Heart Rate monitoring, Fall detection and Alarming system with data storage in MicroSD

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Abstract—In the final years the patient health monitoring, has played an important paper for researchers in Embedded Systems. The goal is develop a reliable health monitoring system portable able to measure Heart Rate, proper acceleration (to detect a fallen) and the location from GPS also send SMS to predefined numbers (using Gsm module) and write periodically the condition to microSD. The Embedded System will be designed for patients that need a constant periodically monitoring by family or doctor but does not have a critical condition. If the system detect a critical condition send an SMS with GPS location alerting to predefined numbers for bring a quick service.

Index Terms—Stm32f4 microcontroller, Heart Rate Sensor, Gps, Accelerometer, Gsm, Lithium Battery.

1 Introduction

HEALTH is one of the global challenges for humanity. According to the constitutions of World Health Organization (WHO) the highest attainable standard of health is a fundamental right for an individual. Healthy individuals lead to secure their lifetime income and hence to increase in gross domestic product and in tax revenues. Healthy individuals also reduce pressure on the already overwhelmed hospitals, clinics, and medical professionals and reduce workload on the public safety networks, charities, and governmental (or non-governmental) organizations. To keep individuals healthy an effective and readily accessible modern healthcare system is a prerequisite.

2 Caracteristics of the Embedded system

The portable embedded system will have the following characteristics:

- Know the location of the patient periodically
- Check periodically the Heart Rate of the patient
- Detect a fallen of the patient
- Send SMS to predefined numbers
- Create card based patient data monitoring

With which the embedded system will be able to create an alarming system based in Hear Rate monitoring and fall detection, which will send an SMS with the patient location to predefined numbers (family, doctor, clinic, etc...) if detect a critical condition. This first functionality is illustrated in Fig. 1.

Also create a card based patient data monitoring writing periodially information of the sensors to the microSD. This second functionality is illustrated in Fig. 2.

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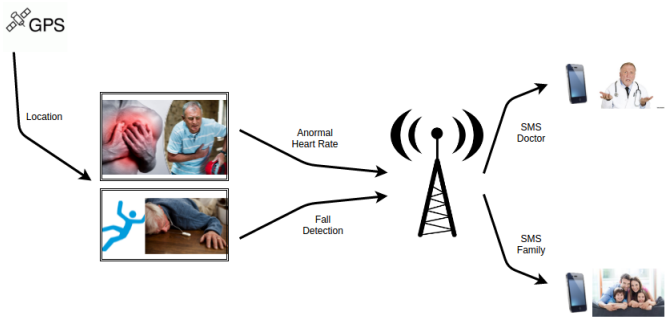

Fig. 1: Alarming system in a critical condition

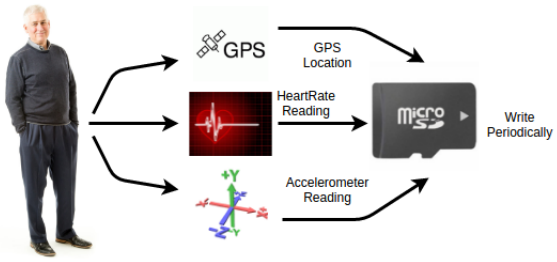

Fig. 2: Card based patient data monitoring

3 Embedded system to develop

To implement the functions listed above, will be need use a microcontoller able to do:

- Read location from GPS
- Read ADCs for X, Y and Z from Triple Axis Accelerometer
- Read ADC from HeartRate Sensor
- Send SMS using GSM modem
- Write periodically to microSD

The embedded system is illustrated in Fig. 3.

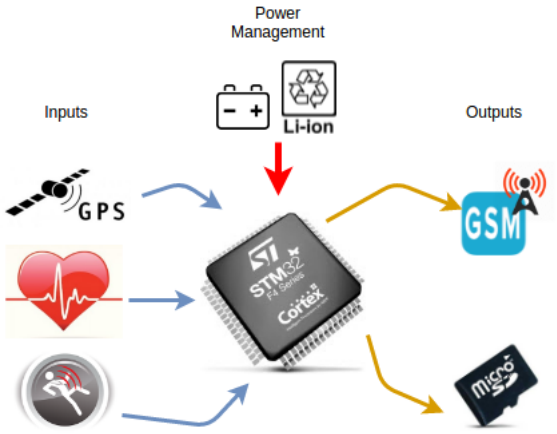

Fig. 3: Embedded System Inside

In the next subsections, will be explained each part of the embedded system:

3.1 Microcontroller

Will be used a microcontroller with the balance between performance, power efficiency and integrated peripherals to avoid problems in the future. After searching the good microcontrollers available today the best option is stm32f446re of the STMicroelectronics. The main features of the microcontroller is illustrated in Fig. 4.

