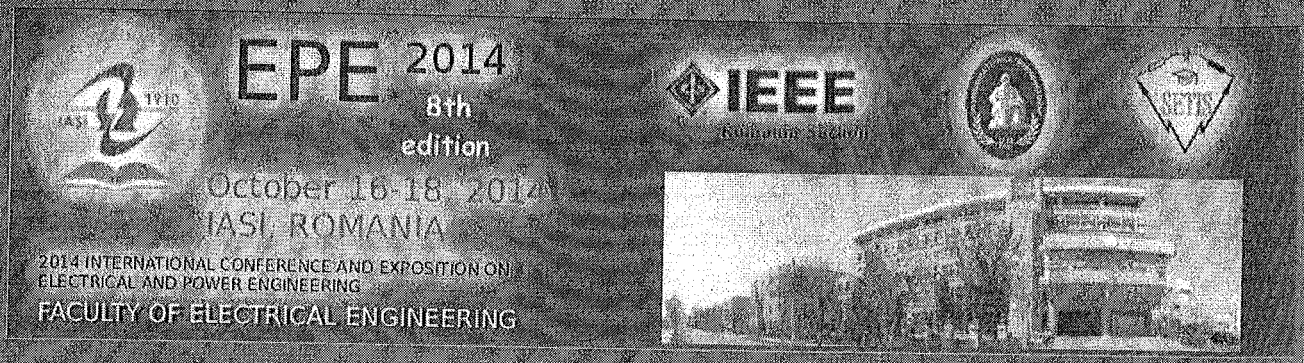

EPE 2014

PROCEEDINGS

of the

2014 INTERNATIONAL CONFERENCE AND EXPOSITION ON ELECTRICAL AND POWER ENGINEERING

Organized by

Faculty of Electrical Engineering, "Gheorghe Asachi" Technical University of Iaşi

IEEE Romania Section

SETIS – Graduates Association of the Faculty of Electrical Engineering in Iaşi

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Editors: Mihai Gavrilas, Faculty of Electrical Engineering, Iasi
Cristian-Gyozo Haba, Faculty of the Electrical Engineering, Iasi
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IEEE Catalog Number: CFP1447S-USB
ISBN: 978-1-4799-5848-1

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Papers

Key-note lectures

Applied Informatics and Automation

IEEE Catalog Number
CFP1447B-USB

ISBN
978-1-4799-5348-1

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Faculty of Electrical Engineering
Bd. D. Mangeron Nr. 23
700050 Iasi, Romania
Email : epe@ee.tuiasi.ro

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NeuroParkinScreen –A Health Care System for Neurological Disorders Screening and Rehabilitation

Iuliana Chiuchisan[1], Oana Geman[1,2], Iulian Chiuchisan[1], Andrei Coriolan Iuresi[1], Adrian Graur[1]
[1]Faculty of Electrical Engineering and Computer Science, "Stefan cel Mare" University of Suceava, Romania
[2]Human Development and Health Department, "Stefan cel Mare" University of Suceava, Romania
13 Universitatii Street, 720229 Suceava, ROMANIA
iulia@eed.usv.ro, geman@eed.usv.ro, iulian@eed.usv.ro, aiuresi@gmail.com, Adrian.Graur@usv.ro

Abstract — **Parkinson's disease is the most common degenerative movement disorder and a progressive nervous system disorder that affects body movement, memory, speaking and daily mental and physical activities. In Romania are over 75.000 Parkinson patients and the government spends over 1.5 million USD with them. Nowadays, there is no screening test for early detection of Parkinson's disease. In this paper is presented a noninvasive low cost health care system for Neurological Disorders Screening and Rehabilitation that can be used by doctors and patients, and also for research purposes. The system can assist the doctors/medical experts in monitoring, screening and rehabilitation of patients with Parkinson's disease or other Neurological Disorders, leading to an early and efficient diagnosis. From a technical point of view, the system uses the latest and most appropriate methods for medical signals acquisition and processing.**

Keywords — neurological disorders; health care system; tremor measurement; accelerometer sensor; Wiimote.

