Fall Detector for Pacients

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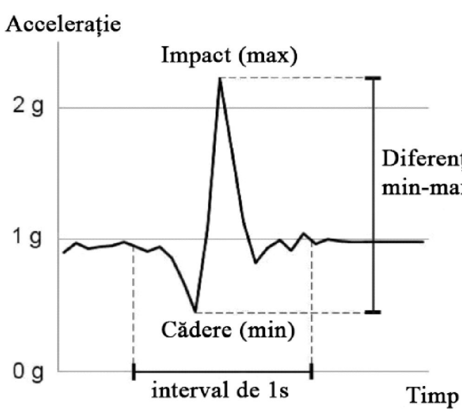
***Abstract* — Loss of consciousness and injuries resulting from falls are two of the most common problems that older patients face today. These problems are the main causes for which patients are transferred from the comfort of their own home to assisted care living. These types of accidents are the basis of over 35,000 deaths per year from injuries caused by falls and their impact, so failure to act in a timely manner can prove fatal.**

The objective of this project is to create a functional, portable and convenient patient alert system based on a microcontroller and an application programming interface specific to the application used for this alert system. Studies show that dedicated fall prevention programs targeting high-risk groups can help reduce injury rates by 20-40%. Fall prevention activities also have the potential to substantially reduce patient care costs and injuries associated with falls.

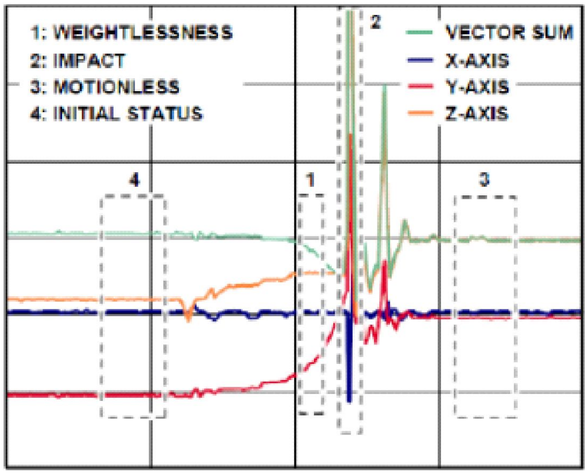
Keywords — Fall; MEMS; accelerometer; pacients

- Introduction

There are two ways to detect falls: by visual observation or by an acceleration sensor or accelerometer. Visual observation of the falls limits the activity of the observed person. Although this approach can provide accurate information, the costs are much higher than those involving the use of an accelerometer. Therefore, in this paper, a MEMS accelerometer was used to detect falls.



The accelerometer notices a sharp difference in values between the initial state and the moment of impact. This information is very useful in detecting impacts. An important thing to note is that the various activities that take place during a day, such as jumps or sharp bends, are similar to the standardized model. Thus, for a good accuracy of readings, other parameters must be implemented and satisfied.

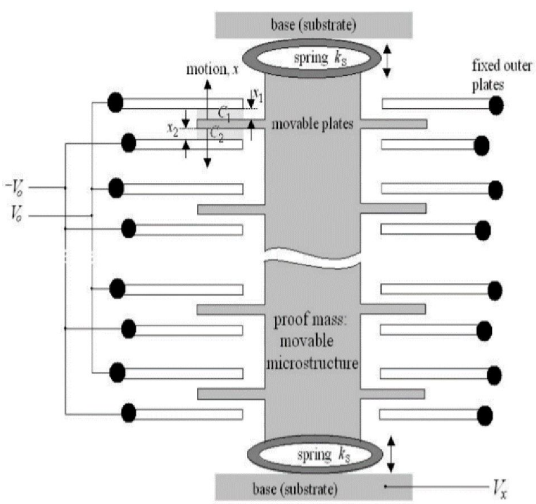


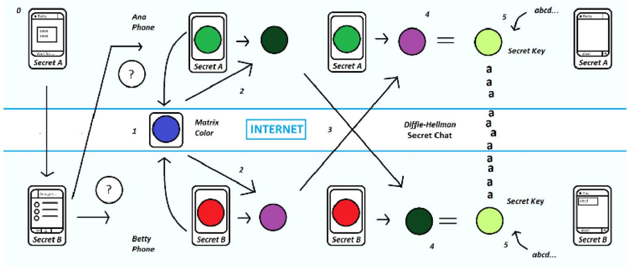
The first state is represented by the initial state, or the moment before the actual fall. The second state is the free fall recorded by the accelerometer, at which time there is a change in the values recorded on the Y axis. As can be seen in the sum vector graph, the fluctuations that occur at the moment of impact are major. The last observable moment is that of rest, in which all 3 axes are superimposed, there are no large fluctuations, but only noise due to the minor movements. [1]

