Fraunhofer
PORTUGAL

RESEARCH CENTER FOR ASSISTIVE INFORMATION AND COMMUNICATION SOLUTIONS

1 *Image Source: http://www.scmp.com/week-asia/business/article/2069562.*

EVALUATION OF SPATIAL-TEMPORAL ANOMALIES IN THE ANALYSIS OF HUMAN MOVEMENT

Unsupervised anomaly detection for generic time series provides information regarding unplanned events in Industrial scenarios

Motivation

Anomalies can be defined as events that do not follow the expected behaviour of a system. Specifically, if the behaviour is cyclic, an anomaly can be identified as a break from that repetitiveness. These events are usually associated with malign processes, hence the importance of their detection. There are many domains in which anomaly detection has been studied, such as credit card fraud, flawed motors and price manipulation in stock markets. In the medical domain, this subject is being studied applied to arrhythmia detection in ECG signals, schizophrenia progression in diagnosed patients and in dementia detection systems.

Manufacturing industries rely on human movement libraries that must be followed by the employees who are assigned to conduct tasks to complete given work cycles. Those movements are well studied on the scope of industrial engineering to optimize production and improve ergonomics in the workplace, aiming to promote the standardization of the production process and assess, *a priori*, the cost of a given task based on the time of its execution.

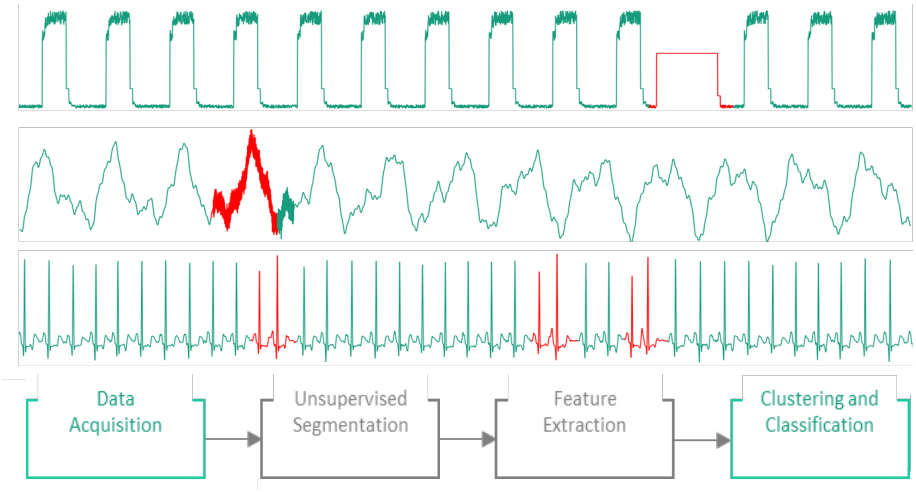
Work study is the discipline that aims to analyze the work method and its target execution time, starting from a detailed analysis of the movements that are performed on a given task. However, the current solutions for conducting a work study are technologically obsolete and integrate a set of technical and social barriers that compromise the validity of the study. Manufacturer employees on industrial scenarios perform several repetitions of a given task during the complete working day. The repeatability of task execution is identified as a risk factor for the development of musculoskeletal disorders.

Therefore, a system that would be able to detect wrongly performed tasks constitutes a valuable asset and can be used as a training tool to simultaneously increase productivity and monitor ergonomics in order to minimize the likelihood of work-related injuries in the given industrial setting.

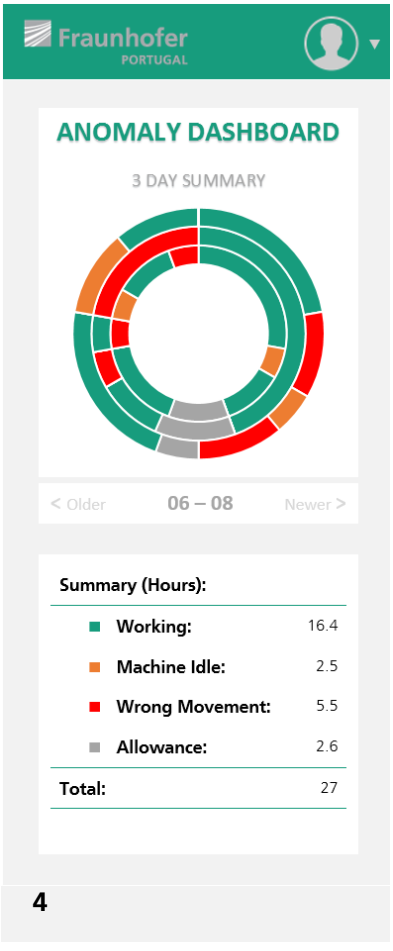
FRAUNHOFER AICOS
Rua Alfredo Allen, 455 / 460
4200-135 Porto, Portugal

+351 220 430 300
info@fraunhofer.pt
www.fraunhofer.pt

2



3



4

Proposed Approach

The proposed approach was designed to detect anomalies in time series data that exhibits a periodic pattern. This Thesis main application focuses on the analysis of Human movement during industrial scenarios. In order to achieve this, inertial sensors integrated into an IoTiP wearable (previously developed by Fraunhofer AICOS) are used to acquire data during the full range of movements performed by the employees, resulting into a ubiquitous method to acquire work study data without inconvenience for the employee.

Inertial data in the form of time series is processed using an unsupervised pipeline which requires no *a priori* knowledge: (1) unsupervised segmentation, which is able to identify the total of work cycles, either normal or anomalous, during a complete working day; (2) feature extraction and selection, in which a multitude of statistical, temporal and spectral features are calculated to characterize each segmented work cycle and (3) unsupervised classification which allows to group similarities in data in order to the classifier to decide precisely the nature of each work cycle, being able to distinguish the cluster of normal and the anomalous cycles, in which incorrect movements or unexpected events occurred.

The information provided by the algorithm can be displayed on an interactive dashboard presenting analytics regarding manufacturing environments. This valuable information allows the detection of unplanned events that can be used to optimize the productive process.

Applications

The proposed solution is intended to be applied in industrial scenarios where repetitive tasks and events are dominant in a work day, and tests were already performed on real human movement data acquired on a real Industry context, showing promising results.

Furthermore, once the framework was designed to detect anomalies in periodic time series, its applications are not restricted to industry contextual data, being able to detect unusual events in distinct paradigms. To prove this, various artificial and non-artificial datasets were used, such as the well-known Numenta Anomaly Benchmark, a dataset composed of pseudo periodic signals and the MIT BIH arrhythmia database composed by ECG signals with normal and abnormal heartbeats. The presence of anomalies on those datasets is documented, allowing the comparison between the results and the ground truth. The good outcome of the performed tests in both datasets were favorable and corroborated the generic mechanism achieved by the proposed algorithm.

Given its characteristics, the presented framework could be used in other scenarios with predictably good results, for instance new rehabilitation methods for ambient assisted living scenarios and total productive maintenance in industry.

2 *Plotted features. Blue points are normal cycles and the rest are anomalous.*

3 *Examples of anomalies in time series data. Pipeline.*

4 *Anomaly Detection Dashboard.*