I. INTRODUCTION

Neuropsychological dysfunction affects more than 160 million Europeans that represent 38 percent of the population of Europe in each year, according to the report presented by European Brain Council [1] and European College of Neuropsycopharmacology [2] in 2013.

At the same time, 27 percent of the adult population (including people with age between 18 and 65 years) suffer from a mental disorder such as psychosis, anxiety, eating behavior disorder. Taking into account the experience with disability and premature death, social and professional reintegration, and costs of health systems, neurological disorders are the most important health problem in Europe. The diseases that cause the biggest disabilities are depression, Parkinson's disease, Alzheimer's disease, alcohol dependence and vascular accidents. It was estimated that approximately 83 million people suffer from neurological disorders and this number underestimates the actual number of patients, considering the fact that have been taken into account only people under the age of 65 years.

Parkinson's disease (PD) is a chronic, progressive disorder, neurodegenerative and appears in about 100-250 cases per 100.000 persons. In Europe were reported approximately 1.2 million of Parkinson's patients [3]. In 2003, the Parkinson's disease affected around 1 million persons only in USA, representing approximately 1 percent of the population aged over 65 years. In 2006, there were approximately 1 million of reported cases. Worldwide, it is estimated that four to six million people suffer from the Parkinson's disease [3].

Early diagnosis of Neurological Disorders, such as Alzheimer, epilepsy, Parkinson's disease, and other dementias, that influence the lives of patients, their families and society, helps them to have a better and healthier life.

Parkinson's disease (PD) is a progressive movement disorder and nearly one million people in the United States are living with this disease [4]. The cause is unknown and presently is no cure to this disease but there are treatment options and medication to manage its symptoms [4].

In this paper we propose a health care system for monitoring, screening and rehabilitation of patients with Parkinson's disease or other Neurological Disorders, because there is still no reliable screening test for PD early identification, and this is a major problem and challenge for our research.

II. HEALTH CARE SYSTEMS

Recent advances in Information and Communication Technologies (ICT) and networking have opened new possibilities that could revolutionize the health care services (telemedicine). Wireless connectivity provides the infrastructure and support for mobile real-time monitoring at distance of the patient as well as the system for tracking localization into de case of emergency.

The increasing demand for e-Health services has led to many research efforts, leading to the development of different e-Health systems [5]. This systems are used in special areas such as cardiology [6], trauma [7], neurosurgery [8], pathology treatment [9], emergency [10], patient monitoring [11], aeronautic cure [12], marine purpose [13] etc. With the advantages of wireless technologies, there are also many wireless-based e-Health systems emerging [14].

Over the past 5-10 years a number of connected wearable devices have been developed to improve health care services. Health care providers have increasingly become connected through the use of mobile computers, tablets, smart phones, and other portable devices. The researchers in different fields such as Information and Communication Technologies and Internet of Things are now working on developing further connectivity to improve not only communications between

health care givers and patients, but real time monitoring of patient health as well [15].

According to [16] it's expected that "development of smart entities will encourage development of the novel technologies needed to address the emerging challenges of public health, aging population, environmental protection and climate change, conservation of energy and scarce materials, enhancements to safety and security and the continuation and growth of economic prosperity".

Wireless technology provides a highly connection that allow the development of new services in the following areas:

- Medical: monitoring and management of equipment from different environments such as hospitals, doctor's offices, or other care-giving institutions;
- Quality of health services: remote monitoring of chronic conditions of patients;
- Sports-fitness: monitoring of sports wearable devices that provide real-time data in order to analyze and enhance training.

Health care systems are being developed also to provide support for medical decisions in setting a diagnosis and a treatment. A general health care system may include health information networks, Electronic Health Records (EHR), telemedicine services, personal wearable and portable communicable systems, health portals, and many other ICT-based tools designed to assist the doctors in disease prevention, diagnosis, treatment, health monitoring and lifestyle management.

