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Neurodegenerative Disease Monitoring Using a Portable Wireless Sensor Device

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1. Introduction

Neurodegenerative diseases are characterized by progressive loss of neurons in the central nervous system. The disorders are clinically well-defined as a disease-related dementia, Alzheimer's disease the most typical case, or as a movement disorder, Parkinson's disease (PD). The risk of developing these diseases increases significantly with age: Parkinson's disease affects 1% of the population over 65 years of age, rising to 2% for those over 80 years.

Parkinson's disease is a common neurodegenerative disorder that often impairs motor skills and speech of the patient. PD is characterized by muscle rigidity, tremor, slowing of physical movement (bradykinesia) and in extreme cases, loss of physical movement (akinesia). In particular, PD is due to a loss of dopaminergic neurons (related to the neurotransmitter dopamine), and subcortical neurons in the brain. Replacement therapy with dopaminergic drugs (levodopa, pramipexole) effectively reverses all the symptoms and signs of the disease. After a changeable period of time, however, this excellent initial response to dopaminergic treatment is complicated by the appearance of disorders known as motor response complications (MRC). These complications are divided into two main categories: (i) fluctuations in motor response and (ii) the emergence of abnormal involuntary movements known as levodopa-induced dyskinesias (LID) (Konitsiotis, 2005).

Generally, motor fluctuations appear first as a shortening of the initially soft and lasting dopaminergic response. For patients with advanced PD, a few hours after the administration of medication the patient begins to notice the reappearance of signs and symptoms of the disease. This is known as "end of dose deterioration" or "wearing off". This may happen several times a day, so the patient can actually spend several hours per day in an "off" state. During the short visit with the neurologist, the patient may appear to be well and thus the neurologist misses the symptoms related to wearing off. As a result, changes in the recent drug treatment availability do not take place in time. It is now well known that early treatment of wearing-off fluctuations delay the onset of more severe complications in the future, as well as the appearance of LID. Therefore any strategy that can detect early changes associated with wearing off would provide a valuable clinical tool that would allow early treatment interventions.

The quantitative assessment of the human body and motor movement disorders has been a topic of great interest for decades. Advanced equipment has been used to study various pathologies of the motor performance of the human body. However, sophisticated equipment alone is not a guarantee for success in the detection and analysis of motor disorders. In many situations, deficiencies in motor performance are not always frequent and motor disorders can occur only in very specific situations that are difficult to imitate or reproduce in a laboratory. The underlying testing and monitoring processes have not experienced the innovation and advancement required to fulfil the needs that such detection and analysis present.

Amyotrophic lateral sclerosis (ALS), often referred to as "Lou Gehrig's Disease," is a progressive neurodegenerative disease that affects nerve cells in the brain and the spinal cord. Motor neurons reach the spinal cord from the brain, and from the spinal cord to the muscles throughout the body. The progressive degeneration of the motor neurons in ALS causes these motor neurons to die and when this happens the ability of the brain to initiate and control muscle movement is lost. With voluntary muscle action progressively affected, patients in the later stages of the disease may become totally paralyzed.

The cases for Parkinson disease and ALS are expected to double worldwide by the year 2020 (Von Campenhausen et al., 2005). Proper medical care of these patients is becoming increasingly complex and expensive. Lengthy hospital stays for monitoring and adjustment of the patients' treatment and the problems related with it, contribute to cost increase and morbidity due to the hospitalization itself. But there is a clinical deficit of objective data on which neurologists can base the assessment and care of patients with chronic neurologically-based movement disorders.

2. Patient monitoring

The patient monitoring is a technique that has become popular in recent years in the field of research, and soon the number of actual implementations in clinics and hospitals will begin to increase. Monitoring of patients is not new, in fact, today there are many hospitals that supply devices (thermometers, gauges, pulse and blood pressure, pulse oximetry, electrocardiogram, electro-devices, etc). The disadvantage of these devices is their large size and weight, and the little mobility they offer. The key innovation lies in one word: continuous monitoring. It consists of a series of devices and techniques designed to monitor, continuously and for a period of time established by the specialists, the physiological parameters of the patient. The specific values and the time evolution of these parameters allow a more precise analysis of the evolution of the disease, and therefore more effective treatment.

There are two main factors that have contributed to the rise of this technology. On one hand, the development of new physiological sensors that allow the measurement of more and more parameters related to the human body. Advances in biological, chemical, electrical and mechanical sensor technologies have led to their wider use as wearable sensors or implants. Improvements in the manufacture of sensors and techniques for nano-engineering, along with parallel advances in technology of microelectromechanical systems (MEMS) offer the potential for implantable or attachable sensors getting smaller.

On the other hand, the popularization of wireless sensor networks (WSN) and the recent advances in their use as body sensor networks (BSN), has been another key development for recent continuous monitoring of patients (Yick et al., 2008). The human body is a complex

interior environment that responds and interacts with its external environment, but is somehow "independent." The monitoring of the human body using a wireless sensor network can be achieved by attaching the sensors to the body (or even implanted in the tissues).

The wireless sensor networks are formed by a group of sensor nodes with certain capacity for sensing environment variables and transmitting them wirelessly. These nodes allow forming ad-hoc networks without an established physical infrastructure or a centralized management. These kinds of networks are known for being easy to deploy and for being auto configurable.

The majority of the researches carried out in the field of wireless sensor networks are focused on the network architecture, as well as on the communication protocols within the network. But few advances have been made in the development of novel sensor node architectures. The efforts are focused on the miniaturization of the nodes and the reduction of the energy consumption (Anastasi et al., 2009).

The objective of the work described in this chapter is to develop a single device which could be used in several application fields, due to its capability of being able to acquire signals coming from different types of sensors. Apart from that, the treatment of the data can be carried out in multiple ways, as the device is equipped with an SD card, a RF transceiver (IEEE 802.15.4 specification compliant) and a USB connector, for communication as well as for charging functions.

In order to test its versatility, an application field has been chosen and several tests have been carried out related to that field. More concretely, the application field that has been selected the validity of the objectives proposed in this work has been e-Health, and thus, a continuous monitoring system has been developed.

3. System architecture

The study of the state of the art shows that the devices and methods developed so far for the testing activities in patients affected by PD and ALS lack the most important characteristics of the device described in this article:

- **Accuracy**: the data provided by the device show exact values for the parameters the doctors are interested in. They are not based on subjective appreciation of the performance of the tests carried out by the patients.
- **Ease of use**: both for the clinicians and for the patients. The patient can carry out the tests without having to move from their own homes. And the data is stored in a PC, which offers the possibility of sending it to the hospital via Internet, for the doctors to analyze the results.
- **Frequency**: the ease of use of the system makes it possible to carry out more frequent tests, so the tracking of the variations of the motor functions of the patients is more accurate.
- **Versatility**: using the devices presented in this article, several different tests can be performed, and in each test, several parameters can be measured. For example, for the finger tapping case, both the speed and the regularity (periodicity) can be obtained, which enriches the results of the test and enhances the analysis and the conclusions obtained with it.

