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Stereotype movement recognition in children with ASD

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Abstract

The Autism Spectrum Disorders (ASD) covers different events, being one of them body rocking, mouthing, and complex hand and finger movements [1]. The traditional methods for recording the number of occurrences and duration of stereotypes are inadequate and time consuming. Therefore, it was used a commercial system with accelerometers sensors that records the movement of wrist and sends the collected data through a wireless network to the computer. Statistical methods were used to characterize the signal acquired from a previously expressed stereotypy. The parameters that were analyzed are: RMS, Standard Variation, Peaks and Valleys. At the end, the proposed methodology facilitates to identify behavioral patterns special relevant when studying interaction skills in children with ASD.

Keywords: Stereotypical motor movements; accelerometer; ASD.

1. Introduction

ASD is a psychological disorder that manifests as a lack of communication and social interaction. Typically, autistic children have stereotypical behavior, in particular when there is a change in their daily routine or when the environment is full of new perceptions; as a consequence, they tend to block the excess of sensations manifesting repetitive movements.

This study involves the implementation of a portable device to monitor motor stereotypes, typically performed by individuals with ASD. The eZ430-Chronos from Texas Instruments, Fig. 1, is a wireless smart watch with a three-axis accelerometer integrated [2]. A statistical method was developed in order to detect and quantify stereotypical movements. The system was tested in a classroom environment under intervention sessions with children with ASD. The sessions were recorded on video for further validation of the system.

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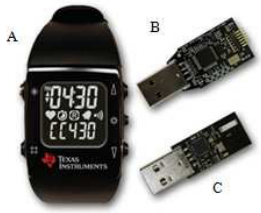


Fig. 1. Commercial eZ430-Chronos watch [2], A) e430-Chronos, B) eZ430 USB emulator, C) USB-RF Access Point

2. Related Work

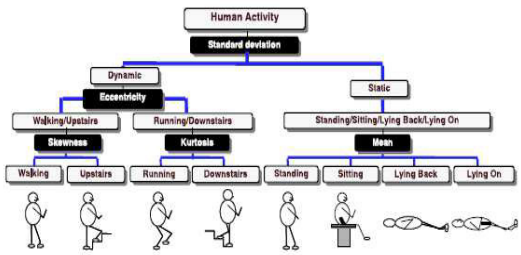
Recently, there has been an effort to develop systems to detect autistic behaviors and activity recognition using accelerometers. The following studies represent some of the developed work in order to characterize and quantify the stereotyped movements.

The work carried by Goodwin, M. S. [3] is based on the use of three-axis accelerometer to measure and register movements; the accelerometer has the capability to transmit data under a wireless transmission. These sensors are placed on the wrists and chest, in order to detect hand flapping and body rocking, Fig. 2 A).

By obtaining the characteristics of each acceleration component (acceleration of the axis x, axis y, axis z), the author analyzed: (1) distances between the means of the axes; (2) variance of different directions; (3) correlation coefficients; (4) entropy; and (5) FFT peaks and frequencies of the stereotypical motor movements [3]. At the end, all data were analyzed using Weka toolkit [4], winch performs cross validation.

In the study carried out by Baek [5] it was used a two-axis accelerometer, to acquire data from different movements performed by the user during an activity day. The data was analyzed to obtain, for each movement, the Mean, Standard Deviation, Skewness, Kurtosis and Eccentricity. These parameters were then subjected to Multilayer Perceptron classifier, Fig. 2 B), which performs the differentiation of the movements made by the user.

A)



B)

Fig. 2. A) (a) sensor placed on each wrist. (b) sensor placed on the chest. (c) Receiver for sensor data. (d) laboratory setting. (e) video coding software [3]; B) Classification into the eight activity states by the five pairs of features [5]

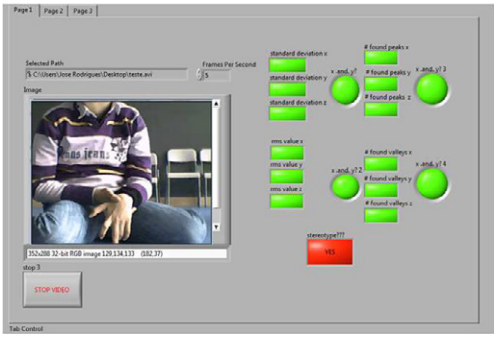
The results obtained referred works were promising but the analysis was done on data recordings from healthy adults. The work presented in this paper intends to collect data from autistic children, analyze data in real time and video record synchronization for further validation of the methodology.

