Classifying persons with dementia from control subjects when ascending and descending stairs based on a single pelvis-mounted sensor

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ABSTRACT
As part of a larger program of work to understand how people with dementia navigate their environment and use visual cues we present data which uses a single sensor – an IMU placed on the pelvis – to classify people into two groups on the basis of hesitancy when ascending/descending stairs: individuals with dementia vs age-matched controls. The classification was conducted on data collected from 34 people (14 controls; 20 people with dementia, comprising 10 with typical Alzheimer's disease [tAD] and 10 with posterior cortical atrophy [PCA]) walking up a set of 4 steps. Attributes used to discriminate those with and without dementia were the mean and root mean square values of: resultant acceleration, roll, pitch and yaw. Each person's data was allocated to one of two datasets (N=17, N=17). A weighted nearest neighbor classifier was trained on each dataset in turn and subsequently used on the remaining dataset. Overall accuracy of the classifier was 0.67, with a precision of 0.62 and recall of 0.47.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous; I.2.m. Artificial intelligence: Miscellaneous; I.5.2. Pattern recognition: Design methodology; J.4. Computer applications: Social and behavioural sciences.

INTRODUCTION

The overall aim of the *Seeing what they see* project[1] is to better understand the functional impact of dementia-related visual impairment; and to then develop home-based interventions which address these issues and improve the quality of life of people with dementia and their carers. Dementia-related visual impairment, which is caused by degeneration of the brain rather than the eye, is an under-recognized difficulty of living with some dementias [1] . To examine the impact of visual impairment on behaviour within a simulated real-word environment a series of experiments were conducted at UCL's PAMELA facility. These consisted of a number of tasks (e.g. walking along a straight corridor/u-shaped corridor, walking up/down stairs). Some of these experiments have shown people with dementia have dysfunctions in their locomotion and navigation [2]. In this abstract we focus solely on hesitation behaviour while descending or climbing stairs and ask the question, is it possible to accurately classify whether or not a person has dementia simply by monitoring physical behaviour on a common everyday task? In subsequent analyses we will look to conduct a finer classification to approach a method for detecting hesitation behaviour as a measure of distress or anxiety while performing physical tasks.

METHOD

Participants (14 controls, 10 tAD and 10 PCA) were asked to walk up and then down a temporary set of stairs consisting of 4 steps (see Figure 1). Trials were conducted with and without a visual cue and in low and high lighting levels. Each trial was conducted twice, resulting in 16 trials per participant. For the analysis presented in this extended abstract we have used all trials for each person. Participants were asked to wear an eye-tracker as well as three MTw (XSENS) inertial measuring units, one on each foot and a third on the pelvis. This extended abstract focuses on the analysis of the pelvis marker only, which was collected at 100Hz. A custom Matlab script was written which converted the local accelerations and rotation angles into the global reference frame of the laboratory (x-axis positive superior, y-axis + left and z-axis + posterior). The mean and root mean square values of the resultant acceleration and the rotation angle (around each axis) were calculated from when the person began to climb/descend the stairs to when they reached the top/ bottom step. These 12 attributes were used in the classifier. The full dataset for each subject was allocated randomly to one of two datasets

[1] https://www.ucl.ac.uk/dementia-vision

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S1 (N=17) and S2 (N=17), which contained equal number of control, PCA and tAD. A weighted nearest neighbor classifier (KNN) was then trained on S1 and applied to S2; subsequently S2 was trained using a weighted KNN classifier and tested on S1.

Figure 1: Stairs showing cue (right) and no cue (left).

RESULTS

A typical time series plot of the acceleration data from the pelvis IMU is shown in Figure 2.

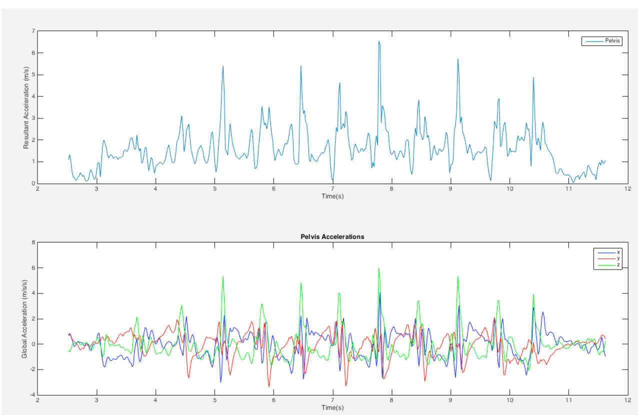

Figure 2: Time-series plot of data showing resultant acceleration [m/s/s] (top) and accelerations in x, y and z [m/s/s] (bottom).

The overall accuracy of the classifier was 0.67, with a precision of 0.62 and recall of 0.47. The classifier was more accurate at correctly classifying people with dementia than classifying controls (see Table 1 and Table 2).

Table 1: Confusion matrix based on S1(train) and S2(test) based on results from the respective test data

		Predicted	
		Control	Dementia
True	Control	65	47
	Dementia	41	118

Table 2: Confusion matrix based on S2(train) and S1(test) based on results from the respective test data

		Predicted	
		Control	Dementia
True	Control	39	72
	Dementia	24	136

Discussion

The results show that using a single marker it is possible to classify people into two groups: those with and without dementia with a reasonable degree of accuracy. However, the dementia patients varied in terms of disease severity as well as their clinical phenotype. In particular, there are two sub-groups within this group – those with posterior cortical atrophy (PCA) and those with a more typical amnestic form of Alzheimer's disease (tAD) [3]. PCA patients, who exhibit progressive deterioration of vision but relatively spared memory and insight, have the potential to offer insights into the visual problems associated with more atypical forms of dementia. In our case it will allow us in later analysis to understand the impact of visual impairment and visual cues on a person's performance, in particular on hesitation within a task as an indicator of their self-efficacy. The ability to automatically measure hesitation as a person conducts their daily activities could be used to provide more personalised support as well as a more detailed measure of deterioration.

Limitations & Future Work

There are a number of limitations in the current analysis: the numbers of each group are unbalanced, we have not separated analysis into ascending and descending, or investigated discrimination between phenotypic subgroups. These will be investigated in subsequent analysis. Further work will also deliver a more detailed analysis to include expert coding to define self-efficacy and level of distress while performing the task. Finally, in future the dataset will be made available to the community.

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