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Telematics and Computing

Miguel Martinez
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Miguel Martinez
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PREFACE

The purpose of this volume is to present the recent advance in selected areas of Telematics. The papers were carefully chosen by the editorial board on the basis of the at least two reviews by the members of the reviewing committee or additional reviewers. The reviewers took into account the originality, scientific contribution to the field, soundness and technical quality of the papers. This volume contains papers on various topics of computing, telecommunications, image processing and security.

This volume contains 10 papers related to various aspects of the development and applications of Telematics, security, mobile and health computing.

This issue of Research in Computing Science will be useful for researches and students working in he different areas of Telematics and Computer Science, as well as, for all reader interested you want to enrich your knowledge in this file.

In total, we received 25 paper that were submitted for evaluation; each submitted paper was reviewed by 2 independent members of the editorial board of the volume or additional reviewers. The acceptance rate is 59%. We would like express our gratitude to all people who help to elaborate this volume. Special thanks to COFFA-IPN for their support. Also we want to give special recognition to the professors Arodi Carvallo, Griselda Sanchez and CDT-UPIITA for their support to achieve the success in the publication of this volume. The submission, reviewing, and selection process was supported for free by the EasyChair system, www.EasyChair.org.

Roberto Zagal
Miguel Martínez
Félix Mata
November 2015

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Mobile application for automatic translation with Augmented Reality

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Abstract. In this paper we describe a mobile application for automatic translation. This application is useful for people that need to translate short text, especially from traffic and emergency signs. Using the camera of the mobile device the text within the image is recognized, then it is translated, and finally it is shown superimposed into the original text via augmented reality. In order to automatically translate the text obtained from the camera, we used image analysis, optical character recognition, online translator and augmented reality. Several test were run to verify the performance of the application and we describe the obtained results considering different scenarios.

Keywords: Augmented Reality, Automatic Translation, Mobile Application

1 Introduction

When people travel to a foreign country one of the main problems is the communication, especially if they do not understand the local language. Nowadays there are some devices for helping people in this issue, for instance, the electronic dictionaries in which the text we want to translate is manually introduced, or smartphones with applications where the text is recognized via voice and translated to the selected language. One approach that has been studied during the last year is the automatic translation using an image taken with a camera as an input. Most of the works done in this approach follow the same stages: image analysis, text detection and optical character recognition.

In [1] a scene text extraction system for handheld devices is described. The system uses the built-in camera of a PDA to capture images and send these images to a server, where the text information within the scene is extracted. Using a

commercial Chinese and Japanese to English translator the recognized words are translated and sending back to PDA where the words translation is shown over a augmented reality overlay. Another related work is presented in [2] where the authors developed an application for automatic translation designed for Windows Phone. The application identifies the text to be translated interpreting the user gestures on the display. The user can tap or swipe on the screen to point out the position of the text to be translated. Due to the computational resources of the smartphones all the processing is done locally, only the translation is done using the Bing dictionary web service. In [3] an application called TranslatAR was developed. This application shows the translated words obtained from a scene taken with a smartphone camera (Nokia N900). The translation is displayed over an augmented reality overlay. The Google Translate service was used for the translation and the augmented reality overlay was created with OpenGL. Besides there was implemented a tracking algorithm to keep track of the word of interest and present the translation in a live augmented reality overlay.

In this paper we describe the development of a mobile application for Android devices which uses the device camera for detecting and extracting the text included in the visualized image and show its translation with augmented reality. The KLT tracking algorithm [4] was implemented combined with the sensors of device to improve the tracking of the words. In the following sections we present an overview of the system and description of each one of the implemented phases(Section 2); the required features of the mobile device (Section 3); the experimentation and results(Section 4); and finally our conclusions and future work (Section 5).

2 System Overview

In Figure 1 we show the system architecture. The system implements all the phases shown in the figure using only the resources of the mobile phone, just the automatic translation is done with an external source. The system allows three kinds of input:

1. Text
2. Image from gallery
3. Image from live camera

The first one is used when the user provides the text that is wanted to be translated, this is the most simple scenario because no further processing is needed, so the translation phase is done directly from the provided text. In the second one, the user wants to translate a text contained in a stored image, in this case an image processing and optical character recognition is needed in order to extract the text from the image. Finally, the third one is the most challenging situation due to the fact that the input is not a static image, but a live scene that needs to be tracked in order to locate the text that will be translated. In this section, we describe in detail the implemented phases to process the live camera input (the other inputs share the phases).

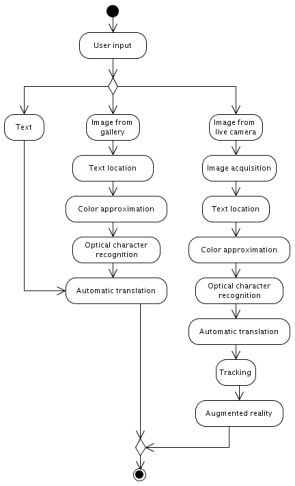

Fig. 1. System overview.

2.1 Image Acquisition

If the input of the system is the live camera, then there is not a static image to be processed instead there are video frames. In order to obtain an image we used OpenCV library [5]. Through a Listener provided by OpenCV we can detect when a frame changes and save the new image.

Once we have an image it is necessary to specify the area where the text is contained. There are two ways for the user to specify such an area; the first one is to set a reference point by touching the screen in the center of the text that wants to be translated; the second one is by drawing a rectangle using the touchscreen as shown in Figure 2, the text should be enclosed in a rectangle.

Fig. 2. Manual text selection of the word “EXTINTOR” (extinguisher).

Fig. 3. Image segmentation of the word "MILLONARIO" (millionaire).

2.2 Text Location

After we have the reference point, a first segmentation is performed by identifying possible edges of words using image gradients. For this segmentation both vertical and horizontal tolerance is used to handle the spaces between characters in a word. The algorithm we use to locate the text in the image is based in [3]. In Figure 3 we show an example of the detection of the lower and upper limits using the gradient of the X axis.

2.3 Color Approximation

Every pixel in the image it is represented as a three component vector (RGB) and using a k-means clustering method [6] the background color of the image as well as the color of the text contained in it is identified. By taking the mean value of the clustering we select to wich of the two classes (text or background) the color belongs. This method allows to improve the character segmentation and is used to approximate the color displayed in the augmented reality overlay. For the proper operation of the above algorithm it is necessary that the background color is solid and contrasting with the color of the text contained in the image.

2.4 Optical character recognition

The segmented characters obtained in the above phases are stored as temporal images. These images are processed by the OCR module, we used the Tesseract OCR engine [7] for this purpose. Tesseract is a free distribution OCR engines supported by Google and distributed under Apache license. In Figure 4 we show the recognized characters for the word "DUCKING".

Fig. 4. Character recognition of the word "DUCKING".

2.5 Automatic Translation

Automatic translation is one of the major task in natural language processing. There has been a significant effort during the last decades [8] and despite of the problems of processing natural language, promising results has been obtained [9]. Nowadays there are some commercial software available for automatic translation, we have selected Google translate [10] and WordReference [11] as translate service because they provide a HTTP service. The text we have obtained using the OCR module is sent to the selected dictionary.

2.6 Tracking

Tracking is an important task in video processing, it is used to locate specific objects in a video stream [12]. In our system the object of interest is the text and this object is static, but we assume that the user can move the device when is trying to focus a specific area.

The KLT tracking algorithm was implemented to position the translated text over the original text location, even if the user moves the device during the process. We also use the accelerometer of the device to detect a relevant sudden change in motion and stop the tracking process in order to warning the user that is necessary for the correct function of the system to stay as motionless as possible during the translation process. By stopping the tracking process significant use of memory and processing time are reduced.

2.7 Augmented Reality

Once we have the translated text contained into the image and its position, this translation is displayed over the live video stream. For this purpose we implemented an augmented reality module. This module creates an additional 2D layer to display the translated text using the color of the font and background obtained during the Color Approximation phase. In Figure 5 we show an example of a Spanish-English translation.

Fig. 5. Translation showed with AR for the Spanish word "EMERGENCIA" (emergency).

We also performed a coordinate conversion, because the resulting image has a standardized size of 320x240 pixels for all devices, however the devices screens have a very variable size and although the original image is scaled to cover the width and height of the screen, the matrix processed retains its original size. The conversion is performed as follow, given a point $P(x, y)$ located in a screen of size S_{HXW}, its position $P_1(x_1, y_1)$ into the original matrix of the image M_{hXw} is calculated by:

$$x_1 = xw/W$$
$$y_1 = yh/H$$

3 Mobile device features

The application was installed and tested successfully in two different mobile devices. One of these devices was a smartphone and the other one was a tablet. Both devices run over Android operating system and the minimum required version for the operating system is 2.3. In Table 1 we show the features of the smartphone and the features of the tablet are shown in Table 2 .

Table 1. Features of the smartphone Vodafone V860 Smart II.

Feature	Description
Display	320x480 px, 3.2 in.
Memory	1 GB ROM, 512 MB RAM
Video	VGA@20 fps
Chipset	Broadcom BCM21553
CPU	823 MHz ARMv6
Sensors	Accelerometer, proximity and magnetic field

Table 2. Features of the tablet WonderMedia XTAB-781+.

Feature	Description
Display	800x400 px, 7 in.
Memory	8 GB ROM, 1 GB DDR RAM
Video	VGA@30 fps
Chipset	WonderMedia WM8850
CPU	1 GHz ARMv7
Sensors	Accelerometer

4 Experiments and Results

The environment where the application has to run is highly variable. It includes changes in the distance, lighting, inclination, background, font and size of the text within the images. In order to verify the performance of the application in all these situations several test were run. All the test consider the text location and character recognition over some of the 8 different signs.

4.1 Distance test

In this test 24 images were selected from the 8 different signs using the live camera (video). For every sign 3 images were taken from different distances (20, 40 and 60 centimeters approximately). In Figure 6 images at different distances are shown and the obtained results are summarized in Table 3. The best result was obtained using medium distance, both the text location and the character recognition had 80% of success.

Table 3. Results obtained at short, medium and long distances.

Distance	Text location	Character recognition
Short	60%	73.3%
Medium	86.7%	80.0%
Long	73.3%	46.7%

4.2 Lighting test

The lighting conditions may affect the performance of text location and character recognition. For this test 3 different images with variations in the lighting

Fig. 6. Images taken (from left to right) at short, medium and long distance with a sign of "RUTA DE EVACUACIN" (evacuation route).

conditions where taken from each one of the 8 available signs. In Table 4 we show the results with the 3 lighting variations. As we can see the most affected functionality is the character recognition. Figure 7 shows an example of a wrong character recognition due to the use of an artificial lighting (smartphone integrated flash), the letters *N* and *T* directly receive the flash light which causes a reflection and this changes the color of pixels and finally these two letters are erroneously recognized as the letter *M*. The best result was obtained using natural environment lighting.Text location shows a 100% of success while character recognition had 80% of success.

Table 4. Results obtained using natural environment lighting, artificial lighting and night lighting.

Lighting	Text location	Character recognition
Environment	100%	81.3.3%
Artificial	68.8%	37.5%
Night	50.0%	56.3%

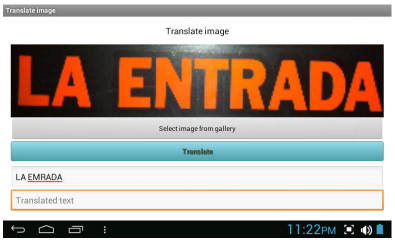

Fig. 7. Wrong character recognition in a sign with the words “LA ENTRADA” (the entrance).

4.3 Inclination test

Another factor affecting the performance of the application is the inclination of the image that contains the text to be translated. The image could be taken from different angles so the text within would also be distorted. In order to run the test 11 images in different angles were taken from the same signal and the contained text was recognized. In Figure 8 we show the images taken from different inclination angles. As we can see in Table 5 the most affected functionality is the character recognition while text location shows no problem. The best results where obtained with an inclination angle between -30° to 30° because the text is less distorted.

Table 5. Results obtained using twelve different inclination angles.

Inclination angle	Text location	Character recognition
-75° to -45°	100%	11%
-30° to 30°	100%	87%
45° to 75°	100%	33%

Fig. 8. Images taken from different angles of a sign with the words "PELIGRO ELECTRICIDAD" (danger electricity).

4.4 Miscellaneous tests

In addition to the tests performed in the above sections, characteristics of text that can affect the application performance were also tested. Three of these characteristics are background, font and size of the text. Table 6 summarizes the recommended conditions and text characteristics to get the best results.

Table 6. Recommended conditions and text characteristics.

Condition/characteristic	Recommendation
Font size	10% to 90% of the device display
Font	Sans-Serif family with a constant spacing between characters (without kerning)
Background color	Uniform background color in the area containing the text
Font color	Uniform font color and contrasting with the background
Lighting	Uniform environment light
Inclination	Tolerance of 30° to the horizontal plane passing through the center of the object

5 Conclusions and Future Work

The application has to deal with an uncontrolled environment and the changes in the environment make it very difficult to ensure proper operation all the time. The most challenging task is character recognition, even though OCR engines have improved more effort is required. Thanks to the current mobile devices resources all the image processing phases was locally implemented. The use of integrated sensors like the accelerometer helps to save valuable time and processing, improving the performance of the application. With the improvements on the capabilities of mobile devices and OCR engines these kind of applications will be fully operational and available in our every day life.

Acknowledgments

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Comparative study of embedded computing platforms using sequential programming

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Abstract. This paper presents a comparative study between three embedded computing and low-cost platforms. Computing platforms are 32-bit RISC based processors, ideal for low power applications. During the experimental phase, six numerical methods were implemented in C++ language for performance comparison among them. The operating system used was Linux, with a specific distribution for each platform. Experimental results show that the Dual-Core ARM Cortex-A7 processor based platform shows a slightly higher performance regarding to Cortex-A9 Dual-Core processor based platform and ARM Cortex-A7 platform.

Keywords: Embedded computing, ARM processor, Numerical methods, Parallella, Cubieboard, Raspberry

1 Introduction

Today the computer systems are everywhere. It should not surprise that millions of computer equipment will be built each year to be used as desktops, laptops, workstations and servers. The amazing thing is that from the transistor miniaturization, many of the computer systems have electronic devices highly integrated dedicated to the execution of specific functions [4]. Embedded systems are found in a wide variety of everyday devices such as consumer electronics (phones, tablets, digital cameras, calculators and audio players) [1], for domestic use (microwave ovens, automatic answering, smart thermostats, video surveillance systems and lighting systems) [9, 13], office equipment (projectors, copiers, printers, scanners and alarm systems)[7] and automotive (control of transmission, anti lock brakes, fuel injection and active suspension)[11]. An embedded system typically costs much less than a team of computing and have specific characteristics that distinguish between them [12]. Fixed function systems: Such systems are usually inexpensive and are designed for repeatedly execute a specific program [5]. Restricted systems: Such systems are designed under metric (restrictions) high performance with low power consumption, and using semiconductor materials highly integrated [8]. Reactive and real-time systems: Such systems must react to the changing environment with the least possible delay;

the metric governing the design of such systems is the measurement of variables and decision making in real time [10]. Currently there are embedded systems developed under the paradigm of Single Board Computer (SBC, for its acronym) that promote the teaching of Computer Science [3]. This paper presents a comparative study of the performance of three low-cost embedded systems, which have been widely used in the development of everyday applications. The rest of the paper is organized as follows: In Section 2, are presented the characteristics of the platforms of experimentation, in Section 3, a brief description of the numerical methods that were used for the experimental phase Section 4, in Section 5 are presented results and finally in Section 6, some conclusions.

2 Development platforms

2.1 Parallella

Parallella is a high performance computing device, which can be used as a standalone computer, such as an embedded system or as part of a cluster. The Parallella platform includes a dual core ARM A9 processor low power of consumption, which is able to work with different Linux distributions, this makes the platform be attractive for its wide versatility with working environments, which besides being accessible, give you ease of use to the user. One of the applications in which can be used the Parallella platform is processing and image analysis, a clear example is the face detection, this issue has been extensively studied with low-cost computing and innovative algorithms [14].

2.2 Cubieboard

Cubieboard is a single computer , open source produced by company Cubietech, based in Zhuhai, China. It has a good performance mainly in an tasks of office, games and entertainment, thanks a with its A20 processor.

The A20 processor is based on a dual core ARM architecture Cortex-A7 and integrates a GPU ARM Mali-400 MP2, delivering good performance and a reliable system performance, plus compatibility with different games. The A20 processor supports 2160p video decoding and encoding of 1048p, this makes the Cubieboard a good solution for mobile or desktop applications. Due to capacity, relatively small size compared to other cluster more robust and low cost of platform Cubieboard has been used for processing databases [15].

2.3 Raspberry

Raspberry Pi Model B is a credit-card sized computer of low cost, that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is capable of doing everything you would expect a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games all this with an 700 MHz ARM 1176JZF-S

processor and 512 MB RAM. The Raspberry Pi B has the ability to interact with the outside world, and has been used in a wide array of digital maker projects, from music machines and parent detectors to weather stations and tweeting birdhouses with infra-red cameras. Also implementing multi-label classification algorithm with low cost. With the facilities available in Mathematica software for Raspberry Pi, the line of code required for implementing data mining algorithms can be reduced sufficiently [6].

Below, in Table 1 shown relevant characteristics of system the platforms to evaluate :

Table 1: Comparative table about the characteristics of the target platforms

Platform / Features	Parallella	Cubieboard	Raspberry
Processor	Xilinx Zynq Dual-core ARM A9 XC7Z020	AllWinnerTech SOC A20 Dual-Core ARM A7	700 MHz ARM 1176JZF-S
RAM	1 GB DDR3	1 GB DDR3	512 MB DDR3
Storage	Micro-SD memory	3.4 GB NAND flash or Micro-SD memory	Full-size SD-Memory

3 Numerical methods

The numerical methods are essential to approximate analytical values so difficult or impossible to obtain. One of the basic problems in the numerical approach is the search for roots of a function, that is, when the value of x-axis value of the ordinate is zero or very close, that is below a threshold determined so that is searched f (x) = 0. The numerical methods listed below are used to obtain an approximation to the root of certain functions. It should be mentioned that each method has advantages and drawbacks, which include convergence capacity, types of function where the method can never converge, among others. Finally, numerical methods can be used even if the objective function can be treated in an analytical form allowing the use of computer systems. The numerical methods listed below are used to find roots of a function, using a classical reference [2].

3.1 Bisection

This method is based on the intermediate value theorem, also it is known as binary search method. It has a function f that is continuous on the interval [a, b] with $f(a)$ and $f(b)$ of different signs, ie $f(a) * f(b) < 0$. According to the intermediate value theorem, there is a value in p (a, b) such that $f(p) = 0$. Although the method is applied even if there more a root in the range, for

simplicity it is assumed that the root of the interval is unique. The method requires split several times by half subintervals of [a, b], and in each step, locating the half containing a p.

To begin, suppose that $a_1 = a$ and $b_1 = b$, and let p_1 the midpoint of [a, b]; ie,

$$p_1 = a_1 + (b_1 - a_1)/2 = (a_1 + b_1)/2 \tag{1}$$

If $f(p_1)$, then $p = p_1$; if not so, then $f(p_1)$ has the same sign to $f(a)$ or $f(b_1)$. If $f(p_1)$ and $f(a_1)$ have the same sign, then $p \in (p_1, b_1)$ and took $a_2 = p_1$ and $b_2 = b_1$. If $f(p_1)$ and $f(a)$ have opposite signs, then $p \in (a_1, p_1)$ and took $a_2 = a_1$ and $b_2 = P1$. Then we apply the process to the interval $[a_2, b_2]$.

3.2 Newton - Raphson

This method, also known as Newton - Raphson, is one of the numerical techniques to solve a problem of search of roots $f(x) = 0$ more powerful and popular. You can be viewed in different ways, one of which is the possibility of deriving a technique that allows for a faster convergence than that offered by other types of functional iteration.

It begins with an initial approximation p_0 to calculate

$$p = p_0 - f(p_0)/f'(p_0) \tag{2}$$

and if is checked

$$|p - p_0| < tolerance \tag{3}$$

not be redefined

$$p_0 = p \tag{4}$$

and is iterated again.

3.3 Müller

This method is an extension of the secant method, the method of Müller uses three approaches x_0, x_1 and x_2 and determine the next approximation x_3 to consider the intersection of the x axis with the parabola passing through $(x_0, f(x_0))$, $(x_1, f(x_1))$ and $(x_2, f(x_2))$.

3.4 Secant

This method starts with two initial guesses p_0 and p_1, the approximation p_2 is the intersection of the axis line connecting x and $(p_0, f(p_0))$ and $(p_1, f(p_1))$. The approximation p_3 is the intersection of the axis line connecting x and $(p_1, f(p_1))$ and $(p_2, f(p_2))$, and so on. The method must iterate until they get $|p - p1| <$ *tolerance* and each iteration should be replaced with the values to be treated, that is $p_0 = P_1, p_1 = p$, etc .

3.5 Fixed Point

A fixed point of a function g is a number p for which $g(p) = p$. Given a problem to find a root $f(p) = 0$, you can define a function g with a fixed point p in various ways; for example, like $g(x) = x - f(x)$ or $g(x) = x + 3f(x)$. Conversely, if the function g has a fixed point in p, then the function defined by $f(x) = x - g(x)$ has a zero at p.

3.6 Steffensen

This method can be considered as a combination of fixed point and Aitken methods. As the Aitken method essentially accelerates the convergence of other method, this method can be defined as accelerated fixed point method. This method has a fast convergence and does not require, as in the case of Newton's method, the evaluation of a derivative. Moreover, it has the additional advantage that the iteration process only needs a starting point. Then, it is found a $p = g(p)$ given an initial approximation p_0.

It must be calculated in each iteration:

$$p_1 = g(p_0) \tag{5}$$

$$p_2 = g(p_1) \tag{6}$$

$$p = p_0 - ((p_1 - p_0)^2)/(p_2 - 2p_1 + p_0) \tag{7}$$

and must iterate until $|p - p_0| < tolerancia$.

4 Experimental phase

In this phase, tests were performed with the above numerical methods programmed in C++ language, where C++ is a language created for the extension of C that allows the manipulation of objects, besides being a compiled language.

The tests that were performed consisted in evaluating the following expressions (objective functions), development platforms and programming language C++, in all of them a plain text editor and the GNU g++ compiler were used.

Objective Functions

$$f_1(x) = x^3 + x - 6 \tag{8}$$

$$f_2(x) = x^3 + 4x^2 - 10 \tag{9}$$

$$f_3(x) = 8x - cos(x) - 2x^2 \tag{10}$$

The source code is compiled and executed on a Linux distribution; Cubieez for Cubieboard, Linaro for Parallella and Raspbian for Raspberry platform, in each platform shows execution times of programs, with the "time" command in Linux, thus obtaining the Table 2, Table 3 and Table 4.

The Table 2 shows the execution times each of numerical methods programming in C++ language on the platform Parallella.

Table 2: Execution time (seconds) on Parallella with C++.

Method Numeric \ Function	$f_1(x)$	$f_2(x)$	$f_3(x)$
Bisection	0.018	0.018	0.018
Newton - Rapshon	0.021	0.028	0.021
Müller	0.020	0.019	0.019
Secant	0.018	0.018	0.021
Fixed Point	0.018	0.018	0.018
Steffensen	0.018	0.021	0.018

As can be seen in the Table 3, showing the execution times of numerical methods implemented Cubieboard.

Table 3: Execution time (seconds) on Cubieboard with C++.

Method Numeric \ Function	$f_1(x)$	$f_2(x)$	$f_3(x)$
Bisection	0.010	0.010	0.018
Newton - Rapshon	0.010	0.019	0.010
Müller	0.010	0.010	0.010
Secant	0.010	0.010	0.009
Fixed Point	0.010	0.009	0.009
Steffensen	0.010	0.009	0.010

The Table 4 shows the runtimes in Raspberry platform with numerical methods programmed in C ++ language.

Table 4: Execution time (seconds) on Raspberry with C++.