In order to comply with this characteristics or requirements, in this work we describe the system developed, which is based on the architecture shown in Fig. 1.
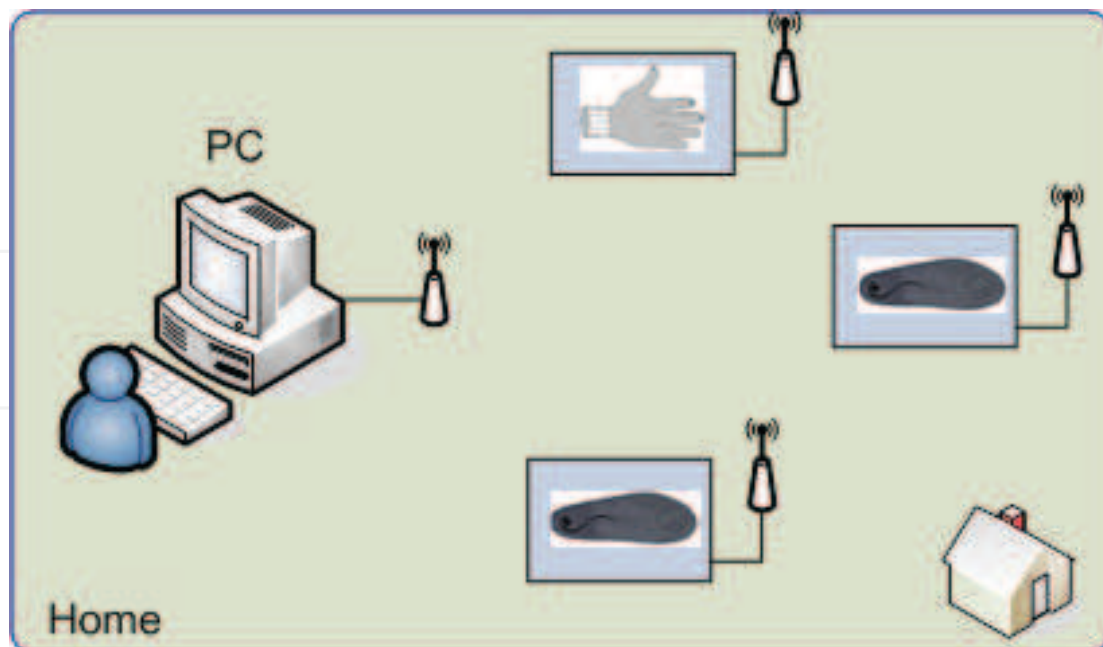
Fig. 1. System architecture

The whole system architecture is composed of four main building blocks:

- **Sensorized glove**: this glove is equipped with five sensors, which are attached to it. Each sensor is a FSR sensor and is connected to the circuit with a simple interface, done with a division resistor. When the user presses the FSR sensor, its resistance varies, and it is converted in voltage, in order to be acquired by the A/D converter.
- **Sensorized insole**: each insole is designed with five FSR sensors, in order to measure the area where the patient puts more pressure and to analyse the way he/she walks.
- **Hardware device**: this is the main development of the present research work. It consists of a tiny electronic circuit, based on a low cost and low energy microprocessor (PIC), protected by a case specifically designed for it. Its main functions are the acquisition and processing of the signals coming from the sensors, and transmitting them to the PC via the USB connection. The selected microprocessor has an 8 channel 10 bit A/D converter and an USB interface, which can be easily programmed and this allows saving space with another chip converter.
- **PC application**: the fourth component of the system architecture is in charge of receiving the data sent by the hardware device via the USB connection, storing and visualizing them, using a graphical user interface. This application was done in Windows with Visual C++ environment.

4. Device architecture

The main aim of the system is to gather data from any kind of sensor in order to store those data in an SD card or transmit them to Base Central Unit (BCU), connected to PC through USB connection. The SD card gives the system the possibility of having longer recording periods which allows the device to be used at a further distance from the BCU.

The data gathered and stored in the SD by the system is downloaded to a PC, by USB connection or by the radio transceiver, which operates in the 2.4GHz ISM band, using the BCU.

4.1 FSR sensors

The sensors used in this work have been Force Sensitive Resistors (FSR). A force-sensitive resistor (alternatively called a force-sensing resistor) has a variable resistance as a function of applied pressure. In this sense, the term "force-sensitive" is misleading – a more appropriate one would be "pressure-sensitive", since the sensor's output is dependent on the area on the sensor's surface to which force is applied.

The sensors used in this work are manufactured by Tekscan, and are constructed of two layers of substrate film. On each layer, a conductive material (silver) is applied, followed by a layer of pressure-sensitive ink (Vecchi et al., 2000). Adhesive is then used to laminate the two layers of substrate together to form the force sensor. The active sensing area is defined by the silver circle on top of the pressure-sensitive ink. Silver extends from the sensing area to the connectors at the other end of the sensor, forming the conductive leads. Fig. 2 shows a picture of the Tekscan FSR sensor.

Fig. 2. Tekscan FSR sensor

After choosing Force Sensitive Resistors (FSR) as transducers, both a sensorized glove and an insole have been designed, and then used to carry out several tests related to Parkinson Disease (PD) and Amyotrophic lateral sclerosis (ALS).

4.2 Hardware architecture

The design of the device was related to its main functionality explained above. Measurements obtained from sensors are transmitted through wires to an IDC connector located at one edge of the device. This connector allows these inputs to be connected to A/D channels extended from the CPU. An interface stage is needed for each input due to sensors, done basically with some operational amplifiers and passive filters.

The architecture of the approach presented in this work is shown in Fig. 3. The CPU of the portable wireless device is the 18LF4550, a Microchip PIC18 Microcontroller with nanoWatt technology. It is an 8-bit System On-chip mainly featured by USB and SPI communication interfaces; it has a maximum number of 13 input A/D channels; each with a 10-bit resolution. It is also characterized for its low power consumption in deep-sleep mode, ideal to work as sensor node in monitoring applications. Also, this CPU has an RTC (Real Timer Clock), ideal for use in applications where is necessary to store the data sample time.

Analogical input signals attached to the IDC connector are converted into digital values which are put in an established frame structure according to a particular protocol. The frame arranged is ready to be transmitted via USB or RF.
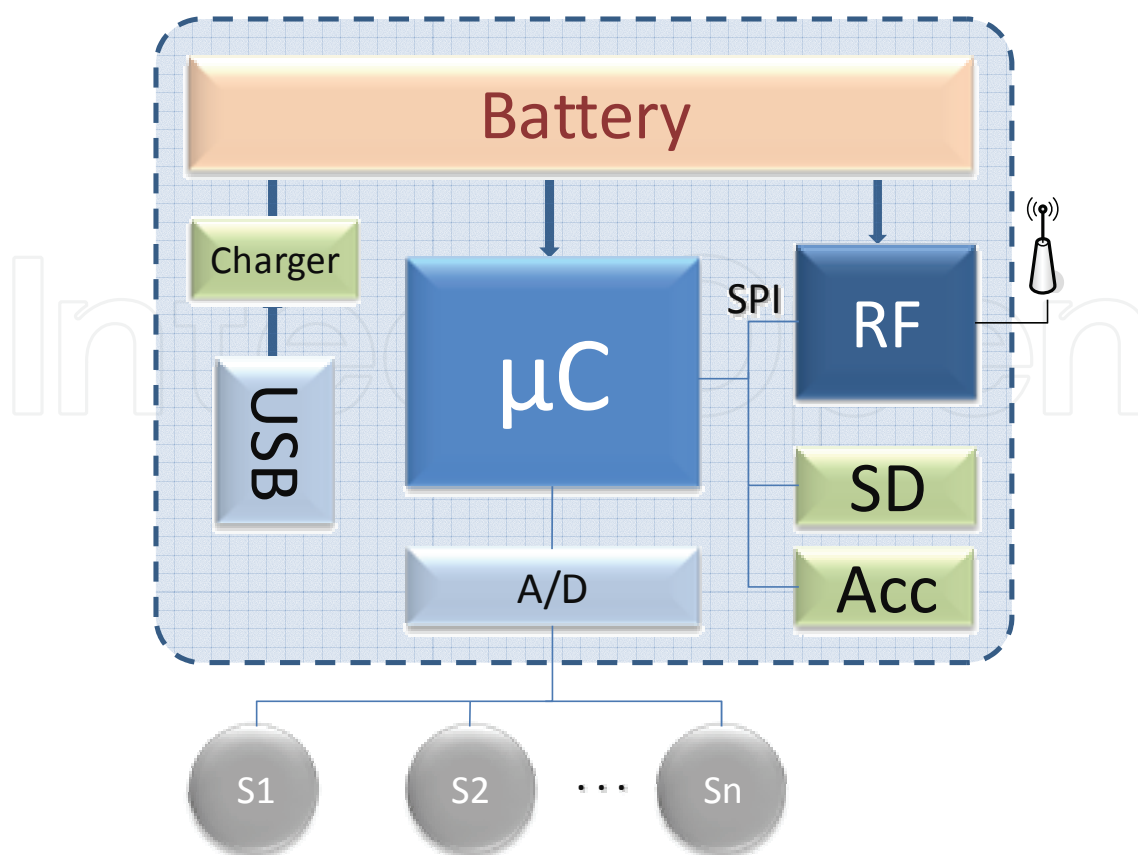
Fig. 3. Wireless device architecture

