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Fig1. Illustration of indoor location and activity monitoring based on sound analysis.

LISTEN2MYSOUND

CONTEXTUAL INFORMATION BASED ON PERVASIVE SOUND ANALYSIS

Motivation

As the responsible for one of the five traditional senses, our auditory system is constantly picking up large amounts of information about our surroundings. This information may be event-dependent, such as walking or the closing of doors, or location-dependent, such as the humming of computers or air conditioning systems. This project's aim is to translate this innate ability of ours to any microphone equipped mobile device, thus adding an additional layer of information to existing projects such as Activity Monitoring or Indoor Location.

The developed algorithms rely exclusively on the recorded sound of a smartphone, thus eliminating any need of infrastructure and associated maintenance costs. The use of sound also has the advantage of collecting information not only from the user (as in the case of inertial sensors) but also from their surrounding environment.

As such, we took three distinct approaches:

SoundSignature

Each room has its own acoustics and background noise sources such as computer fans or air conditioning. We use these characteristics to determine in which room the user is.

The developed algorithm starts by filtering out all transient noises, leaving only a frequency spectrum of the background noise. From this spectrum, a relevant set of features is extracted and processed by machine learning

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Advantages

- Common sensor on smartphones
- Does not require any infrastructure
- Gathers information not only from the user but also from their environment

Use cases

- Location-based targeted advertisement
- Immersive museum experiences
- Indoor navigation systems
- Monitorization of the elderly

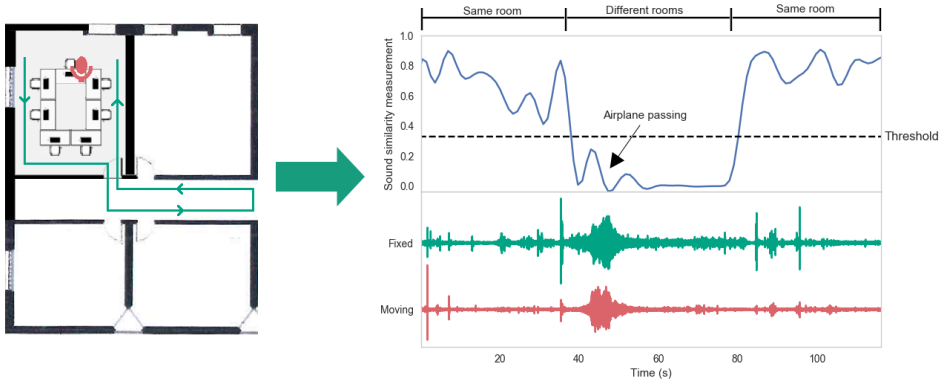

Fig2. **To the left is represented an experiment designed for SoundSimilarity. In green is the route taken by a subject holding a smartphone; in red is the position of a fixed sound recorder (e.g. laptop). To the right, below are the resulting sound waves; above is the similarity measurement between these waves. Through simple machine learning, a threshold is computed: if the measurement is above this the microphones are in the same room; if it is below the microphones are in different rooms.**

algorithms, generating a system capable of identifying in which room the user is.

As shown in Fig3., an accuracy of 83.32% was achieved between 6 different locations inside a building.

SoundSimilarity

By comparing the audio from two or more microphones in real-time, we can say whether said microphones are physically near each other. With that goal, we employ a novel sound similarity measurement that relies on the correlation between signals.

From 11 pairs of sound recordings, the developed algorithm could always identify whether the respective microphones were in the same room, albeit with an approximate 1 second lag. This distinction can be achieved even when far apart microphones are subject to the same sound (such as an airplane flying overhead, as represented in Fig2).

This technology may improve indoor location services by locating users relatively to other users.

Activity Monitoring

By using an algorithm like the one used in SoundSignature but keeping the transient noises, we can also train a classifier to separate these into activities.

From a dataset with sound recordings of 16 classes, a 95.15% accuracy was achieved.

Future Work

While the developed algorithms are already showing promising results, they are yet to be tested in real world scenarios. As such we intend to develop a smartphone application that implements the developed solutions.

Also, we are testing how different smartphone positions (in hand, pocket, etc.) might influence the results.

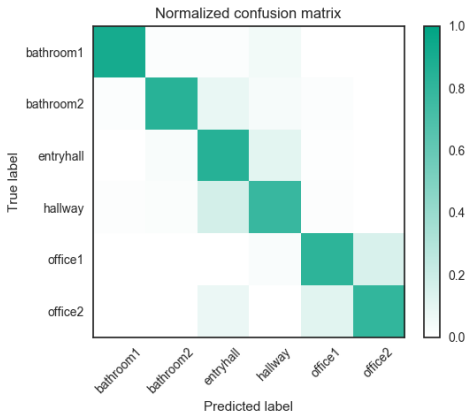

Fig3. **Normalized confusion matrix from SoundSignature.**