the only structure in the body where vessels can be directly seen, without intrusive procedures. Imaging this structure is extremely important in the diagnosis of various pathologies, particularly diabetic retinopathy, the leading cause of avoidable blindness in the world.

Accessing the retina can be achieved through ophthalmo-scopes, Optical Coherence Tomography (OCT) scans, fundus cameras, etc. The acquisition of retinal images through fundus cameras is the preferred method for the screening of common retinal pathologies. However, these devices are very expensive and tend to be bulky, limiting their use to specific places.

Outcome:

– Improvement in the optical system of project EyeFundusScope;

– Optimize the results of the industry project MobileDRS;

– Customized low-cost optical magnification and sensing devices.

Partner: FCT NOVA – Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa (Portugal).

ScreeningFallRisk – Screening Tool to Assess the Risk of Falling

Description: Falls are a very important problem for older adults since they affect 30% of the elderly population, tend to be recurrent and result in serious consequences, such as injuries, loss of independence, institutionalization and even death.

Falls can be prevented if the major risk factors are identified and timely mitigated, even though, fall risk screenings are still not established as a common procedure due to lack of resources.

Most of the known fall risk factors result in physical impair-ments that can be assessed systematically, using specific movement tests and movement sensors.

Outcome: The aim of this project is to extract the most relevant fall risk factors from an existing database built for this purpose. The database comprises personal and clinical information and some of the metrics that can be extracted from movement sensors. Additional metrics will be computed and evaluated. The multiple fall risk factors will then be combined into a risk model able to identify the elders with higher likelihood of falling.

Partner: FEUP – Faculdade de Engenharia da Universidade do Porto (Portugal).

SmartReminders – Eating and Drinking Recognition for Triggering Smart Reminders 23

Description: Malnutrition and dehydration are key problems in the elderly population. The causes for these problems are that seniors frequently skip meals and forget to drink water. As medication is often taken with meals, skipping a meal usually results in missing to take the medication and this leads to poorer medication compliance.

By recognizing eating and drinking gestures during the day, it is possible to trigger smart reminders that will advise the user to take a medication in the key moment when he/she is eating, or alert that he/she is skipping a meal, or forgetting to drink water for a long time.

This gesture recognition may be based on analysing the signals of inertial sensors from off-the-shelf smartwatches, or other sensors used around the wrist, to observe and classify the movements performed during the day.

Since the arm has a great number of degrees of freedom and wrist movements and gestures are very diverse, the inertial sensor signals obtained from free daily living conditions in this position are expected to be very noisy. Therefore gesture rec-ognition problems are not trivial and should be addressed using

classifiers that are able to take into account both sequences of sub-gesture motions and model inter-gesture sequential dependencies, for example higher order Hidden Markov Models. In order to achieve high recognition accuracy, other levels of information, such as location and time of the day could also be added in a higher level classification layer.

Outcome: The goal of this project is to develop the first version of our Eyes of the Internet of Things (EIT) framework for recognizing specific movements.

The focus on nutrition is because eating and drinking gestures are easier to collect in-house and the tool can be tested in the scope of My-AHA, and then re-used for the DeM Nutrition Companion.

Partner: FEUP – Faculdade de Engenharia da Universidade do Porto (Portugal).

UHMAN – Unsupervised Human Motion Annotation

Description: Every day, each of us is generating data from wearable and smartphones' sensors. This data could be used, but it is unlabelled or wrongly labelled.

Physical inactivity is one of the main causes of several health diseases, as heart diseases, besides being correlated to overweight and obesity. On the other hand, the practice of physical exercises may increase cardio-respiratory and muscular fitness, functional health, improving bones and joint health, and cognitive functions. With this, human physical activities recognition has been increasingly sought, in order to give the necessary motivation to physical activities practice. Moreover, besides healthcare, human physical activities recognition has applications in sports, elderly oversee and safety.

The development of a human activities recognition algorithm involves the collection of a large amount of labelled data, where a high volume of data will increase the algorithm performance. Most of the time, the annotation of data labels is too expensive, time consuming or difficult to obtain. Moreover, this ground truth information may not be available. With this, the development of an unsupervised annotation method is challenging and particularly interesting within an exploratory machine learning context, in order to automatically label a large amount of unlabelled data.

As so, the aim of this project is the development of a framework for unsupervised human activities recognition using smartphone and wearable sensors.

Outcome: Novel unsupervised machine learning algorithms to annotate human motion data from smartphone or wearable sensors signals. This work will ease the process of data acquisition and annotation, which most of the time is too expensive, time consuming or difficult to obtain. The result of this project will be applied in several FhP-AICOS projects, especially the ones that use machine learning techniques applied to time series data.

Partner: FCT NOVA – Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa (Portugal).

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AAL	Ambient Assisted Living
AC	Autonomic Computing
ACP	African, Caribbean and Pacific Group of States
AI	Artificial Intelligence
ANI	Agência Nacional de Inovação (Portuguese National Innovation Agency)
ARS Centro	Administração Regional de Saúde do Centro (Regional Health Administration of the Central Region)
C3	Companion Competence Centre
CAPEX	Capital Expenditure
CCDR-N	Comissão de Coordenação e Desenvolvimento Regional do Norte (Regional Coordination and Development Commission of the Northern Region)
EAN	European Article Number
EEG	Electroencephalogram
EIT	Eyes of the Internet of Things
EITCC	Eyes of the Internet of Things Competence Centre
EMG	Electromyography
FCC	Fall Competence Center
FCT	Fundação para a Ciência e a Tecnologia (Foundation for Science and Technology)
FhP-AICOS	Fraunhofer Portugal Research Center for Assistive Information and Communication Solutions
FoG	Freezing of Gait
FR	Functional Reach
FTE	Full Time Equivalent
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HAR	Human Activity Recognition
HCI	Human-Computer Interaction
HDMI	High Definition Multimedia Interface
HF	Heart Failure
ICT	Information and Communication Technologies
ICT4D	Information and Communication Technologies for Development
ICT4DCC	Information and Communication Technologies for Development Competence Center
IMU	Inertial Measurement Unit
IoT	Internet of Things
IP	Information Processing

KPI	Key Performance Indicators
LAI	Leaf Area Index
MSc	Master of Science
NGO	Non-Governmental Organization
OCT	Optical Coherence Tomography
OPEX	Operating Expenditures
PD	Parkinson's Disease
PNS	Pedestrian Navigation Systems
POMA	Performance Oriented Mobility Assessment
R&D	Research and Development
R&I	Research and Innovation
RAS	Rhythmic Auditory Stimulation
RD&I	Research Development and Innovation
RF	Radio Frequency
RGB	Red, Green and Blue
SC	Smart Companion
SiP	System-in-Package
SME	Small or Medium-sized Enterprise
SPAD	Soil Plant Analysis Development
SV4D	Sustainable Villages for Development
TCGFE	Texture-Color-Geometry Feature Extraction
TKR	Total Knee Replacement
TUG	Timed Up and Go
UAV	Unmanned Aerial Vehicle
UI	User Interface