The USB device module is a mini-USB 2.0 compliant allowing fast transmission of data. It allows also charging the battery using a standard chip with a LED to monitor the charging action.

The device has also 3 more LEDs, whose main functionality is to indicate states in the program or can be programmed for different functions.

The device is designed also to use a 3-axis accelerometer in case it was needed; it also offers the option to record data in a micro-SD card placed in the bottom side. In order to increase the time access to the SD card, which means saving power, a proprietary system files access was implemented, based on the standard FAT32.

The wireless device has a radio frequency chip, the MRF24J40, from Microchip, which works in the 2.4GHz and has a SPI interface to communicate with the CPU. This chip was mainly chosen due to its IEEE 802.15.4 specification compliant (Hardware CSMA-CA mechanism, Automatic ACK response and support RSSI/LQI), additionally it has a hardware security engine and offers a low power consumption: 2uA in sleep mode, 22mA in TX mode (at +0dBm) and 18mA in RX mode.

The distribution of the device's components is illustrated in Fig. 4, where the left side shows the layout of the PCB and the distribution of the chips on the device. On the right side the connection procedure of the device with different kinds of sensors through a sensor interface is shown. This connection is possible by using the IDC connector, which includes pins for a VCC signal, the GND and 10 signals which are directed to the A/D converter. That was done due the fact that the main functionality of this device is to be a multifunctional wireless device.
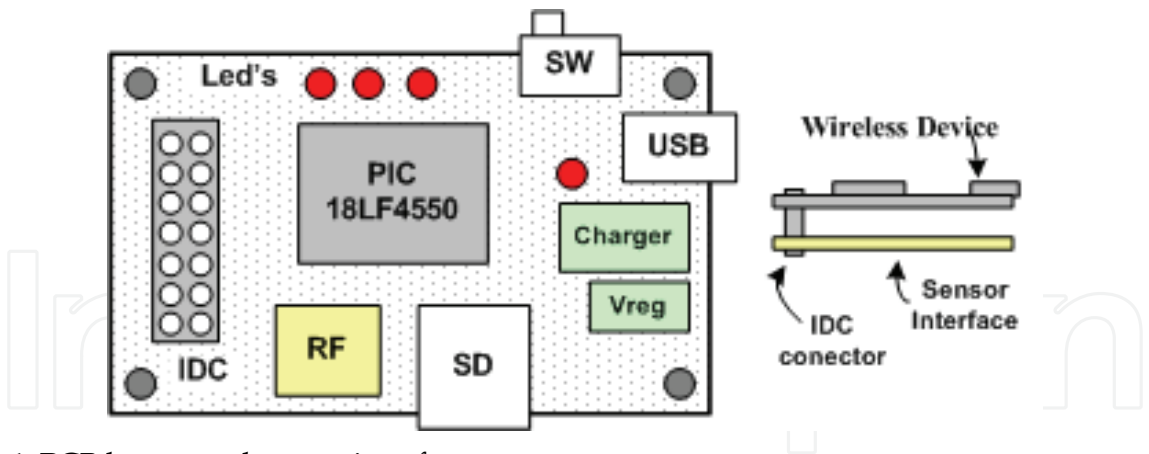
Fig. 4. PCB layout and sensor interface

4.3 Embedded software

The developed software to be embedded into the device has a modular scheme. This design allows the software to be independent from the platform and also gives flexibility.
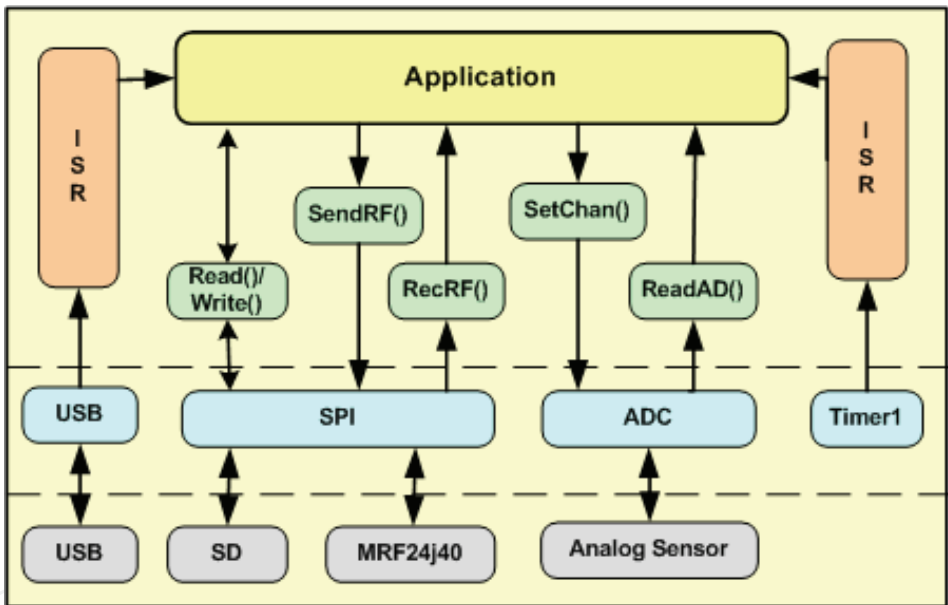

Fig. 5. Embedded software architecture

The whole software structure is divided in 4 layers as depicted in Fig. 5. The layers are separated by dotted lines and a short description for each one is given below:

- **Physical level**: is the lowest level and it depends on the hardware directly. The modules present in this level correspond to the physical modules of the node; these are the force sensors, accelerometer (not mounted), the USB port, the mini-SD slot (optional) and the RF module, which is controlled by the CPU using the SPI bus.
- **Controller level**: the functions developed in this level permit the application level to invoke controller functions. The ADC module converts analogical signals from the force sensors to digital, and the SPI allows communications of the CPU with the accelerometer and the mini-SD card and the RF chip. In this layer the set of USB and RTC (Real Time Clock) functions are also included.

- **Interface level**: this layer is the interface between controller and application; it contains the main functions that the device performs during its duty cycle. These functions range from reading ADC channels or communicating through the SPI interface, to sending and receiving data from the USB, the SD card and the RF chip. Interruption routines are also developed in this layer.
- **Application level**: this is the top level layer and executes related actions according to received interruptions (external switches or internal interruptions).

4.4 Data frame

The structure of the data frame, which is sent by RF or USB, is composed of a header which contains the ID of the device, followed by 4 bytes, indicating the measurement time, and a byte which indicates the length of the data.