III. Health Care System for Neurological Disorders Screening and Rehabilitation

Over the past several decades, Information Technology (IT) has produced major breakthroughs in health care and has had a great impact on transforming it from in-hospital to more advanced at-home health care [16] and the factors that contribute to this transformation include: the nature of new diseases and their treatments; demographic changes in the population; demand for health care cost containment; increased availability of complex health care medical equipment and services at home; increase in rehabilitation services and increased focus on self-care and quality of medical service.

This paper presents a health care system for Neurological Disorders Screening and Rehabilitation, named NeuroParkinScreen System (NPS). The system manages data in order to support physicians in diagnosis, treatment and monitoring of patients with Parkinson's disease and also to facilitate the interaction between doctors and patients. The NPS system uses the remote controller, popularly known as a Wiimote™, component of the Wii™ console that is a popular gaming console. The Wiimote™ has an infrared (IR) image sensor that can track up to five objects simultaneously, Bluetooth connectivity, and three-axis accelerometer [17]. Different applications that use the image sensor capabilities and the accelerometers have already been developed, but few have been applied to tremor acquisition [18], [19].

The health care system presented in this paper involves the following user parts:

- **The patients**, from home, will have access to system portal (user interface) using a personal computer or laptop, with video camera connected. Using Wiimote™ which contain an accelerometer sensor, the patient will connect through our system's user interface. The patient has to follow some given steps for tremor acquisition. After that data will be automatically saved and transferred to the network server using File Transfer Protocol (FTP). The expert system for PD screening will analyze process and compare the Parkinson's tremor data. On the server will be stored also some future applications for tremors, gait, handwriting etc.
- **The doctors**, from hospital, office or other locations, will have access to patient's medical information and they will analyze and manage the patient's medical history, evolution, reaction to medication, etc.
- **The researchers** will have access to health care system database that will contain only patient's name initials, in complying with his privacy.

In Fig. 1, is illustrated the general architecture of the NeuroParkinScreen System.

A. NeuroParkinScreen User Interface

The NeuroParkinScreen system supports the health care services by facilitating communication in real time between doctor and patient through a friendly user interface that is accessible at any time and from any device such as PC, tablet or laptop. The user interface provides access in real-time to data acquisition using Wiimote™ accelerometer sensors and has live sessions capabilities. Users are not required to have sophisticated computer skills in order to use services provided by the health care system. In Fig. 2, is illustrated a capture of User Interface of the NeuroParkinScreen System.

The access is made through 4 types of users: administrator, doctor, patient, medical staff, and researcher. The administrator user has full rights access (insert, edit and delete information in database) with restricted access only to the confidentiality between doctor and patient. The medical staff user (nurses, assistants, experts etc.) has restricted access and can only add and edit some information in database.

Using the NeuroParkinScreen User Interface the doctor can analyze and process data received from patient, and also can prescribe a medical treatment. The patient has access to his personal data and medical history and can communicate with his personal doctor using text messages or through Skype.

The User Interface was designed using HyperText Markup Language (HTML), Hypertext Preprocessor (PHP) and C# languages. For database management we used the open-source relational database management system, MySQL. Some characteristics of user interface solution are: rendering content on any devices such as PC, tablet or laptop, rapid access and easy management of Web content. System administrator may easily modify, add or remove content using this user interface.

