# Cognitive State monitoring through the usage of ambient sensor technology

DS applications and challenges in Medicine, Natural Sciences, and Engineering

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## Abstract

In our world, where sensor technology has become ubiquous, new possibilities as well as challenges have opened, including the medical sector. Early detection of health issues as well as monitoring of health state can lower the burden on the affected people, while at the same time lower the cost of medical interventions. Based on advancements in sensor technology, this has not only become a vast field of research over the last couple of years. It is already a reality in a variety of medical fields, including automatic blood-sugar monitoring, sleep-phase tracking, and mobile heart-monitors. But with the influx of sensor technology in our daily lives, privacy issues need to be addressed to maintain acceptance by the users. Careful selection of the sensors and ensuring the relevance of the measured data is crucial for the future.
The cognitive state is a relevant measure for a variety of diseases as well as the general aging process. In our project, we were looking for a new way to monitor this state unobtrusively yet continuously. Based on findings in literature, there is a correlation between dementia and chaotic behaviour.

A total of N=48 people (35 women, age 81.08 (SD 9.73)) were monitored continuously over a span of four weeks. Simple passive infrared sensors were used to track presence and absence of people at specific locations and thus generate basic movement-patterns of the people in their flats. While these sensors inflict only minimal privacy incursions, they lack the preciseness of video-cameras or body-worn sensors in the detection of movement or activities.
The location information is put into matrix form and eigenvector analysis is performed on this data. Through computation of the reconstruction error, the regularity of the movement patterns is analysed. Additionally, we measured the cognitive state of the people by means of a standardized clinical test. Besides the reconstruction error, age was taken as an additional feature for regression and classification tasks to predict and classify the cognitive state.

The Spearman correlation of the computed reconstruction error alone and the cognitive score is $\rho = -0.65$ with a p-value $< 0.001$. The RMSD of the cognitive-score prediction, based on linear regression, is RMSD = 3.43. For the classification, the area under the curve (AUC) of the ROC is AUC = 0.94.

For prediction of the cognitive state, using only the reconstruction error and age proved to be too difficult of a task. Nevertheless, the reconstruction error should be considered as a new feature in an ensemble of digital biomarkers. For a simple binary classification, on the other hand, the information at hand was plenty and high performance was achieved.