System electronic the alarm the fall for older adult the care center the older adul San Martín

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Summary — The present titling work consists of the development of electronic system of fall alarm for older adults of the center of care "San Martin" using the wearable technology, this system will help to the elderly, their relatives and the institutions in charge of their care, because it will inform and alert the geriatric assistants and their families that there has been a fall. To do this study was taken the positions in which the elderly are concentrated in the course of the day and the activities they perform. In the process involving data collection, we used an acceleration sensor and an impact sensor that allowed the acceleration test to be performed in the different positions and at the moment of a fall, the data that was obtained will be processed, compared and if the data is a fall will proceed to send the alert by wireless communication wi-fi to my central module, after several tests, it is concluded which is the range of acceleration that detects a fall.

Índex of terms — falls, old adults, technology wearable.

I. INTRODUCTION

The center of care of the elderly "San Martín" of the city of Ibarra, is an institution that is dedicated to the care of the elderly, has auxiliary people and helpers with high vocation and experience, this entity is attended to 20 stable people (who live in the center) and two occasional (who spend only the morning and afternoon). Older adults who are in the center all day are at risk, due to diseases such as Arthritis, Alzheimer's, Deafness, Visual Problems, characteristics of their age. Dr. Salome Gordillo, owner of the institution, stated that the greatest recurrence of care in the center is related to injuries caused by falls. They constitute one of the most serious epidemiological problems, generating a cascade of consequences of all kinds, including social and economic.

Falls are now a health problem often overlooked by older adults and their families. At an older age, the likelihood of falling also increases, diseases increase, adding to this problem a number of risk factors that exist in the institution.

At the care center for the elderly, there is no alarm or alert system that allows the caregiver to be notified if an older adult has suffered a fall and because of this accident is badly injured. For this reason there are many people who have not been able to be attended immediately, there is no demand for personnel that serve a single person and this with the whole time.

The development of an electronic fall alarm system for older adults at the San Martín Senior Care Center seeks to have an immediate and permanent control of the elderly who suffered a fall by means of the generation of several types of alerts such as: activation of a local alarm and emergency call to the center manager, this will allow a timely intervention of early relief. Those in charge of this institution and relatives of the elderly can have immediate notice and know if they were taken care of in time.

II. BASIC CONCEPTS

A. *Old Adults .*

La persona considerada como adulto mayor o tercera edad es la última etapa de vida por el deterioro de las capacidades del cuerpo que superan los 60 años. Para el año 2025 se estima que existirán 1200 millones de ancianos [1]. Según el INEC en la provincia de Imbabura en el año 2013 se registró un total de 44 mil adultos mayores que equivale un 11% de la población de esta provincia

1) *Caídas en los adultos mayores:* The person considered as an older adult or third age is the last stage of life due to the deterioration of the body's capabilities that exceed 60 years. By the year 2025 it is estimated that there will be 1200 million elderly people [1]. According to the INEC in the province of Imbabura in the year 2013 a total of 44 thousand elderly people were registered that is equivalent to 11% of the population of this province

Figure 1. Older adult suffering a fall

According to the OMS, it is estimated that 424,000 fatalities fall annually, making falls the world's second leading cause of death due to unintentional injuries. Each year 37.3 million falls occur which, although not fatal, require medical attention. [2]

B. *Platform de Open Source*

When talking about free or open source platforms, you can mention many existing in the electronics market. These platforms are chosen according to the use, need, technology, characteristics that meet the perspectives needed to develop projects.

The platform most used today in the market, for its good operation, ease, its different characteristics that have and which can help at the time of construction, design a project is Arduino, it has a range of plates, which have different uses, functionality according to the needs of the projects.

1) *Arduino:* is an open source prototyping platform based on easy-to-use hardware and software. Through the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. Arduino was born in the Ibera Interaction Design Institute as an easy tool for the fast prototype, aimed at students with no experience in electronics and programming. As soon as it reached a wider community, the Arduino board began to change to accommodate new needs and challenges.