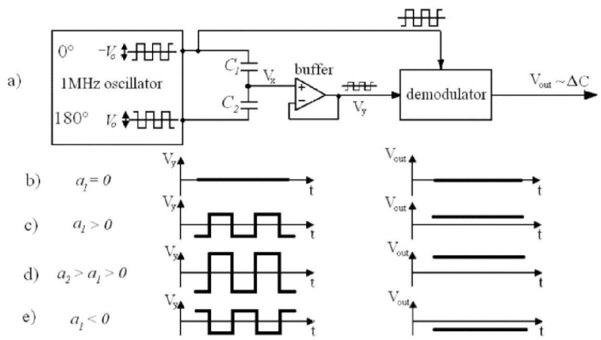
MEMS or micro-electro-mechanical systems represent the technology underlying the accelerometer used in this paper. This type of sensors are very small in size, ranging from 1µm - 100µm, making them a very good choice for a portable system.

Each sensor has many sets of capacitors. All the upper capacitors are connected in parallel with a total capacity C1 and all the lower ones are identically linked having the capacity C2, otherwise the difference in capacity would be negligible and could not be detected.

Acceleration is measured using the difference in capacity between C1 and C2. The spatial orientation can be determined depending on the waveform and the amplitude of the signal.







The ESP8266 WiFi module is a stand-alone SoC ("System On Chip") with a stack of TCP / IP integrated protocols, which can provide access to any microcontroller to the WiFi network. ESP8266 can host an application or download all Wi-Fi network functions from another application processor. This module has sufficient processing and storage capacity on board, which allows it to be integrated with sensors and other application-specific devices through its GPIOs, with minimal front-end development and minimal loading during running. The high degree of chip integration allows for minimal external circuits, so the package is designed to occupy a minimal area on the PCB. ESP8266 supports APSD for VoIP applications and Bluetooth coexistence interfaces, contains a self-calibrated RF that allows it to operate in all operating conditions and does not require external RF parts. [2]

Telegram is an instant messaging application based on the "cloud" system and voice over IP ("VoIP") service. Users can send messages and exchange photos, videos, stickers, audio files and any type of file.

The Telegram client code is an open source software, but the source code for recent versions is not always published immediately, while its server code is "closed-source" and proprietary. The service also provides an API to independent developers.

Telegram messages and materials are encrypted when stored on their servers, and client-server communication is also encrypted. The service offers end-to-end encryption for voice calls and optional "secret" encrypted discussions between online users, but not for groups or channels.

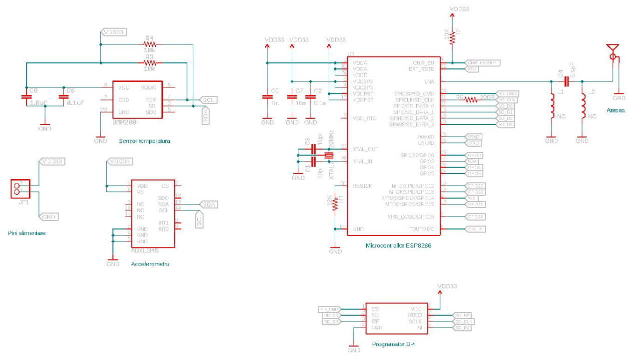
Telegram uses a symmetrical encryption scheme called MTProto. The protocol was developed by Nikolai Durov and other Telegram developers and is based on 256-bit symmetrical AES encryption, 2048-bit RSA encryption and Diffie-Hellman key exchange. [3]

• Implementation and obtained results

• *Schematic*

The electrical diagrams of the circuits used in this project were realized in the Eagle program. Eagle is one of the leading developers of solutions that allow engineers to design and build the next generation of electronic products.

Electric symbols can be created manually or used from existing libraries. The software provides functional symbols, packages and blocks for many of the most commonly used components on the market today.