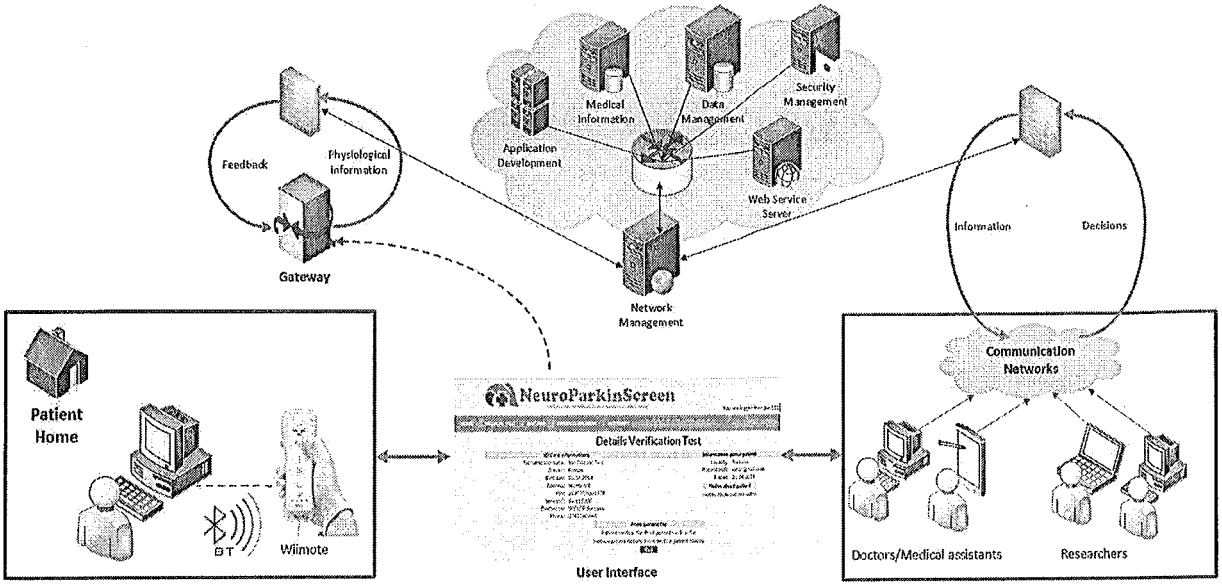

Figure 1 The general architecture of the NeuroParkinScreen system

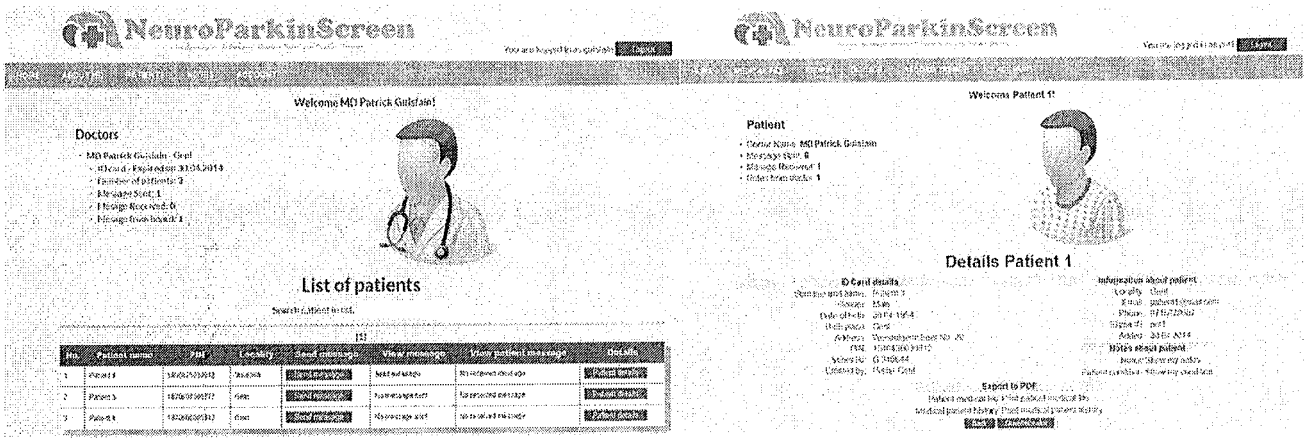

Figure 2 User Interface of the NeuroParkinScreen system

B. System for tremor measurement

Parkinson's disease is a neurodegenerative disorder that implies the malfunction and death of nerve cells in the brain. Some of these dying neurons produce dopamine, a chemical that controls movement and coordination. The classical motor symptoms include resting tremor, bradykinesia and rigidity [20]. This motor symptom varies between Parkinson's patients.