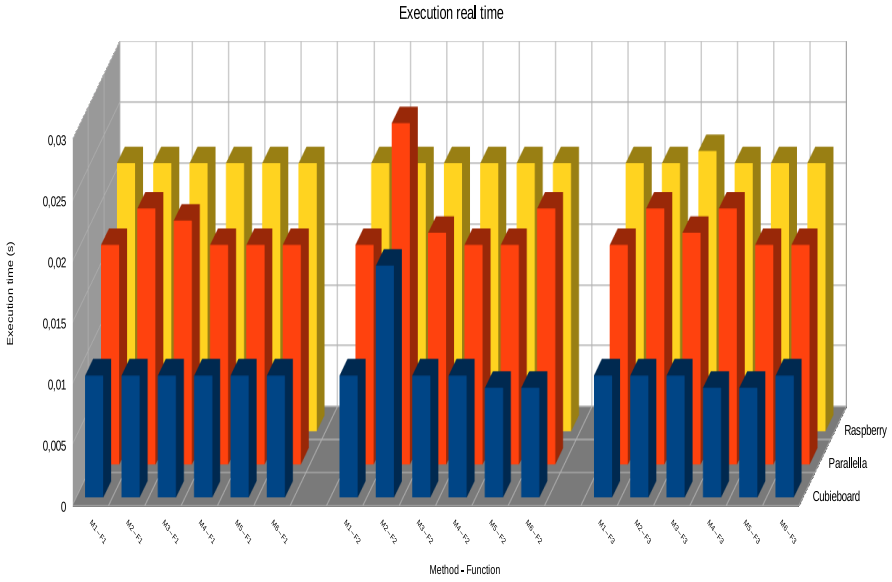
Method Numeric \ Function	$f_1(x)$	$f_2(x)$	$f_3(x)$
Bisection	0.022	0.022	0.022
Newton - Rapshon	0.022	0.022	0.022
Müller	0.022	0.022	0.023
Secant	0.022	0.022	0.022
Fixed Point	0.022	0.022	0.022
Steffensen	0.022	0.022	0.022

5 Results and Conclusions

In this section the results from previous tables are presented graphically to enhance the understanding of the information.

Fig. 1 shows Parallella, Cubieboard and Raspberry execution times with numerical methods programmed in the C ++ language.

Fig. 1: Chart of execution times in the three platforms with C++ language.



In the chart they are shown the execution time of the numerical methods, where M1 is bisection, M2 is Newton - Rapshon, M3 is Müller, M4 is Secant, M5 is Fixed Point, M6 is Steffensen and function (8), (9) and (10) are the objective functions respectively.

The Fig. 1 shows that the real time are kept steady except for the method of Newton - Rapshon presented unstable behavior to resolve the function (9) in Parallella and Cubieboard. Based on the results shown in Figure 1, the methods implemented in the C++ language, comparing the performance time Parallella with the performance of Cubieboard can see that in every one of the methods performance was better in Cubieboard as seen by comparing in the chart, the Raspberry showed a slightly lower performance compared to the other two platforms, though more stable in the times of execution.

According to the results, we can conclude that the Cubieboard platform is slightly best in the execution of algorithms of numerical methods, so it is convenient to use this system embedded in numerical applications for higher speed in the execution of numerical algorithms.

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Performance Analysis of Preemptive and Non-Preemptive Schemes in Hybrid Wireless Sensor Networks focused on the study of epilepsy

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Abstract. Epilepsy is a central nervous system disorder characterized by increased and abnormal synchronization of electrical neuronal activity and manifesting in spontaneous recurrent crisis. Then, electroencephalographic changes are presented. Different studies, such as the electroencephalogram [EEG], electrocardiogram [ECG] and electrogastrography [EGG], allow monitoring physiological signals associated to possible epileptic seizures. However, they require wired connections and therefore monitoring is restricted on factors such as limited physical movements, loss of information by disconnecting sensors and the patient needs to be in a specific area. Building on this, a system capable of wirelessly monitoring patients in mobile environments is proposed. Such system, without the above restrictions, opens up possibilities for the ubiquity study.
Specifically, this work aims at studying the performance of a Wireless Sensor Network (WSN) with Cognitive Radio capabilities for a Body Area Network (BAN) performing continuous monitoring (EEG, ECG) and event monitoring (EGG).

Keywords: Wireless Sensor Network (*WSN*), Cognitive Radio (*CR*), Body Area Network (*BANET*), Electroencephalography (*EEG*), Electrocardiography (*ECG*), Electrogastrography (*EGG*), Epilepsy.

1 Introduction

Epilepsy is a brain disorder that is characterized by an enduring predisposition to generate epileptic seizures causing neurobiological, psychological and social consequences of patients suffering this condition. This disease can be detected, according to Serratosa, by the presence of only one seizure.

Currently there is a lot of devices and tools to monitor biological signals of human beings in a wired manner for the analysis of epilepsy [1]. These signals may determine certain patterns that provide information for the prevention or control of this disease. Among the most commonly performed studies is the electroencephalogram (EEG, neurophysiological examination based on the registration of bioelectrical brain activity under different conditions), electrocardiography (EKG / ECG, representing the electrical heart activity) and electrogastrography (EGG, recording technique of gastric electrical activity). However, there is not a system that allows monitoring all these signals simultaneously and wirelessly. Therefore, in order to incorporate these features, a communication protocol for the hybrid WSN (capable of monitoring both continuous and event data) is need as well as the study of the performance of the body area network (BAN). In particular, we propose the use of a WSN with cognitive radio (CR) capabilities, where nodes can efficiently use the radio-electric spectrum to transmit event data using the continuous monitoring channels. As an additional benefit of using this technique, the lifetime of the system is increased by allowing continuos monitoring nodes to turn off their radios in order to allow event nodes to transmit their information. As such, the proposed system is also energy-efficient.

In the literature, there are papers such as [2], [3] and [4] that study WSNs with similar objectives. The reference [2] describes a wireless sensor network focused on the study of epilepsy but, the paper does not consider a cognitive ratio, [3] and [4] have a WSN including different studies of biological signals but those have a different application (to monitor athletes).

However, non of these studies propose the use of a CR system to efficiently perform the required tasks, Also, the present study evaluates the performance of the network under different environments and analyses the energy consumption and successful event probability in order to allow a practical implementation in a future work.

The WSN is based on a TDMA scheme where the first time slots are assigned to the continuous monitoring data transmission while leaving the rest of time slots available for the event-driven detections. By doing this, a collision-free system is design in such a way as eliminating any information loss.

2 System Model

First, we present the different types of bioelectrical signals that can be used for the detection of epilepsy.

2.1 Bioelectrical Signals

Cells of nerves and muscles of the human body by interaction with themselves generate bioelectric signals (also called biopotential) [5]. If the nerve or muscle cell is stimulated strong enough, above a specific threshold, then a potential action will be taken. This represents a flow of ions through the cell membrane and can be measured by non-invasive intra-corporeal methods. Examples of studies applied for these signals are detailed in *Table 1.*

Table 1. Common studies to measure biopotential signals [6].

Study	Description	Voltage	Frequency
ECG	Electrocardiogram. Representation of the heart's electrical signals.	0.5 - 4 mV	0.01 - 250 Hz
EEG	Electroencephalogram. It is the representation of the electrical signals produced by the brain.	5 - 300 μV	150 Hz DC
EGG	Electrogastrogram. It is the representation of the electrical signals produced by the stomach.	10 μV - 1 mV	1 Hz DC
EMG	Electromyogram. Representation of electrical signals from the muscles.	0.1 - 5 mV	10 KHz
ERG	Electroretinography . Representation of electrical signals from the retina.	0 - 900 μV	50 Hz DC

2.2 Bioelectric signals useful for the study of epilepsy

There are a lot of studies to measure bioelectrical signals; however not all of these signals are useful for all circumstances. Inquiring about the functionality of studies for epilepsy, different tests have been done to identify which are consistent in order to obtain patterns that infer or detect a possible seizure.

The primary study for epilepsy is the EEG, since a seizure sets in an abnormal brain activity and the EEG provides graphics depicting the brain function. Also, and based on [1], the constant study of the heart (ECG) is proposed. According to this, the system keeps a constant monitoring of signals from the brain and heart. Also, it is possible to combine studies based on gastric events. However, by adding these signals to the system, it must be considered that the gastric behavior can vary depending on the situation (ie, gastric events may be conditional on certain thresholds that the doctor or expert define). It is considered then that the EGG be included but with restrictions defined by doctor's parameters.

In conclusion, it is determined that the system will operate through the measurement of three different studies: EEG, ECG and EGG. From these signals, the system acquires continuously all information from the heart and brain while gastric electrical activity will only be considered under certain parameters that the expert determines (from this point to the end of the article, the EGG will be cited as study of *event monitoring*).

2.3 Communication Scheme

In this section, the proposed communication scheme to send both continuous monitoring and event monitoring data in the WSN is described in detail. It is considered that nodes in a Wireless Sensor Network are able to perform basic

operations like sensing and communicating with other sensors, placed in a given area [7]. In this case, nodes are placed in the head of patients in order to obtain the measurements of the EEG while other nodes are placed in the patient's body to obtain the ECG and EGG signals. Also, the sink node is considered to be any wireless device (such as a smartphone or tablet) that communicates to the nodes in the network. Hence, the sink node would also be carried by the patient. As such, in this WSN, nodes are placed extremely closed to each other. The communication range among nodes is reduced. Building on this, nodes can perform direct communications and there is no need to use techniques such as clustering or multi-hop communications to relay data to the sink node.

Another important characteristic of this BANET, is that the number of nodes assigned to each biological signal is known: For the nodes that send data in a continuous monitoring fashion we have $N_c = 18$ (16 for EEG and 2 for ECG) nodes, while there are $N_e = 4$ (for EGG) nodes sending data only when a certain event occurs. For instance when the signals lay outside a certain predefined range selected by the physician. Hence, the system is formed by $N = 22$ nodes. As such, a Multiple Access Time Division (TDMA) scheme is selected. Indeed, this scheme is contention-free and nodes do not waste energy in packet collisions or overhearing like in random access protocols. Note that, in most WSNs, this cannot be done, since the number of nodes is usually not known.

2.4 Non-Preemptive Scheme

In the TDMA scheme, each node is assigned an specific time slot. Specifically, nodes resources are assigned according to Fig. 1.

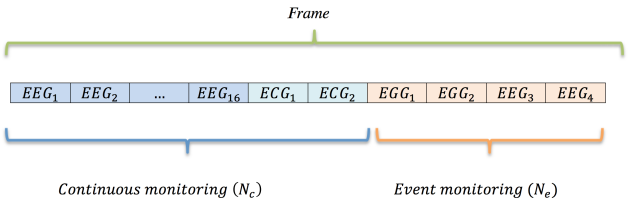

Fig. 1. TDMA-based protocol for evaluating the performance of the hybrid WSN

Note that nodes in a continuous monitoring regime, are assigned a particular time slot at the beginning of the frame while nodes in the event detection regime, are assigned a channel at the end of the frame. As such, whenever the event nodes do not transmit information to the sink node, the channels at the end of the frame would be empty. This entails an extra energy consumption since the sink node is constantly receiving the signal from all the frame and bandwidth wastage. Specially if gastric events rarely occur. However, no data is lost, since nodes (both N_e and N_c) can transmit their information in any time they have

something to transmit. As such, this is an non-preemptive scheme in the sense that at no point, nodes lose the assigned channel.

2.5 Single Event Detection

In this system, we consider that only one type of event can occur in the network. As such, the system is designed in order to transmit both continuous monitoring data (EEG and ECG data) while the EGG information is transmitted in an event reporting manner, i.e., only when the electrical signal of these nodes is above or below a certain threshold set by the medical staff. The event reporting happens at the end of the frame as shown in Fig. 1. Hence, each node transmits in the previously assigned time slot with duration of T_s seconds. We consider that the system has N_c nodes for the continuous monitoring for EEG and ECG studies while there are N_e nodes for the EGG event reporting data. The model used in this work considers the arrival rate of the event, i.e., the number of events per second (cases when the sensed values of the EGG signal lies outside the *normal* values, as specified by the medical team). Specifically, we consider that there are λ_e events per second. Also, an exponentially distributed random variable for the occurrence of the events is considered. As such, we assume that the inter-arrival time of events is $1/\lambda_e$ seconds per node.

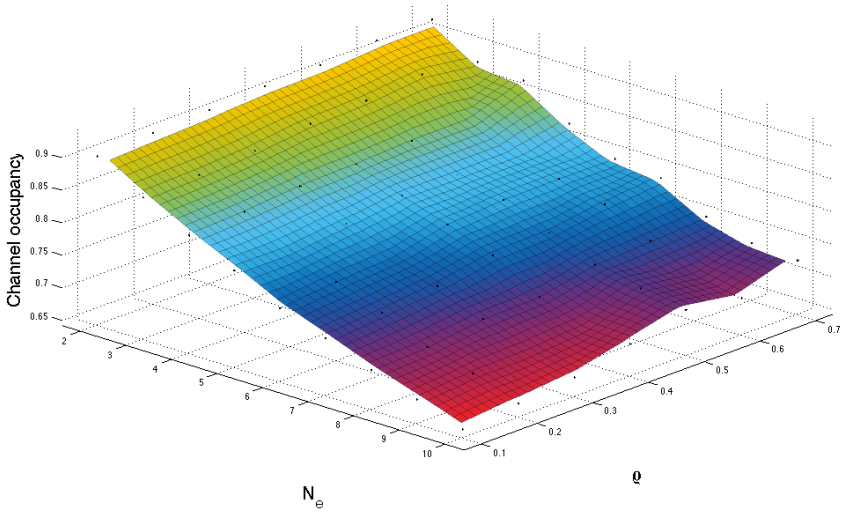

Fig. 2. Channel occupancy for $\lambda_e = 0.3$

Additionally, the model explicitly considers that not all events are correctly detected. Indeed, in an ambulatory system where patients can walk or have

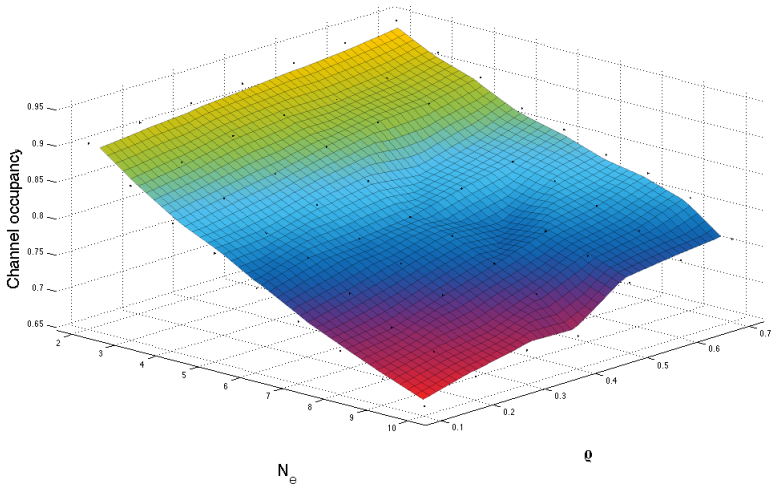

Fig. 3. Channel occupancy for $\lambda_e = 0.5$

movements it is likely that some events are not correctly detect due to the misplacement of nodes or even because of the type of the sensor used or external variables, such as sweat or clothes. This is modeled though the use of ρ which is defined as the conditional probability that given that an event occurred, it is detected by the node.

The system is evaluated in terms of the channel occupancy. Delay is not considered since it is clear that each node can transmit in the pre-assigned time slot in the frame. Hence all nodes can transmit each $(N_e + N_c)T_s$ seconds. In this case, this reporting delay is constant.

Channel occupancy is the average number of time slots used in the frame divided by the total number of time slots. Since events occur randomly in the system, and they are not always detected, we are interested on investigating the performance of the system in terms of the resource wastage, or resources not used for different environments. In particular, Fig. 2 shows the channel occupancy for $\lambda_e = 0.3$ while Fig. 3 and 4 are for $\lambda_e = 0.5$ and 0.7 respectively.

Evidently, channel occupancy takes values between 0 and 1. In these experiments, we observe the system behavior for different number of event nodes and detection probability. From these figures it can be seen that as the value of ρ increases, also the channel occupancy increases since nodes detect correctly each event. On the other hand, as the value of the number of nodes increases the channel occupancy decreases. This is because the more time slots assigned to the event detection at the end of the TDMA frame, the more slots that are not used when an event is not present. Hence, more bandwidth wastage occurs.

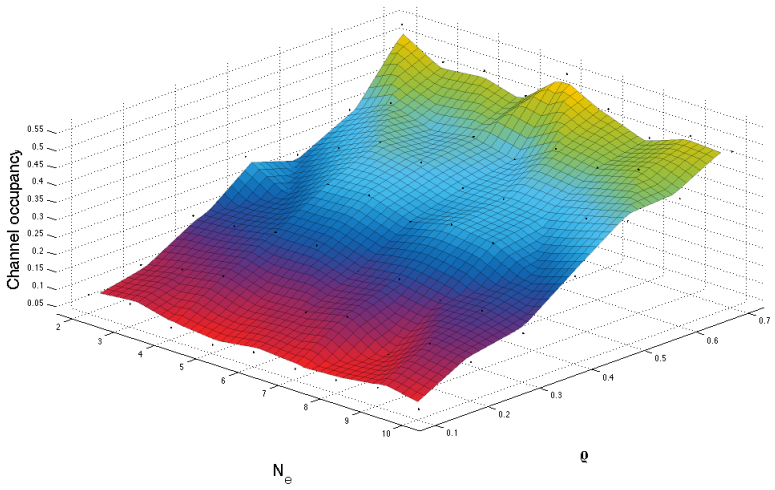

Fig. 4. Channel occupancy for $\lambda_e = 0.7$

2.6 Multiple Event Detection

In the previous analysis, all nodes were assumed to have the same detection probability ρ. We believe that this is accurate in the case that all nodes are in a similar placement in the patient. However, in the case that nodes are placed in different parts of the body in different conditions, this might not be true. On the other hand, other types of nodes can be used in the system. For instance EGG signals can be monitored using different types of nodes. In this case, the detection probability may be different for each individual node. We model the case where each type of node i has a different detection probability ρ_i. For example, we consider three different types of nodes such as: ρ_0, $\rho_1 = \alpha\rho_0$, $\rho_2 = \beta\rho_0$ where α and β are values that vary in the range of 0.1 to 1. In Figs. 5 and 6, the channel occupancy is plotted for $\rho_0 = 0.1$ and 0.5 respectively and with $\lambda_e = 0.8$. From these results it can be seen that the different values of the detection probabilities has an important impact on the channel occupancy. As expected, as the value of α and β decreases, the occupancy also decreases since there are more empty slots by node that do not detect the event.

3 Preemptive System

In view of the bandwidth wastage produced by the non-preemptive scheme, we now propose a preemptive scheme where nodes reporting event information, i.e. EGG data, use the assigned times slots to continuous monitoring nodes. The rationale behind this scheme is that we consider that event data information has priority over continuous monitoring data. As such, we propose to turn on and

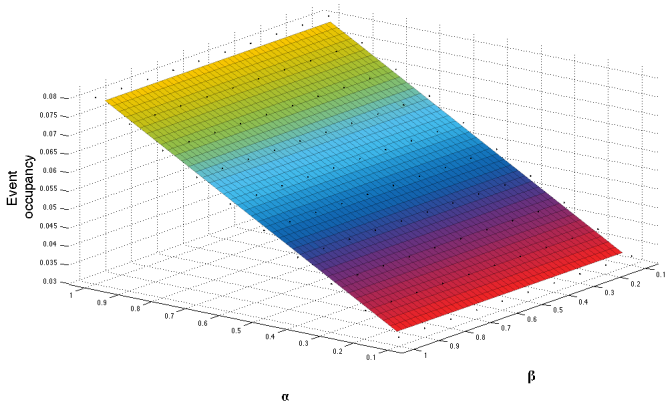

Fig. 5. Event occupancy for $\lambda_e = 0.8$ and $\rho_0 = 0.1$

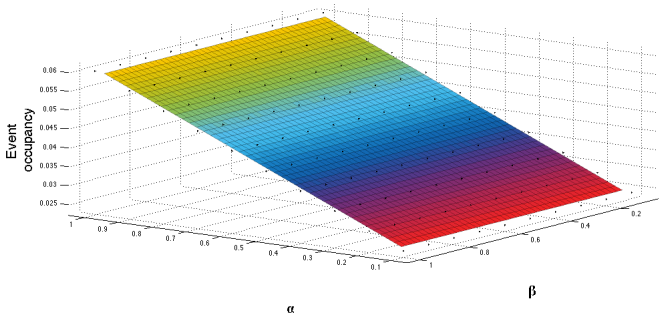

Fig. 6. Event occupancy for $\lambda_e = 0.8$ and $\rho_0 = 0.5$

off the continuous monitoring nodes in order to have empty slots that can be used by event reporting nodes. As such, some continuous monitoring data is no longer transmitted to the sink node (when the node is off) losing information. In this sense, the proposed mechanism is preemptive. To this end, we propose to use a Cognitive Radio Network composed of a primary network (the continuous monitoring nodes) while a secondary network (nodes in the event reporting scheme) uses the time slots not being used by the primary network. Note that continuous monitoring nodes always use their assigned time slot whenever they are actively transmitting. However, event reporting nodes have to scan all the possible channels in order to identify an empty slot and transmit their information.

It is important to notice that the time that a continuous monitoring node remains in the on and off modes has a major impact on the performance of the system. On one hand, the more time nodes remain in the on mode, more continuous information is relayed but event reporting nodes find less available channels

to transmit their information and viceversa. Building on this, we propose to use randomly exponentially distributed times for continuous monitoring nodes to remain in the on and off modes in order to study the system's performance. In more detail, continuous monitoring nodes remain active (on) an average time of $\frac{1}{\gamma}$ seconds while they remain in the sleep mode (off) in average $\frac{1}{\delta}$ seconds. This cognitive radio system is depicted in Fig. 7

The system performance is studied in terms of successful event reporting which reflects the capacity of the secondary network to find empty slots from the primary network. Additionally, the energy consumption is obtained.

For the successful event reporting, Figs. 8 and 9 present the probability that an event is successfully transmitted to the sink, i.e., the probability that a node in the secondary network finds an empty time slot to transmit its information. In these figures, it can be seen that as the average time that nodes remain in sleep mode increases (low values of δ) and the average time that nodes remain in the active mode decreases (high values of γ) the event reporting probability increases since it is more easy to find empty slots. Conversely, when δ is high an γ is low, there are very few opportunities to transmit event data. Comparing a scenario with low event reporting, such as the one presented in Fig. 8, to a scenario with high event reporting, such as the one presented in Fig. 9, it can be seen that in the successful event reporting decreases in a high event occurrence case. Again, this is because there are less available resources in the system. Note that the event occurrence (the value of λ_e) is determined by the specific condition of the patient and it is not a parameter controlled by the network.

It is important to note that the adequate value of the successful event reporting has to be set by the medical staff since they can adjust the value of δ and γ in order to have a functional system. For instance, for a particular patient, the medical staff can determine that a successful event reporting of 0.8 might be

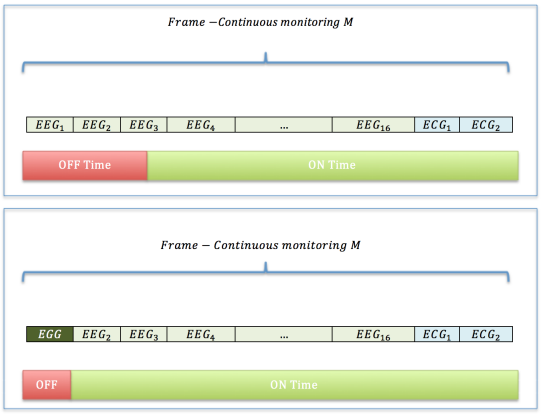

Fig. 7. TDMA-based protocol with ON/OFF processes

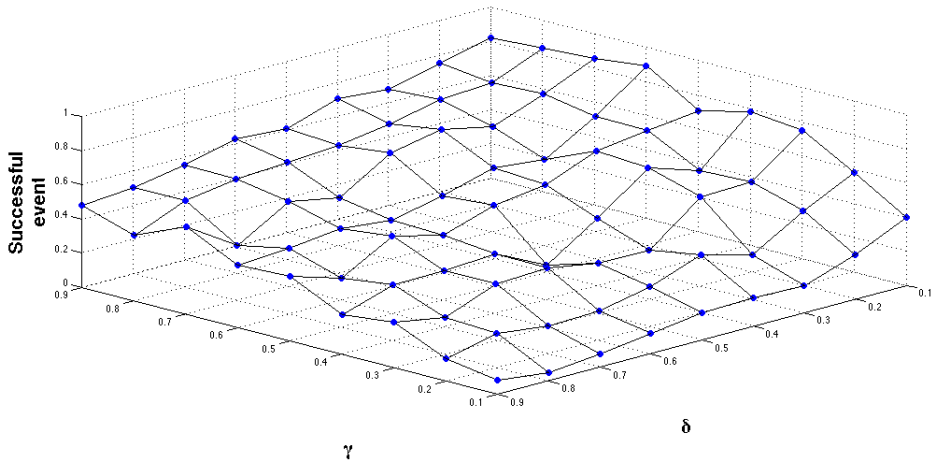

Fig. 8. Probability of successful event for $\lambda_e = 0.25$ and $\rho = 0.25$

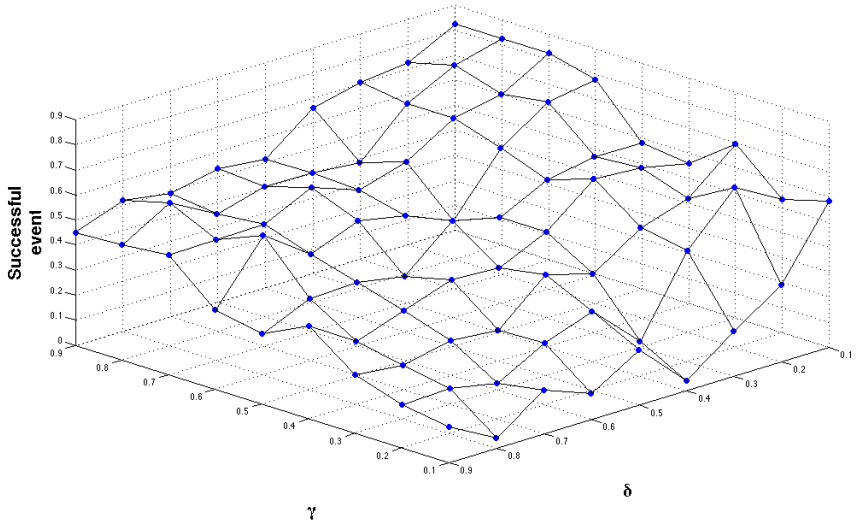

Fig. 9. Probability of successful event for $\lambda_e = 0.95$ and $\rho = 0.95$

sufficient, while other patient may require a probability of 0.9. These values may be adjusted according to the medical history or age of each individual patient.