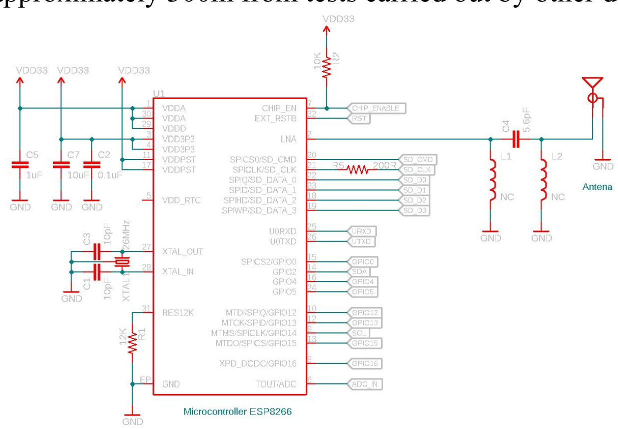
The main building block of the project is the ESP8266 microcontroller block which contains all the inputs and outputs from and to the sensors used.

Its power supply is 3.3 volts, in the electrical diagram being rated with VDD33. To prevent fluctuations from the battery, ceramic capacitors of different values were used to filter and stabilize the input voltage in the microcontroller. The values used are 10µF, 1µF and 0.1µF, the capacitor with the smallest value being placed as close to the input pins in the module.

A 26 MHz oscillator crystal was used to set the working frequency of the microcontroller. Two ceramic capacitors with values of 10pF were used to filter the signal to ground.

To improve the perceived distance of the WiFi signal, a copper antenna integrated into the PCB was used, connected to a π-type LC upstream filter that allows high frequencies to be passed, such as the 2.4GHz WiFi signal.

The integrated copper antenna is a vital part of the project because without proper positioning, without proper signal filtering and without a design that respects the manufacturer's limits, the signal reception distance would not be greater than 10m. The reception distance of the signal with the integrated antenna is approximately 300m from tests carried out by other designers.



(1)

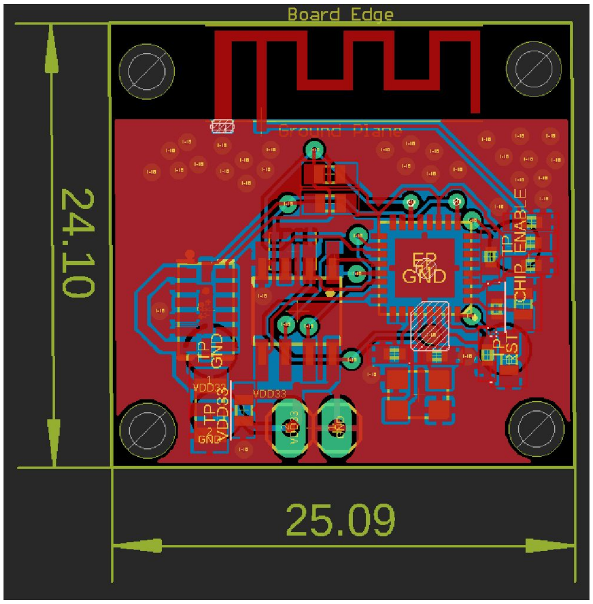
- *PCB Design*

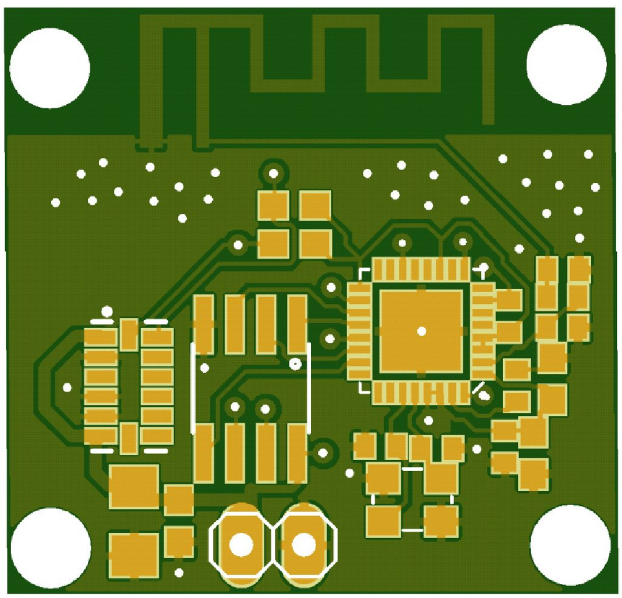
In addition to designing the electrical schematic of the project, a PCB was designed to obtain a finished product, small in size and ready to be used by patients. The board was designed in the EAGLE software based on the electrical scheme designed in the same program.