There are a large number of Arduino boards, in which are differentiated by the processor to use, number of pins, analog inputs, digital outputs, size, number of inputs and / or outputs required, if the power and programming goes to be realized with the own plate, if it is going to interact with its own circuitry or if it is going to communicate with external mobile devices like: PDA's, receivers, cellular, among others; thus, are among the most well-known Arduino boards: Arduino Uno, Arduino Mega, Arduino Zero, Arduino Pro, Arduino Nano, among others. [3]

C. *Wireless Networks*

Wireless networks allow a user or device to stay connected via electromagnetic waves without the need for a wired or wired network. There are a variety of technologies that have been developed such as fixed telephone is no longer used, has been replaced by mobile telephony. It is much easier to access the internet from any device. As Figure 2

shows, the classification of the wireless networks according to the scope, and according to the standard to which they are established and next is the description of each one.

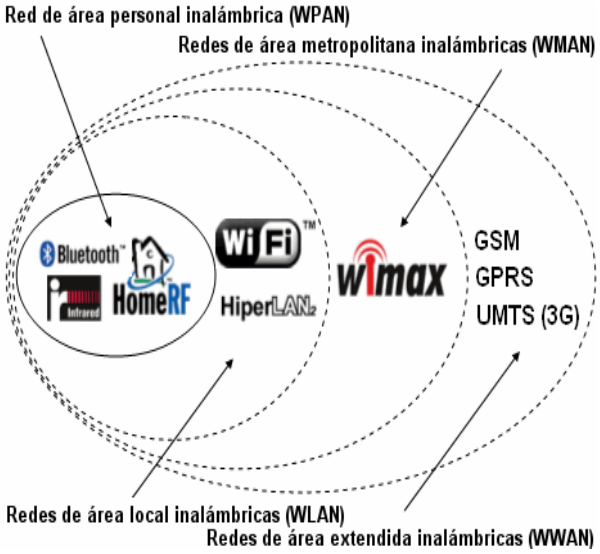

Figure 2. Classification of wireless networks.

1) *Communication modules*: They are modules for sending data in a wired and wireless way, in this way, can communicate between different devices in a remote way, as this work the development of a portable system refers only to wireless technologies that have this flexibility of do not need to be connected by a physical medium, for them it is necessary to have network coverage concepts. [4] For the development of the system is this wireless technology in this case WI-FI.

- WIFI

It is the wireless communication standard most used by most devices for their performance, speed and range; one of its advantages is the use of MIMO antennas for efficient spectrum use, its network address allocation allows greater connection of devices and network infrastructures, under the standard 802.11 b / g with USART or SPI communication pins, has a consumption of 40 mA, power of 18 dBm and with a consumption of up to 100 mA and a distance of up to 30 meters. [6]

III. EXPERIMENTAL DEVELOPMENT.

A. Analysis of the current situation.

An interview was conducted with the administrator of the care center for the elderly San Martin, the questions asked to obtain information about the institution and the falls.

Currently there is no method to alert elderly attendees or to know if a fall accident has occurred, the only alarm is when a cry is heard from the person suffering the incident, or look at an older adult falls and the person observing can inform the nurses of this setback. There have been cases of minor and serious fractures, where an older adult falls and did not receive the medical attention in time because there is no alert that indicates of this event.

The time period from the time the older adult suffers a fall, until the geriatric assistant attends the patient, is approximately ten to fifteen minutes, this elapsed time is essential for the care of the injuries caused by the fall.

An inspection was also carried out at the San Martín senior care center where the system to be designed must have coverage of a wireless network that reaches all places in the center, it is necessary to acquire repeaters to extend the WLAN signal, these they will have to be placed in high parts so that people can not manipulate the devices and in this way, avoid damages in the equipment or configuration.

Geriatrics auxiliaries request that the alarm system should be located in the living room, to be able to listen to the alert issued by the system 24 hours a day, because it is the place where they pass and winged of this room is the rooms of the caretakers who have the shifts at night, thus avoiding the falls that occur continuously in the morning or night time.