As for the energy consumption, Figs. 10-12 show the energy consumption for the event reporting, for the continuos monitoring and the total energy consumption in the network respectively considering a value of $\rho = 0.5$ and different event arrival rates. The more that nodes in the continuous monitoring remain

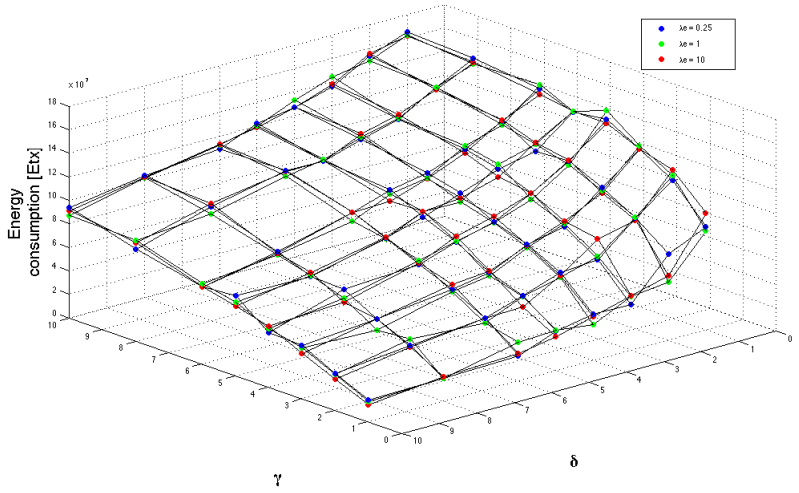

Fig. 10. Successful event energy consumption for $\rho = 0.5$

in the sleep mode the less energy they consume while the event nodes consume more energy since there are more event transmissions. And the same is true for the total energy consumption.

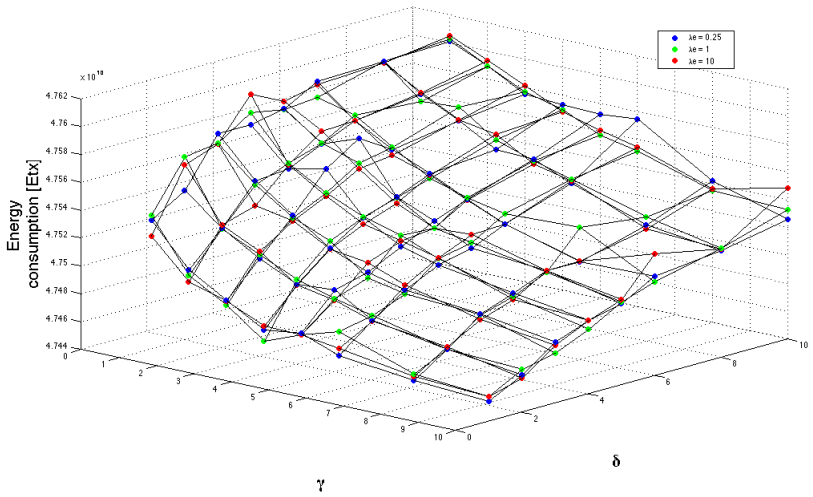

Fig. 11. Continuous monitoring energy consumption for $\rho = 0.5$

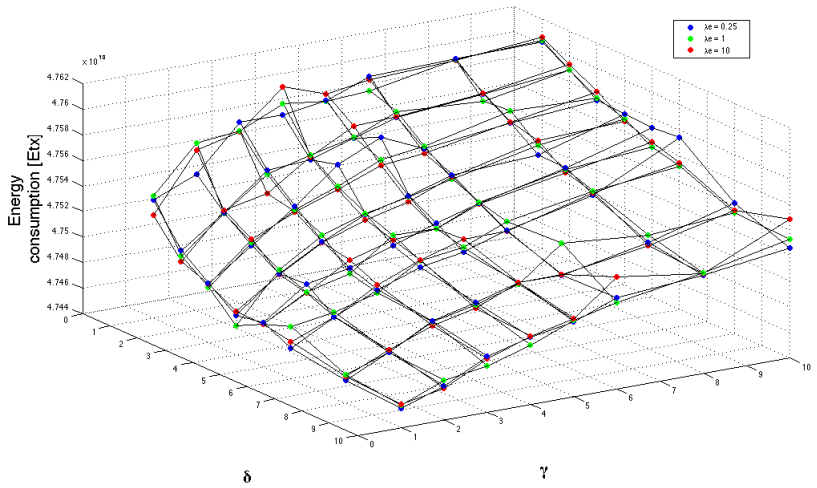

Fig. 12. Total energy system consumption $\rho = 0.5$

4 Conclusions

In this paper a hybrid wireless sensor network for the detection of epilepsy is proposed and studied. The network is capable of transmitting information regarding the EEG, ECG using a continuous monitoring scheme while the EGG signals are transmitted via an event detection scheme. Two different techniques are proposed. Namely a non-preemptive technique that does not lose information but produces bandwidth wastage and a preemptive scheme that allows some information losses but with a better channel utilization. The selected scheme in a practical implementation would heavily depend on the medical needs and conditions of the patients. The system is studied in terms of channel occupation, successful event reporting and energy consumption for different scenarios of event arrivals and event detection probabilities.

From the results obtained in this work, it can be concluded that both schemes, the preemptive and non-preemptive schemes are well suited for the transmission of the EEG, ECG and EGG signals. However, the non-preemptive scheme requires higher data rate transmissions while it consumes more energy and entails resources wastage while the non-preemptive scheme consumes less energy and uses more efficiently the data channels but it entails some information loss.

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Novel approach to eliminate discontinuities in phase unwrapping applied to Phase-Shifting Profilometry

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Abstract. In order to obtain the 3D information using fringe analysis, phase maps are required and must be recovered from the wrapped phase, so that phase unwrapping is a critical step in the optical measurement by fringe projection. The phase wrapping is the process that determines the values of phase in a range from 0 to 2π and the phase unwrapping is a process in which discontinuity of 2π is removed. Although the phase unwrapping removed of discontinuity of 2π, by several factors in some cases there are errors different to 2π, we propose a new approach to solve this problem by adding a post-processing step, which consist in search the number of sections that contains discontinuities and after these discontinuities are eliminated, the compensation of the values for each section is carried out. The wrapped phase map is extracted from the deformed fringe patterns by the use of Phase-Shifting Profilometry (PSP) technique and particularly using four-step algorithm. Our experimental results show that if the proposed approach is applied after the phase unwrapping step, then obtains better results than the obtained by only using a the phase unwrapping step. Here, the phase unwrapping algorithms; "Itoh Traditional", "Itoh inverse", "Graph Cuts" and "Simple unwrap" are applied to the PSP.

Keywords: Phase wrapping; Phase unwrapping; Phase-Shifting Profilometry; depth image; optical measurement.

1 Introduction

One of the best techniques used in the optical measurement is the fringe projection technique, which utilizes a group of defined fringe pattern (sinusoidal or periodic) projected from a digital projector to the object surface, therefore the object's shape creates distortions in pattern. Then the distortions are captured with a digital camera from another angle, and finally the image is processed to obtain the 3D information of surface [1] [2] [3].

Between fringe projection techniques, Fourier Transform Profilometry (FTP), Wavelet Transform Profilometry (WTP) and Phase-Shifting Profilometry (PSP) are the most used methods, each of them present diverse advantages and disadvantages with respect to other. For instance, when only one image is processed commonly the Fourier

Transform Profilometry is applied, which works as a spatial phase modulation of the pattern carrier with a fundamental frequency f0. Different phase demodulation algorithms can be applied to this carrier pattern. FTP extracts only the term of modulated phase through filtering spectrum, using one or two dimensions FTP and its inverse [1].

When is used more than one image pattern, the PSP algorithms are used due to its numerous advantages, point - by-point measurement (which allows the resolution level pixel-camera), less sensitive to variations in reflectivity surface (facilitating the measurement of complex objects with strong variations in texture) and less sensitivity to ambient light [1] [2][4][5]. In this research we only focus on the PSP technique.

There are numerous methods of phase-shifting in which stands out: "three-step", "four-step" and "double three-step". These methods differ in the number of input images, like the "three-step" approach will use 3 images, "four-step" will use 4 and so on.

To get the height of an object is necessary to obtain the information immersed into the phase; usually these information is wrapped into the phase. The phase modulation is the result of the deformed pattern, projected on the surface and the fringe pattern can be described by phase maps. By analyzing the phase maps, the 3D shape can be recovered [3].If more images are employed the quality of result will improve, but the runtime will increase. We consider that a good relationship runtime-quality is given by the 4-step method, therefore is the method that we select.

Two basic steps to the phase treatment are necessary, which are: the phase wrapping and the phase unwrapping. The phase wrapping is the process that determines the values of phase in a range from 0 to 2π. The phase unwrapping is a process in which discontinuity of 2π is removed to generate a phase map [6] [7] [8].

The phase wrapping can be expressed mathematically as:

$$x_W(n) = W[x(n)] \tag{1}$$

Where $x(n)$ is the original continuous phase, $W[\,]$ is the phase wrapping operation and x_W (n) is the phase wrapping [9].

Knowing that the phase unwrapping is an important part of any optical measurement numerous algorithms have been proposed to create better results in either response time or better resolution in measurements. For example "Itoh traditional", "Itoh inverse", "Graph cuts", "Quality guided", etc. [10].

2 Methodology

The PSP four-step used can be described as follows:

$$I_1(x,y) = I'(x,y) + I''(x,y)\,cos[\phi(x,y) + 3\alpha] \tag{2}$$
$$I_2(x,y) = I'(x,y) - I''(x,y)\,sin\,[\phi(x,y) + 2\alpha] \tag{3}$$
$$I_3(x,y) = I'(x,y) - I''(x,y)cos\,[\phi(x,y) + \alpha] \tag{4}$$
$$I_4(x,y) = I'(x,y) + I''(x,y)sin\,[\phi(x,y)] \tag{5}$$

Where $I'(x,y)$ is the average intensity, $I''(x,y)$ is the intensity modulation, $\phi(x,y)$ is the phase to resolve. In our case we consider α= pi/2.

$$\phi(x,y) = tan^{-1}\left(\frac{I_4(x,y)-I_2(x,y)}{I_1(x,y)-I_3(x,y)}\right) \quad (6)$$

As shown in Fig.1(a), a set of images with the different fringe pattern projected are acquired, then a pre-processing stage is applied to eliminate the angle distortion of the camera view, an image calibration by using an estimate geometric transform is performed. Later an equalization of histogram for each image is carried out. To obtain the phase map we use the Equation 6. In the next step the phase unwrapping is treated with different algorithms ("Itoh Traditional", "Itoh inverse", "Graph Cuts" and "Simple unwrap"). Finally to the best phase unwrapping algorithm is applied by using the new approach proposed in algorithms 1 and 2, as a post-processing stage.

Before to apply the proposed method to real objects, a simulation of the process by using depth images in grayscale is carried out to verify all equations without errors of calibration.

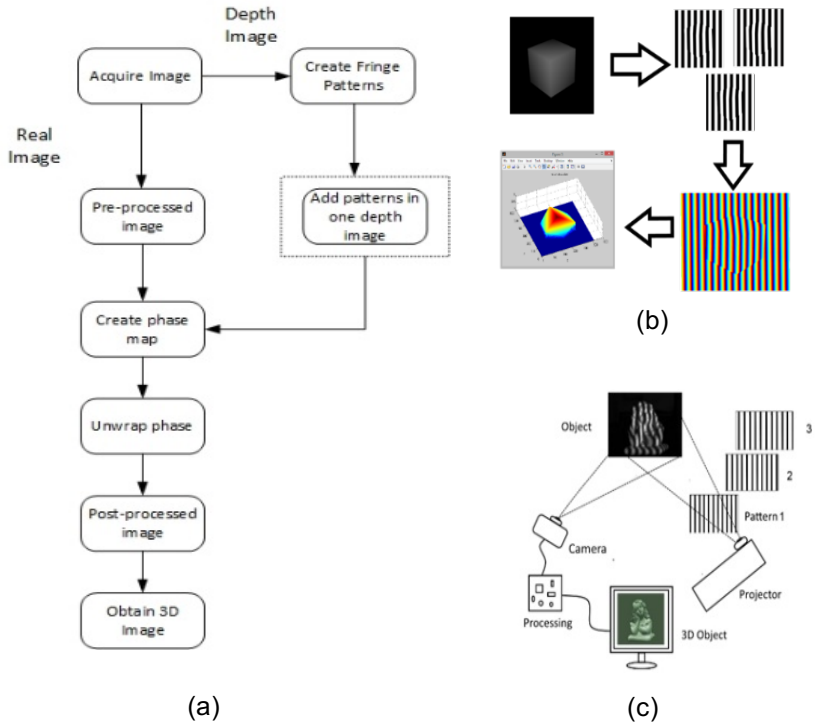

Fig. 1. (a) Methodology. (b) An example using depth images. (c) System architecture.

The complete process of PSP is simulated as if it were real objects (using depth image).In Fig.1(c) the real system architecture can be observed. Here, the sinusoidal

defined patterns are projected to an object, then the image is captured, after angle pattern will be shifting (usually 120 ° in case of three step and 90 ° in four step algorithm), then re-capture the image and so until get 3 or more images, the images being processed by using Equation 6 to obtain the phase map (contains the information of the height of the object), finally tridimensional object is obtained by the phase unwrapping. Fig.1(b) show one example using depth images where projected patterns are created artificially and is given the same treatment that used in images of real objects (except the calibration of the distortion angle).

To calculate error, we used the difference between the reconstructed image (pixel by pixel) and the three-dimensional representation of the depth image. In the depth image each pixel has a value of 0 (black) to 255 (white) which may be represented by a value from 0 to 1 (depth) to obtain the reconstructed image as in Fig. 2.

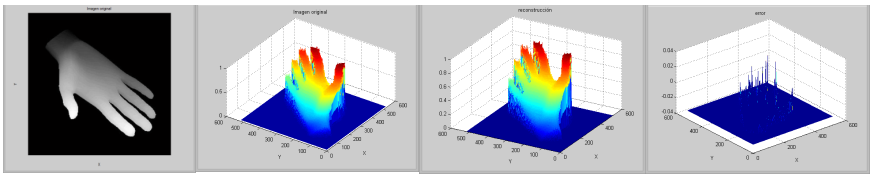

Fig. 2. (a) Example of depth image, (b) Three-dimensional representation of the depth image, (c) Reconstructed image using PSP, (d) Three-dimensional representation of the error.

2.1 Algorithms of phase unwrapping

Since there are many algorithms of phase unwrapping and the main authors differ which is more suitable, the most used were analyzed:

- **Simple unwrap.** This algorithm simply corrects the phase angles in a vector adding multiples of $\pm 2\pi$ when absolute jumps between consecutive elements [11].
- **Itoh traditional.** The algorithm of Itoh involves unwrapping the rows one by one to verify discontinuity between the values of the row, followed by an unwrapping in columns (same as one by one) [10].
- **Itoh inverse.** The algorithm of Itoh Inverse involves unwrapping the rows one by one to verify discontinuity between the values of the columns, followed by an unwrapping in row (same as one by one) [10].
- **Graph cuts.** The algorithm implemented for Phase Unwrapping via Graph Cuts use max-flow/min-cut calculations described by José M. Bioucas-Dia and Gonçalo Valadão in 2007 [12].

Fig. 3 shows the results evaluating the most common algorithms of phase unwrapping with three different test objects (a fish, a box with a half disposable cup and one mask), Fig. 3(a) shows the result of applying a simple unwrap algorithm, Fig. 3(b) shows the result of applying the Itoh traditional algorithm, Fig. 3(c) shows the result of applying the Itoh inverse algorithm and Fig. 3(d) shows the result of applying the Graph

cuts algorithm. At the end of the test the best results are given by the Graph cuts algorithm. Although the phase unwrapping removes the discontinuity of 2π, in some cases there are errors different to 2π creating sections with jumps in the image, therefore we propose a post-processing stage to solve this problem. At first instance by finding the sections where jumps occurred through a reference line and are evaluated pixel by pixel to check the discontinuity, if one discontinuity is founded, its value is store in a matrix (with the pixel position and value where occurred the discontinuity) then all values of discontinuity are eliminated for each section compensating the value with one sum. The methodology is completely described in the algorithms 1 and 2.

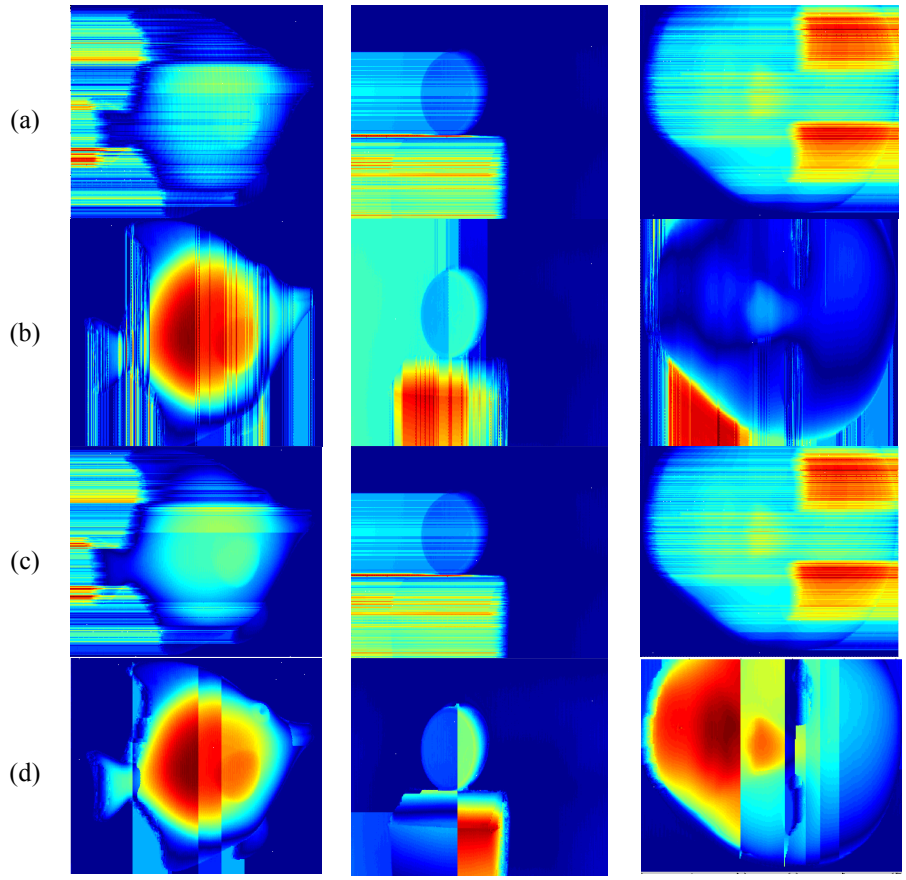

Fig. 3. The results evaluating the most common algorithms of phase unwrapping with three different test objects (a fish, a box with a half disposable cup and one mask), (a) Simple unwrap, (b) Itoh traditional, (c) Itoh inverse, (d) Graph cuts.

Algorithm 1: Find sections

input wi =unwrapping image (M x N)

```
1:   // Define  reference line
2:   line = wi (number of row cross section , :)
3:   number of sections = 0
4:   for i = 2→N
5:           current pixel = line (i)
6:           previous pixel = line(i-1)
7:           discontinuity = current pixel – previous pixel
8:           if discontinuity > threshold
9:                   number of sections ++
10:  // border values are stored
11:                  Section Value(number of sections, 1) = i
12:                  Section Value(number of sections, 2) = i - 1
13:                  Section Value(number of sections, 3) = discontinuity
14:          end if
15:  end for
16:  Section Value(number of sections +1,2)= N;
```

Algorithm 2: Delete discontinuity

input wi =wrapping image (M x N), *line = wi (M/2 , :), Section Value(:,1) = previous pixel to discontinuity, Section Value(:,2) = next pixel to discontinuity, Section Value(:,3) = value of discontinuity*

```
1:   e = discontinuity to fix = 0
2:   if number of sections > 0
3:           for j = 1 → number of sections
4:                   v1 = Section Value(j,1)
5:                   v2 = Section Value(j,2)
6:                   e = Section Value(j,3)
7:                   for l =1 →M
8:   // linC = line to correct
9:                           linC = wi (l , :)
10:                          for k = v1→v2
11:                                  linC(k)=linC(k) -e
12:                          wi (1 , :)= linC
13:                          end for
14:                  end for
15:          end for
16:  end if
```

Finally the image with discontinuity is corrected but to correct the background it is necessary to apply a mask created from raw data.

3 Experimental results

A set of four images which contain a real object were considered [13] and are shown on Fig. 4 where four different shifting angles of the fringe pattern are projected to a fish. Another set of images were taken and are shown on Fig. 5. These images are ideal to observe a discontinuity error different to 2π such as shadow effect inherent in projection, on-uniform reflectance but a good calibration of projection. In the phase map is evident this aspects as Fig. 6 that show the difference between a good and bad calibration as well as the shadow effect.

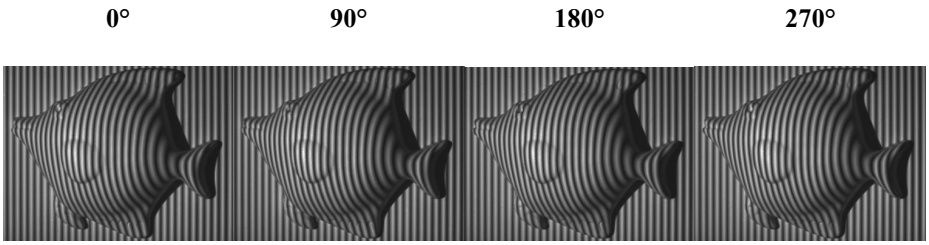

Fig. 4. Patterns projected to a fish taken of data raw of Chen Lujie [13].

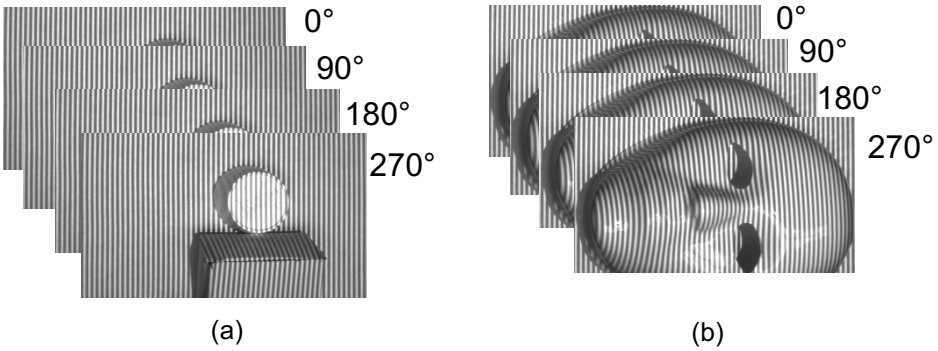

Fig. 5. Images taken for us, (a) Patterns projected to a box with a half disposable cup, (b) Patterns projected to a mask.

The Computer used to carry out the experiments is a Lenovo Y510p with 8GB of RAM, Intel® Core™ i7-4700MQ 2.4GHz and Windows 8.1 64 bits. The algorithms were implemented in Matlab R2013b. In the experiment system, the sinusoidal fringe patterns was generated by Acer K11+ with native resolution of 858 X 600 (SVGA) and 200 lumens and capture by DAVID-CAM-3-M with 1280x960 of resolution.