Resting tremor is one of the cardinal features of Parkinson's disease (PD) and for many patients and doctors is a disease defining symptom. The tremor is defined by rhythmic, involuntary and alternating movements of body parts [21]. These movements can vary according to the body part that is involved and the frequency and the circumstances under which the tremor occurs. Tremor can be seen at different body parts, especially at hands and feet, and may occur at rest, during postural holding or voluntary movements. The frequency can vary from low (4–5 Hz) to high (8–10 Hz) [22]. Orthostatic tremor is a form of postural tremor, and may occur in Parkinson's disease, with or without co-existent resting tremor, at different frequencies (4 and 6 Hz, 8 and 9 Hz or 13 and 18 Hz) [23]. Instruments such as an electromyography (EMG), accelerometer or gyroscope have been used to detect and quantify tremor [24].

A system for tremor measurement and analysis was developed using the three axis accelerometer built into remote controller, Wiimote™. This remote contains a three-axis accelerometer that has a range of ± 3 G, which is sufficient for tremor recording [17]. The accelerometer built into the Wii™ Remote has three axes: x (lateral), y (anteroposterior), and z (vertical). The device records both the actual acceleration induced by movement and the component of the gravitational force. The system collects acceleration data from Wiimote™ accelerometer sensor via a Bluetooth linked to a personal computer. In order to make an adequate tremor acquisition, it's necessary for patient to try to keep the hand with Wiimote™ in a horizontal position facing to PC or laptop for about 5 or 10 seconds.

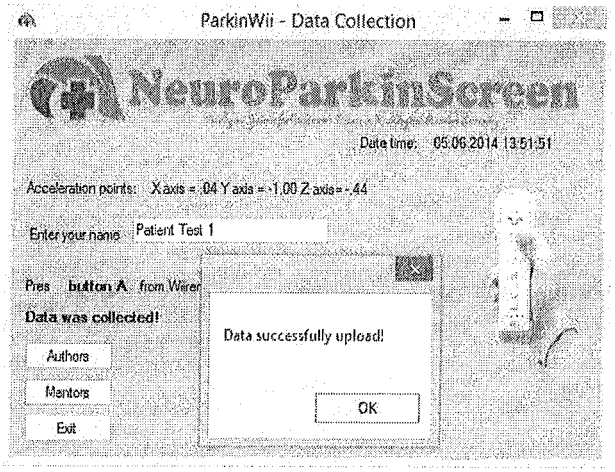

Figure 3 Data acquisition using Wiimote™

After the patient releases the Wiimote™ A button, the tremor acquisition session is finished and the patient will receive a message about data collection. Data are automatically saved into a *.txt* file. The file is uploaded continuously, through FTP protocol, in a database stored to network server (Fig. 3).

From this point the tremor data are ready to be segmented, filtered, and processed in order to derive features associated with movement characteristics of interest (e.g. in Parkinson's disease case we will analyze and process the periodic component from 4 to 6 Hz, associated with tremor). Tremor signal can be characterized using some advanced tools such as multivariate empirical mode decomposition (EMD) followed by Hilbert time-frequency representation of the signals. Another pioneering technique is singular spectrum analysis (SSA) which decomposes a single channel data into its corresponding uncorrelated components including sinusoidal components. Periodic and semi-periodic components can be effectively detected or restored using simple techniques such as autocorrelation or using the above (EMD or SSA) more advanced approach [25]-[28].

Using MATLAB we analyzed Y axis data recordings from a PD subject and a normal subject and we applied the Fast Fourier Transform (FFT) filter. In figures 4 and 5 is presented a single case of the processed signal acquired from a patient with PD and a normal patient. In papers [29] ÷ [32] were presented more extensive comparisons in this domain. Some of the physiological information and time series parameters measured from gait and tremor have been combined in developing an automatic diagnosis system for monitoring Parkinson's patients in [29] ÷ [35].

In future research, an expert tremor analysis system will be designed in order to compare data from Parkinson's patients with data from normal (control) subjects in order to generate an early prediction of the disease. This correlation will represent a novel diagnosis procedure, much less invasive and cheaper than imaging diagnosis of the PD.