B. System requirements.

For the analysis of the system requirements, reference is made to the ISO / IEC / IEEE 29148: 2011 standard, whose function is to relate the need presented by the San Martín Senior Care Center with the solution that the project can provide through parameters that the system must meet. [7]

The standard defines the construction of a good requirement that provides attributes and characteristics taking into account the repetitive application throughout the life cycle of the system. ISO / IEC / IEEE 29148: 2011 is closely related to previous standards for the application process, such as ISO / IEC 12207: 2008 and ISO / IEC 15288: 2008.

C. Selection of the Hardware y Software.

Once the system requirements were analyzed, the ARDUINO IDE software was selected, and in terms of hardware the embedded system Arduino Uno, Arduino Nano, Sensor MMA7361, Impact Sensor, WIFI ESP8266-1, Shiled Etherned, GSM-900.

D. System Design.

As part of the system design, the block diagram that guides the operation and the processes to develop the project is shown below.

The block diagram of Figure 3 shows the structure of the system consisting of two main blocks the central module and sensor module these devices were communicated through the WI-FI communication device of the WLAN network of the institution.

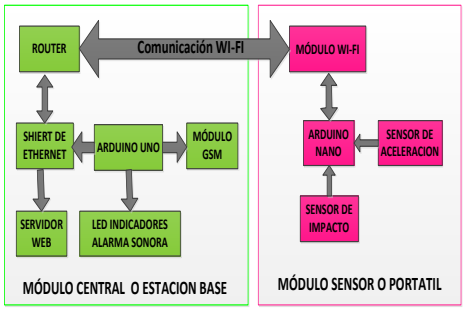

Figure 3. System Blocks Diagram.

The data collected by the sensor module will be transmitted to the central module through wireless communication, through the sending of characters. If a fall alert is presented, a main alarm is generated (both audibly and visually) and an alternative alarm where the GSM electronic device will be used to send a message to the center manager or an elderly relative.

1) *Module Central:* will be in charge of the communication with the sensor module, also of the reception of data of the sensor module, the processing and the generation of alarms automatically.

This will manage the situation of the alerts, locally in the institution (main alarm) and outward to the manager of the center or to a relative (alternative alarm) as long as a fall fin consists of the following devices:

- Arduino Uno

The Arduino one is the brain of the central module, it is in charge of receiving data, reading, comparing, processing, and transmitting data. It is directly connected (allowing to connect to other plates on top and stack it on the Arduino board) to Shield Ethernet, GSM module, indicator lights and audible alarm.

- Shield Ethernet

The Shield Ethernet connects to the local network via RJ45 cable to the Router, has a built-in micro-SD slot that allows storing the web server.

The Web server can be viewed by the people in charge of the senior center, it is not necessary to add hardware for operation, the web page is basic, each page of the server is stored in a document with HTM extension where the code is in HTML

The web server is raised upon receiving a request made by the client (manager of the institution or people who work) on port 80 (web page) every time a request is received the server will be raised to display the stored information.

- Router

The Router will allow to connect via RJ45 cable to Shield Ethernet, also will be connected to the module WI-FI of the central module for the data transition. The Router performs its respective mapping for the communication of the wireless network and the wired network does not give any treatment to the network since its consumption is very limited, only a fixed address is needed to the central server since all point to this system when there is an alert.

- Módule GSM SIM 900

This GSM module has a slot for entering a SIM card (it is a removable smart card used in mobile phones). It will connect to the Arduino Uno, which is responsible for processing and sending the information to the GSM Module.

You must define a cell phone number that can be from a relative or from the center manager to receive an SMS text message informing that the older adult has suffered a fall. As a recommendation the user will activate a text message package in the SIM that will be used in the GSM module for sending messages.

- Indicators the alarm

The warning indicators consist of two LEDs and a buzzer. It allows to know the state of the system if there is a drop or if there is a communication failure between the center module and the sensor module.