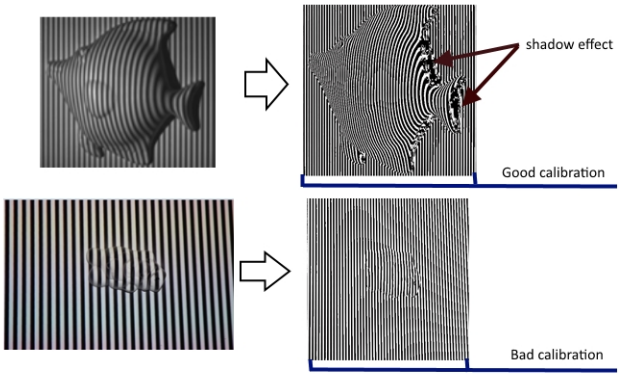

Fig. 6. Examples of shadow effect, good and bad calibration of projection.

The different test objects are a fish, a box with a half disposable cup and one mask. Fig.7 shows the comparison between the phase unwrapping before and after the algorithms proposed were applied, also shows the reference line (96th row cross section) where the jumps are more noticeable, moreover it is shows the 3D reconstruction as a mesh and a surface. It can be observed that the most of the discontinuity errors were eliminated with the algorithms proposed. Only persist the error in the background of each image but not in surface in the test object.

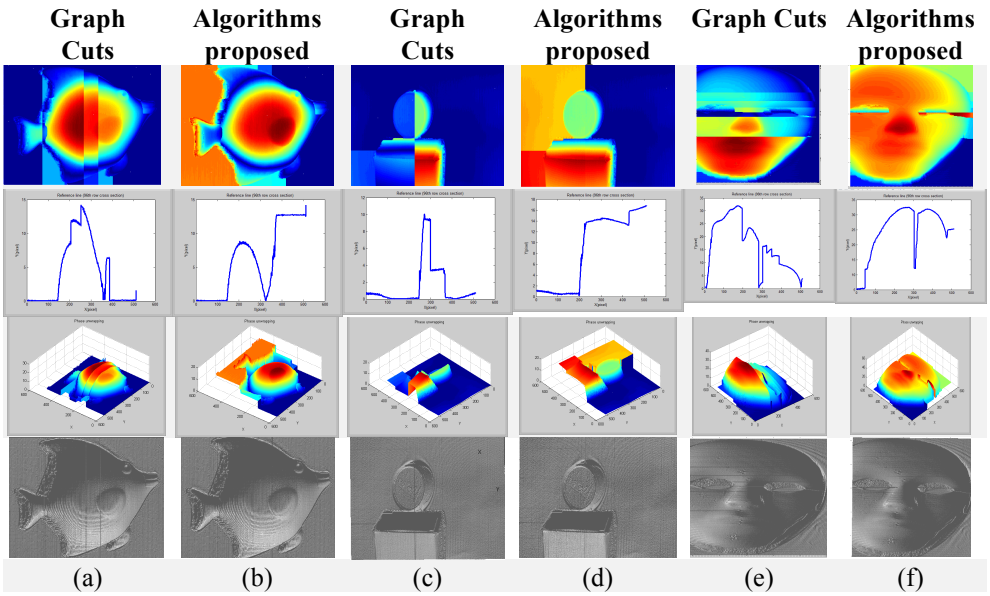

Fig. 7. Comparison between the images before of the algorithms proposed ((a), (c), (e)) and after the algorithms proposed ((b), (d), (f)).

4 Conclusions and Future Work

This research described as use the Phase-Shifting Profilometry to obtain tridimensional information (particularly four-step method) through each stage; pre-processing (where the image will be adequate for the future processing), phase wrapping (stage where extracted the phase information using PSP), phase unwrapping (process in which discontinuity of 2π is removed to generate a phase map) and post-processing (stage where we propose two algorithms to eliminate the discontinuity after of phase unwrapping).

Moreover, a novel approach can be described as the elimination of the discontinuity different to 2π (applied to PSP) caused by bad calibration, noise in the image and shadow effect. This discontinuity is achieved by finding and correcting each section of discontinuity. The new approach are divided in two algorithms after of the phase unwrapping, the first algorithm finds all the sections where there are jumps inside the image and the second algorithm compensates the discontinuity with only one sum. The proposed algorithms are simple to implement and show more accurate results in the surface of the objects than previous works presented, in which only a simple unwrapping algorithm is used. Finally in the new approach only persist the errors in the background but eliminates the errors in the surface.

As future work it is proposed to implement the algorithms in an embedded system based on the ARM processor and improve post-processing adding a mask to remove background noise. Also correct the error in the background through a mask from raw images or using a quality-guided method.

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Noise-reduction method based on color channel discrimination applied to laserline 3D reconstruction

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Abstract. In this paper, we present a noise-reduction method which relies on a RGB model, which most imaging device by default has, and the laser-line colors commonly used for image processing such as digitizing. It was observed that there is a white line on the projected surface and the noise could be interpreted as the light's laser color. We proposed an approach using the standard format RGB where the two color channels different to the laser color are used and tested along three different threshold values as a pre-processing methods for noise-reduction on surface reconstruction. We digitized six different objects, adding a linear interpolation, and comparing the results against the border detection method. As a result, the proposed approach was faster using almost the same number of points and its reconstruction was smoother compared to the border detection method. This could lead to a light algorithm for noise-reduction not requiring heavy methods unavailable in some languages.

Keywords: noise-reduction, laser-line, digitizing, RGB model, surface reconstruction.

1 Introduction

In this paper it is proposed a method for noise reduction focused on the color channels, resulting in a very light algorithm consuming less resources and having faster performance in the preprocessing step for noise-removal and binary image generation, which could be implemented along with more complex steps for digitizing methods.

There are noise reduction methods that use statistical, probabilistic, calibration [1], or primitive matching [2] approaches, some even go far by adding a training module for pixels which uses Gaussian Mixture Model, k-means clustering and covariance [3], making it a heavier algorithm. Such methods are implemented in modern desktop and specialized computers, however other less developed and limited systems such as microcontroller development boards or mobile devices could have slow processing.

It has been the standard that most image capturing devices employs the RGB color space, which is also the same color space used in the laser-line surface reconstruction.

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When the laser-line is projected over a surface, it is noted there is a white line that by additive color is the result from the max value of all color channels. When a channel representing the same as the laser-line color was set to zero, the resulting image has a more defined line with lesser noise which is later converted to a grayscale image.

To binarize the image, three different methods were tested, Otsu's method [4], Kapur (or maximum entropy) [5], and a basic differentiation for an array. Applying such methods to a set of images it was found its global threshold. With the threshold found, the binary step was applied and the binary image reduced to one single pixel thick. This thickness was found by average of the pixel's position, and for the gap in the images, it was used a linear interpolation that always fills each gap found in the line, thus forming a false surface.

With each range image as a bi-dimensional matrix it was possible to map the position for each voxel in a 3D space once we get its rectangular form.

With the rectangular form of each point in the matrix, the mesh was formed letting to have a visual representation of the point cloud where it was possible to make an esthetical comparison between each result from a similar method [6].

2 Color and Image Devices

Image devices and sensors, both works as a radiation convertor into electrical signal [7]. This is because the "color" perceived by the human eye is in reality radiative energy absorbed or reflected by the different materials surrounding us. This creates a wavelength where at a certain level a color is perceived, this wavelength is known as the visible spectrum, measured in nanometers. This spectrum goes from 380nm to 740nm, any value over or below these values goes unperceived by the human eye, however the image sensors are different. Image sensors (commonly CCDs) work by accumulating electrical charges proportional to the intensity of received light [8], this is done with a photo-cells set that follow a pattern of Green, Red and Blue to produce an image, these produced images can be altered by wavelength not perceived by the human eye, being a reason it could give some undesired data.

Most image sensors use the RGB format, which it is named after R (Red), G (Green) and B (Blue) since it simplifies the design and architecture of the system which can take advantage of a large number of software routines due this space color has been around for years [9] and can also be transformed to other color spaces, however this space is limited to the number of bits used to store an image, 8-bits is the most common.

However, there have been a numerous color spaces and variations of RGB, where some color space model is used to reduce the effects of white ambient light [3].

3 Proposed Approach

The whole algorithm for surface reconstruction is shown in Fig.1. Said method was first tested on a ceramic bell painted in black shown in Fig. ***2***. The distance between the object and the camera is 30 cm, while the camera and laser had 25 cm distance and a 90° between said distances. Once the system is setup, then the lights are turned off leaving a dark room where a finite number of images are captured. The image set is

loaded and cropped into an interest region to get the object's center, leaving a shorter image reduces the time used in the processing required in each step. To get a better data of the line, the channel corresponding to the laser line color is set to zero, from there the three color channels are reduced to one single channel (grayscale image) to later get the binary image with an integer number as a threshold. Such value was found by applying a threshold selection method, among three different methods: Kapur, Otsu and the basic differentiation.

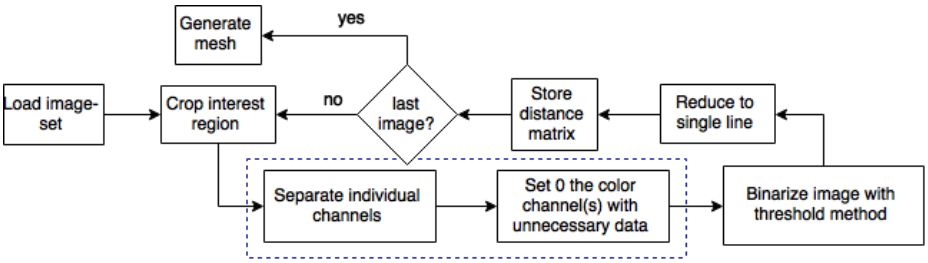


Fig.1. Flown diagram of the whole algorithm, the marked part is the proposed approach.

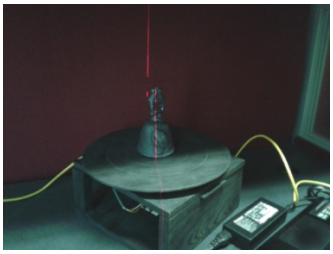


Fig. 2. One of the used objects was this ceramic bell. The rotatory platform was manually operated.

First tested method was a basic differentiation where one vector v with size n returns a vector v' with size n-1 where each element i is the result of subtracting the i element from the next i element, Equation (1):

$$v'(i) = v(i+1) - v(i) \tag{1}$$

First method had unsatisfactory results since sometimes the selected threshold yields a high value giving a totally black image, or with a low value gives a distorted image.

Second method, Equation (2), was Otsu's method [4] which is one of the most employed threshold selection methods:

$$\omega_0 = \sum_{i=1}^{t} p_i \qquad \omega_1 = 1 - \omega_0$$
$$\mu_0 = \frac{\sum_{i=1}^{t} i * p_i}{\omega_0} \qquad \mu_1 = \frac{(\sum_{i=t+1}^{N} i * p_i) - \mu_0}{\omega_1} \tag{2}$$
$$\max\left(\sigma_w^2(t)\right) = \omega_0\omega_1(\mu_1 - \mu_0)^2$$

Where the t variable is the threshold value currently evaluating while N is the maximum value in the range the pixel can take, or as in RGB model this is 255 (meaning t

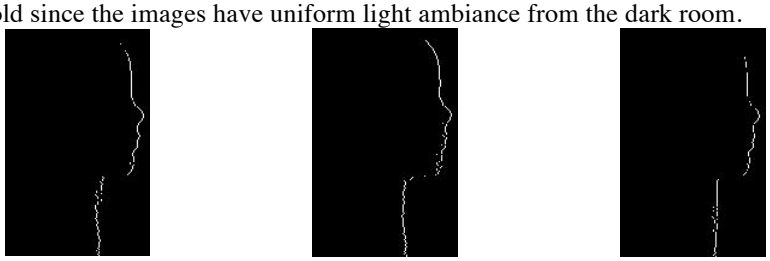
goes from 0 to 255), and p values are the probability obtained from the image's histogram, being ω_0 the cumulative probabilities from 1 to t while ω_1 from $t+1$ to N, similarly μ_0 and μ_1 are the cumulative moments of the histogram. The optimal threshold is the maximum variance σ_w^2.

Third method, Equation (3), was the maximum entropy [5], using the same variables as Equation (2) it is added the log of the probabilities, resulting in:

$$H_f(t) = -\sum_{i=0}^{t} \frac{p_i}{\omega_0} log \frac{p_i}{\omega_0}$$
$$H_b(t) = -\sum_{i=t+1}^{N} \frac{p_i}{\omega_1} log \frac{p_i}{\omega_1} \quad (3)$$
$$t_{opt} = \max (H_f(t) + H_b(t))$$

The maximum value of the sum of both entropies H_f & H_b, is the selected threshold.

By comparing the results, Figure 3, from each method, it was selected the Otsu's method with a complexity of O (N), this because even though some images had a few distortion, the Kapur method had a considerable loss in information, while the differential method sometimes had a completely black result. It was employed a global threshold since the images have uniform light ambiance from the dark room.



(a) (b) (c)

Fig. 3. Results from the reduction to a single line after getting the binary image from each threshold. (a) differential; (b) Otsu's method; and (c) maximum entropy.

As it is shown in **Fig. *4***, the binarized image gives better results when two channels are used instead of three when the threshold method, Equation (4), is applied.

$$f(x,y) \begin{cases} 0 \; or \; false, & p(x,y) \leq u \\ 1 \; or \; true, & p(x,y) > u \end{cases} \quad (4)$$

Where $p(x,y)$ is the current pixel in x,y and u is the global threshold value.

To reduce to a single pixel the center's line was calculated by using Equation (5). As a measure to get the correct center's object, a c corrective constant is added to address possible distortion in depth due the laser-line was a little off the center in the object since the system is not in a fixed position and the camera is not completely centered on the object due lack installations in the workplace requiring to assemble the system from zero each time it was used. This c corrective constant was found by heuristic ways.

$$md(x,y) = \frac{\sum p(x,y) * x}{\sum p(x,y)} + c \quad (5)$$

md is the distance matrix; p is the current pixel and c is the constant factor to rectify the depth.

For the missing data in each line, a linear interpolation, Equation (6), is used, it searches for the rows where there are only zeroes after the first pixel in the image is

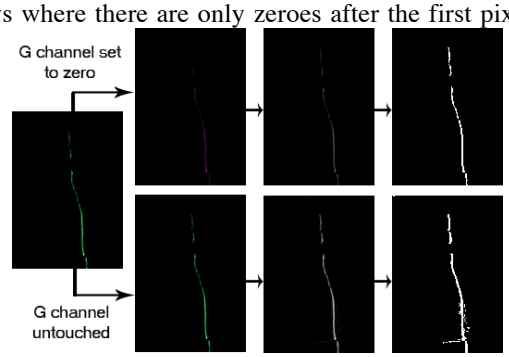


Fig. 4. Results from making color channel representing laser color equal to zero. As it is shown the noise is reduced when two channels are used instead of three.

found until the last one, once identified it takes the rows after and before each column with missing data, and makes use of those two points by using its x and y values and takes the slope from the first known value pixel in the interval as the missing value.

$$md(x,y) = (y - y_e + 1) * \frac{md(x_l, y_l) - md(x_e, y_e)}{y_l - y_e} + x_e \quad (6)$$

Where:

- x_l & y_l *: are the later known x and y position.*
- x_e & y_e*: are the earlier known x and y position.*
- x & y*: are the current x, y position of the missing pixel.*
- md*: is the distance matrix.*

The result for each described step until now is shown in **Fig. *5***. As it appears in (b), the binary image is almost identical to the original image (a), and the result for the line reduction (c) gives a slight deformation. However, since the filling gap is made to totally seal the model, any hole in the object will be given a false surface (d), requiring a better method for more complex objects where holes are part of said object.

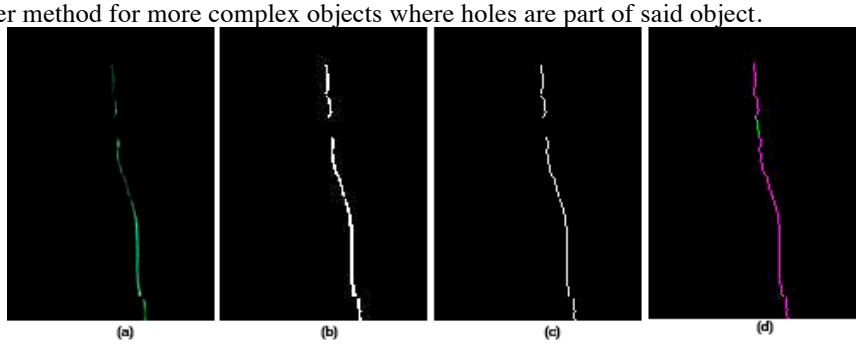


Fig. 5. Results from each step in the proposed approach. (a) original image. (b) binary image, (c) single line reduction. (d) interpolation.

Finally, with the distance matrix completed, each value in the matrix is converted to rectangular form (7).

$$x = D * cos\theta \quad (7)$$

$$y = D * sin\theta$$

Where D is the Matrix value and θ the displacement angle.

Applying the triangulation principle for surface reconstruction, the mesh is then generated by using the distance matrix in its rectangular form.

The used computer is described in Table 1 listing some technical aspects like CPU, GPU and RAM. The camera was a digital camera Lumix brand. And the whole algorithm is shown in Algorithm 1 as pseudo code for surface reconstruction which can be implemented on a variety of systems, being this algorithm one contribution of this paper.

Table 1. Hardware specs.

Hardware	
Processor	Intel® Core™ i7-4700MQ CPU 2.4 GHz.
Memory (RAM)	16.0 GB.
GPU	NVIDIA GeForce GT 755 M
Camera	Digital Camera Lumix

Algorithm 1: Algorithm for surface reconstruction

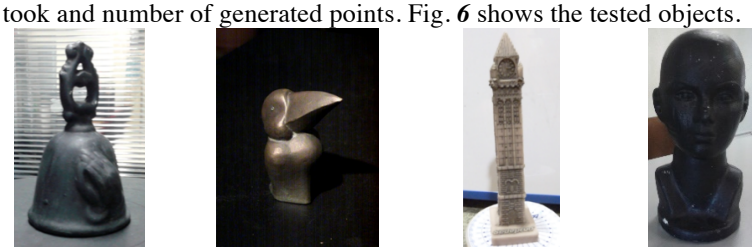
Load n images (p); interest region [x1:x2] & [y1:y2]; dm[n, y2-y1]=NaN; c=distance between laser-line and object's center; θ[n]; U=threshold

1: **for** i=0 until n
2: ***Cut interest region*** x2:x1 & y2:y1
3: ***Matrix channel equal Laser-Color*** (LC), i[:,:,LC]=0;
4: Convert to grayscale
5: Binarize according threshold U: p(x,y) $\begin{cases} 0, & p(x,y) \leq U \\ 1, & p(x,y) > U \end{cases}$
6: **for** k=0 until y2-y1 **do**
7: pd=$\frac{\sum p(xp,k)*xp}{\sum p(xp,k)} + c$;
8: **if** pd>0 **then**
9: dm[i,k]=pd;
10: **end if**
11: **end for**
12: **for** k=first known position(x_l, y_l) of dm[i,k]!=NaN until last known **do** (x_e, y_e)
13: **if** dm[i,k]==NaN **then**
14: dm[i,y]= $(y - y_e + 1) * \frac{md(x_l,y_l) - md(x_e,y_e)}{y_l - y_e} + x_e$;
15: **else**
16: find next missing interval
17: **end if**
18: **end for**
19: **end for**
20: deg=360/n;
21: **for** k=0 until n **do**

```
22:       θ[k]= deg*π / 180;
23:  end for
24:  for i=0 until n do
25:       for j=0 until y2-y1 do
26:            X[i,j]=dm[i,j]*cos(θ[i]);
27:            Y[i,j]=dm[i,j]*sin(θ[i]);
28:            Z[i,j]=j
29:       end for
30:  end for
31:  Build mesh with base matrices X, Y & Z.
```

4 Experimental Results

A similar method [6] was taken as comparison which uses also RGB as basis, although the method couldn't be completely implemented since there was no underwater nor more complex system with four color lasers at disposal, the core for noise-reduction relies on an edge detection method as a common method [10], a subtraction for noise reduction for each color channel, and the interpolation method (6) for missing data. Results are shown in **Fig. *7*** (a), (c), (e), (g), (i) and (k). With the proposed method, the noise reduction essentially uses only two color channels. And its result are shown in **Fig. *7*** (b), (d), (f), (h), (j) and (l), while the **Table *2*** contains the number of used images, time it took and number of generated points. Fig. ***6*** shows the tested objects.



(a) (b) (c) (d)

(e) (f)

Fig. 6. Tested objects: (a) bell, (b) raven, (c) tower, (d) polystyrene head, (e) pig & (f) skull.

Finally it was made another digitizing with the bell and head, Fig. **6** *(a) & (d) respectively. This time with 256 images and subsets for both objects, using both methods where it was measured the time and points between both and the results are shown in*

Table *3* and **Table *4***.

In this new reconstruction both objects were better represented. In the bell the hands appearing in Fig. ***6*** (a) are more defined, while the head had a better definition, notably

in the ears when comparing **Fig. *7***(j) against **Fig. *8***(d). The 3D reconstructions by using 128 and 64 images also show defined objects, while using 32 images and less have an object without a defined curvature from the base and instead were too squared.

Table 2. Results for each reconstruction with proposed method

Object	Images	Threshold	Time	Points
Bell	36	5	5.947295 seconds	5364
Raven	56	15	10.844818 seconds	13982
Tower	72	8	3.890804 seconds	12159
Pig	64	25	7.143672 seconds	9534
Head	64	15	8.713225 seconds	10918
Skull	256	10	15.574079 seconds	36714

Table 3. Results from bell object

Bell				
	Border Detection		Proposed Approach	
Images	Time	Points	Time	Points
256	25.311303 sec.	36218	14.12059 sec.	36288
128	12.910331 sec.	18100	6.284609 sec.	18137
64	6.721035 sec.	9051	3.475062 sec.	9064
32	3.600887 sec.	4527	2.034301 sec.	4529
16	2.323144 sec.	2256	1.284535 sec.	2255
8	1.493166 sec.	1116	0.947402 sec.	1116

Table 4. Results from head object

Head				
	Border Detection		Proposed Approach	
Images	Time	Points	Time	Points
256	26.103478 sec.	42541	12.053969 sec.	43050
128	12.536345 sec.	21246	6.207357 sec.	21523
64	6.957200 sec.	10618	3.535140 sec.	10764
32	3.857809 sec.	5300	2.007538 sec.	5360
16	2.237772 sec.	2642	1.356919 sec.	2680
8	1.494562 sec.	1299	0.937214 sec.	1320

As it is shown in the results, while both methods had almost the same points, the time with the proposed method was almost half the time the border detection method in all cases as it is shown in **Fig. *8*** where the 256 images were used.

5 Conclusion and Future Work

This paper presents a novel approach for noise reduction using the data from just two color channels from the RGB space color model for laser based images, and a whole algorithm for surface reconstruction. This method was tested along a linear interpolation on six different objects, resulting in a sealed surface reconstruction not letting any holes even if the original object had them.

By applying the proposed approach it is possible to reduce the time in the pre-processing phase, therefore, improving the computing time performance in comparison with previous work. It was found with 64 and more images the object's features could be seen or noticed in the reconstruction and the object is almost rounded meaning it works with some curved surfaces, while with less than 64 the result is an almost squared object.

