Development of an acquisition and visualization of forearm tremors and pronation/supination motor activities in a smartphone based environment for an early diagnosis of Parkinson’s disease

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Abstract. An application ProSupino was designed for android mobile phones and to collect in real-time forearm movement data from the tri-axial accelerometer while a subject develops with one of two series of pronation and supination movement tasks (PSMT_Flat or PSMT_Up). The results of a controlled study showed sensitivities and specificities larger than 85% in scaling of the primary motor symptoms, which suggests that ProSupino could be used to collect forearm motor related information on a daily.

Keywords: smartphone application, Parkinson’s disease, motor symptom, accelerometer, sensor

1 Introduction

An ageing of the world’s population challenges for our societies and economies. In 2015, the world's average life expectancy at birth has risen to 71.7 years which is projected to 75.5 years by 2050 according to the United Nations World Population Prospects. Currently, many elderly people live with one or more chronic diseases, have a mobility limitation, or suffer from a mental health problem. Especially, increasing age is the highest risk factor of neurodegenerative diseases, such as Alzheimer’s disease and Parkinson’s disease (PD) which are incurable since they are resulted from the progressive loss of structure or function of neurons.

Developing sensor and smartphone application technologies could make it possible to keep tracking individuals with PD under varied and indoor/outdoor circumstances and analyzing their daily data to make a quantitative assessment. Especially, smartphone sensors such as accelerometers and gyroscopes can provide information regarding the patient’s movement status such as displacement, velocity, angular velocity, acceleration, etc. Robert LeMoyne et al presented a wireless accelerometer
configuration with glove mounted setup for monitoring simulated PD hand tremor [1]. Siddharth Arora et al quantified gait and postural sway of PD by extracting features in time and frequency domains of data obtained from accelerometers built in a smartphone [2]. Kun-Chan Lan et al. proposed a PDR-based method to continuously monitor and record the patient’s gait characteristics using a smart-phone [3]. N. Kostikis, et al compared quantitative measurements, which are four metrics obtained by using smartphone-based platform, of hand tremor in twenty-three PD patients with UPDRS [4]. V. Parra et al proposed an Android application to quantify the tremor in Parkinson’s disease during the execution of routine movements through the use of a Smartphone’s accelerometer [5].

In this study, an android application, ProSupino is suggested to quantitatively assess primary motor symptoms such as resting tremor, bradykinesia, rigidity and posture disturbance using an accelerometer built in a smartphone. The application proSupino measures the intensity, duration and frequency of the user’s tremors as well as the velocity, acceleration, angular velocity, vertical/horizontal displacement, delay time of movement, etc. and send reports by email, social network or Google drive storage. Anyone who is able to grab and hold a smartphone for 5 min could use this application.

2 Materials and Methods

The application ProSupino was designed for android mobile phones and to collect in real-time forearm movement data from the tri-axial accelerometer while a subject develops with a series of pronation and supination movement tasks (PSMT) according to directions given through interfaces of the application. ProSupino was written in Java and run on most Android phones. Figure 1 presents flowcharts of each interface. At the initial launch of the application, ProSupino will prompt a subject to read and agree to an informed consent through the interface of an informed consent. The subject cannot use ProSupino unless he or she selects the Agree button, which is located after the terms of content. ProSipino then flicks to and selects the Start button near the bottom of the screen. After the Start button has been selected, a screen for the interface of initialization appears, in which subject’s name and age are entered in each text field, and gender (male or female), side of hand usage (right or left), medication status (normal or medicated), and type of task trial (exercise or test) are checked on a proper radio button for each. In addition to it, if the radio button ‘medicated’ is selected, measure of the medication effect is also checked on one of the radio buttons (highest, high, middle, low, or lowest) and time of the latest medication is entered by using pop up lists. Then a screen for PSMT instruction is displayed after registering the information by selecting the Register button located in the bottom of the initialization screen. There are two menu bars Flat and Up for selecting one of two series of pronation and supination tasks. If one of the two menu is selected, then a pop up movie screen displayed for visual and sound instructions for an initial forearm posture and series of three tasks including of resting, BendingUp & proSupino, and LR proSupino accordingly. If the instruction is ended, then a subject is instructed to start the PSMT and then a screen is displayed in which the subject’s forearm
movement data from the tri-axial accelerometer are captured at 10Hz and displayed on the screen during the PSMT. The PSMT consists of two series of tasks, PSMT_Flat and PSMT_Up. In PSMT_Flat, a subject is supposed to sit down at a table, put its forearm in the supinated position on the table, and carries out a series of consecutive tasks, BendingUp & proSupino and LR proSupino, after 30sec rest period. In PSMT_Up, a subject is supposed to sit down at a table, bend up its forearm in the neutralized position with the elbow at the level of its shoulder, and then carries out a series of consecutive tasks, BendingUp & proSupino and LR proSupino, after 30sec rest period. If the PSMT is completed ProSupino pops up the scored result of the PSMT on the screen while the raw data are stored in a memory device of the subject’s smartphone and sent to a predetermined site through a Google drive, an email, or a social network service as it is configured at the application preferences.

3 Results and Discussions

A controlled study was conducted with thirty three subjects. Six of them (four male and two female, mean 65 years) were diagnosed with PD, nine of them (seven male and two female, mean 64 years) were healthy with age-matched and no PD symptoms and eighteen of them (nine male and nine female, mean 24 years) were healthy young subjects. All the subjects were right-handed. The subjects with PD were classified according to the UPDRS. Time and frequency-domain features were extracted from raw accelerometer data and used to scale the activities of the forearm movement during the tasks. The resulted scale was compared to the UPDRS scores. The results show 85.63% and 89.07% of mean sensitivities and specificities, respectively.
scaling of the primary motor symptoms. It suggests ProSupino could be used to collect forearm motor related information on a daily basis allowing for the use in early diagnosis of patients with PD and also in constantly informing to the physician about the patient’s clinical state so as to readjust appropriately the treatment plan personalized and minimizing the side effects.

4 Conclusions

An application ProSupino was designed for android mobile phones and to collect in real-time forearm movement data from the tri-axial accelerometer while a subject develops with one of two series of pronation and supination movement tasks (PSMT_Flat or PSMT_Up). ProSupino was written in Java and run on most Android phones. The results of a controlled study (thirty three subjects, Six with PD, nine healthy age matched, and eighteen healthy young) showed of sensitivities and specificities larger than 85% in scaling of the primary motor symptoms, which suggests that ProSupino could be used to collect forearm motor related information on a daily basis allowing for the use in early diagnosis of patients with PD and for the treatment plan adjustment in a personalized way.

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References