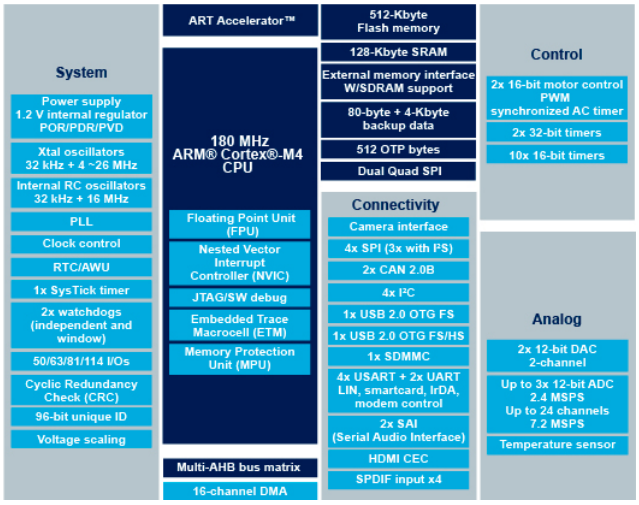

Fig. 4: Characteristics of the STM32F446

The important is that can begin to build a prototype with the Nucleo stm32f446re board, which have the programmer incorporated. The Nucleo STM446 Board is illustrated in Fig. 5.

In summary:

- 1x UART GSM Module
- 1x UART GPS Sensor
- 1x SPI Accelerometer Sensor

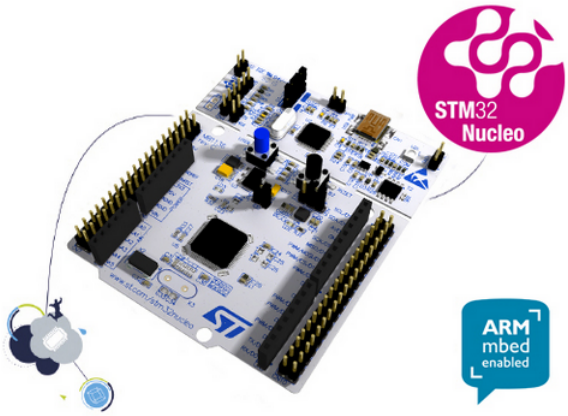

Fig. 5: Nucleo STM446 Board

- 1x SPI microSD Card
- 1x ADC Heart Rate Sensor

3.2 GPS Sensor

There are two good options in the market, which are:

1) LS2003H-G of the LOCOSYS company, is a complete standalone GNSS smart antenna module. The LS2003H-G Module is illustrated in Fig. 6.

Fig. 6: LS2003H-G Module

In which the main features of LS2003H-G are:

- Support 99-channel GPS
- Capable of SBAS (WAAS, EGNOS, MSAS, GAGAN)
- Support GPS, GLONASS, GALILEO and QZSS
- Low power consumption
- Indoor and outdoor multi-path detection and compensation
- SMD type with stamp holes; RoHS compliant
- Up to 10 Hz update rate

2) NEO-M8N of the u-blox company, is a concurrent GNSS module. The NEO-M8N Module is illustrated in Fig. 7.

In which the main features of NEO-M8N are:

- Concurrent reception of up to 3 GNSS (GPS, Galileo, GLONASS, BeiDou)
- Industry leading 167 dBm navigation sensitivity

Fig. 7: NEO-M8N Module

- Security and integrity protection
- Supports all satellite augmentation systems
- Advanced jamming and spoofing detection
- Product variants to meet performance and cost requirements
- Backward compatible with NEO7 and NEO6 families

Anyway the communication between the GPS Sensor with microcontroller is UART (Universal Asynchronous Receiver Transmitter).