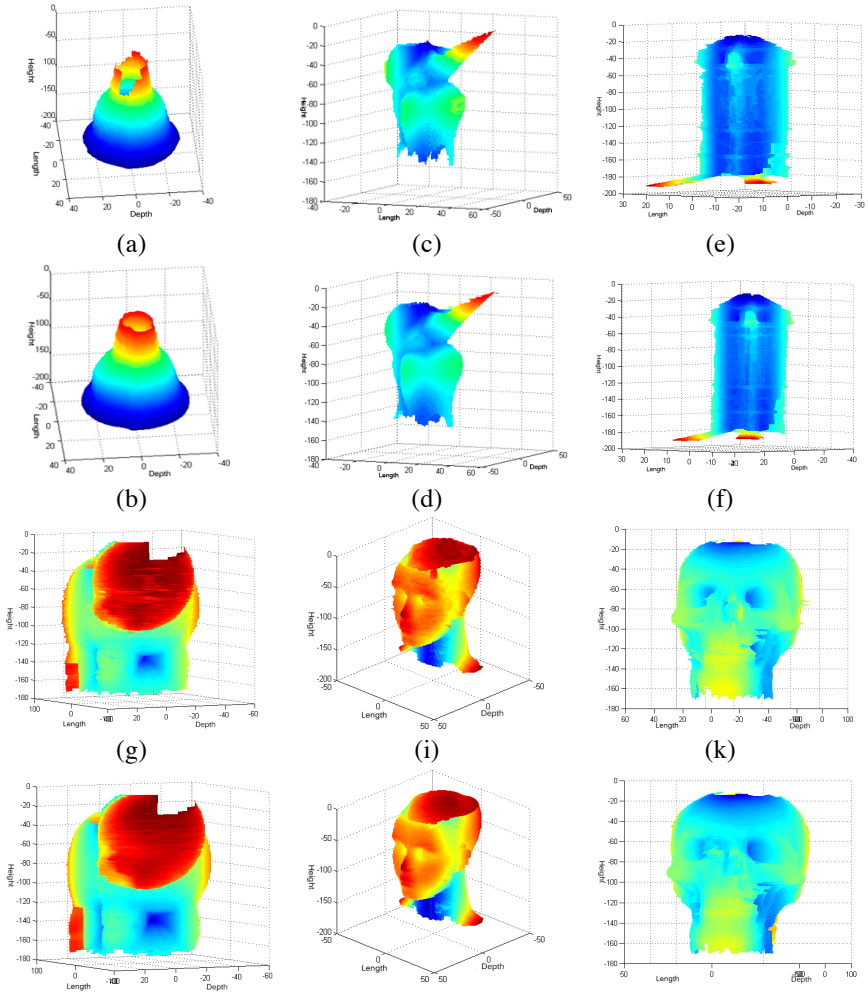
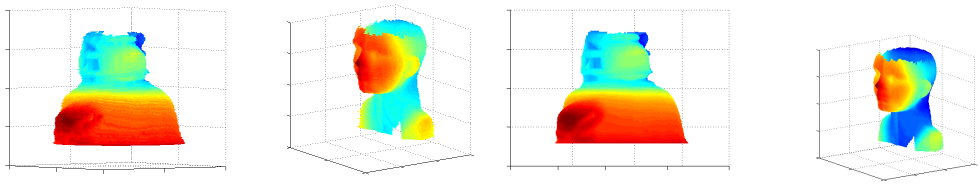


Fig. 7. Reconstruction results with both methods using in (a) and (b) bell, (c) and (d) raven, (e) and (f) tower, (g) and (h) pig, (i) and (j) head, (k) and (l) skull. (a), (c), (e), (g), (i) and (k) were made with the edge detection method, (b), (d), (f), (h), (j) and (l) with the proposed method.

Since the RGB standard model has a limited range and not the most accurate model to represent the color spectrum of the human vision, the method could be tested with more color spaces such as XYZ, HSV, HSI, YCbCr, CIELuv, CIELab, etc., expecting to

obtain results with less noise. By using different space colors it is expected to get a narrow range for the threshold.



(a) **(b)** **(c)** **(d)**

Fig. 8. The surface reconstruction with 256 images. (a) and (b) were achieved with the detection border method. (c) and (d) with the proposed method.

And finally implementing it in a less powerful system, being a reason this method is proposed since it is going to allow a reconstruction system by employing different devices not necessarily a personal computer, but could be employed a mobile devices and microprocessor based embedded development boards.

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Sandbox UFPS - cloud development platform for server management, creation and deployment of web applications of academic use

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Abstract. This work consists in the implementing of Sandbox UFPS, this is a development platform in the cloud and server management for academic use, which allows the administration, configuration and deployment of web applications, making use of web technologies such as PHP, Python, JSP, .Net (apache, tomcat, glassfish, IIS) and servers of relational and non-relational databases (MySQL, PostgreSQL, MongoDB), to be used by students and teachers of the Systems Engineering program at Universidad Francisco de Paula Santander. The process of development of this platform was carried out, first identifying the needs, tools and services used in development of this type of applications, then implementing, documenting and testing these services obtaining an integrated platform where students can create your projects, within each project the students can deploy different instances of servers and tools as they need; and using version control GIT (GITLab) for a collaborative work. The benefits are significant, students can deploy and host web applications in just a few steps, learn to configure, install their web applications and have a development environment close to what they will find in their working lives. To improve availability, backup and security of the information handled by Sandbox, a load distribution between machines is being designed and implemented to offer efficiency that allow to use the advantages of cloud computing and improve the development platform.

Keywords: Cloud computing, platform as a service, scrum, server management, web applications.

1 Introduction

The National Institute of Standards and Technology (NIST) US defines cloud computing as a model that allows access to the network, to request and a convenient way, to a shared group of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be implemented quickly with minimal management effort or interaction of the service provider [1]. The definition formulated by

George Reese is [2]: "The cloud is not just a fancy way of describing the Internet. While the Internet is a key foundation for the cloud, the cloud is more than just the Internet. The cloud is where you go to use technology when you need it, as long as you need, and not a minute more. You do not install anything locally, and do not pay for the technology when you are not using it. "In this way, the Cloud becomes a service that we can consume under our own needs.

The services offered may consist of hardware or software, or a combination of both, and is conceptually in the Cloud online. Another factor contributing to the concept of the Cloud by its intangible essence is the fact that neither the user nor the developers know where or how your service is hosted (and certainly do not need to know). Or perhaps even the provider of cloud services could determine immediately where is an instance of the services within its data center [3]. Joyanes in [4] sets out in clear terms the Cloud Computing model makes a description of their architectures and outstanding models. It emphasizes that the cloud is the technological platform per excellence of this decade and the future of computing.

A study by Gartner [5], pose a magic quadrant where are detailed the infrastructure providers in the cloud leaders today (2014). It can be seen that leaders are Microsoft with Azure and Amazon Web Services being the last one the most important in the market; Google appears in the visionaries' quadrant and evolving away from Azure and Amazon. Then the major computing platforms are defined in the cloud.

Amazon Web Services: Provides a wide range of computer services, storage, databases, data analysis and big data, applications and implementations that help organizations to move quickly, reduce IT costs and scale applications [6].

Google Apps: is a set of messaging and collaboration software for businesses. The main services are offered in Google Apps are: email (Gmail), instant messaging (Google Talk), calendar (Google Calendar), document management (Google Docs) and site management (Google Sites). Google also offers REST API services which are called the Google Data API for programming not only for Google Apps, but also for other web services offered by Google as Google Maps, YouTube and Google Health. It focuses on software as services (SaaS).

Google App Engine: Corresponds to infrastructure (IaaS) and platform as a service (PaaS) of Google. It is an environment for developing and deploying web applications on Google's infrastructure. The App Engine supports Python and Java as the main programming languages, automatic scaling and load balancing. It also provides a data warehouse that allows to create, retrieve and delete functions and data, provides Google Data APIs to access to the components of Google Apps such as mail, calendar, search and Docs.

Microsoft Azure: A computer and Internet services platform hosted in data centers managed or supported by Microsoft. It includes many independent features, with relevant services to developers that can be used separately or together [7]. With Azure is possible to build, deploy and manage applications quickly. They can be integrated the applications in the cloud with existing traditional IT environment. Azure has 4 main models for building and running applications: 1) Virtual machines, 2) Cloud Services, 3) Websites and 4) Mobile services.

The references are few who are in academic applications of cloud computing, in Colombia EAFIT University has a datacenter which offer development environments to students, access to virtual machines and different services and infrastructure and platform tools as service [8]. Universidad de los Andes - Colombia, in its lab Computer and Systems Engineering, has a server system for managing computer projects oriented to students' thesis or computer projects, offer virtual machines, access to databases, storage and specialized software [9].

Knowing the definition of cloud computing, services offered and major suppliers, can now contextualize the problem that is showing in the development of projects semester and graduation projects of students in Systems Engineering at The Francisco de Paula Santander University, in these works students implement computer solutions that solve problems for companies in the region. These works are essential because these developments allow students to learn to conceptualize the theoretical with the praxis, thereby making more complete and competitive learning. They have been presented loss of information (source documents and model codes), delay in deploying applications, collaborative work difficulty, and difficulty in getting the servers to deploy applications. Hence the idea of developing this platform arises. The concept of Sandbox responds to a separate test environment from the production environment, taking this definition to this context we can say that Sandbox is a development platform in the cloud where students find development tools and deployment of web applications.

Sandbox was created as an alternative for students where they can develop, deploy, test and manage their applications without having to rely on payment of a hosting or servers shifts at the University or rely on the availability of administrators. This idea was born in the Systems Department of the university in the second half of 2011 using technologies such as PHP and JSP with relational databases PostgreSQL and MySQL, a year later students of the subject Web Applications make as project of it Tools that would optimize the platform, is how in the second half of 2012 these tools are integrated into the platform and give more strength to the project. Due to the success of these implementations the need to give more coverage to the tool was seen, by which is chosen to take a model of successful cloud, and it is to simulate the implementation by Amazon Web Service (AWS) it is thus a platform for the administration of development on a cloud environment is created, which is available anytime and anywhere, allowing to develop, configure and deploy applications using different tools and services, saving time and money to students. This development can be replicated and used as reference for software development companies both nationally and internationally.

In this article, section 2 shows the research work methodology, then Section 3 presents the results and functionalities are specified and services offered by the platform UFPS Sandbox, finally the findings and the profits are set.

2 Methodology

The research carried on this project is the Applied Technological Research, Padrón [10] states that: 1) it starts on a problematic situation that needs to be tapped and improved. The situation is systematically described under relevant criteria, it starts from some theories that help solve the problem, and a prototype which is verified and validated so that solves the problem situation is proposed, finally give conclusions and recommendations. In this case the problem situation corresponds to the development, deployment and configuration of web applications from Systems Engineering students, which is important to improve, control and manage, the theories that will be used to improve the situation are: agile development methodologies, cloud computing, software engineering and web programming. Based on these theories the procedure is to analyze, design and implement development platform Sandbox. Finally, an evaluation and validation of the platform is made to test it, refine it, and correct any shortcomings and ensure that solves the problem situation proposed.

It is based on the statements made by Padron and the principles of agile software development, the next step is to establish the methodological design of this research, which is summarized in Figure 1. The methodology of the agile development that is fundamental basis for this work is Scrum [11], which allows developing the system through iterations, in each iteration a part of the software product is obtained, which is validated by the customer, to ensure it accomplishes with what is expected. For the project the following roles scrum were defined: 1) the scrum master was the project manager, 2) development team was formed by its authors, 3) the product owner corresponds to: a teacher and a group of students from Systems Department UFPS.

Proposed by Scrum follows cycle is adapted: the research phase of the project includes planning of scrum and the selection of detailed requirements using use case model; the design phase includes iteration planning and defining the architecture of the iteration; the development phase corresponds to the execution of the iteration and where a product is built increased and finally the validation phase contains demonstration and retrospective of the iteration.

The performed iterations were: 1) Overview of the Sandbox platform, 2) Functionalities of student. 3) Functionalities of Administrator. 4) Functionalities of teachers. 5) Functions for monitoring and control platform failures. Use cases to specify the requirements defined in each sprint implement were used. The following summarizes each of the phases of the methodology carried out.

2.1 Research

At this stage will be carried out an analysis of services, tools and features that will be included in the Sandbox platform. They way to integrated it into the platform was studied. System requirements were determined, the problem analysis was executed, and the favorable technological framework environment for system development of each iteration was generated.

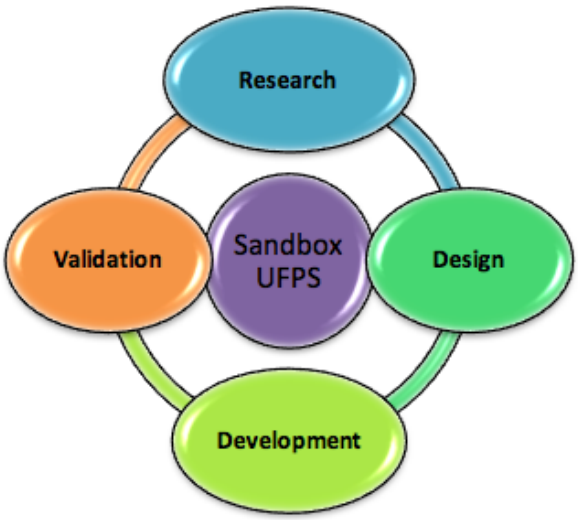

Fig. 1. Methodology

2.2 Design

It was executed in a set with the previous stage, the scope and limitations of each iteration was defined, risks were identified, the budget and timetable of development were adjusted, the design of the system architecture was made, which will be expanding and improving with each iteration.

2.3 Development

At this stage, the source code that fulfill the proposed design and the requirements defined for iteration was created, the obtained prototype was tested and evaluations required were made for the robustness of the system. The adjustments to the design of the system architecture were performed. Daily follow-up, control and synchronized meetings are held between members of the development team and a weekly with the product owner and scrum master.

2.4 Validation

Given the functional prototype, the instruments to assess and validate their performance by students and teachers in order to receive an important feedback to the system were defined, obtaining at the end a closer product to the needs of users. The adjustments that are required were carried out, and the lessons learned, findings and the relevant aspects of the iteration were registered.

3 Cloud Platform Sandbox UFPS and Results

As the main result was obtained a platform in the cloud that provides services and tools for development of web projects by students and teachers of the Engineering Systems program UFPS. With this platform, students can access to a development environment close to what they will have in working life where they can configure, manage, and deploy web applications at any time, from anywhere and at no cost.

On the platform students can create their development projects, creating instances in database managers, and various web technologies such as JSP, PHP, .NET and Python.

In the past 6 semesters the average of applications that are hosted in Sandbox are 71 per semester, this number is obtained from the statistics compiled by the administrators of this tool in the past three years. See Table 1.

	2nd Semester 2012	*1st Semester 2013*	*2nd Semester 2013*	*1st Semester 2014*	*2nd Semester 2014*	*1st Semester 2015*
Number of Applications per Semester	42	63	66	72	84	96

Table 1. number the applications used Sandbox.

3.1 System Architecture

The system architecture consists of a server hardware of the following characteristics: A QuadCore 2.4GHz, with 8GB of RAM and disk space of 250 GB, this hardware is distributed in virtual machines each with one core processor, 2GB of RAM and 50 GB of disk space. Therefore the Sandbox system in a complex of 3 VMs and whose architecture can apre-astern in Figure 2, in this same way you can see how a balanced load between servers is done. Which is done leaving all data-to Processing in the Sandbox 2 and can be seen in the following figure:

Sandbox server 1: Initial server where the application of these tools administration is saved, administrative application built JSP on a database administrator in PostgreSQL that manage the database; on this server codes are also housed in different technologies such as Python, PHP and JSP system users. The server is responsible for performing all the processing code, freeing the data processing managers it gives database.

Sandbox Server 2: Server where the database system users and the repository projects are housed. In this server only consultative processes and data storage is done.

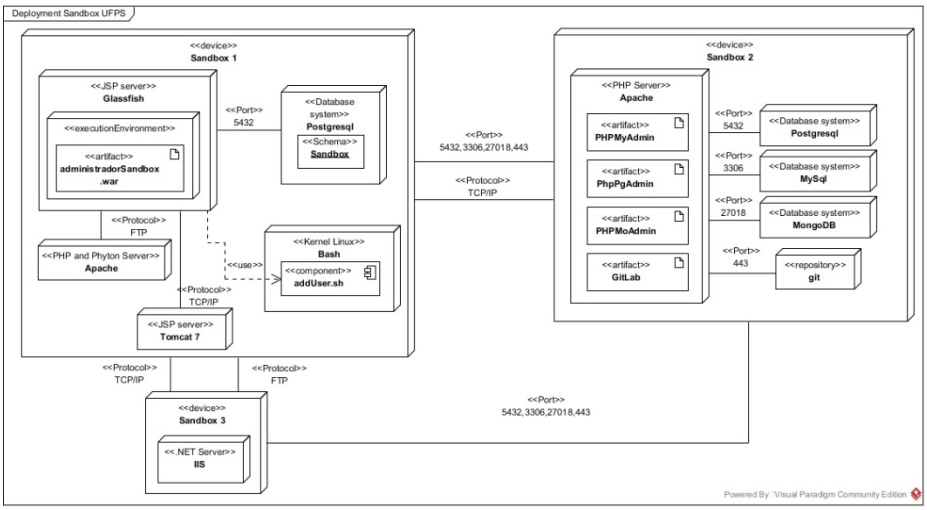

Fig. 2. Sandbox UFPS Architecture

Sandbox Server 3: .Net server where deployments projects on .Net users were made. In this sandbox server as in 1 only code processing is performed.

The idea of this architecture is to distribute the server load by locating databases on a different machine where project operations are conducted; this way the server load times of the requests made are lightened.

3.2 Functionalities of UFPS Sandbox.

To detail the functionalities provided Sandbox UFPS the use case diagram UML was used. First, actors for this system are defined, which are detailed below:

- Student: It is the main user of the application is responsible for creating the projects and define instances of the technologies to be used.
- Teacher: Responsible for the review of projects can also create instances of the technologies sandbox provides.
- Administrator: Actor who is responsible for the configuration and system support. Create and assign permissions and access levels for students and teachers.

These roles and share some features and have also functionalities unique to each as seen below:

3.2.1 New Project: functionality that allows the user to register a project on the tool, this process begins selecting instances needed for the project, then if necessary add users to the project and finally is saved, in this step the Sandbox system generates the necessary deployment of instances on the server settings, then performs the associa-

tion of these configurations to other accounts related to the project users, these users can be students or teachers.

This functionality will only be executed by the student and teacher users.

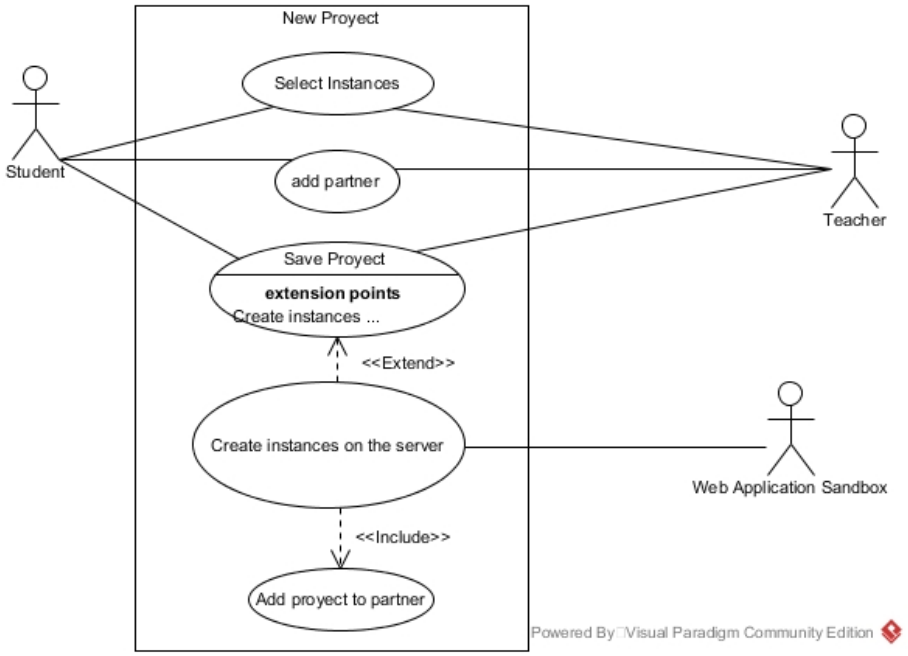

Fig. 3. New Project Use Case

3.2.2 Deployment Instances: This functionality is used by the user to upload their projects to the server, so the cost of two types of deployment for instance, the first is upload applications through the application interface and second one is increasing their databases through each handler.

In the first type of deployment tool uses two types of settings, which are through the server scripts run custom commands to deploy in the server, the other is through file transfer upload scripts to the server. These processes are executed by the tool automatically; in the second type interfaces handlers databases are used, such interfaces are: PhpMyAdmin, PhpPgAdmin and PhpMoAdmin

This functionality is available for student and teacher users.

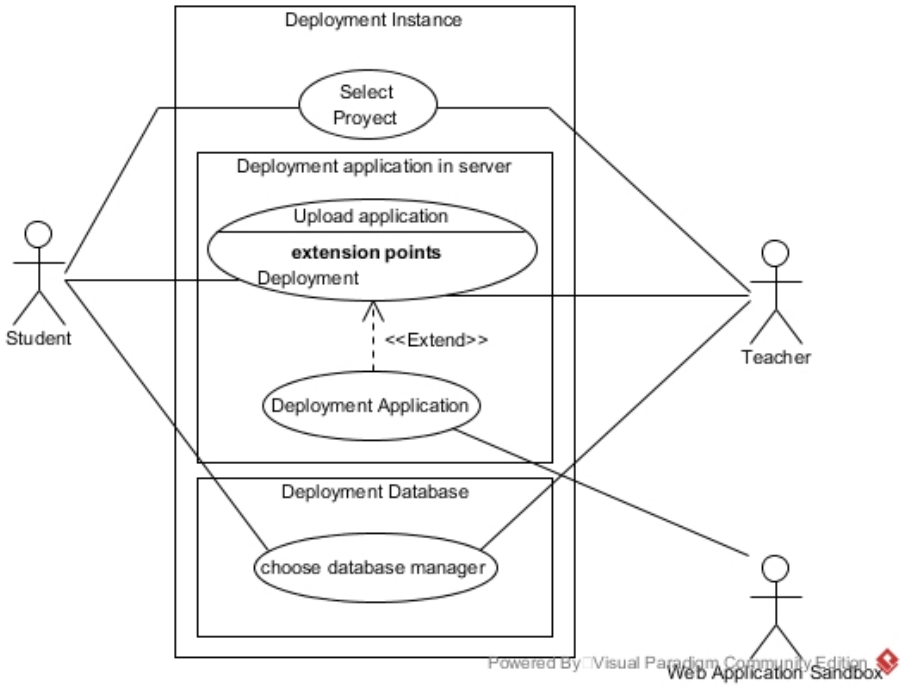

Fig. 4. Deploy Instance Use Case

3.2.3 Add Instance: Functionality used to allow the user to configure how to use technologies added to the server, choosing between using a script on the server for deploying or using the FTP in a file server.

This feature is only available to the administrator.

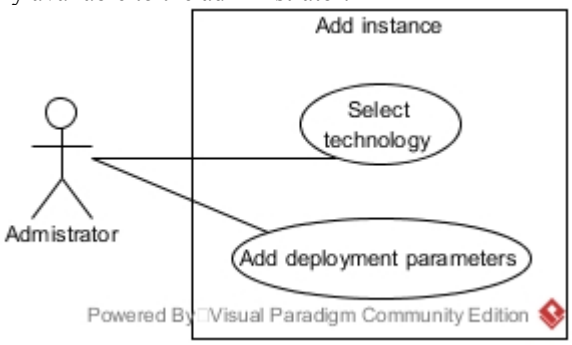

Fig. 5. Add Instance Use Case.

3.2.4 List Projects: functionality that allows users to list the projects by range permitted and thus select the project that want to see and access to this; the use case starts

when the application displays a list of projects by type of user, the user selects the project view and then can access the instance which want to check, so the Sandbox runs the deployment for instance. This functionality is available to all users with a slight variation of permits, which are:

Student: Can only access the projects that they have been added or created.
Teacher: Can access the projects that have been added to their classes.
Administrator: Can view all projects.

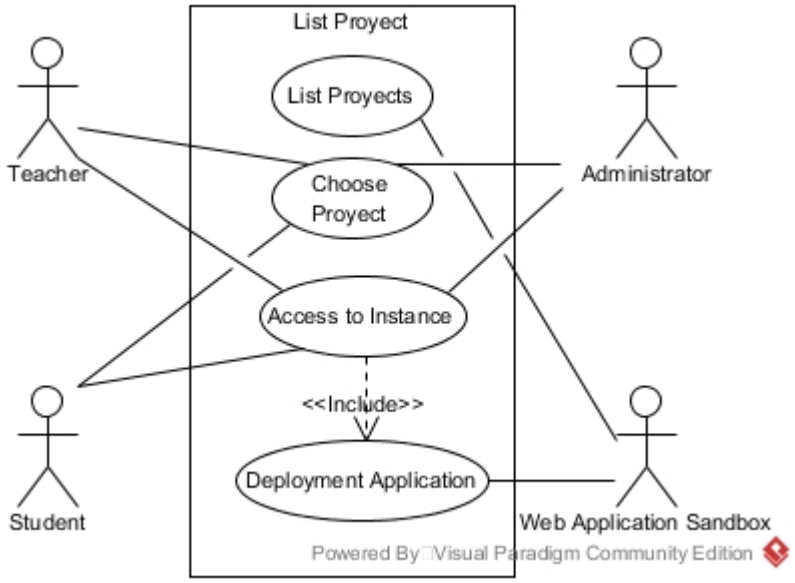

Fig. 6. List Projects Use Case

4 Conclusions

The Sandbox is a software tool created to bring the student a little closer to the real world of software development, so it was necessary to choose an instances structure that are used on a project, these instances are a variant of technologies needed to make the product as close to a real-world solution in this type.

This makes easy the management of projects both by students and teachers as well as the integration of the development team for such projects; it helped to these tools to have a high degree of acceptance in the academic community of the Engineering Systems UFPS curriculum.