Fig. 6 shows the data frame enclosed information of the measurements taken; the first two bytes give information about the frequency of sampling and the next byte gives the number of sensors measured. According to this last parameter, the rest of bytes corresponding to each sensor in groups of two bytes due to the 10-bit conversion configuration of the A/D converter.
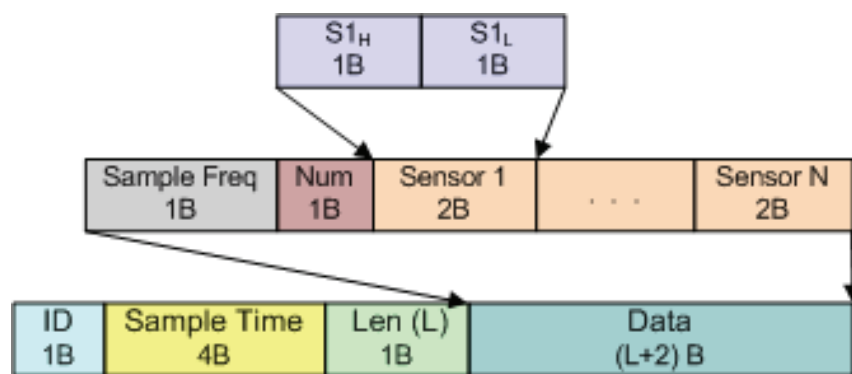

Fig. 6. Data frame

5. Device test in ALS disease

One of the ways of overcoming the lack of data in ALS disease is to develop new easy-to-use testing devices, which can be left in the patient's own home and used to carry out periodic tests without having to go to hospital to do so. The comfortable testing processes and devices make the patients more willing to wear them outside the home, and this leads to a wider amount of data available for the doctors.

Two of the more widely used tests with neurodegenerative disease patients are the Finger Tapping Test (FTT) (Jobbágy et al., 2005) and the Hand-grip Strength Test (Long, 1970). In the case of the FTT, the patient is asked to tap two of the fingers of one hand as quick as possible, and the main parameter measured by the doctors is the tapping frequency. On the other hand, in the hand grip strength test the measured parameter is the force the patient is capable of apply when grabbing an object.

The Finger Tapping Test (FTT), originally developed as part of the Halstead Reitan Battery (HRB) of neuropsychological tests, is a simple measure of motor speed and motor control and is used in neuropsychology as a sensitive test for brain damage (Christianson & Leathem, 2004). Although motor functioning in humans is controlled by many areas of the

brain, the motor strip rostral to the central sulcus is the most important, and the functioning of this area is reflected directly in the FTT. As well as direct motor effects, the speed, co-ordination, and pacing requirements of finger tapping can be affected by levels of alertness, impaired ability to focus attention, or slowing of responses. Tapping frequency can distinguish patients with motor dysfunctions of cerebella, basal ganglia, and cerebral origins from normal subjects.

At the onset of ALS the symptoms may be so slight that they are frequently overlooked. With regard to the appearance of symptoms and the progression of the illness, the course of the disease may include muscle weakness. Muscle weakness is a hallmark initial sign in ALS, occurring in approximately 60% of patients. The hands and feet may be affected first, causing difficulty in lifting, walking or using the hands for the activities of daily living such as dressing, washing and buttoning clothes.

ALS is a very difficult disease to diagnose. To date, there is no one test or procedure to ultimately establish the diagnosis of ALS. Methods for the evaluation of strength in people with ALS include a clinical neurological exam, manual muscle testing (MMT) (Aitkens et al., 1989), and rating scales. These methods are subjective and lack sensitivity to detect small changes. The purpose of the Hand Grip Strength Test is to measure the maximum isometric strength of the hand and forearm muscles.

The devices and methods used so far for the proposed tests have not had any significant improvement or innovation for many years. Traditional ways of performing the tests are still used.

For the finger tapping test, several methods have been proposed and used. The standard method consists of asking the patients to start with the finger tapping process and an examiner using a stopwatch to keep track of the 10-second trial interval. Electronic devices which are based on the same testing methodology have been marketed. The electronic device has an internal timer that starts on the first tap and stops counting taps when the 10 seconds have elapsed. The use of automatic timing is intended to increase the accuracy of testing (McDermid, 2000).

Other devices used, which can be found in the literature, include precision image-based motion analyzer and passive marker-based movement analyzer (Jobbágy et al., 2005); the Halstead-Reitan finger tapping test (HRFTT), developed and manufactured by Reitan Neuropsychological Laboratory, which uses an electronic counter and a tapping key; finger tapping devices containing pressure sensors (Soichiro et al., 2004); systems consisting of accelerometers and touch sensor (Yokoe et a., 2009) (Okuno et al., 2007).

In the case of the hand-grip strength measurement, the innovations carried out in recent years have been even poorer. The most usual way to carry out this specific test is by using hand-grip and pinch-force dynamometers, which offer very poor information about the way the hand grabs objects. Electromyography has been also used in some studies (Long, 1970).

In this work we have used our wireless device to carry out both of the tests. It is integrated in a system consisting of the mentioned device, a sensorized glove (see Fig. 7) which is worn by the patient, and a PC or base station, which is in charge of receiving the data sent by the device, and visualizing them graphically in order to be analyzed by the doctors.

As mentioned before, the sensors used in this test have been Force Sensitive Resistors (FSR). The approach followed in this research work has been the one of attaching several sensors to a glove. This design allows complying with one of the key characteristics identified in the system architecture section: versatility. We consider that this design is more versatile in order to allow carrying out different type of tests and obtaining a wide range of results.
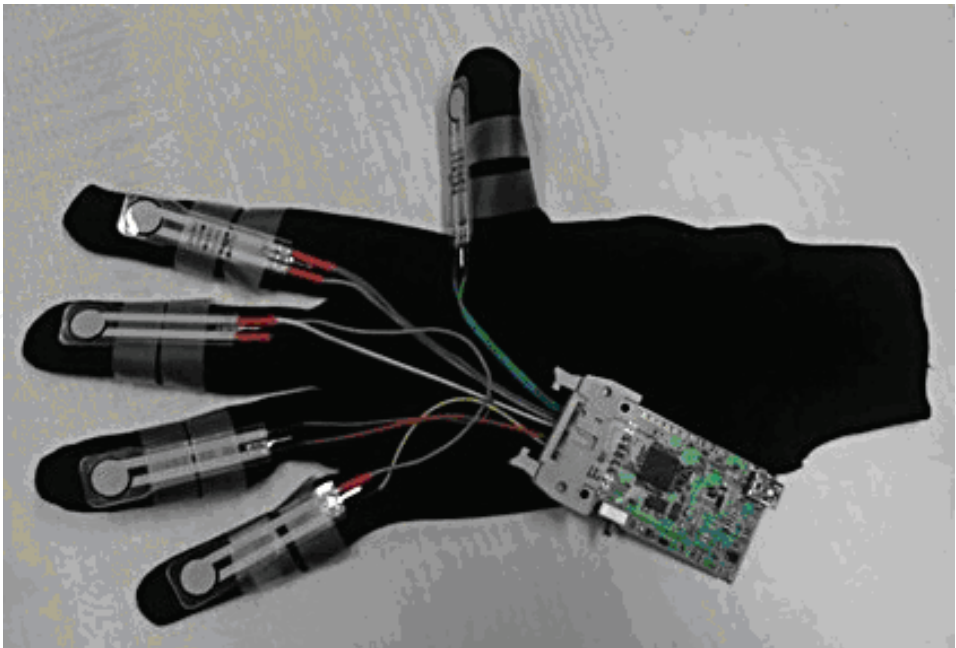
Fig. 7. Sensorized Glove attached to the wireless device