3.3 Triple Axis Accelerometer Sensor

There are good options in the market but the Analog Devices Company have a list of excellent accelerometers, but a good option for this application is ADXL362. The ADXL362 Module is illustrated in Fig. 8.

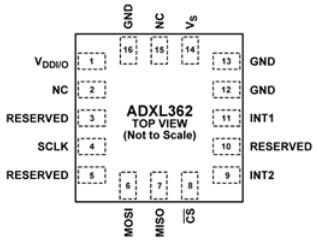

Fig. 8: ADXL362 Module

In which the main features of ADXL362 are:

- Ultralow power
- High resolution: 1 mg/LSB
- Built-in features for system-level power savings
- Low noise down to 175 g/Hz
- Wide supply and I/O voltage ranges: 1.6 V to 3.5 V
- Acceleration sample synchronization via external trigger
- On-chip temperature sensor

The communication between the Triple Axis Accelerometer Sensor with microcontroller is SPI.

3.4 GMS Module

There are two good options in the market, which are:

1) SIM900 of the SIMCOM company, is a complete Quad-band GSM/GPRS module in a SMT type and designed with a very powerful single-chip processor. The SIM900 Module is illustrated in Fig. 9.

Fig. 9: SIM900 Module

In which the main features of SIM900 are:

- SIM900 is designed with a very powerful single-chip processor integrating AMR926EJ-S core
- Quad-band GSM/GPRS module with a size of 24mmx24mmx3mm
- SMT type suit for customer application
- An embedded Powerful TCP/IP protocol stack
- Based upon mature and field-proven platform, backed up by our support service, from definition to design and production

2) M95 of the Quectel company, is one of the smallest Quad-band GSM/GPRS modules, ultra low power consumption and extended temperature range. The M95 Module is illustrated in Fig. 10.

Fig. 10: M95 Module

In which the main features of M95 are:

- One of the smallest Quad-band GSM/ GPRS modules
- Easier soldering process with LCC package
- Embedded Class-AB amplifier
- Power consumption as low as 1.3mA

- QuecFOTA TM
- Jamming detection
- DTMF decoding

Anyway the communication between the GSM Module with microcontroller is UART (Universal Asynchronous Receiver Transmitter).

3.5 microSD Card

Any microSD can be used in this application. For example, microSD card is illustrated in Fig. 11.

Fig. 11: microSD Card

The communication between the microSD Card with microcontroller is SPI.

3.6 Lithium Ion Battery

Low power embedded system is a challenge for this application, as well as hardware and software optimising for energy efficiency. Will use an energy measurement system that enables to understand the effect of the different improvements.

First will develop the embedded system to be sure the battery to choose, obviously as the system is portable the type of the battery will be a Lithium Ion Battery. For example, Lithium Ion Battery is illustrated in Fig. 12.

Fig. 12: Lithium Ion Battery

Therefore will need a charger that accurately balances and charges Lithium Polymer. A battery charger that could be used is illustrated in Fig. 13.

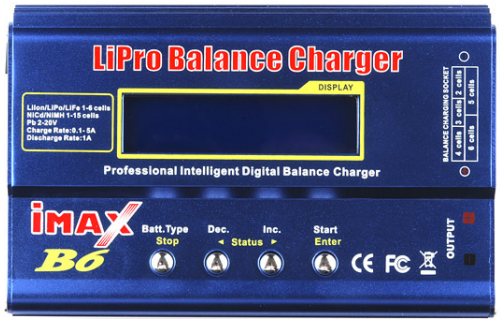

Fig. 13: Battery Charger

3.7 HeartRate Sensor

Is the difficult decision of this project, choose an appropriate Heart Rate Sensor, three are the alternatives:

1) AD8232 of the Analog Devices company, is a Single-Lead Heart Rate Monitor Analog Front End. The AD8232 Module is illustrated in Fig. 14.

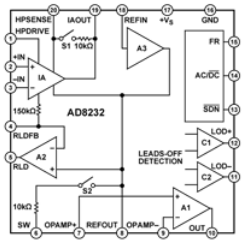

Fig. 14: AD8232 Module

But consequently need an electrode pads and biomedical sensor pads in funtion to measure the Heart Rate. The Typical Sensor Placements are illustrated in Fig. 15.