On the other hand, was created a tool that allows to engage a wide number of technologies thus ensuring a larger life cycle, this solution was suggested considering that previous versions got outdated in a period of time of 2 or 3 years.

The Sandbox is a software tool created to bring the student a little closer to the real world of software development, so a structure of instances that are used on a pro-

ject were chosen, these instances are a variant of necessary technologies so that the product is as close to a real-world solution in this type.

This facilitated the management of projects for both by students and teachers as well as the integration of the same development team for such projects; this helped these tools have a high degree of acceptance in the academic community of the curriculum of the Engineering Systems UFPS.

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Expert system for appointment generation in a medical center using fuzzy logic

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Abstract. This work describes an algorithm that optimizes the actual way of programming appointments in a first level health service. It integrates specialities, X-ray department, clinic laboratory, social work and cures. The schedule assignation was supported on the fuzzy logic theory which offers the advantage of working with wider decision ranges than the traditional logic based on true-false. The design methodology of the algorithm, the definition of the input and output variables and rules were proposed based on a specific case, then the system was tested with a simulated database. A web page was proposed to create and update recurrent appointments into the departments considered. This system is designed modular, so it is in a single place and diminish the required time of the traditional multipoint methodology of assignation. Implementation can be adapted to the specific medical center.

Keywords: fuzzy inference system, informatics, medical appointments, healthcare system

1 Introduction

The applications of medical informatics are very important because the analyzed and structured information becomes knowledge that allows improvements in the quality of health services and also in a better use of the resources. Besides, the development of intelligent systems that help the systematization of the information can improve the performance and automatization of the care process of the patients providing a better service.

The present work was created thinking on any medical center where the amount of patients to be attended sometimes overpasses the capacity of the clinics available. For instance, in Mexico City there are 20.4 million people, according to an ONU report in 2012. There are several institutions that provide health services, either public, such as IMSS, ISSSTE, ISSEMYM and SEDESA-DF, or private. For instance, SEDESA, attends more than 5 million medical consultations, 145 thousand hospital stays and more than 750 thousand urgencies are attended around a wide range of health centers [1, 5].

It is therefore necessary for health providers to optimize economic resources and staff and also to optimize the time spend by the patient in the clinic. This is the reason

of being interested in the automatization of the patient attention process. Moreover, once the information is digitized, many interesting possibilities open up allowing a better use of resources assignation in an intelligent form, such as the medical and laboratory appointments.

The present work describes the design and implementation of a technologic solution that makes use of a Fuzzy Inference System, taking as inputs the priority of the next appointment and if necessary other appointments such as clinic analysis, X-ray and social work, depending on the indications of the medical doctor or specialist. An intelligent system was developed to generate a clinic diary in order to assess an optimized generation of appointments, which takes into account the particular needs of each patient according to the medical specialities, medical studies requested as well as the status of availability, capacity and special requirements in each of the department considered.

2 Description of the problem

Nowadays, in the clinics, the information of the patients are concentrated into medical records and on the other hand, the administrative management of the healthcare center contains data about the capacity and availability of the different resources associated to each department. However, this information is not concentrated in one department and when the patient needs to request several appointments at different offices, it has to be done independently. Therefore, the process of generating the next appointments becomes complicated when results of other departments have to be available for the next visit to the doctor. In these cases, it is necessary to coordinate the availability of medical staff and all the resources to prevent the patient from wasting time generating separated appointments and taking the risk of visiting the doctor without the required studies. The probability of having this kind of problem is high since the patient does not have all the information about the availability and delivering times of all the departments.

A solution to this problem could be the use of a specific place to do all the appointments needed, where the information from all the departments can be consulted, not only about availability but also taking into account the delivering times and specific needs of the patient and doctor. In this kiosk, a few number of persons could help the patient to choose the optimum schedule for the next appointment, using the inference system result as a start point in the decision.

The system for appointment generation considered one kiosk that has access to all the departments' information. A Fuzzy Inference System was developed, whose inputs are all the patient's needs and resources conditions, availability of each department, and the output is an optimum day and hour that is proposed to the patient and he can decide if that suits him or he prefers another day or time. The algorithm takes information from a data base that contains medical records of the patient and also the characteristics of each department such as schedule and resources availability of the medical staff and facilities of the medical center. The departments considered in the fuzzy inference system are: medical specialities office, clinical laboratory and X-ray service. The social work and cures department was not included in the fuzzy system because non subse-

quent appointments are needed. However, they are also monitored and stored. The proposed date represents the optimum value according to the specifications in the inference rules. Then, according to the decision of the patient the system register the dates in a data base to schedule the appointments for each of the required departments. The system is then ready for the next assignation. Figure 1 shows the general structure of the proposed system for the appointment generation.

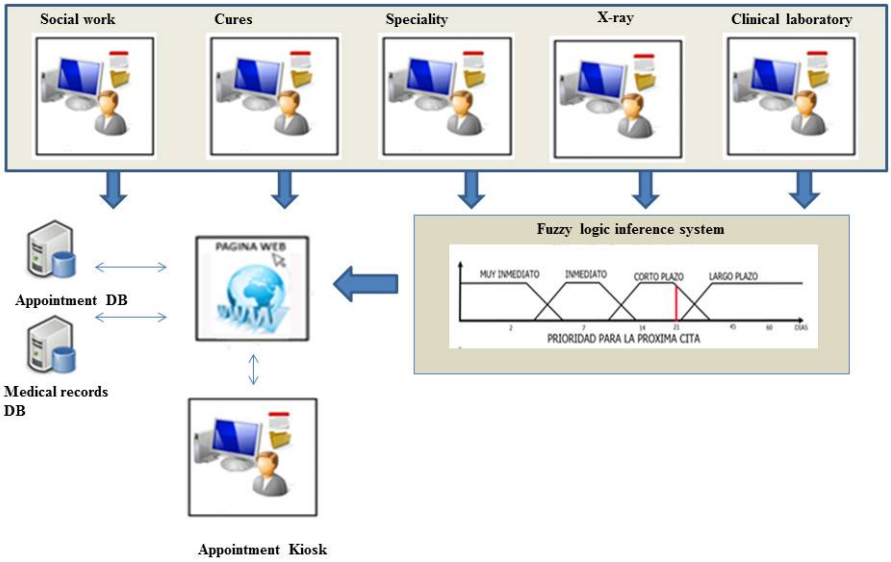

Fig. 1. Structure of the appointment system

All the system will be communicate in a transparent way through a Web page between the different modules, achieving that each module receives the needed information for its correct functioning in the required format and that the data base is updated every time a new appointment is assigned.

3 Theoretical considerations

Fuzzy logic is a tool, branch of artificial intelligence, whose characteristic is that instead of having only two possible values, 1 and 0, all possible values in between are allowed to define the membership value in a set [6,7]. A fuzzy set expresses a membership value of an element in the set. Therefore, if the universe X is a collection of objects denoted as x, then the fuzzy set A in X is defined as a set of ordered pairs as shown in equation 1.

$$A = \{(x, \mu_A(x)) | x \epsilon X\} \quad (1)$$

Where $\mu_A(x)$ is the membership function (MF) for the fuzzy set. The MF maps each element of X to a membership value between o and 1. Usually X is called discourse

universe or simply universe and it may consist of discrete objects into a continuous space. In practice, when X is a continuous space, usually X is segmented in several fuzzy sets whose membership functions cover X in a uniform way overlapping with the surrounding functions. It means that any value in X has a different membership value for each of the sets, becoming ambiguous or uncertain. Actually, this is the way in which humans describe variables in the common language. Figure 2 shows an example of five sets defined as trapezoidal functions. It has a membership value of 0.8333 in the 'young', a membership value of 0.2667 in 'middle age' and zero for the rest of the sets.

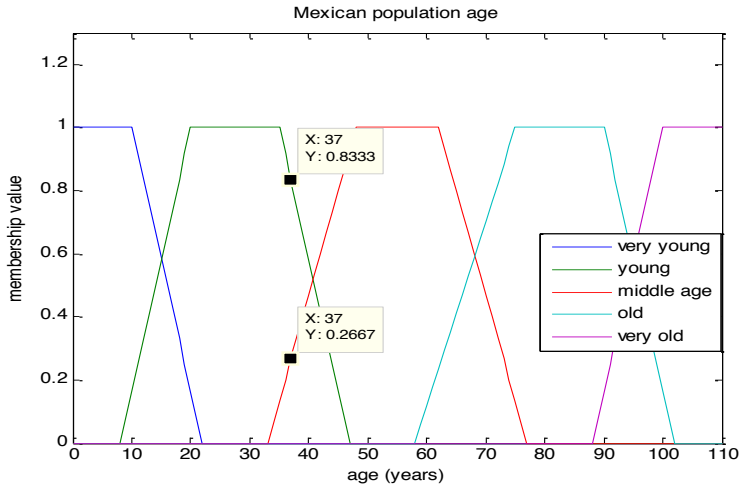

Fig. 2. Example of membership values for 5 fuzzy sets representing the age of Mexican population

The fuzzy system described in this work uses trapezoidal functions because they appropriately represent the fuzzivity of the cases used with a low computational cost. The trapezoidal function is defined with 4 parameters {a, b, c, d} as described in equation 2 [6]; where the parameters {a, b, c, d} determine the four corners that define the trapezoid.

$$trapezoidal(x;a,b,c,d) = \begin{cases} 0, & x \le a \\ \frac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \frac{d-x}{d-c}, & c \le x \le d \\ 0, & d \le x \end{cases} \quad (2)$$

A fuzzy inference system is based on the concepts of fuzzy sets, If-Then rules and fuzzy reasoning. Due to the multidisciplinary nature of its applications, a fuzzy inference system (FIS) is also known as fuzzy expert system, fuzzy model, fuzzy associative memory, system based on fuzzy rules or simple fuzzy system [6,7].

A FIS allows grouping several If-Then rules based on fuzzy systems. In this work a Mamdani method was implemented, using the max-min composition method to fuzzify and the centroid method to defuzzify. The rules in the Mamdani method take the form shown in equation 3.

$$R_j\colon\ If\ x\ is\ A_j \text{ then } u \text{ is } B_j,\ j = 1,2,\dots,r \qquad (2)$$

Where $x = (x_1, \dots, x_n)\ \in X\ and\ u\ \in U,\ y\ A_j(x) = min_{i=1\dots n}\{A_{ji}(x_i)\}$ for $A_j = A_{1j}x$

The Mamdani method is based then on a set of antecedents that trigger a specific consequence by means of a collection of k propositions of the type If-Then.

4 Development

This section describes the methodology of the algorithm's design. The methodology considered for the development is:

A. Identification of the involved departments for the generation of appointments and to stablish their specific characteristics as well as the general characteris tics of the healthcare center.

The departments to be considered and the general requirements of the system were stablished based on the analysis of the information of a healthcare center in Mexico City, this is shown in Table 1.

Table 1.Requierements of the considered departments.

Department	**Schedule**	**Turn**	Assigned appointments
Speciality 1 room	07:30 – 15:00	Morning	In case of first appointment the duration is 45 minutes, for the subsequent is 30 minutes
Speciality 1 room	14:30 – 20:30	Afternoon	
Social work	07:00 – 15:00	Morning	Depends on the number of cases
Cures	07:00 – 15:00	Morning	15 per day
X-ray	08:00 – 18:00	Complete turn (morning and afternoon)	30 per day
Clinical analysis lab	07:00 – 15:00	Morning	50 per day

It is important to determine the facilities and staff available according to the attention level of the clinic. In this case the considered case is a level 1 center with the characteristic shown in table 2 decided based on reported statistics [1-5]. The system was designed to be scalable.

B. To identify the variables involved in each of the departments

Once the information about facilities and attention capacity was known and the requirements of each department analysed, the next step was to stablish the procedure to assign an appointment. The procedure starts with the first appointment of the patient that wants to be attended in the clinic where it is decided the required speciality. Therefore the first appointment is always programmed in manual form. The patient is assigned to a specialist according to the availability. Then, the subsequent appointments will depend on the medical diagnosis.

Table 2. Typical facilities for a level 1 clinic in Mexico City.

Department	Number of consulting rooms
Clinic Records	1 attention module
Speciality 1	3 consulting rooms
Speciality 2	5 consulting rooms
Speciality 3	4 consulting rooms
Social work	1 area
Cures	1 area
X-ray	1 room
Clinical laboratory	1 laboratory shared with another speciality clinic

The FIS takes into account only level 1 clinics, with 3 different specialities. Urgencies do not exist, however, in some cases the specialist wants his patient to be attended in a specific manner due to the disease. This is the reason of proposing a priority index in which the attention times were categorized for the three specialities as shown in Table 3.

Table 3. Ranges of priority per speciality

Priority function	Time
High	1 day
Normal	1 week
Low	1 month or more

The generation of automatic appointments was limited to those subsequent because it is case when there is several department consideration. In order to know the needs, a visit to a public health clinic, in Mexico City, was made to observe the care protocol. Table 4 shows the considerations for the generation of appointments.

C. Definition of the input variables for the FIS and information reconditioning.

After stablishing the medical departments in which the appointments will be generated it is necessary for the specialities to fix the period according to the treatment, diagnosis and particular characteristics such as age or severity of the disease and also if the patient needs X-ray plates and/or laboratory analysis. All this information will be given by the specialist. The input variables of the FIS were five: 1) Priority for the next

appointment; 2) Delivery time for requested clinical analysis; 3) Availability of clinical laboratory; 4) Time for requested clinical analysis and 5) X-ray availability. All these variables are given in time and were defined according to the specifications of the clinic.

Table 4. Considerations for the appointment generation

Department	Turn	Appointments per turn	Duration of the appointment	Appointments attended at the same time
Speciality 1	Morning	34	1 hour	4
Speciality 2	Morning y Evening	17	30 minutes	1
Speciality 3	Morning y Evening	17	30 minutes	1
Laboratory	Queue system	50	Depends on the type of study	Queue system
X Ray service	Queue system	30	20 minutes	1

For instance, the ranges in time for the input Priority for the next appointment were stablished as: 1) *Very immediate*: limits the appointments between 1 to 3 days after the last generated and confirmed appointment; 2) *immediate*, limits the appointments between 2 to 14 day; 3) *Short term*, limited between 10 and 30 days; 4) *long term*, all those generated for 35, or more, days after the last appointment. These 4 intervals are transformed into trapezoidal membership functions to be inputs for the fuzzy inference system.

The ranges in time for Delivery time for requested clinical analysis were: 1) *None*: when no analyses are requested; 2) *Less than a week*: when the analyses requested take less than a week to deliver results and 3) *More than a week*: when the analyses requested take a week or more. In a similar manner, the other 3 variables ranges in time were stablished.

D. Definition of the output variables

The identified outputs for the system were three: 1) Speciality office optimum schedule, 2) Clinic laboratory optimum schedule and 3) X-ray service optimum schedule. The first and the third variables are given in minutes since the appointments are given in specific times and the duration of each appointment depends on the characteristics of the department, facility and capacity, as shown in table 4. The time of laboratory optimum schedule is given in days since the laboratory works only the first hour in the morning and all patients are asked to be at 7 o´clock. The three output variables were separated in three trapezoidal membership functions as short-term, mid-term and long-term.

E. Generation of the inference rules of the FIS

In order to generate the outputs is was necessary to generate 576 inference rules that correspond to the combination of all membership functions from each input variable. The max-min method was selected to fuzzify and the centroid method to defuzzify. The inference rules were created considering all the requirements and also the official work

schedule in Mexico to take into account the days off.

F. Integration of the FIS to the general system for appointment generation

The FIS was design modular so it can be integrated, when it is required, to the general system responsible for the generation of appointments in the kiosk.

A quality of the algorithm is the use of the concept of priority in the clinical laboratory since the appointments are generated according to the specialist indications and at the same time taking into account the time needed to have the analysis results and X-ray result which are defined by the staff availability and capacity of the equipment. All of them define the next appointment and not as commonly done, according to the patients' arrival.

5 Results and evaluation

The integration of the system allows managing the appointments according to the traditional way of patients' care but considering three specialities, clinic laboratory, X-ray, social work and cures specific conditions.

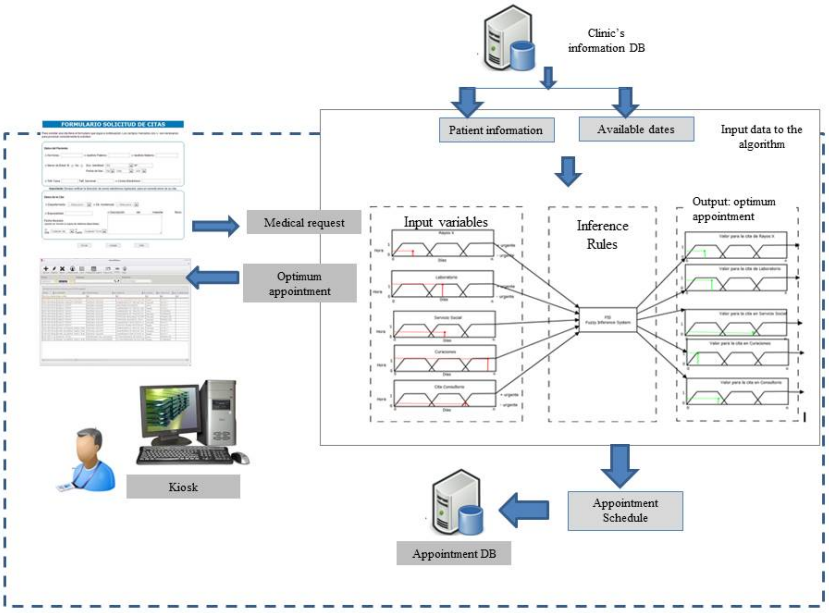

Fig. 3. Design of the informatics system for appointment generation.

Once the department criterion was stablished, the membership functions ranges were defined for the five input variables and the three output variables summarized in tables 5 and 6. For the definition of the inference system 576 rules were used the Mamdani method [6,7]. The algorithm of the FIS module was simulated and evaluated in an exhaustive way using a simulated clinical database, which allowed to adjust the membership functions and the rules according to the priority, capacity of the department and schedule for the next appointment request of the physician.

The appointment assignation was proposed consulting the database of the simulated clinical records, administrative records of the specific department and then evaluating the algorithm's inputs. The kiosk has several simultaneous tasks that modify the status of the of the appointment data base, until it is confirmed by the person in charge. The complete process is done through a Web page as shown in Figure 3.

Table 5. FIS Input Variables

Priority for the next appointment	
Very immediate	Trapezoidal(0,0,1.5,3)
Immediate	Trapezoidal(1.5,2,10,14)
Short term	Trapezoidal(10,14,21,30)
Long term	Trapezoidal(35,40,60,60)
Delivery Time for requested clinical analysis	
None	Trapezoidal(0.5,0.5,1
Takes less than a week	Trapezoidal(0.5,1,29,32)
Takes a week or more	Trapezoidal(29,32,35,35)
Availability of clinical laboratory	
Short term	Trapezoidal(0,0,7,14)
Mid term	Trapezoidal(10,20,30,40)
Long term	Trapezoidal(30,40,50,50)
Time for requested clinical analysis	
Short term	Trapezoidal(0,0,10,15)
Mid term	Trapezoidal(12,15,25,32)
Long term	Trapezoidal(28,33,50,55)
Very long term	Trapezoidal(50,55,60,60)
X-ray availability	
Short term	Trapezoidal(0,0,14,20)
Mid term	Trapezoidal(15,20,30,40)
Long term	Trapezoidal(35,40,55,65)
No plates	Trapezoidal(55,65,70,70)

Table 6. FIS output variables

	Speciality Optimum Schedule (minutes)	Clinical Analysis Optimum Schedule (days)	X-Ray Optimum Schedule (minutes)
Short term	Trapezoidal (0,0 ,14400,20160)	Trapezoidal (0,0,7,12)	Trapezoidal (0,0,10080,17280)
Med term	Trapezoidal (14400,20160,30240,43200)	Trapezoidal (7,12,19,28)	Trapezoidal (10080,17280,27360,40320)
Long term	Trapezoidal (20240,43200,86400,86400)	Trapezoidal (14,28,60,60)	Trapezoidal (27360,40320,86400,86400)

The person in charge observes in the monitor a calendar that allows him to move

among the days and choose the optimum schedule provided by the algorithm or a further time. The displayed information is the day and time of the appointment, complete name and identification number of the patient, complete name of the specialist and the department for which the appointment is generated. As an additional tool the system allows to generate an appointment for social work and register it in the appointment database.

The user of the system is the person in charge of the kiosk, who is able to generate the appointment and also the personal in charge of the different departments and the specialists that can consult the appointments. Every time an appointment is generated, the patients' card is updated and also the appointment data base. The obtained result from the algorithm is the optimum according to the established rules, but it may be the case that the patient does not accept the schedule because personal reason so a manual selection can be carried out for a later day or time.

6 Conclusion

The proposal of modular design permits the creation of new departments or the selection of those that will be included in the algorithm. The procedure here described was based on a real case but tested with a simulated database. This allowed to evaluate the feasibility of the design both, from the expert system based on a FIS system, and from the complete system as a service algorithm for appointment generation.

The preliminary test, with the simulated data base from the clinical and administrative recordings from the analysed healthcare center was a valuable tool for the evaluation of the design.

The proposed system design counts with a Web page but the expert system can be integrated to another service as a modulus, which permits to evaluate the real efficiency in any specific healthcare center.

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Definition and implementation of a Model for the Creation of Mobile Node Knowledge Networks

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Abstract. In this paper we show the development of a model for creating Knowledge Networks (KNM) networks based on mobile nodes, this model will share relevant and useful for different types of users anywhere, anytime (anytime, anywhere). The KNM enables communication between mobile entities that are part of a network of mobile nodes, these nodes share their statements and information and offer services that allow them to manage knowledge, mainly in the processes of collecting, sorting and searching of information according to a profile and needs to generate knowledge networks. The KNM aims to make available to users, developing tools for both synchronous and asynchronous communication and to develop the training process with the use of mobile devices with limited capacity Internet connection.

Keywords: Knowledge, mobile nodes, knowledge network.

1 Introduction

Knowledge, of any kind or source, is an intangible active, and in consequence, invisible and hard to value. One of mankind's characteristics is his ability to use his own experiences and turn them into actions, which are susceptible of being generalized so they can be transmitted to the following generations. Such natural quality of the individual has transformed into a gradual and systematic process of knowledge, whose purpose has been, amongst others, a higher accessibility to personal development so that it increase the human race's adaptation capacity to the demands of its environment and its social context.

Today's society is facing and endless amount of challenges, which include defining better and more timely ways for it to communicate and collaborate.

Knowledge is the most important variable in any organization, without leaving aside the importance of material, technological or financial resources, it is currently considered as one of the most benefiting or prejudicial factors.

This situation requires models and ways to communicate and above all, share and increment knowledge to face the changes demanded by organizations. Changes with a focus on integral development, considering that traditional and current administration models are in a critical phase, in which they cannot resolve problems or satisfy the

needs of today's society; it's necessary to migrate to Knowledge Management solutions and create networks that allow the transfer and exchange of knowledge.

Knowledge Management has the capacity to generate knowledge and induce learning [4] define it as the ability that people have to understand and manage information using technology and knowledge sharing (shown on Fig. 1).

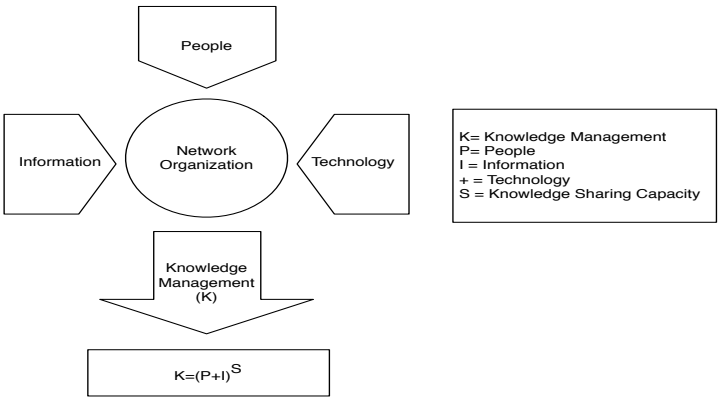

Fig. 1. Knowledge Management (Source: Duta v De Meyer)

However, most specialized authors agree in defining knowledge management based on the different stages that make it up and/or in its objectives. [2]

In the globalized society of the twenty first century, knowledge networks constitute the maximum expressions of man as a knowledge producer and his need to exchange and transfer what he learns and creates, based on the social interaction in a technological platform given a very particular context.

Knowledge production is closely related to the information needs and the formal organizations created for that purpose. This integration has producing knowledge based on society's integral needs as its objective. The main challenges are: Communication, Collaboration and Sharing (CCS).

Given this issue, it is important for organizations to implement knowledge management models and networks to allow their staff development through schemas that allow sharing and generating knowledge in an easy, practical and cheap way.