2) *Módule sensor:* allows the immediate and reliable detection of the fall in real time when the older adult is performing activities in their daily life, will be portable and portable at all times.

Its interface will include an easily accessible button to turn off the alarm generated by a fall. The user interface is completed with light signals in the Arduino nano indicating that there is a fall and an audible alarm that by means of the sound can be located and find the place where the injured adult is found, is constituted by:

- Arduino Nano

It is the brain of the central module, responsible for receiving the data generated by the sensors (accelerometer and impact), processes, compares them with defined ranges and exceeds these ranges, sends via the WI-FI device the alert that exists a fall.

It has 8 analog inputs, each providing 10 bits of resolution (ie 1024 different values) in these pins will proceed to connect the acceleration and impact sensors. It also allows the wifi module to connect to it via the receive (RX) and transmit (TX) pins of the data.

- Accelerometer Mma7361

For the automatic detection of the fall is taken into account to use the acceleration sensor MMA7361 is an analog sensor that is presented in the 3 axes (X, Y, Z) with a high precision, is connected to the Arduino Nano the same one that compares the data generated from the accelerometer in its 3 axes.

This sensor has the GS (g-Select) ping which is the acceleration sensitivity as we can see in Table 30 when using the 6g mode we have a sensitivity of 2016Mv / g, with a voltage on the output pin from 1, 85 V up to 1.44V. The analog-to-digital converter of the Arduino has a range from 0 to 1023, according to the data sheets of these electronic components.

Tabla 1. Sensibilidad de aceleración 6G.

Mode 6g	Voltage on the Pin (V)	Range the Converte A/D (Arduino)	Sensitivity
6g	1,85	1023	
0g	1,65	511	2016mV/g
-6g	1,446	0	

Source. (GENUINO, 2015).

Therefore, if -6g is equivalent to 0, 0g is equivalent to 511 and 6g is equal to 1023, the following Table 31 is available, where the range of the digital analogue converter corresponding to each one can be considered according to gravity. If the

acceleration is very fast it will go from 6g to -6g if the acceleration is lower, and the acceleration is decreasing to 5, 4.3, etc.

When defining a range of sensitivity based on Table 2 we proceed to compare the defined range with the data that the sensor emits on its axes X, Y, Z, if these are in the range established as the detection of a fall will proceed activate the alarms, but as long as the data obtained by the coordinates are not in this range the system will operate normally, without activating the alarms.

Table 2. Digital analog converter range.

Gravity	Range del converte A/D
-6g	0
-5g	85,2
-4g	170,4
-3g	255,6
-2g	340,8
-1g	426
0g	511
1g	596,2
2g	681,4
3g	766,6
4g	851,8
5g	937
6g	1023

Source. Autor

We proceed to determine the range of the acceleration sensor of -3g = 256 and 3g = 766 where if the data obtained in the X, Y, Z axes are greater than 766 and less than 256 there is a fall while they are not inside this range will not exist fall alerts.

- Sensor the impact

The wireless vibration or impact sensor is designed to detect any vibration, shock or impact. Once the vibration is detected, the sensor transmits a signal to the Arduino. It has an adjustable sensitivity according to the need. This will activate when the older adult suffers a fall by the vibration and the blow that is generated.

- Módule WIFI ESP8266-1.

Allows to connect to another network wirelessly, the processing and storage capacity allows integration with the sensors, the Arduino Nano and other devices This module is configured by AT command.

The WI-FI module is responsible for sending the sensor module alert to the central module. This is done using it sent two character or bits, this type of variable is used because it is the most effective in wireless transmissions and avoids errors in reading data. The first character or bit indicates which portable module it is. The second character or bit indicates the alarm number (if 1 is a fall alert and s is 2 will be a deactivation of the alert).