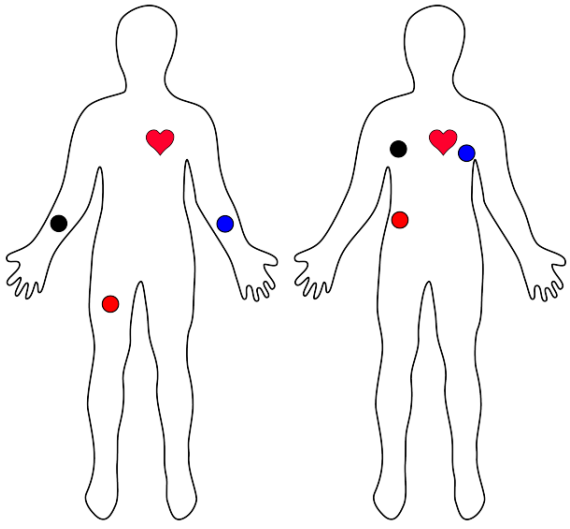

Fig. 15: Typical Sensor Placements

2) APDS-9008 of the Avago Technologies company, is a Miniature Surface-Mount Ambient Light Photo Sensor in order to use, need a linear operational

amplifier as MCP6001 of Microchip. The APDS-9008 Module is illustrated in Fig. 16.

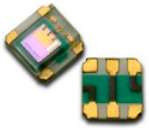

Fig. 16: APDS-9008 Module

But consequently to measure the Hear Rate is different to the previous sensor. The Sensor Placements are illustrated in Fig. 17.

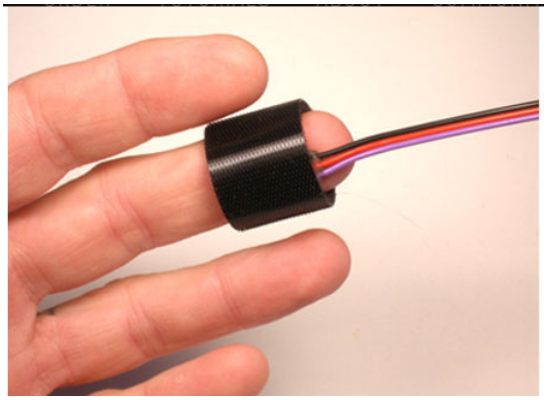

Fig. 17: ypical Sensor Placements

3) RMCM01 Polar OEM receiver of the Polar company, is a heart rate monitor chip which is able to decode the signal coming from the popular Polar heart rate belts. It is able to decode both coded and uncoded belts. The RMCM01 Polar OEM receiver is illustrated in Fig. 18.

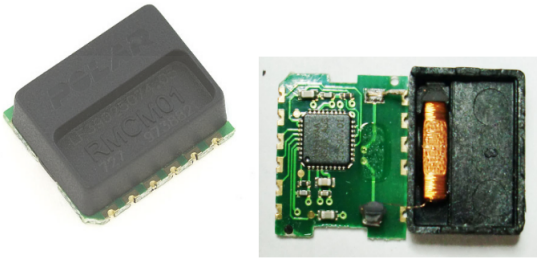

Fig. 18: RMCM01 Polar OEM receiver

But consequently to measure the Hear Rate is different to the previous sensor. The Sensor Placements are illustrated in Fig. 19.

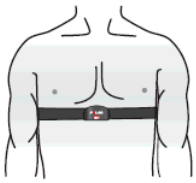

Fig. 19: Polar Sensor Placements

Anyway an Analog to Digital Converter (ADC) will be necessary in order to communicate with the microcontroller.

4 Conclusion

- The ideal system will has a significantly reduced size and weight, which improves its versatility and mobility.
- Any abnormalities in health conditions are informed via SMS to the indicated mobile number through GSM in order to create an alarming system.
- Create a reliable card based patient data monitoring.
- The healthcare family and professional can know news about their patients from a remote location at any time with their location.
- A low cost portable and power efficient Embedded System.