Person Identification using Door Accelerations

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Motivation
Person identification is important for a range of applications; however, existing methods require the identified person to perform an action (e.g., fingerprint scan) or carry an identification token (e.g., RFID), which is not acceptable in some applications. The goal of our research was therefore to develop a completely unobtrusive identification method based on the door acceleration. This was possible by sacrificing identification accuracy.

Machine learning
First, 1000 entrances by 12 people were recorded as the training data. Second, 266 features were extracted from preprocessed entrance data. Third, feature selection was performed to reduce the number of features to 36. Finally, the classification models were trained using four machine-learning algorithms.

To classify an entry, the selected features are extracted from the raw acceleration signal in order to obtain a feature vector, which is finally classified using the most accurate classification model, which predict the identity of the person who entered.

Dynamic Time Warping
The second method applies dynamic time warping (DTW) to compute the similarity between the raw signal to be identified and each labeled entrance. DTW algorithm finds the optimal match between two time series by non-linear stretching of both time series in the time dimension. The identities of the most similar entrances are used to identify the person using voting. Majority and distance weighted voting were compared and the influence of the number of the most similar labeled entrances used for voting on the identification accuracy was analyzed.

Data preprocessing
First, the acceleration signal is used to compute the angular velocity and door swing angle. The signal is then split into four door opening phases shown below. Those are further split at local extremes and zero crossings to obtain a total of 14 phases.

Calculate features
The following features (illustrated below) are computed for each of the 3 parameters and each of the 14 phase of door opening: extreme value, duration of the door opening phase, slope of the linear interpolation, standard deviation and area under the curve.

Results
The following algorithms were used to train the identification classifier: k-nearest neighbors (k-NN), support vector machine (SVM), random forest and classification tree (j48). The highest accuracy (after the feature selection) was achieved using the k-NN algorithm.

Conclusion
Two approaches for person identification using door accelerations were compared: the classical machine learning with domain-specific features achieves 83.7% identification accuracy, while dynamic time warping achieving somewhat better accuracy of 86.3% (tested with 1007 entrances by 12 people). Identification accuracy varies across different people; some pairs of people are often mutually misidentified.

The identification accuracy is not high enough for secure access-control applications. Nevertheless, the results are promising for applications that do not require a perfect identification accuracy. The key advantage is that this approach is completely unobtrusive to the user and therefore suitable for identification in offices and homes with limited number of people, which enables personalized smart-home automation.

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