It performs sending characters as long as there is a fall alert that are generated by the sensors, processed by the Arduino Nano and sent to the WI-FI module. At the time of sending the WI-FI module sends a request to see if the channel is empty for the transmission, if it is free to send its wireless frame, establishing that the central module is present in the network, verifies that the device has service active and accepting the request on port 88 of the destination or central module that the client or sensor module intends to use. Informs the destination that the Wi-Fi module intends to establish a communication session on port 88, after establishing the communication receives the data sent from the sensor module, these are processed by the Arduino One and activates the alarms that are generated by the fall of the elderly.

IV. IMPLEMENTATION.

The implementation of the different devices is performed to be able to have a system that is able to differentiate the daily activities that the elderly perform a fall, the system is reliable to prevent the generation of false alarms and undetected drops. Fall detection is immediate and reliable.

A. Implementation of the Módule sensor.

For the implementation of the sensor or mobile module the following parameters must be taken into account:

- The correct functioning of the sensor module is that in the place where the device is located, the system works correctly, is reliable in detecting a fall and does not generate false alamas or falls undetected.

- That it is not annoying for the elderly, this means that a suitable place should be found for the placement of the system, where it can be worn and not be tedious for the older adult in daily life and accomplish his tasks.

After taking into account the aforementioned parameters and perform functional tests, the decision is made that the system will be placed in a harness that the older adult will wear on his chest. Because the sensor module works perfectly in the chest, the impact and acceleration sensors correctly detect a fall, by the acceleration that occurs when falling and by the blow that is generated. Also because of the weight and size that the device has can not be placed elsewhere.

It was verified that the older adult uses 3 to 4 garments (I divided a shirt, shirt, vest, jacket or sack) in his trunk (upper part of the humid body) because it is ideal to put him under clothes that cover the system not to concentrate the attention of the people in the device, being the most discreet place and does not affect in the daily activities that it performs as shown in Figure 4.

This part of the body guarantees the reliability, the good operation of the system since no false alarms or undetected drops.

Figure 4. Implementation of the módule Sensor on the chest the old adult.

The chest harness is formed by joining several pieces combined between flexible fabric straps and polycarbonate parts, thanks to its elastic straps it is fully adjustable, each strap has its adjustment system that can fix the harness to the contour of our body and prevent the central module from moving or loosening.

The sensor module is completely centered on the torso, a strap surrounds the chest and two straps go from the module to the back where they are joined in one piece and become a single strap that come together. Figure 5 shows how this node is constituted.

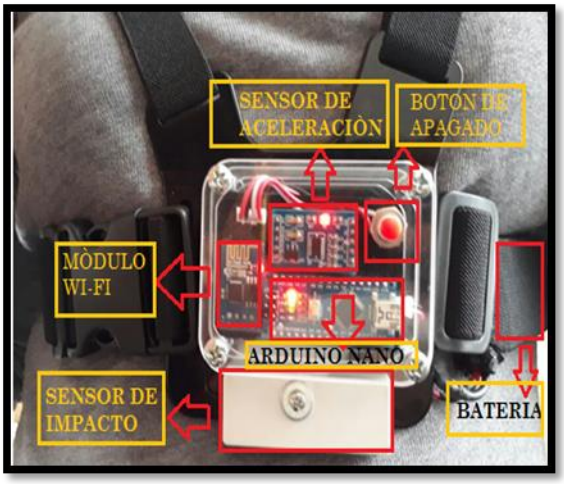

Figure 5. Design end the module sensor

B. Implementation of the Módule Central.

For the implementation of the central module is taken into account to place in a place where the geriatrics assistants spend all day so that the alerts can be heard. In this case it was installed in the room in a closet as shown in Figure 6.

Figure 6: Implementation of the project in the Elderly Care Center.

Figure 7 shows the central module with its devices mentioned above.