The result obtained is a PCB on 2 layers, with 22 SMT components, populated on both layers. The dimensions are 25.09mm x 24.01mm, thus allowing patients to wear the device without problems.

Device programming is done through the circular copper areas, placed on the bottom layer of the PCB called TP1 - TP4.

The test points TP1 and TP2 can also be used to power the system.





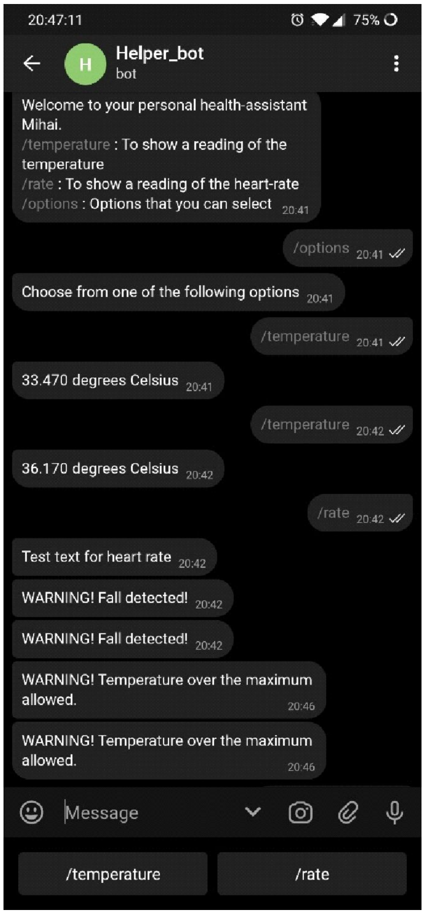
- *Phone App*

In order to be able to use the bot correctly and at the same time with a high degree of security, the generation of a code specific to the bot is necessary for attaching it to the application used. This code is automatically generated through the Telegram application, and attached to the program running on the chip. Thus, only the application to which the specific code is attached can receive data from the system.

The "CHAT_ID" parameter is a code specific to each system caller. The application can only transmit data to callers who have the code passed in the database. As a result, data security is enhanced and caller filtering can be done easily. Multiple caller codes may be passed, which allows the transmission of data to more than one person at the same time for alert.

```
#define BOTtoken "610248758:AAGeheZuzg2XlNVZ_HDwSFOYRaSGlfS9Qkg"
#define CHAT_ID "411771501"
```

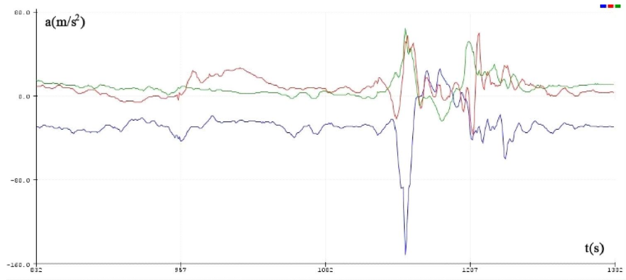
The query of the data is done either by calling the existing buttons, or by writing commands such as "/ start".



- *Signals and results*

Two of the most common types of falls in elderly patients or those who are not under supervision are either front or back. The direction of the axes and the amplitude related to the direction of orientation can be observed. In the case of falls on the back, the direction of movement of the hand is behind the patient, in the attempt to mitigate the fall. The increase in amplitude is relatively sharp, but not as sharp as in the case of frontal falls.

The normal activity of a patient can be observed followed by a jump in the following image. The amplitudes and waveforms of the normal activity are similar to each other, the moment of jumping easily being observed. The amplitude of the X axis decreases dramatically due to the specific movement of the hands when jumping. After the moment of jumping all, the 3 axes return to their initial state.



• Conclusions

In this paper it is described the working principle of a fall detection wearable device, as well as a proposed design. The obtained results are based on live tests with different individuals testing the product under different normal daily activities and simulated falls.

Acknowledgments

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References

1. "Automatic fall monitoring" , Natthapon Panmurat, 2014
2. ESP8266EX datasheet, Espressif Systems, 2018
3. Diffie-Hellman Key Exchange, Tariq Bin Azad, 2008