Setup Personalized Environmental Preferences of a Smart Home by the Recognition of its User's Gait

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Introduction

In recent years, human life expectancy has steadily increased [1]. Such a social trend appears to be beneficial, at first, but an increasing number of cognitive ability impairments that may lead to pathological aging situations was actually observed [2]. Most of the time, people who are affected by such deficits suffer from a loss of autonomy. Moreover, with the progression of the disease (*i.e.*, with the decline of skills), they tend to become more and more dependent on either, or both, their family and the medical staff. Although most of these people are relocated to specialized medical institutions, they usually prefer to stay at home [3] and their families desire to keep them at home as long as possible [2]. In that sense, assistive technologies such as smart homes, which contains several sensors and actuators, represent an encouraging solution [4] to allow people with a loss of autonomy to stay at home while they receive the assistance they require. Currently research has focused on personalizing the assistance provided through such a technology according to the deficit of its resident [5]. However, since each resident is unique, he/she has habits and preferences in his/her home, such as a particular temperature for a given room or a lower light level depending on the time. Hence, exploring a way of adapting the smart-home both to the disease of its resident (based on previous research in this field) and to his/her preferences of living appears to be interesting as well. To this end, we propose, in this work, a device capable of exploiting the gait, which is considered to be biometric as a mean to recognize the walker and automatically setup the smart environment to his/her respective preferences.

Gait Recognition

This work introduces the design a of a smart-card that will be capable of gait recognition. The schematic representation of such a piece of hardware is shown in Figure 1.

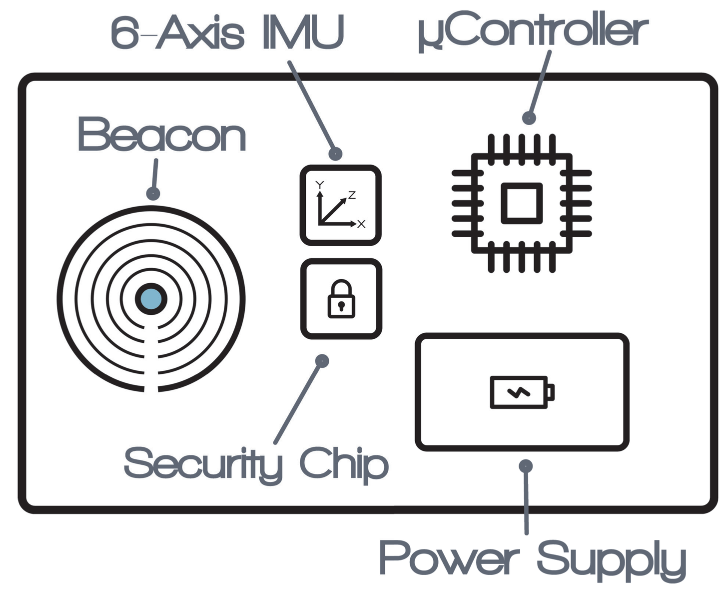

Figure 1: Schematic representation of the smart-card used to perform the gait recognition.

This smart-card should be composed of :

- A beacon, for the control of the access of the smart-home (restrict and monitor entries-exits).
- An Inertial Measurement Unit, for the analysis of the gait of the carrier.
- A micro-controller to command the whole system.
- A security chip to keep personal data safe and securely encrypted.
- A power supply.

The recording of raw inertial data produced by the IMU implies first to extract several discriminative features. Hence, we opted for 70 well-known features (*i.e.* Standard Deviation, Skewness, Kurtosis, DC Component, Energy, Entropy, *etc.*), all computed from a fixed non-overlapping time window, from both time and frequency domains, where a FFT was used to achieve the conversion from one to another.

Once discriminating features extracted from raw inertial data are computed, the next task consists of a classification process. To achieve this, we choose the K-NN classifier because it is a fast, simple, flexible, powerful and efficient algorithm [6] which is light enough to operate on a micro-controller. This algorithm needs to be tuned according to two main parameters: the number of neighbors ($\mathbf{k}$) and the distance measure that is required to compare unlabeled new data.

Results

In order to validate the proper functioning of our proposed smart-card, we have first built a quick prototype using the *Arduino 101* board.

Then, the K-NN classifier was tuned with $\mathbf{k=1}$ and the Manhattan distance was selected as the comparative distance measure. Secondly, a data collection has been proceeded which involved 9 participants, where each one walked over a distance of 3 meters. This procedure was repeated four times since the card was placed in different positions such as inside a backpack, inside both right and left front pockets of a jacket and inside a handbag that was placed both on the right and left shoulder of the carrier. Finally, a 10-folds cross validation method was employed to quantify the trained model. The results we have obtained for each participant are shown in Figure 2.

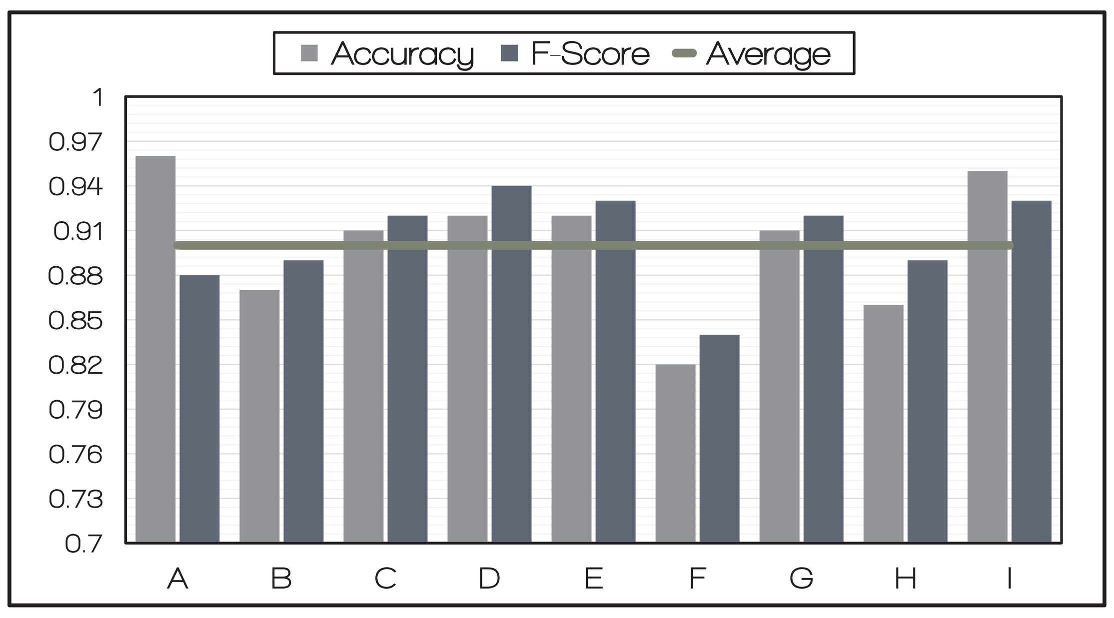

Figure 2: Accuracy and F-Score measures of gait recogniton obtained for each anonymized participant.

Conclusions

The mean recognition rate of 90% we obtained demonstrates that our system is reliable enough to recognize, with sufficient confidence, a person through its gait. Consequently, this observation leads us to acknowledge that this method is an encouraging way to customize the environment of a smart-home according to preferences of its resident.

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