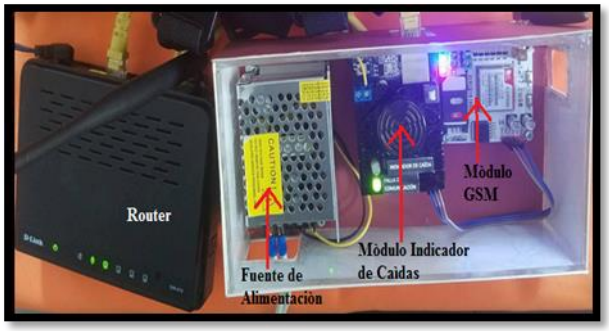

Figure 7: Elements the módule central.

C. Servidor Web

The web server will keep updating every 5 seconds (it was taken into consideration every 5 seconds because it is a prudent time for web server fans to recommend, also because it is a reasonable time to update the page at the time of a crash or when there is a failure of the module communication).

When the system indicates that there is no alert (communication failure or failure), the html file will be loaded by default indicating that there is no drop, as shown in Figure 8, which shows the characteristics of the prototype and the state in which the system is located, providing information to the user (staff in charge of the care of the elderly).

Figure 8. Page for client display when there is no fall.

When the system detects a crash and sends the alert to the central module, the page is modified, changing its presentation as shown in Figure 9, where you can see the information needed for the care of the older adult who suffered the accident and the state of the system.

Figure 9. Page for client display when there is a fall.

When there is a communication failure between the central module and the portable module, the

web page will be modified, changing its presentation as shown in Figure 10.

Figure 10. Page for client display when there is a communication failure

D. Communication between the central module and the sensor module..

Allowing the user to have a secure system at the moment of the information transmission, that the central module correctly receives the data emitted by the sensor module. There are two states of communication, in the moment that there is communication and when there is a failure in communication, then each one is described.

1) *There is communication between the central module and sensor modules:* Cuando exista conexión entre el módulo central y el módulo sensor se evidencia en el "led indicador de falla" generando una luz verde como se observa en la Figura 11 y la alarma auditiva estará apagada

Figure 11. Communication between the central module and sensor.

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2) *Communication failure between the sensor module and the central module*: This alarm is generated when there is no communication between the sensor module and the central module. This inconvenience can be generated: at the moment that the modules are not turned on, in the time that the lipo battery of the sensor module is downloaded, there is a problem in the network and in modules, etc.

When there is no connection, it is evident in the "fault indicator LED", generating a red light as shown in Figure 12 and the audible alarm (central module buzzer) is turned on. The page displaying the Web server is shown in Figure 10.

Figure 12: Alarm the failure the communication auditory and visual.

E. Alarm activate by fall.

There are two types of alarms that are:

1) Alarm Main: This warning signal will be local (in the institution) by sending an audible alarm (buzzers on both modules) and visual (led drop indicator and web server) at the time an older adult

suffered a fall In Figure 13 you can see the visual alert in which the "led indicator of fall" generates or lights a red light, in the Arduino nano of the sensor module you can see that a red LED is turned on, it will also turn on the audible alerts the central module and the portable module. The page displaying the Web server can be seen in Figure 9

Figure 13: Alarm auditory y Visual (a) Módule Central (b)Módule Sensor.

2) *Secondary alarm:* it is produced through him sent a text message that may be, to the caregiver of the elder care center "San Martin" or a relative. The number to be sent the message will be defined by the institution and configured in the Arduino Uno Firewall, if you want to change or modify the number that receives the message should call the technician who installed the system.

It is recommended that the user activate a text message package to the SIM that is in the GSM module for sending messages. As long as there is no fall, text messages will not be sent. The person receiving this message may be inside or outside the institution. In Figure 14 you can look at the SMS text message that the person receives, at the time a fall occurred in the older adult, indicating the name of the patient who suffered the accident

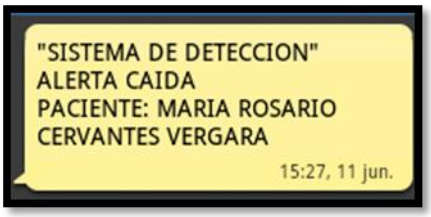

Figure 14. Sent a text messange to the person in charge of the institution.