5.1 PC application

In order to gather the data and to be analyzed, a PC application was designed. It has been developed in Visual C++ using the Object Oriented Programming methodology (OOP), which is based in classes. The architecture is shown in Fig. 8. There are five blocks; the most important ones are the USB process and the graphical routines.
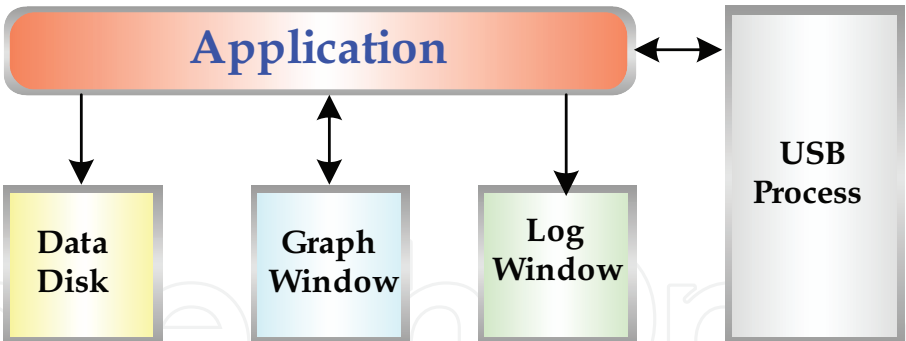

Fig. 8. PC application diagram

The data obtained by the hardware device after gathering and processing the signals coming from the FSR sensor, are sent via the USB connection to a PC, where an application is running. This application receives the data and visualizes and stores them.

Due the fact that the data rate of the device is low (less than 1KBps), the HID protocol has been implemented in the Sensor Device, providing the PC application an easier method of gathering the data, because most operating systems recognize standard USB HID devices, like keyboards and mice, without needing a special driver. In this way, the software can run in any compatible PC with Windows XP Operating System installed.

The application has some functionality that makes it easier for the doctors to analyze the data gathered by the hardware device. These functionalities are:

- **Start/Stop**: this button allows the exact moment in which the test starts and ends to be controlled. When the test starts, a new process is created in the application, which is constantly controlling the USB communications with the device, and passing the gathered data to the GUI window.
- **Zoom**: the zooming tool enables the signals corresponding to the force applied by the patient's each of the fingers to be visualised more accurately. It is also possible to analyze only one finger in the application or to compare with other tests carried out previously.
- **Log**: the application enables a registry or log with the messages corresponding to the events that appear during the testing process (communication states) to be visualised.
- **Files**: the application allows the data in files with ".csv" format to be saved, in order to edit and analyze later in a PC program such as Excel. Also, in the new version of the program, it is possible to save in a Matlab binary format, as some clinicians have experience with that mathematical tool.
- **Options**: in this option, the user can configure the device, by changing the sample frequency, the date of the device in order to maintain well synchronized, etc.

5.2 Hand-grip results

Fig. 9 shows a screen capture of the PC application, where a hand-grip force test is being carried out. As it can be seen in that figure, the force signal corresponding to each of the fingers is plotted using a different colour. That way the analysis of the graph is easier for the clinicians, where they can see for example that the patient has more force with one finger.
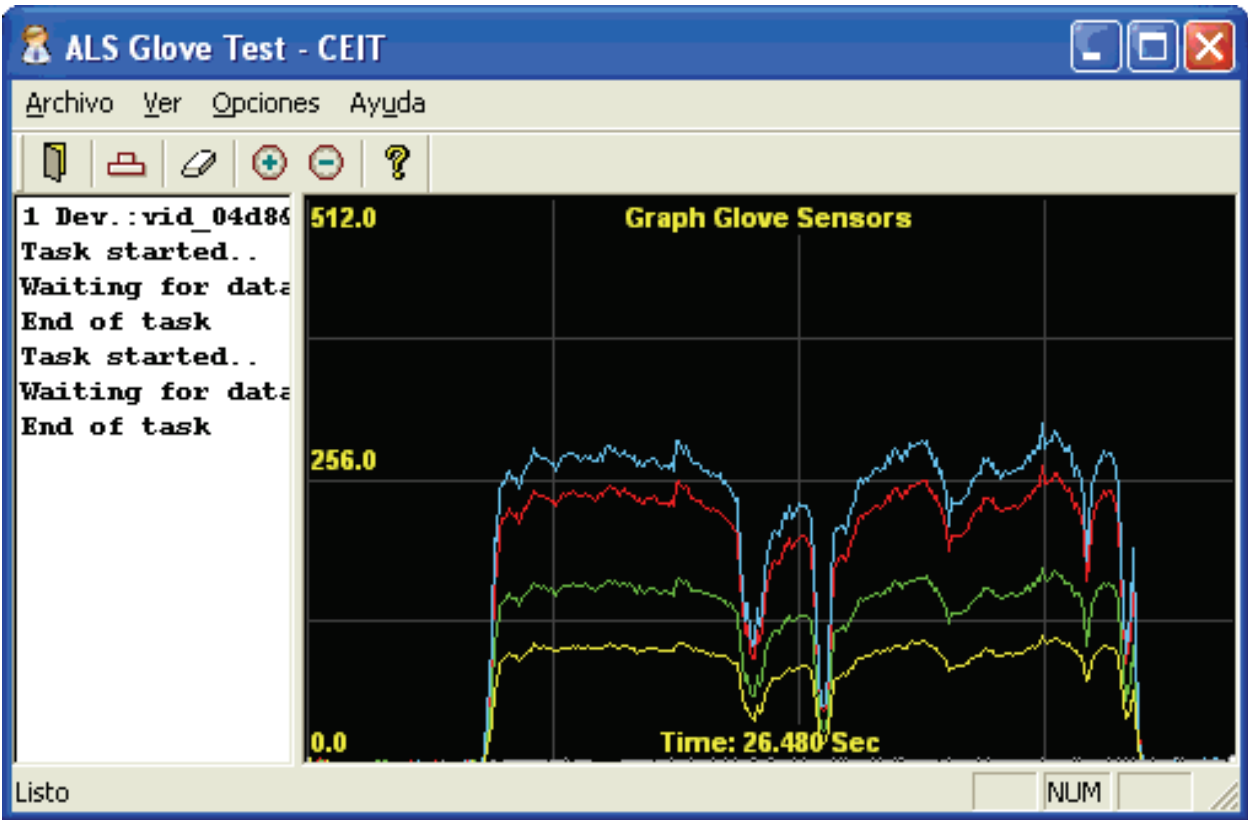