The structure of the paper is defined in the following way: Section II describes the context and the Model proposal to create Knowledge Networks; section III describes the technology that was used for this, section IV identifies the implementation of the model with its results and finally section V presents the conclusions and future work.

2 Context

We shall define a Knowledge Network as a community of people, who in a formal or informal way, either part or full time, work for a common interest and base their actions in the formation, development and sharing of new knowledge [1].

In a more social and dynamic context, knowledge networks are the human interactions that produce, store, distribute, share, access and analyze knowledge produced by mankind in a systematic way or by personal or group interest of sharing any kind of data by any means, generally electronic; in order to develop their capacities for creating, understanding, power, study and transformation of reality surrounding territory in a given social and economic context [5].

As mentioned earlier, knowledge networks are the result of the human activity essentially formed by producing, managing and transferring knowledge and largely structured by organizations created for that purpose. In this regard, there are several models aimed at the technological and social.

In this fashion, some authors, such as Andreoli [2] propose a knowledge network model with a technological approach based on three fundamental elements: a central core, collaboration clusters and knowledge generation units. They state that a network is made up of an entity or groups of people who lead or coordinate activities aimed towards knowledge generation making use of previously defined topics, then generate groups or research facilities where and analogous network can group a network or more of them. Electronic communication media mainly gives support of this integration.

Also, Atwell propose a model of knowledge networks based of the same technological standpoint but directed to knowledge management in the so-called virtual communities [3]. This model is structured by three basic elements: the network members, the network tools made up by a pure information network and the discussion topics defined by the members (people or organizations).

These experiences, one being Latin American and another of the European Union, enrich the subject of knowledge networks through different schemas that share two fundamental variables: a group of people who live in a society and a technological platform which optimizes knowledge production and transfer made by the former.

In this proposal, knowledge networks are based in a knowledge node interconnection model, which can be translated into a mobile collaboration network that is more focused in its social and organizational character. In this sense, knowledge networks are made up by different kinds of networks, e.g. social networks, main networks, institutional networks, collaboration networks and transfer networks.

Social networks are inserted in the conception of the collaboration action theory, which defines that "social capital made by reciprocity, voluntary cooperation and commitment" [1] are part of the social system dynamics

Social networks share different types of information, data, knowledge and assets. In the same way, they involve mutual benefit, trust and coordinated work that are intimately mediatized by the globalized information world.

The basic primary networks are divided into social action network, which are "the sum of management, administration, participation or association relationships, that span the plurality of people or micro-organizations" [1]

Institutional networks are all the organizations created or organized to produce knowledge by researching the needs of social networks and/or the problems of the primary networks, to help their development and social advancement. University, research institutes, and technological development facilities either private or public, among others, compose these networks. Social action networks also operate in this kind of networks.

This networks operate by the thousands in every country around the globe, so that there can be various institutions in the same country researching the same problem without being dynamically and effectively integrated in order to save time, money and effort. Because of this problem, collaboration networks were formed.

Collaboration networks are public or private organization in a local, regional and international level, which can cooperate technically and financially with the institutional networks to manage joint product under relevancy, efficiency, productivity and development parameters.

In today's world, these networks dynamically interact in the field of science and technology throughout their different disciplines. Such is the case of the European Union's Alfa program, CINDA program or Red de Montevideo operating as academic networks; in the case of thematic networks, there is CYTED in Latin America; as of research networks there is the European R&D Marco Program and also CYDET in Latin America, among others.

On the other hand, transfer networks are known for grouping entities, people or organizations that have as a purpose mediating or translating knowledge into social networks and are intimately bonded to the technological innovation and knowledge development processes.

The purpose of this paper is to contextualize how this kind of networks could work together making use of current technology and based primarily on information exchange media that are becoming more common, such as mobile devices.

Technology and telecommunications allow creating node networks that are no more that simple users exchanging information and which can be extended to networks of people sharing knowledge.

3 Proposed Model of Knowledge Network Creation

In the real world, individuals share information. According to their characteristics and their need to work with this information, they can be classified in groups of interest and knowledge. In this case, the defining characteristics are the individual needs and the way they interact with other Knowledge Network elements. Under this schema, the networks are characterized by the kind of users that interact among themselves. For example, an academic knowledge network will be composed by students, teachers and researchers with particular interest, each of them with restrictions and a way to interact with other entities of this network.

Along this line, as shown in Figure 2, networks are defined by the sets of entities that belong to different knowledge groups and the sets of media which they use to interconnect and make use of sharing, classification and knowledge sharing services or any kind of service. The set made up by all the elements that exist in a KN will be denoted as S and the set of all the types of interconnection media as A.

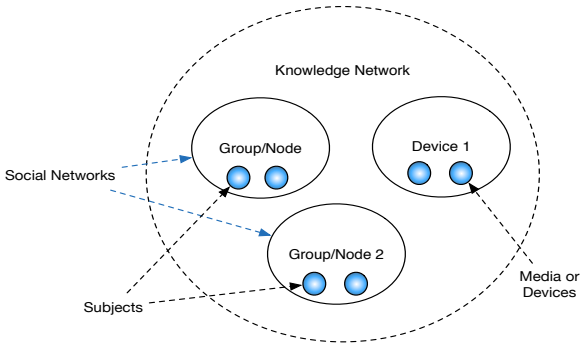

Fig. 2. Node Network Components where a user group collaboration schema

When a group inside the KN is defined, their information sharing capacity along with the media the entities belonging to this group will posses and the set of services that they can provide to other entities when forming an interaction must also be defined.

Then, each of this groups define in a partial form, the way in which it's going to interact with the rest of the groups, because it defines the interchange actions and the knowledge generation that it can do in favor of the entity with whom it interacts.

To define the interactions that can be done in an KN, we can use a directed graph.

$$G = (V, E) \text{ where } V = S \cup A \text{ y } E \subseteq S \cup A \times S. \quad (1)$$

The edges represent a service relationship, that is, as shown on Figure 2, if an edge gets out of a group G1 and goes into a group G2, indicates that and entity belonging to G1 will offer a service interface to an entity belonging to G2 at the moment a collaboration is done. Similarly and due to an edge existing from G2 to G1, an entity belonging to G2 will offer a service interface to an entity belonging to G2 at the moment of collaboration. We shall define the process of executing an action defined in the collaboration interface exposed by another individual as knowledge generation action.

Every edge of G defines a particular collaboration interface; this allows an individual to collaborate in a particular way depending with whom it interacts. Using the academic network example, a student will present different collaboration interfaces when interacting with another student or a teacher. These interfaces must be defined when designing a KN and as shown later, will be reflected in the methods of knowledge generation as in components that will be used to call the services of the same networks.

The definition of E (as shown on figure 3), the devices have the particularity that the information exchange is direct among entities or other devices and allows them to update with valuable and timely information that can be characterized as knowledge. This is due to the fact that artifacts are conceptualized as reactive entities that execute activities in response to request from the entities, but that are also available and updatable anytime, anywhere. As the result of using the services exposed by a device, an entity can make use of knowledge and information in an automatic way, making it aware of the status of some other entities or group or complete network, relational databases with the groups, with another entity or with any aspect modeled in the KN.

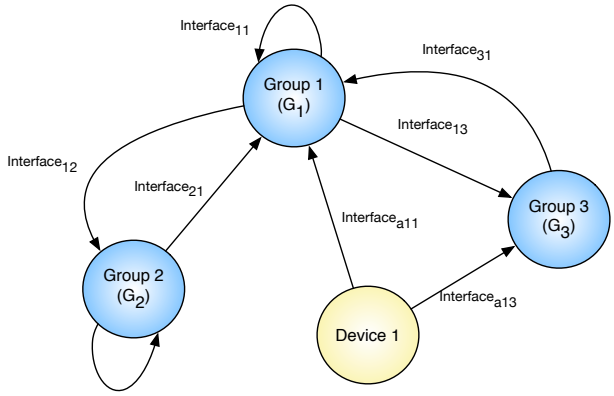

Fig. 3. Definition of the interactions among the different entity groups and the devices within a Knowledge Network

As we said earlier, the relationships defined in the graph are translated into graphic interfaces that will be shown on the user's mobile devices that belong to a KN when the user triggers an information request event. A wide spectrum of collaboration events can be defined, from which the simplest of them gets triggered when two entities of the same group share all their information and filter it according to their needs.

In a graphical way, inside the interaction graph, the names of the entities that the entities will deploy to collaborate with their peers and the interfaces that must be implemented by the entities if they required modifying their status as a result of a knowledge generation action can be defined. For example, if a user I1 belonging to G1 gets integrated into a knowledge group or to another user I2 belonging to G2, this

will make that both individuals exchange their collaboration interface, so that I2 will send I2 an Interface21 and I1 will send I2 an Interface12. When the individuals do the requested interaction, it is assumed that collaboration has ended and the graphical interfaces representing Interface21 and Interface12 disappear from devices I1 and I2 respectively.

4 Model Implementation and Results

The model is designed for mobile systems and basically in node networks (Figure 4 shows the architecture), where it is defined that each user has access to one or more interconnection devices and that the groups that generate one or more knowledge networks are connected using interconnection domains. This is done using various Wireless Technologies that can operate between them, so that this is not an obstacle when communicating. For practical purposes we worked with devices connected to a IEEE 802.11g standard Wi-Fi network. The end-user interaction is fundamental for the model, because that's what makes the user comfortable and completely familiarized with the service management in addition to offering them in the time and manner in which they are requested.

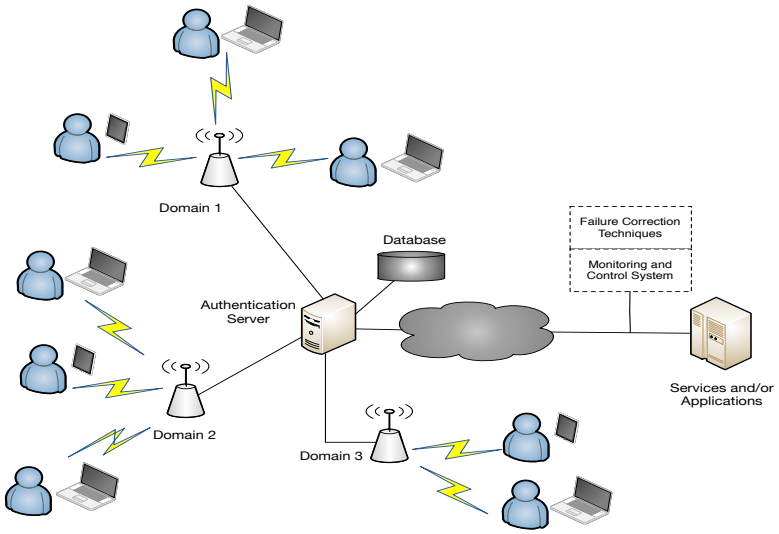

Fig. 4. Architecture of the Model Implementation

We will briefly describe the process that a service request must follow so that the existing services in a Network can be assigned to the end-users.

- The user, through its device, and an interconnection device from the Network domain exchange information to establish an information request in the knowledge network
- Then the user and its interest groups are validated and verified with the purpose of integrating information of its database to the social database and filtering the user's preferences.
- The information that was found according to the defined criteria is once again filtered in a semantic context to integrate just the relevant information according to the needs of the requesting user, when the user needs it.
- Right away, a server will be in charge of offering a list of services and application associated to a user profile database.
- The user must select one of the available services and applications. For this, a connection with the servers where the filtered and defined information is established, so that it can be processed and delivered to the user.
- Software will monitor and control job status and the interaction between nodes based on the aforesaid work model.

The model implementation case study was developed in the Escuela Superior de Compute, which is an academic unit belonging to the Instituto Politécnico Nacional that trains Computer System professionals in undergraduate and postgraduate levels. It has a student body of 4000 undergraduate students and 50 postgraduate students. The educational offer in the postgraduate level is a Master of Science Degree on Mobile Computational Systems.

The case study implementation and tests of the model were done in the "Application Development for Mobile Devices" subject, with the help of 40 undergraduate students and in the postgraduate lab.

Testing was done to measure the ratio of participation and information, resource and service use of the "Application Development for Mobile Devices" students, specifically on the "Android Application Development" topic. We looked for a greater degree of development in programming competences using systems and the knowledge network implementation.

The group was examined on the concepts of Java development for Android version 2.0, the educational model was based on live lessons and practices guided and evaluated during a 4 weeks span, which generated a set of practices and a test where the academic performance of the 40 students was evaluated.

Using said results; students were given credentials to access the Academic Knowledge Network System (Fig. 5) so they could have information on the subject (Application Development for Mobile Devices) according to their requirements at the moment they needed it, using any mobile device with Internet access.

In the next test based over the same topic (Java development for Android OS), but now on version 2.2, which implies a change of libraries and programming logic for sensors and accelerometers; the educational model was based on counseling given by the Facilitator, the system was in charge of giving the students information on the libraries and technical bases for software development when they needed them and it was also in charge of following up with the proposed practices in a span of 4 weeks.

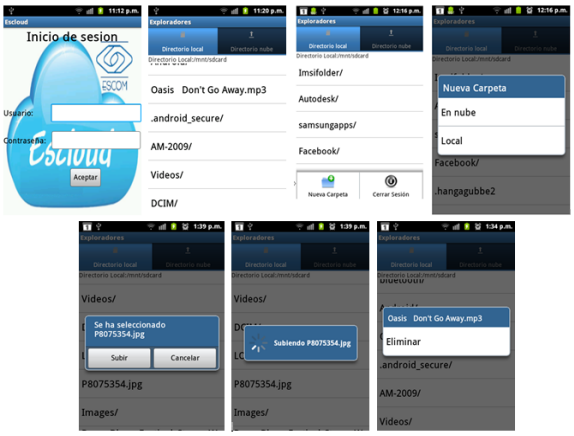

Fig. 5. Interface of the System used for the Model Implementation

The obtained results helped us observe how the students generated a series of statements between them based on the information contained in the core documentation and the updated information generated via the collaboration and interaction of the users within the system.

The system used for this implementation could be tested on different platforms, due to it being developed for iOS, Android and having a responsive interface developed in HTML5, compatible with the majority of browsers and devices.

The model was also tested with different knowledge networks, made up by a group of entities and their devices. In these tests, service domains of a network were split and a network was created for each communication domain. Communication between entities was done by sharing their knowledge bases, but most importantly; by sharing experiences and information sharing and by the interaction between groups and entities.

The main test defined to work with different networks was designed to interconnect different areas of the Instituto Politécnico Nacional so that they could share information and services in a Knowledge Network composed by 3 Academic Units. Each Academic Unit had a set of users and each user had one or more interconnection devices. Each user registered his/her device on the system and could access to it, in a way that a group was form given the user's mobile location and domain. A node that shared information and services was formed by each of the users, which in turn generated a knowledge base. (Fig. 6)

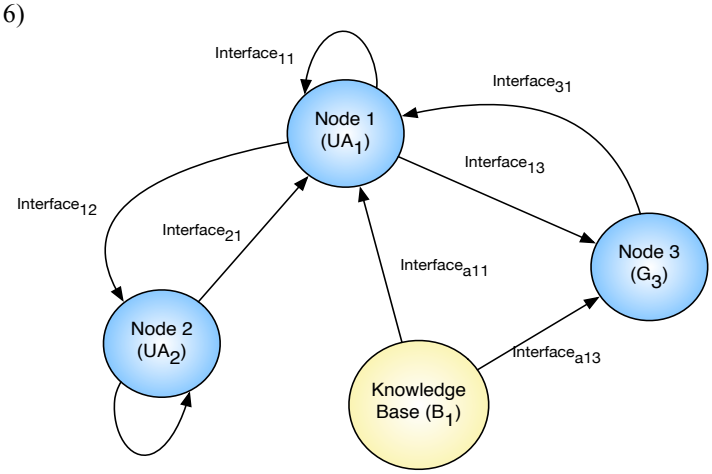

Fig. 6. Interconnection between Test Nodes

Once the groups were defined, communication was established between them and the knowledge base generated by the community was shared.

According to the gathered results, we propose that the project can be applied to a greater amount of nodes. According to technological evaluations and studies, an average of 600 to 1000 simultaneous online nodes or 1000 to 5000 offline nodes can be supported by a simple and basic technological infrastructure. This due to the low hardware requirements, simple communication in which entities don't have to spend a lot of resources and the fact that every day the resources get cheaper.

5 Conclusions and Future Work

The main contribution of the proposed model is the mobility, which translates to saving time and effort in the knowledge network generations. The model itself is another way to help people do their work in any area they desire, not only because it eases work, but because it gives access to well defined, relevant and explicit information when it is required. The gathering, synthesizing, reflecting and discussing of information is essential for knowledge management; technology has to support all four activities. Knowledge will never be definite. It's incubated and grows without end.

It is important to test the amount knowledge acquired by the use of the proposed model with different users. The proposed model is a product of a research project that involves two important aspects of information technologies: Knowledge networks and service nodes communication networks. In such an environment, users can be in constant interaction, which brings feedback, encourages discussions and makes reaching goals a more agile process. Computing technologies, on the other hand, provide us the capacity of bringing the environment to any physical place and in any moment; removing the need to be in front of a fixed computer to be able to access the system.

The kind of architecture that was developed can be useful for other purposes. Thereby, an important conclusion that we have reached is that the architecture if fully flexible and applicable to multiple areas and different user needs. Then, applicability of the architecture can be changed in a simple way. One way that the architecture could be substantially improved would be creating a cloud that allows storing and sharing the knowledge base with the linked services to all users.

As future work, it is important to highlight that this proposal can be implemented over diverse research fields and education; but the possibility of it being implemented on information distribution areas like economics, politics, social and cultural areas is not dismissed.

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NoProfiling: multiplatform application to avoid the profiling of email users

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Abstract. The goal of this paper is to present the development of a Web application and a Mobile application that avoid the profiling of email users generated by BOT-attacks. It was implemented the P protocol, for the first time, that uses a symmetric encryption system in order to cipher the content (plaintext) of the email with a private key. To share that key, this project generates CAPTCHA images, achieving that only a human can observe and read the private key and decipher the encrypted email (ciphertext), allowing to users ensure their information without having to acquire some knowledge about computer security or cryptography. Also, this work provides to P protocol the chance of controlling the CAPTCHA difficulty through its parameters (rotation, deformation and size of characters). Currently, exists techniques to maintain secure the email content, like PGP or GPG through asymmetric encryption or symmetric encryption based on digital signature scheme. However, these systems require knowledge of computer security and sometimes even cryptography. One advantage of this work, is that the users does not need to remember a password to access the email content, but this does not mean that safety decreases as each email has a different key. This process allows to keep users data safe from BOT-attack, considering that the information obtained by these attacks may be exposed to a third party without permission. This application also allows anyone, with a computer or mobile device and internet access, use it with the gmail, yahoo or outlook account.

Keywords: Security, Host attacks, Defense mechanisms

1 Introduction

When an email is sent, it is expected to contain confidential information regardless of it is a free email service. Today, software seeks patterns of words in the text, that is used for collecting information contained in email without the users are aware of this process, such being a method that generates user profiles of email addresses according to the type of information contained to define the interests, devices that perform this process are technically called BOT. The most

common BOT attacks are profiling of users, sending junk email and identity theft.

All types of profiling have in common the aim of collecting personal information from users and according to the analysis are classified. Mainly companies use this kind of technologies to commercial and banking purposes. e.g. Alice asks Bob, by email, to lend her some money to buy a laptop. Then the bot attacker analized the email's content. After that, bot attacker's own sold the information to some bank (because she needs a loan) and to a online store (because she wants to buy a laptop).

All this generate that email users privacy is violated and collected in the users profile become misused, as these profiles can be so specialized and detailed as the information you write in the email. Therefore, the issue focuses on these profiles are released, that is, if made public or they are stolen from companies that generate them, unleashing targeted attacks (e.g. theft identity). This problem has been presented in [1].

As a solution to the problem mentioned above, it was design and programmed a multiplataform application that includes a Web application and one for mobile devices. To enable email users to use the services of their provider and ensure that those who read the emails content is a person and not a bot attacker; all without the user having to configure some extra tool. To achieve this result, the P protocol was implemented using a symmetry encryption system [2]. The bot attackers have a few chances to access to encrypted user information avoiding performing a user profile.

2 Development

The P protocol is a private key algorithm that gives security concept applying CAPTCHA in order to authenticate users for a service. According to [3], it is not mandatory that a user becomes aware of security concepts to protect your information and because of it proposes using CAPTCHA image as a channel to exchange private keys securely. P protocol v. Figure 1 consists of:

- A message (M) and an encrypted message (C).
- A set of character (k) obtained from an alphabet (STR).
- A *HASH* function H: k $\rightarrow$ K that will become the key.
- An Encryption scheme E: K x M $\rightarrow$ C where K is the key.
- A CAPTCHA generator that use as its input characters of the set G(k).

The NoProfiling system is based on the P protocol, described above, and the architectural design is based on the MVC-1 pattern (Model-View-Controller) logic level, which associates the presentation and business logic as shown in Figure 2. In MVC-1 only one component is responsible for receiving and responding requests made by web browsers.

In a physical level, the architecture is based on cliente-server model. This model aims to separate the activities of the system user and those that are going to execute temporarily in the server-side. This architecture applied to this work is

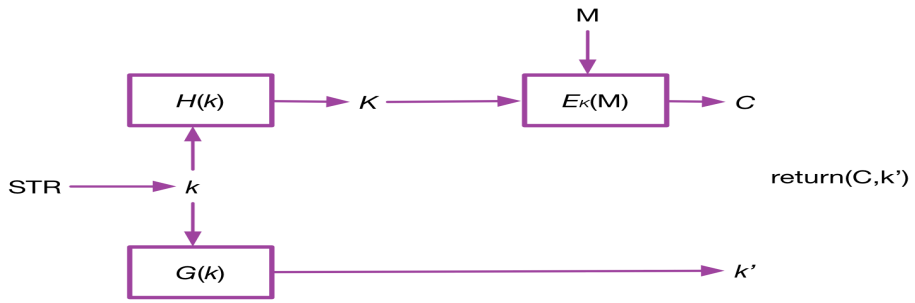

Fig. 1. P protocol

shown in Figure 3. In the first part of the system development were programmed key generation and SHA-256 hash function [4] to create the encryption key and generating CAPTCHA images

The first process is the key generation process that uses a dictionary of characters to get 8 elements which become the private key, to prevent visual confusions letters `l, o, q` and the numbers `1, 0` are removed.

Within CAPTCHA image generation process some transformations are applied to the image in the background, like circles of different diameters, and characters transformation like rotation, deformation and size [5]. These parameters are editable and can define the difficulty of the CAPTCHA.

With the process described above, it was possible to reach sending and receiving encrypted emails, for it used the library `javax.mail`. By using these protocols, is necessary include SMTP [6] and IMAP properties in the session. Each encrypted email sent by our system is marked at the final of the email subject with "- NoProfiling".

HTML5 allows the system to use WebSQL, which stores the email server domain's parameters. Also, Javascript (AJAX with jQuery), CSS, as Web technologies are used.

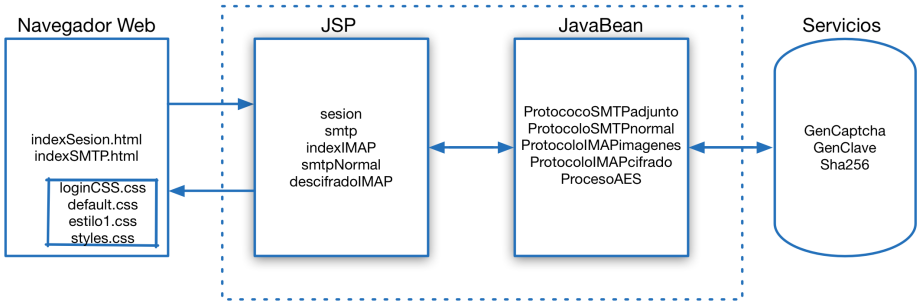

Fig. 2. Software Architecture type MVC-1 of the No Profiling System

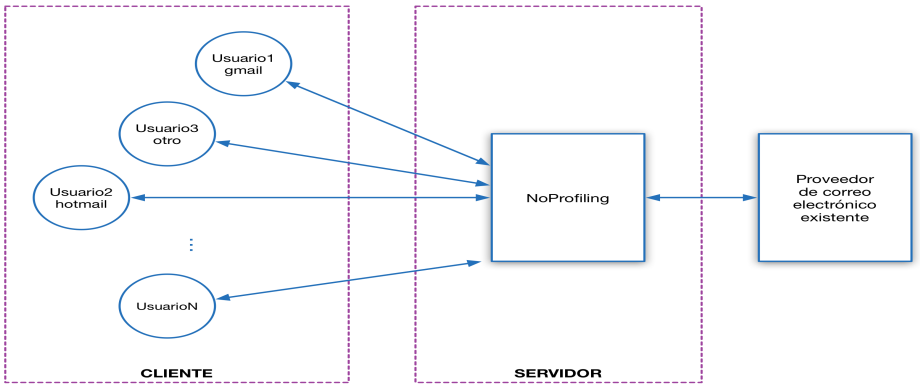

Fig. 3. Client-server architecture of the No Profiling System

Figure 4 (a), shows a login system screen, here, users must enter data in text fields and select the domain from their provider. The information registered here is passed to a JSP page to verify and only if it is correct, users can access and generate the image CAPTCHA from encrypted emails received so far.