F. Desactivation of the alarm.

After an alarm is generated due to a fall, the alarm is deactivated as long as the older adult has been located and taken care of.

The alarm deactivation button is located on the sensor or laptop module that is worn by the older adult. It was taken into account to put it in this module because this ensures that the caregiver goes to where the older adult who suffered a fall is taken care of and deactivates the ward.

To deactivate the alarm, press the button on the sensor module once as shown in Figure 15, after pressing the system it will go to normal state (the led indicator will go out, the audible alarms will turn off, Web server will go to normal state as you can see in Figure 8).

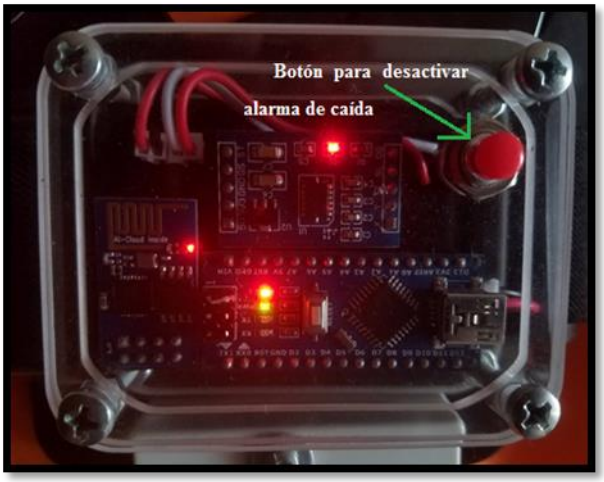

Figure 15. Desactivación de la alarma

V. CONCLUSIONS.

The design and implementation of the electronic fall alarm system for older adults of the San Martín care center was carried out, thus fulfilling the main

objective of this project, which aims to improve immediate assistance to the elderly later of a fall.

The system alarm is generated in auditory and visual mode, activated when the sensor module presents changes in the data emitted by the sensors.

Once the functional tests of the system of falls have been obtained low energy consumption is obtained, with a minimum environmental impact which makes it an ideal alternative to give solutions to specific problems.

The system has a low energy consumption, with a minimum environmental impact which makes it an ideal alternative to provide solutions to specific problems.

After the analysis, the final cost of the electronic fall alert system is a justified investment, because it helps and benefits the elderly, the institutions, the family, thus improving the quality of care provided at the time of a fall .

The system of falls presents an error correction when the central module does not connect with the sensor module notifying visual and auditory alarms.

VI. RECOMMENDATIONS

It is necessary to always have a network connection in order for the system to work properly and not have failures since it works through wifi communication.

It is necessary to have an account of all the variables that are presented in the course of the elaboration of the system and to be able to solve them.

It must be taken into account before you get a Lipo battery the voltage, the current you have. If these characteristics can feed the project and make all the electrical elements work properly and in turn know the duration time of it.

It is recommended to carry out more projects that help improve the quality of life of people.

At the moment of the implementation of the electronic system of fall alarm in the elderly, a problem was obtained of the sensor module where the sensors detected as falling when walking and when lying down, we proceeded to the correction of this error to establish a range suitable for the sensors not to detect as falling in these positions and the system works correctly

A text messaging plan must be contracted to the SIM card that is in the GSM module so that it can send SMS at the moment of a fall.

The system must be maintained at least once a year or when it is necessary to configure or change the telephone number that receives the message stating that a drop has occurred or when it is desired to change the name of the person who will use the message prototype, it is recommended to call the person I install.

It was taken into account at the time of the design of the system that the project can be installed and that it works in any environment (house home or gerontological institution, or domicile), that the only thing that must be had for its installation and good functioning is a network that allows the modules to communicate wirelessly and have electrical power.

An external power supply in the central module must be increased for safety and prevention to the power cuts that can cause the system to shut down and stop working. This source allows feeding the central module always.

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