Fig. 9. PC application showing hand-grip force test results

5.3 Finger tapping results

The main innovation of this system is that it can measure both the frequency of the tapping and the force the patient applies when carrying out the test. Fig. 10 shows a screen capture of the PC application used to visualize the results in real-time, in which an ongoing finger tapping test can be seen.
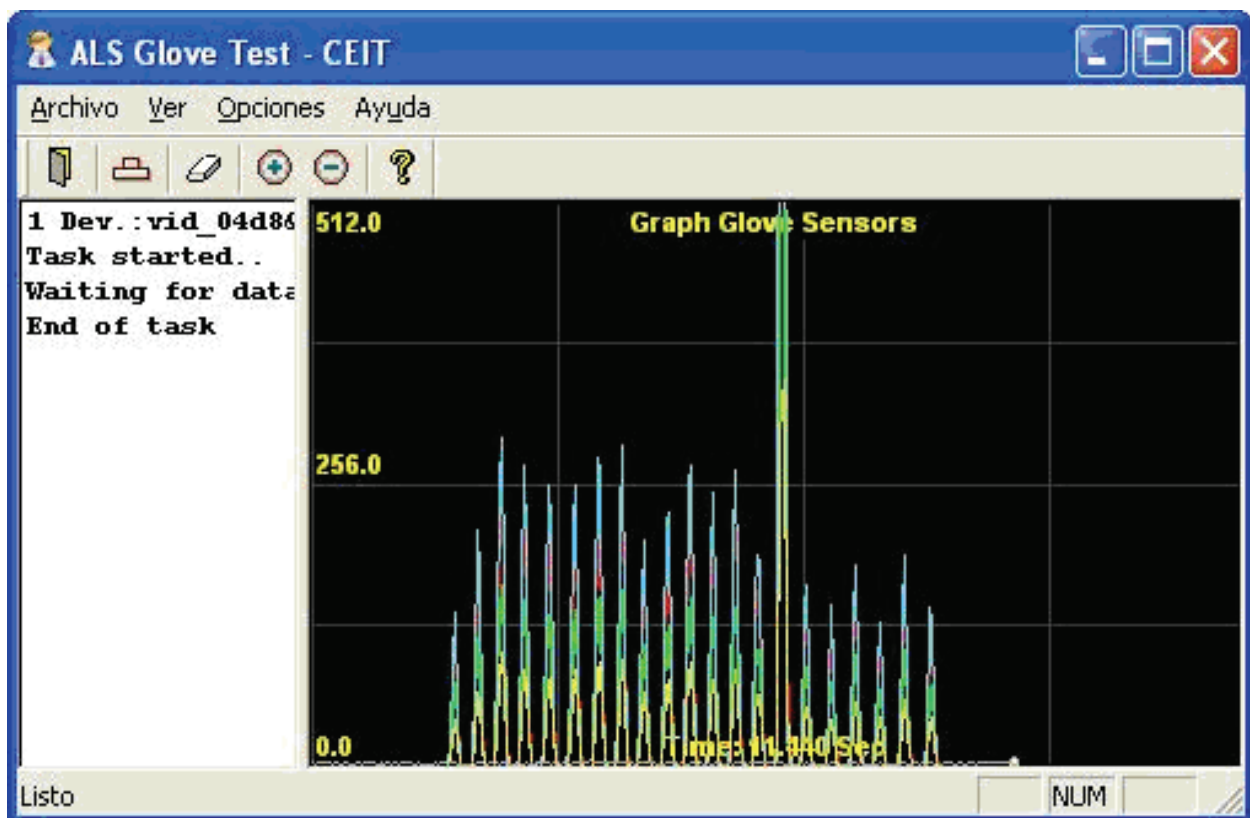

Fig. 10. PC application showing Finger-Tapping test results

Another key point of this finger-tapping test system compared to the existing ones is that the test can be performed using any of the five fingers of the hand. That way, two kinds of finger tapping tests can be carried out: one in which the fingers the patient uses most are involved in the testing process, and another one in which the patient uses the fingers that he or she is less likely to use.

6. Device's test in gait analysis

One of the ways of measuring and quantifying the movement disorders is performing gait analysis. Although several techniques and methods have been developed and used for years, all of them are based on hospitalizing patients and using in-hospital equipment.

Several interviews and meetings held with experts in neurology show that the most common way to carry out the gait analysis is by using sensorized ground platforms, as well as video cameras, in order to capture movement, where the two main disadvantages of these methods are the limited, and short period of time over which the patient can be monitored; and the fact of the monitoring process being carried out in a controlled environment, in which the patient may feel safe.

Recent advances on gait analysis of PD patients include portable digital monitoring systems. These systems allow gathering data by the patient themselves, wearing sensors at home and outside home. The developments performed to date are based on tiny electronic circuits which gather and transmit data coming from sensors, mainly accelerometers (Kauw-A-Tjoe et al., 2007).

Combining the advantages of both approaches used till date (sensorized ground platforms and portable monitoring devices) a gait monitoring system has been developed, using our wireless sensor device. For the approach presented in this test, Force Sensitive Resistors (FSR) sensors have also been selected. Regarding the location of the sensors on the insole, several medical considerations have to be taken into account. As shown in Fig. 11, the most interesting zones to place the sensors are three: the plantar area, the heel and one in the middle. These zones are the ones in which most of the force is applied and, thus, the zones from which more information can be obtained.
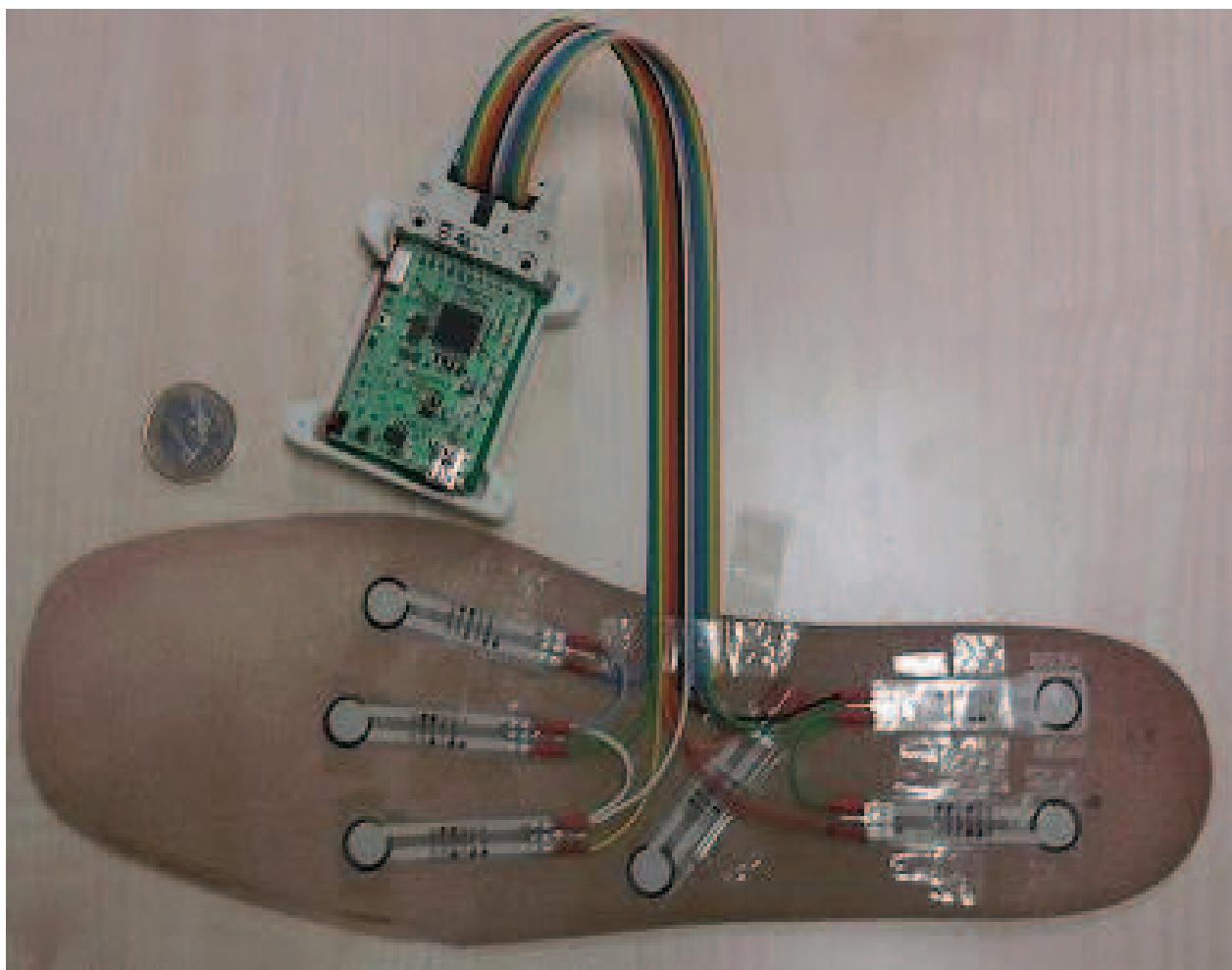
Fig. 11. Insole with the FSR sensors and wireless sensor device

6.1 Gait analysis results

The test methodology carried out consists of several tests performed on patients affected by PD and on healthy individuals. Two people from each group participated in the tests, and each of them carried out three repetitions, in order to avoid random results.