Figures 5 and 4 (b) show the screen displayed for users to perform the tasks of sending and reading encrypted emails. In Figure 4 (b) in the left part have a menu to select the action by default the login show the option to send a email. In this part the user enter data in text fields corresponding to addressee information, before that user select a type to send the email encrypted or normal. If option is encrypted the system execute a JSP page to encrypt the email [7].

Figure 5 shows the screen where the users can read a encrypted and normal email. The screen show two emails the first one is a normal email and the second is a encrypted email this can be identifying bye the word "- NoProfiling" in the

Fig. 4. NoProfiling system screens: (a) login, (b) new email

subject, then is shown the corresponding image CAPTCHA, in the text field the user write the correct characters and clic "Descifrar" to show the email in the text area. Like is showing in Figure 6.

Fig. 5. NoProfiling screenshot: receiving email

The implementation of AJAX into the application is to exchange user's data between JSP, to obtain the result and show it to the user. This technology allows to the server requests are made in second plane avoid that the user does not visualize this activities. The system uses JavaScript language to facilitates implementation the system business logic.

To execute the action to send a encrypted email, the user needs to press the button "Cifrado" it obtains the user's data and the system passes them to JSP pages for the corresponding process.

For reading received emails, exists a preview process that allows the CAPTCHA image generation, this is performed knowing the number of emails that have not reading yet, after that, decrypting process is execute without knowledge of the user [8]. The programming of the mobile application v. Figure 7 it developed in the AndroidStudio IDE, it allows to make the login, this login interact with the process of the system.

Fig. 6. NoProfiling screenshot: decrypted email

3 Results

The obtained results of the test made, consist in:

- Result 1: For the proof to login into the system, contemplating the correct navigation, insert data and access to the system. In this test was entered with valid data and with all inputs completed correctly and different domains. As a result the introduced data was validated by email provides. As a special consideration have that the user needs a email account with access to less secure application permission inside account configuration.
- Result 2: Encrypt an email with a high level of usability. In this test was introduced the corresponding data to email addressee as the same time the subject and the message of the email, "Cifrado" was clicked to start the process. The result of this informed that it was realized the process of sending an email showing a GIF image, finally the system show an alert that the email was sending correctly.
- Result 3: Read and decrypt an email, check the use of CAPTCHAS in these process to received the key to decrypt the message. To realize this test it was clicked in "Recibidos - No Ledos", identified the encrypt email whit the phrase "- NoProfiling" include in the subject, writing the corrects characters of the CAPTCHA showed and "Descifrar" was clicked. As a result to introduce the correct characters of the CAPTCHA it was showed the original message.
- Result 4: The time to processing an encrypted email is 10 seconds approximated, that is because the system create a key to encrypt and insert attachments into the email and then send it. This process create a secure email from BOT attacks.

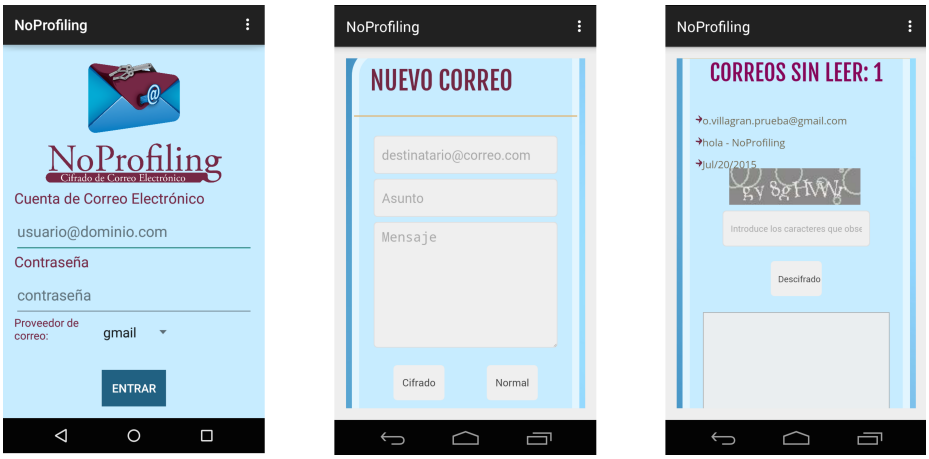

Fig. 7. Screenshot of NoProfiling mobile application

4 Conclusions

Thus, after design and develop the NoProfiling system they based the following conclusions. Technological impact:

- The use of corporative or free email services for academic, professional or personal purposes not condition the expose and use the information contained in it. Given this, the sending email protocols let the manipulation of information before send email on the Internet, offering the possibility to make transforms on information (in case of this project, encrypt).
- The encrypt algorithms implementation on emails services, give security on user information. Thus get to avoid attacks that wants to obtain and use information improperly. The symmetric algorithms when implemented in systems focus on usability offer an advantage in use the same key to encrypt and decrypt information.
- A form to store encrypt information is generate files with a specific extension, in relation with encrypt, that protocols accepts the `pgp` extension. This type to storage enable send encrypt information like attachment into a email. Thanks with that, the information can be send without drawback and then, avoid generate other methods to send encrypt information.
- CAPTCHA are elements that people use frequently although it use isn't knowing, these attribute let the implementation in any system to authentic people, doing a discrimination between people and machines, avoid that BOT attacks get into a system.

Social impact:

- An interface design is a important process to get the user to use the system effectively. For these reason, make the design focus on the final user increase the benefits in the system use.

– Market study on the users will be increase the system use. After email users study it was determined that the users with low or null knowledge on security are the more vulnerables in the face of cybernetic attacks in special BOT attacks that generate user profiles.

5 Future Work

On the results obtained in the develop and implementation in this project combined with the dizzying demand of more features and high level of usability, expose the future work that will be incorporate into NoProfiling system, highlighting:

– Due to existence of other email access protocols, is possible to implement them in the system to offer more options into NoProfiling system to the users.
– The information encrypt can be extend to attachments on the email.
– Include the option to generate a new CAPTCHA image to make a key with other distortions and visualize in other perspective the image. Also, with the evolution of CAPTCHA algorithms it can include the re-CAPTCHA in the system.
– Developing a desk application the NoProfiling system it going to increase the number of users of the system.

The good implementation of the previos features, will achieve the develop of a more robust system to avoid to generate user profiles.

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Controlling a DARwIn-OP Robot by Myoelectric Recognition Device

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Abstract. The main objective of this work is the creation and implementation of an interface that connects a myoelectric recognition device with a robot, so that, through movements of the hand and the arm, the robot executes certain actions previously defined, and that such actions are consistent with the movements of the operator. To achieve this, a gadget called Myo was used, which provides a discreet signal of five hand gestures plus spatial information that comes from its IMU; as for the robot, a virtual and a real model of DARwIn-OP were used, as well as an already elaborated walking routine. The movements and gestures of the hand were chosen so they result natural. The communication between Myo and the model of DARwIn was done through an SDK offered by Thalmic the same company behind Myo, and its written in a programming language called LUA. The virtual model of the robot is taken from the robotics simulation software Webots, and thanks to the purchase of a license for the software on its website, it was possible to continue testing the movement and control of the robot. The result is both a virtual model of DARwIn walking with complete freedom in a 3D environment, and the control of the real robot in a wireless way according to the movements of the arm, as well as several more movements indicated by the hand.

Keywords: Contlo, Myoelectric, Robot, DARWIN-OP, Interactive, Interface, MYO

1 Introduction

From time to time there is a substantial technological advance right after a paradigmatic impasse about what can and cannot be achieved. And so, out of some examples of this evolution, the human-machine interface development is remarkable [1, 2].

The road for this technology began at a time when buttons and levers were the norm. Not much time passed before this fantastic idea was introduced by

science fiction about one day being able to manipulate objects by waving and moving the hand without even touching them. Now, thanks to the advances made in myoelectrics[3–5], these fantasies are not far from reality.

Today, technology is trending towards a revolution were gadgets have become incredibly portable so they can integrate more with people: there are smartphones, smartwatches, tactile interfaces, activity monitors, etc. The basis of this article is then settled in the idea that the next step in control interfaces will be the human body itself, blurring even more the edge between man and machine.

Now that electronic components have been miniaturised to levels that were not thought before, implementation of myoelectrics in control applications is a viable option. Starting there, a new generation of myoelectric recognition devices that wasn't limited to interaction solely with prosthetics [6, 7], but includes a much wider range of applications was born[8, 9]. Controlling DARwIn via this method is intended as a proof of concept project, i.e. showing the capabilities and results of what the synergy between myoelectrics and other engineering areas could have. Through whats described here, it was possible to make DARwIn interpret the movements of the hand and the arm of an operator, so it could perform predefined actions the same way it would if it were connected to a remote.

Lastly, the structure of this paper follows the next order: section two describes the myoelectric acquisition device, as well as the design of the interface to connect it with the robot; section three is all about the implementation for both a virtual and a real model of DARwIn and what were the results obtained. Section five is reserved for the discussion about this work, its scope and its future.

2 Myoelectric Recognition Interface and Control

Despite the fact that today myoelectric applications are common[10, 11], the market seems not to care less about them. On the other hand, myoelectric enhanced control is seen as an excellent option for academic purposes because of its versatility and precision.

Myoelectric control is centred in the recognition of patterns that can be later interpreted as instructions by a controlled device. Of course, there are limitations as to what can be manipulated with such interfaces since every recognised gesture of the hand has to be very well defined to avoid readings in between poses. By doing so, the myoelectric recognition system requires less processing power and it results in a much more compact device. Furthermore, adding a group of spatial sensors, like an IMU, improves functionality while, at the same time, increases usability. The myoelectric sensor used for this project is called Myo, its made by a canadian company named Thalmic, and its focused on rather domestic applications, which makes it a lot easier to use.

2.1 Sub: Myo

Myo is as close as it gets to have a personal myoelectric interface. It consists of a band that has several electrical sensors all around it, and an integrated IMU.

It is placed over the thickest part of the forearm as a bracelet and, once worn and connected, it provides information about the position of the operators arm, as well as data related to one of the five possible gestures of the hand that it can detect: an open hand, a fist, a double tap on the middle finger and a wave in or out of the palm. These digital poses are the result of what the myoelectric sensors "see" in conjunction with a preprocessing stage on the proprietary ARM chip in Myo[12]. It uses the Bluetooth Low Energy protocol for communication, and can be programmed in two different ways: C++ and Lua (Thalmic provides the SDK for both languages and, in the special case of Lua, the compiler as well). The simplicity of Lua made it the choice for this work, and since it can run on different platforms, like Windows and MacOS, it adds up to the versatility of the project.

2.2 Sub: Webots

The first step towards controlling DARwIn was a simulation (which happened to help in the communication with the robot, as will later be seen too). Webots provided a virtual environment for a 3D model of DARwIn. It uses a physics engine to simulate the behaviour of the robot the same way it would do in real life. Besides, it includes a compiling tool allowing for coding in-program instead of using different software for the same purpose. Apart from that, Webots has a remote control module that can be used to send instructions directly into the robot once it is connected to the computer either via LAN or wireless connection. A licence had to be purchased as well, since the free trial to use the software only lasts 30 days.

2.3 Sub: DARwIn

An open source anthropomorphic robot acted as target for the controller. DARwIn was developed by the company ROBOTIS and it's intended as a means of education, development and research. It comes equipped with an Intel Atom Z530 processor and 4GB of SSD[13]. It has more than 20 points of movement, which made it a perfect candidate to combine with the myoelectric sensors since it can perform many different actions. Besides, it is a modular robot, so additions can be done in the future to expand the capabilities of the control interface.

3 Interface between Myo and Webots

The first approach to the solution of this problem is to choose which movements are going to be done by the robot, and which ones by the operator using Myo. Determining both sets of movements marks the direction that the work must follow, and since this project acts as a proof of concept, a good start would be making the robot walk[14]. Myo has the ability to detect five different hand gestures that can later be combined with the spatial information from the IMU, so there is basically an infinite amount of possibilities to control something. It is

then proposed to make the arm act as a joystick, therefore moving the robot in the direction the hand is pointing, e.g. rising the forearm will make DARwIn walk forwards, while lowering it will make DARwIn move backwards. Additionally, several more hand gestures were used to provide a wider range of motion apart from walking.

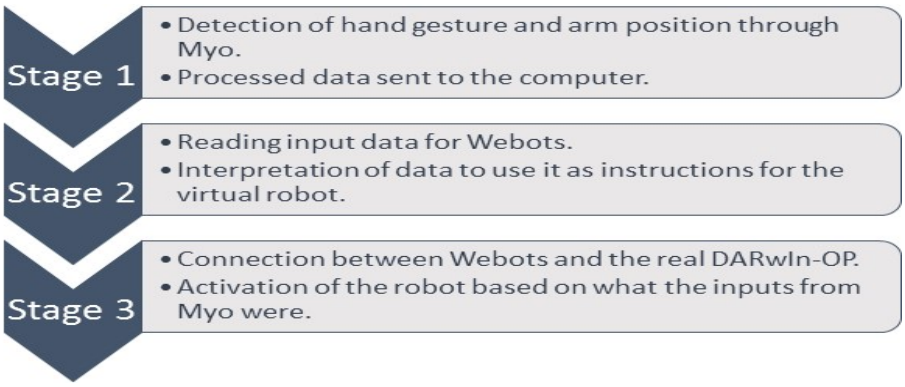

Fig. 1. Stages to control DARwIn with Myo

DARwIn already includes a library that lets the user play movement pages (animations) and control its walk (a gait manager). This reduced the amount of time spent modeling what the robot should do, since it only needed to be adapted to whatever input Myo was giving when it was tested; thus, practically have 3 stages to control the robot DARwIn, as can be seen in the figure 1.

3.1 Sub: Detection from Myo

Myo must be worn over the thickest part of the forearm, like a bracelet, allowing it to detect the electrical impulses coming directly from the muscles. Then, the processor can interpret those signals as a gesture, and the IMU provides additional information as to what is the relative position of the arm at a certain moment. In order to control DARwIn, the operator must move its hand as if it were a joystick, and joysticks have neutral points where no actions take place. Since guessing where the arm of the operator is is not an option, he must be able to set a neutral point whence he is able to move freely the way he intends to. So it was defined that whenever he closed his hand making a fist, Myo would set that point in space as a relative zero. Moving away from this zero will make Myo send a signal that DARwIn must interpret as an instruction to walk towards that direction. Of course, if no parameters are set, the slightest move of the arm will trigger an action in the robot, and therefore it was needed to establish not just a neutral point but a neutral zone surrounding the zero to keep the robot under control. This zone is 0.4 radians wide both vertical and horizontal, and

was implemented as a safe lock via programming. The algorithm and how the neutral zone is implemented can be seen in figure 2.

Algorithm: Myo detection

```
if fist = detected then
    centre yaw  read yaw value
    centre pitch  read pitch value
if centre yaw =/= 0 then
    current yaw  read yaw value
    current pitch  read pitch value
    delta yaw = current yaw - centre yaw
    delta pitch = current pitch - centre pitch
    if delta yaw > 0.2 radians then
        subroutine move to left
        if delta pitch > 0.2 radians then
         subroutine move forwards
        else if delta pitch < -0.2 radians then
         subroutine move backwards
        else
         subroutine no movement
        end
    else if delta yaw < -0.2 radians then
        subroutine move to right
        if delta pitch > 0.2 radians then
           subroutine move forwards
        else if delta pitch < -0.2 radians then
         subroutine move backwards
        else
            subroutine no movement
        end
    else
        subroutine no movement
        if delta pitch > 0.2 radians then
         subroutine move forwards
        else if delta pitch < -0.2 radians then
           subroutine move backwards
        else
           subroutine no movement
        end
   end
end
```

Fig. 2. Algorithm to control Darwin with Myo device

Other movements of the robot are defined in a similar manner. For example, the robot can nod if the operator waves out with its palm, and it shakes its

head when he waves in. Similarly, these gestures can be combined with spatial information from the IMU to create more commands according to what the operator and the user want to achieve.

3.2 Sub: Communicating with Webots

Once the set of movements for Myo and DARwIn was defined, the communication problem between Myo and Webots had to be addressed. That's where Lua comes in: any script written for Lua using the SDK provided by Thalmic can run over another layer of software, i.e. it can work the same way a touchpad or a keyboard work: as inputs. Regardless of what kind of program is open, Myo (using Lua) will keep sending input signals coming directly from the operator's arm and hand as long as it is programmed for that purpose. Considered this, the problem is reduced to how would Webots interpret the commands sent by Myo (since now Webots is able to "listen" to them), and in what way these would reach the physical robot.

A basic walking program for DARwIn, included in its simulation was made, so that the outputs from Myo and the inputs for Webots matched. In other words, the command necessary to make DARwIn walk forward is the same signal sent from Myo when the arm is risen. This allowed for a simple, yet useful, series of instructions compatible with each other that includes (but are not limited to) four commands to make the robot walk: forwards (arm up), backwards (arm down), left (arm to the left) and right (arm to the right). Since Webots accepts characters as inputs for the robot to move, different letters were assigned to each of the outputs sent from Myo, for example, whenever the arm was risen, a letter W was sent to Webots, and then the simulation, in return, would make DARwIn move forwards since the W was programmed to trigger this action.

Other moves performed by the robot were assigned with several different characters as well. For instance, number 1 and number 2 are, respectively, used to make the robot nod and shake its head; numbers 3, 4, 5, 6, 7, 8, and 9 have other reactions too. And for each instruction that is programmed into DARwIns code, another movement must also be adapted for Myo. DARwIn has many more preloaded pages of routines to perform, but if a new one were necessary, it could be done via RoboPlus, an application for modeling them.

4 Implementation in the Real Robot

With the simulation, commands and movements in place, it was time to change from a virtual to a real environment. This was accomplished once more with the help of Webots and one of its tools to program and control the virtual models of its robots.

It was originally intended to connect to DARwIn using a simple serial connection, with Myo dictating characters to a serial output terminal, and the other end receiving them through a cable or a wireless device. This implied that an additional stage for serial communication had to be built directly into DARwIn

so it could read the output from Myo. Webots for DARwIn includes something called remote-control session which lets the user connect directly to the robot. Once the link has been established, three options become available: uploading the controller, beginning a remote-control session, and unistalling the controller.

Then, it was natural the first step was to connect DARwIn to the computer using an Ethernet cable, so the link between both could be tested. The minimum configuration parameters to comunicate with the robot are: a default IP (which is 192.168.123.1) a username and password to DARwIn's domain (included in the manual).

After DARwIn is placed in the correct position, Webots uploads the controller to the internal memory, then it requests for permission to act as a remote control for the robot. From that point whatever input the computer receives within Webots will act directly into the real robots, therefore, the characters needed to make the virtual DARwIn move will be equally valid to make the real DARwIn move too. This procedure was intended to work as a bridge between Myo and DARwIn. The results were successful: whenever Myo sent a signal to Webots, the real DARwIn reacted accordingly, manipulating the robot using nothing more than just the arm, as was planned from the beginning. However, this was still a tethered communication process since the robot had to be plugged all the time into the computer using the Ethernet cable. In order to provide DARwIn with complete freedom of movement, a wireless network connection had to be implemented. Two solutions were proposed: one, creating a wireless network using an additional router so both the computer and the robot were connected to it; or two, having the computer act as an ad hoc so DARwIn could detect it as a wireless network and connect to it the same way it would to a router. As far as simplicity goes, the first solution was optimal, but since creating an ad hoc is by no means a hard task, and it would avoid having to use an additional component, it was preferred over the router.

What had to be done was to enable Windows as an ad hoc via command prompt (since versions 8.x and above had this functionality removed from the UI), just then DARwIn could directly connect without cables. By taking advantage of the already established tethered connection, it was possible to access the graphic user interface of DARwIn (which is Ubuntu) to look for the recently created ad hoc and connect to it the same way a laptop would do to any wireless network. Two different methods can be used to get into DARwIns Ubuntu UI: one involves connecting the robot to a monitor using an HDMI cable, a keyboard and a mouse; the other (which was used for this work) requires the use of software called UltraVNC, which creates a virtual network connection that lets the user view, access and control another computer remotely. Once inside DARwIns computer, connecting to the ad hoc, it could obtain the IP address needed by Webots to create a remote-control session too. As for the final stage of the implementation, duplicating steps to connect to DARwIn via Ethernet was enough for a wireless connection too (the only difference being the IP address Webots used). Since the procedure had basically no changes, the results were

pretty much the same, but now the robot was untethered from the computer and could move freely across the room. Figure 3.

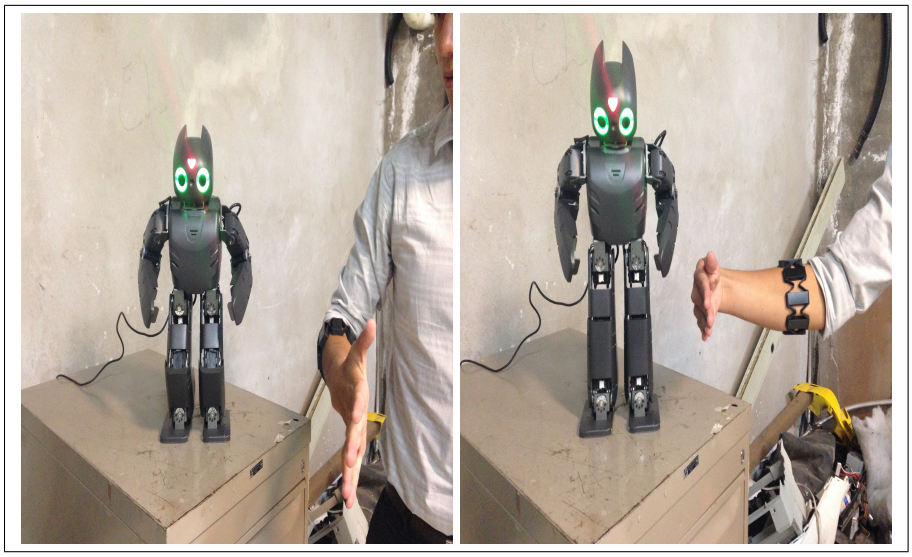

Fig. 3. DARwIn and Myo interacting

5 Results and Discussion

Right after DARwIn was successfully connected to Webots, and Webots was successfully connected to Myo through a script written in Lua, the bridge between these two was completed; the inputs coming from the movements of the arm and hand were interpreted as commands that were later send from Myo to Webots, Webots then read them and used them to control the virtual model of DARwIn, which was also linked to the real robot, making it move exactly as intended from the beginning. The result is full control over DARwIn, without even touching the robot, using an interface where actions are triggered by the natural movement of the arm and the hand rather than pressing buttons or tilting joysticks. Expectations about the reach of the project were fulfilled. As a proof of concept work, its even possible to say that merging myoelectrics with areas of engineering that involve control is viable.

There are limitations, though, as to what can be achieved with current myoelectric technology. Being able to reduce the size of myoelectric sensors comes with a price; processing power is ceded in order to get components to fit in the shape of a bracelet, and battery life is another concern too. This is the main reason why portable myoelectrics are not quite common yet, additional precision

is needed for applications with finer control requirements, and even though the technology exists, it involves having bigger sensors and a larger processing units to obtain the desired results, which is expensive and impractical for the most part. The proposed set of movements for both the arm and hand, as well as the robot, obey this premise. They result simple (yet really useful) because the myoelectric capabilities of Myo are reduced to what the proprietary processor can manage. Engineering is an iterative process, and in some years the processing power will double, or triple, allowing for more significant applications for the technology available today.

Several improvements can be done to both the robot and what Myo sees as input and transforms into an output. The movements of the robot are limited to two of its library components: the gait manager (to walk), and the motion manager (to play motion pages), but since these can be modeled based on the necessities of the project, they could be increased to make motion more fluid, more natural, or both. Pattern recognition in Myo is limited too, but the information from the IMU is easily processed and it allows to increase the number of possibilities that a single hand gesture could have. Communication was done through Webots, but before that, it was said that a serial fully functional interface had been developed. This interface allows Myo to connect to virtually any serial compatible device, leaving an open door to further applications, not just with robots, but with drones, utility vehicles, robotic arms, even Arduino based platforms.

This project has an enormous potential, not just to create videogame-like interfaces as the one demonstrated here, but to built entire machinery applications around myoelectric technology. It is not hard to imagine a crane operator controlling it without being inside, having a wider view of the construction site through images coming from cameras, in a room where is safe to work far from dangers such as falling from a high place, heavy rain, electricity, etc. Opening the garage door, or turning down the temperature without even touching the thermostat are not less real now that what this project has achieved.

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