Our system will be distributed on the Internet, data acquisition being made including on patient's home (eventually assisted by paramedic personnel) and sent to his physician. This will lead to an efficient diagnostic and the patients will not be subject to an additionally stress. From a technical point of view, the system will use the latest and most appropriate methods for medical signals acquisition and processing. On this input information (raw data) several algorithms of artificial intelligence will apply in order to achieve a greater accuracy of the results, and shortening of medical investigation.

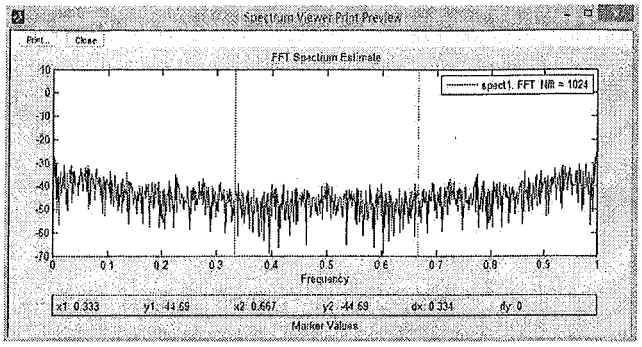

Figure 4 FFT filter applied to Y-axis values measured from a PD subject

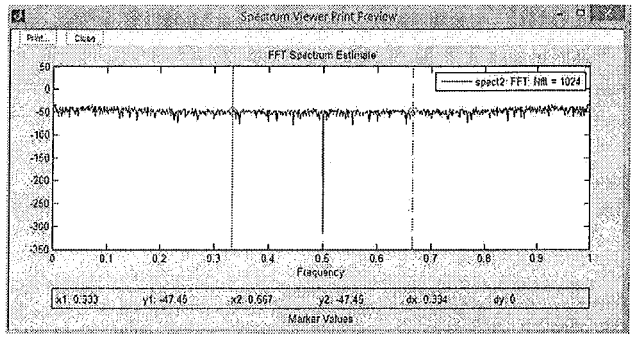

Figure 5 FFT filter applied to Y-axis values measured from a Normal subject

The importance of the developed Intelligent System may be seen from the following perspectives: (1) establishing a new paradigm for detection, recognition, and monitoring of Parkinson's, including fusion of multimodal information algorithmically, incorporating physiological constraints (often in the form of knowledge-based data) into the constrained optimization problem, (2) integrating the proposed system into some of the current medical devices used by physicians in clinics, (3) validation of the results by comparing them with those suggested by clinical experts, (4) selling the prototype of this system, and (5) establishing international collaboration between clinicians and pioneers in neuroimaging, psychologists, and engineers.

The main objective of this paper is to design and develop an integrated intelligent system for Parkinson's screening in its early stages of development followed by an automatic decision making strategy leading to prescription of treatment methodology and rehabilitation.

However, the system will be implemented, tuned and optimized to automatically adapt it to a larger community of patients. It should also distinguish between various tremor and also different states of brain connectivity which might be irrelevant to Parkinson's. Finally the system will be tested on a group of 40-50 new patients to verify the suitability, robustness, sensitivity, accuracy, and efficiency of the system.

IV. CONCLUSIONS

The NeuroParkinScreen System presented in this paper has the potential to improve the health care service and provide an efficient and cost effective system. Keeping the patients under observation for a certain period of time in order to evaluate the severity of symptoms helps the differential diagnosis between Parkinson's disease and other similar neurological diseases.

The system is a health care system, part of a more complex system for Neurological Disorders screening and rehabilitation. The described system presents the following features: gather data from sensors; support user interface; has network connectivity for access to infrastructural services; has requirements such as low power, robustness, durability, accuracy and reliability.

ACKNOWLEDGMENT

This paper was supported by the project "*Sustainable performance in doctoral and post-doctoral research*" PERFORM - Contract no. POSDRU/159/1.5/S/ 138963, project co-funded from European Social Fund through Sectorial Operational Program Human Resources 2007-2013.

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