The parameters to be measured are the amplitude of the signal of each sensor (i.e., the force of the step) and the frequency of the signal, which gives an idea of the cadence of the gait. Table 1 shows the results obtained, where it can be seen that parkinsonian people has more frequency in their steps than healthy people. Fig. 11 shows the results for 2 sensors, gathered on the gait of a healthy person. The signal with the greater amplitude corresponds to a sensor located in the heel and the other one to the plantar area.

Samples		Results	
		Amplitude(V)	Central frequency (Hz.)
Non-Parkinsonian	1	2.64	0.88
	2	2.42	0.82
Parkinsonian	1	1.64	1.76
	2	1.76	1.85

Table 1. Results of the test in patients

A delay can be noted between the two signal in Fig. 12. This is due to the nature of the step in a normal gait. Another difference lies in the amplitude of the signals and this is because most of the weight rests on the heel. On the other hand, Fig. 13 shows the analogous results for a Parkinsonian individual.
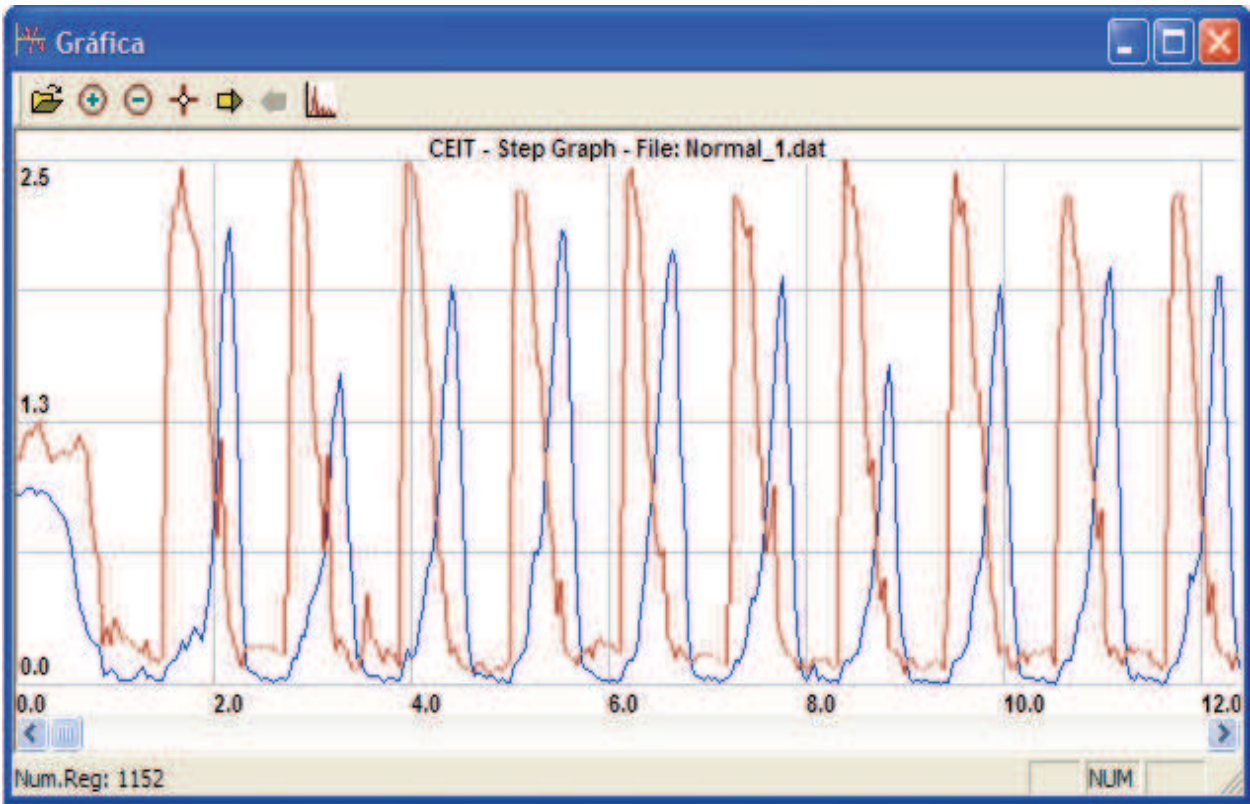
Fig. 12. Signal of a non-Parkinsonian individual over a temporal axis
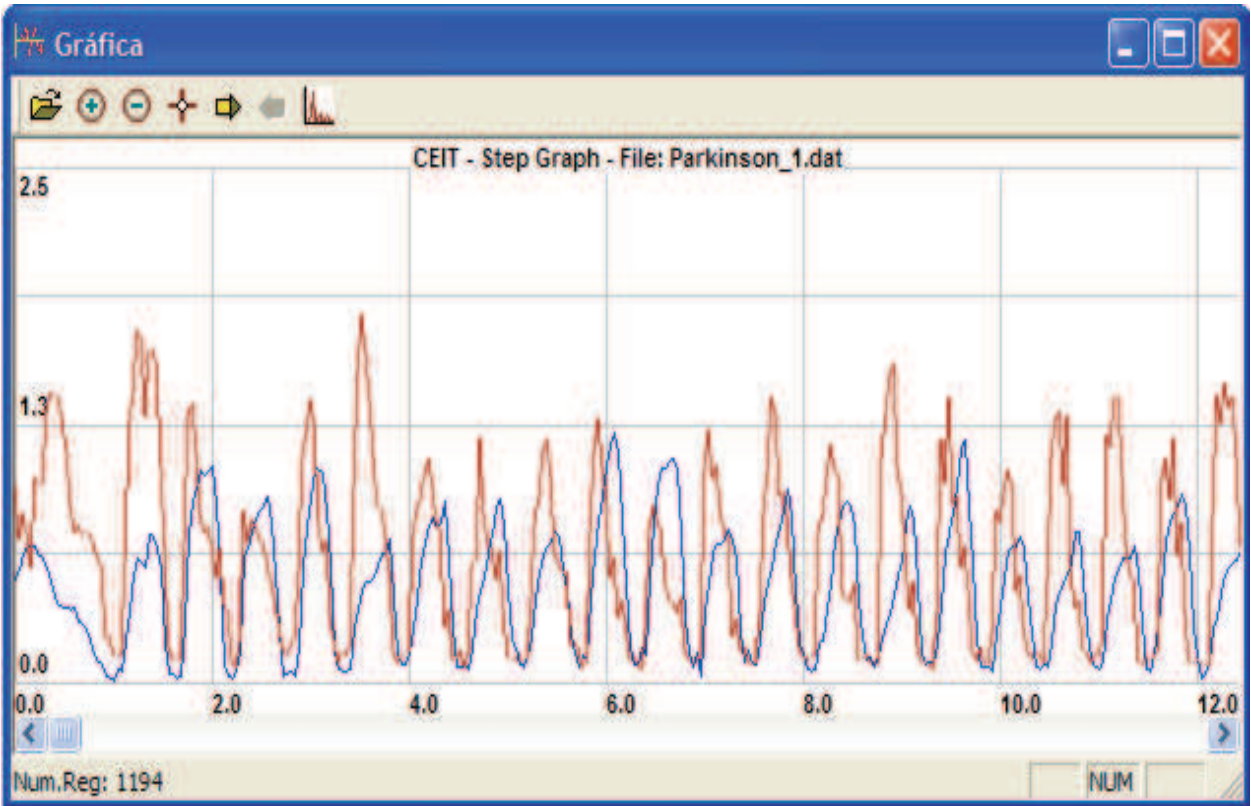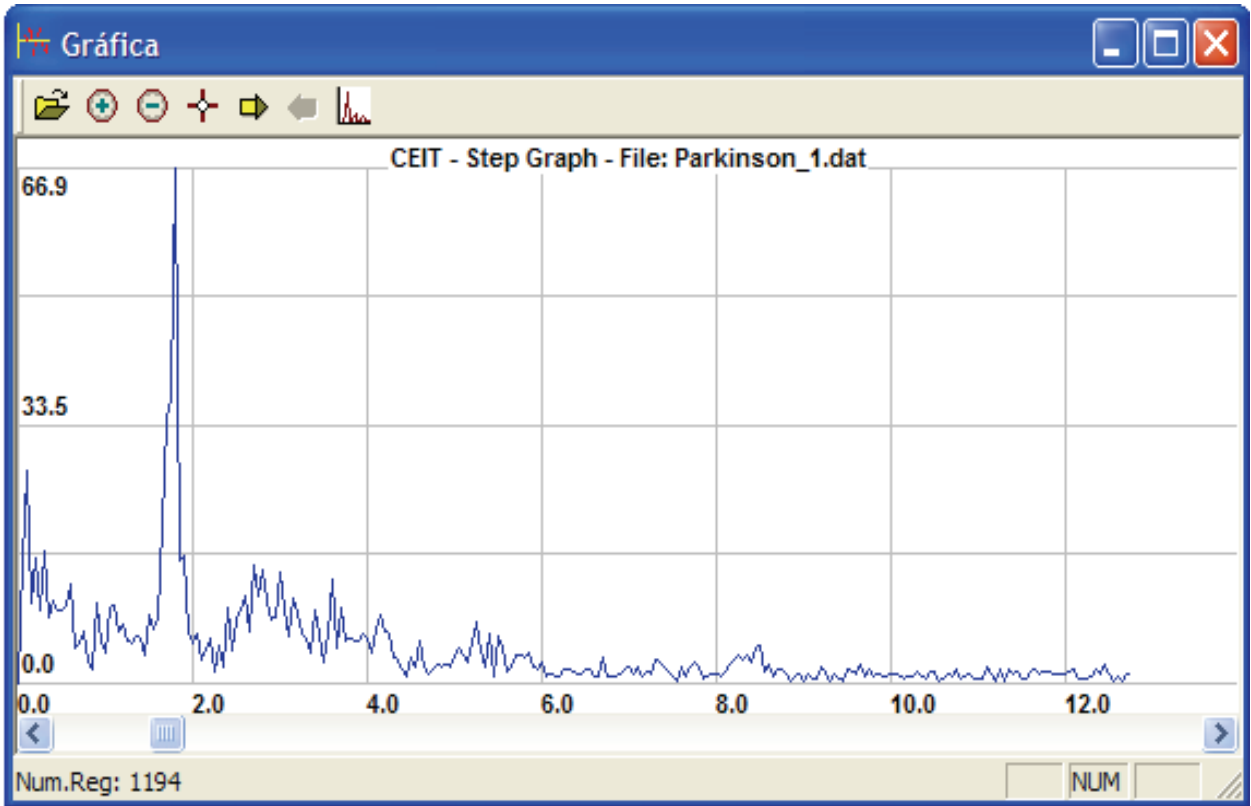
Fig. 13. Signal of a Parkinsonian patient