3. Methodology

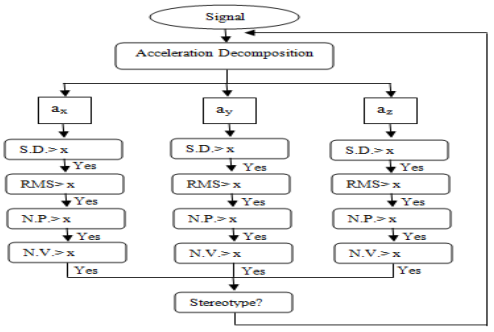
In order to recognize stereotypical motor movement with the eZ430-Chronos watch it is necessary to characterize the signal acquired from a previously expressed stereotyped movement. Dedicated software was developed using statistical methods based on Standard Variation, Root Mean Square (RMS) and Peaks and Valleys determination. Briefly, the features mentioned are compacted in the algorithm classification, Fig. 3 B). The threshold used in expected average (x), was empirically obtained.

4. System Developed

An interface application using LabVIEW from National Instruments [6] was developed in order to acquire data from eZ430-Chronos watch and process data to detect stereotypical motor movements. The program collects a sample data each second and automatically runs the statistical analysis module in order to identify the pattern behavior. If the sample is within the predefined threshold regarding each statistical parameter explained in Methodology, it is considered a stereotyped movement, Fig. 3 A).



A)



B)

Fig. 3. A) Stereotype identification with the eZ430-Chronos and the LabVIEW application; B) Flowchart of the algorithm classification implemented (a_x, a_y and a_z are the component of acceleration in axis O_x, O_y and O_z respectively, S.D. is the standard deviation, x is the expected average, N.P. is number of peaks and N.V. is number of valleys)

5. Results

The session was performed with children with autism and took place in two different schools of Leça de Palmeira (Portugal) in the Special Education Unit Department. The systems were tested on five ASD children with average age of M = 9 years and SD = 3.32 in intervention sessions of ten minutes. The session was recorded for further video analysis to compare with the obtained results.

Considering that the eZ430-Chronos watch is placed on the wrist, for this study, it was only considered the hand flapping of the arm as a stereotyped behavior.

Table 1, shows the obtained results regarding the quantification of the stereotyped motor movements, comparing the total real movements performed by the children (Results Video Analyzed) to the corresponding movements detected by the developed application (Total watch detected), number of stereotypes really detected by the watch (Total watch real detected), number of stereotypes detected by the watch but not detected by video (Total false positive watch detected) and number of movements detected by the video but not detected by watch (Total watch not detected).

Table 1. Results obtained by the eZ430-Chronos

	Results Video Analyzed	Total watch detected	Total watch real detected	Total false positives watch detected	Total watch not detected
Child 1	2	4	2	2	0
Child 2	1	1	1	0	0
Child 3	0	0	0	0	0
Child 4	1	1	1	0	0
Child 5	3	2	2	0	1
Percentage	--	--%	75%	25%	14%

In Table 1 it can be observed that the eZ430-Chronos watch detected 75% stereotypical movement, in 14% the eZ430-Chronos watch did not detect the stereotypical movement performed by the children. This result could be explained by the fact that one child tried to take out the eZ430-Chronos bracelet. It can also be observed that eZ430-Chronos watch detected false-positives (25%).

6. Conclusion and Future work

The results obtained were satisfactory. The developed algorithm for identification of the stereotypes was able to record all movements during the session as well as to detect most of the motor manifestations. The algorithm used to recognize the hand flapping movement with the eZ430-Chronos, requires improvements to overcome the false positives detected. In the future it is intended to improve the gesture recognition algorithms and add the body rocking gesture recognition in the system.

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