Fig. 14. FFT Signal of a Parkinsonian patient

As Fig. 13 shows, there is no delay between signals which suggests that this is due to the typical short steps of a Pakinsonian patient. Two more interesting conclusions are that the amplitude of these signals is lower than in the previous case, and the frequency is greater, around twice as much. This can be seen in Fig. 14, where the FFT of the Parkinsonian patient's signal is plotted.

7. Conclusion

The design of a tiny wireless sensor node platform has been carried out in this work. This device is mainly featured with its multifunctional functionality which has been proven in this paper on e-Health applications, specifically on tests related to patients affected by neurodegenerative diseases.

The presented work is based on the development of two specific tests for the treatment and analysis of Parkinson Disease (PD) and Amyotrophic Lateral Sclerosis (ALS). For each, the device has a different sensorized platform according to the nature of the performed test. Collected data from sensors can be either transmitted online through RF or downloaded via USB to a PC, or just stored in a card memory for a further download and analysis of data. A sensorized glove allows two tests to be carried out, mostly used on ALS patients; those are the hand-grip and the finger tapping tests. In the same way an insole with sensors located strategically is used to carry out a gait analysis which is one of the ways of measuring the movement disorders in parkinsonian people.

Results from both kinds of tests can be visualized and analyzed with the PC application developed in this work which also proves the versatility of the whole designed system. This application provides useful tools for the analysis of results; it was designed taking into account clinicians feedback as part of the work under the scope of the PERFORM project, acting as an interface between the clinician and the system.

The obtained results show and prove the viability and value of the multifunctional characteristics of the designed device. Additionally, by using the several tools provided by the PC application tools, important parameters can be obtained such as the frequency of a signal through the implemented FFT calculation function, the correlation among sensor signals in terms of phase and magnitude, the customization in the selection of specific signals and the zoom tool for a better appreciation of data.

These functionalities of the PC application allow clinician to obtain valuable conclusions like the stability of the gait (from the harmonics of the signals), the relation between air and ground time of the step (in PD analysis), the finger tapping frequency, the relation between the force applied by the different fingers, or the recording of the periods of time in which the patient is in "on" or "off" state.

Future work, which remains to be done is to focus on the accelerometer not mounted in this work. This component will provide relevant information for the gait analysis mainly helping to determine orientation and acceleration parameters of the patient.

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9. References

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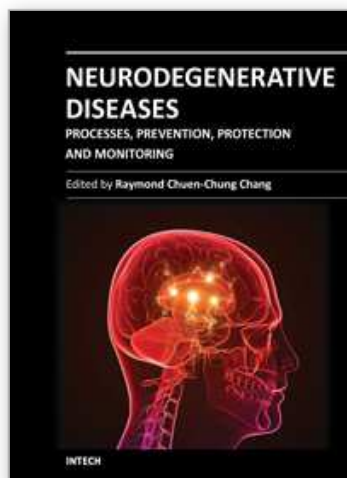
Neurodegenerative Diseases - Processes, Prevention, Protection and Monitoring

Edited by Dr Raymond Chuen-Chung Chang

Neurodegenerative Diseases - Processes, Prevention, Protection and Monitoring focuses on biological mechanisms, prevention, neuroprotection and even monitoring of disease progression. This book emphasizes the general biological processes of neurodegeneration in different neurodegenerative diseases. Although the primary etiology for different neurodegenerative diseases is different, there is a high level of similarity in the disease processes. The first three sections introduce how toxic proteins, intracellular calcium and oxidative stress affect different biological signaling pathways or molecular machineries to inform neurons to undergo degeneration. A section discusses how neighboring glial cells modulate or promote neurodegeneration. In the next section an evaluation is given of how hormonal and metabolic control modulate disease progression, which is followed by a section exploring some preventive methods using natural products and new pharmacological targets. We also explore how medical devices facilitate patient monitoring. This book is suitable for different readers: college students can use it as a textbook; researchers in academic institutions and pharmaceutical companies can take it as updated research information; health care professionals can take it as a reference book, even patients' families, relatives and friends can take it as a good basis to understand neurodegenerative diseases.

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