A solution for acquisition of vital signs on Healthcare IoT Application.

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Abstract

The need to monitor the vital signs of hospitalized patients can be met by information and communication technologies. The IoT technology on health will provide the use and analysis of vital patient data, enabling faster response from the healthcare team. This work uses heart rate, temperature and blood oxygen sensors to monitor the health status of patients, as well as their demand for requests, and the response of the healthcare team. The analysis of the results show that the solution is feasible, the sensors have accuracy within the average and that the requests and care of the health care team can be monitored.

1 Introduction

Internet of Things (IoT) is an emerging technology that can be applied in many areas to provide solutions that can transform the way industry is known, as well as current systems [11].

Given these possible transformations and this emerging emergence, it is expected that by 2020 there will be more than 30 billion devices connected to the internet [5], [10]. Thus, the Industrial Internet of Things (IIoT) and the Internet of Everything (IoE) are concepts addressed by [14], which emphasize the constant technological development followed by standardization and recommendations for data exchange among network types, proposing to use incident reports in these areas to work on standardized models, building secure software, and making data exchange secure [14].

It is clear that the health industry can also be transformed by the IoT, the constant technological development discussed by [14], as well as, according to [13], who affirm that mobile technologies for health will transform clinical intervention, especially in the care of the elderly with chronic diseases that prevent the individual from living independently. According to [13], noncommunicable diseases (NCDs) such as cardiovascular, respiratory, diabetes and cancer are the main causes of morbidity and mortality. For the WHO (World Health Organization) NCDs are one of the major health and development challenges of the 21st century [16]. In Brazil, the number of elderly will reach 33.4 million, representing 15% of the Brazilian population and 5th place in the world [4].

It can be seen that from both sides, information technology and care for the elderly, and/or people with NCDs, with the growth of the elderly population and the number of devices connected to the network, related to the emerging IoT and the possible transformations of the health industry, various technology services may emerge. Thus, with interest in the evolution of technologies for health system and in the changes that impact such systems, it is proposed: Create an IoT solution for acquisition of vital signs using open-hardware to evaluate the use of temperature sensors, blood oxygen level and amount of heart rate for monitoring patients without risk of life during hospitalization. Also monitor the follow-up of care and requests for care to the health care team.

2 Methodology

This is the creation of an embedded IoT solution using three types of sensors to capture vital signs of the patient. Two sensors/actuators will also be used to identify when the patient requests care and to identify when the patient is being treated.

2.1 Acquisition of vital signs, request for service and service performed

The acquisition of blood oxygen level and heart rate signals per minute was performed in 3 participants with a 1 minute interval for each sample. A sample is an average of 15 readings performed at 400 millisecond intervals. For the vital sign of body temperature, the value of the instant of measurement was used.

Service requests were made during solution testing. The simulation of the fulfillment of the service was also confirmed after each request made.

2.2 Analysis of the data

The data analyzes were performed in an exploratory way, testing the acquisition of the signals in three participants with a 1 minute interval for each sample. Five shots were taken for each participant. The analyzes of the visits were made during the vital signs acquisition tests.

3 Related works

In [2] an Fog-based architecture is proposed, using FPGA to process signals, as well as a mesh layer to aggregate data before processing them in the Fog layer. The solution proposed here is similar, but the architecture proposed by [9], an intelligent local layer, is similarly studied and used, which resembles the architecture of [2].

The paper [12] proposes the use of sensors for monitoring real-time vital signs using low-cost hardware concerned with energy efficiency. In a similar way, it is proposed here the use of open-hardware that has relatively low cost, however, cost and energy are not analyzed here.

In [8] and [3], the authors used positional, fall, panic button analysis and context analysis to trigger urgency/emergency assistance, similar to [6]. Here, the call for assistance button will be used in a similar way, and the monitoring of the delivery of assistance to the health care team.

The work [7] used a mesh network through Xbee for communication of several nodes that monitor the temperature of patients with concern to reduce costs and increase the quality of health services. However, here, a star topology will be used, where each node would have its access to the internet.

The works previously related used IoT to monitor health signs and other functionalities such as: Heart rate, SPO2, temperature, fall analysis, blood pressure, environment sensors, air quality, CO2 levels and etc. Each work has its individual contributions, however, according [1], few are sensors that can be used with open API, and few are sensors that are reasonably priced for prototyping.

4 Aspects of implementation

4.1 The hardware

An ESP8266 was used as an open-hardware platform with the following characteristics: 32-bit RISC CPU, 80 MHz, 64 KB RAM and 96KB data, Flash QSPI External - 512 KB to 4 MB, IEEE 802.11b/g/n Wi-Fi, 16 pin GPIO, SPI and I2C.

In order to acquire the temperature, the DS18B20 sensor was able to operate in the resolution of 9 Bits up to 12 Bits. With accuracy of 0.5°C, 0.25°C, 0.125°C, and 0.0625°C, respectively for 9, 10, 11 and 12 bits. Each reading can be performed at 750 millisecond intervals.

To capture the heart rate and blood oxygen level, the MAX30100 sensor was used. This sensor can work with resolutions from 13 up to 16 Bits. By varying the number of samples from 50 to 1000 per second.

A push button was placed on the device to be pressed in the event of a service request and a redswitch presence sensor triggered by a magnet to indicate that the service was performed.

A bluetooth HC-06 was used to send the captured information. It was decided to use the communication through a smartphone with android system to receive the data and transmit the information to the cloud through 3G/4G.

Finally, two 4v7 and 400mA lithium batteries connected in parallel were used. These devices were used for immediate availability on the market and at relatively low cost.

4.2 Software and firmware

The software was developed in two different platforms. One for mobile monitoring for android and another for managing the data in a web system. The application developed for android receives the data of the sensors through bluetooth. In addition, it can be configured to generate alerts when abnormal levels of some vital signal are reached, so that the health care team takes the necessary action. The Web software stores the sent data and displays it on a screen to monitor the patients assisted centrally.

For firmware development, the Arduino IDE and the libraries that are available in its library manager have been used.

5 The architecture

The communication architecture used can work in 2 ways.

- Case 1: Uses the hardware formed by bluetooth and Wi-fi sending the data by bluetooth when it is paired with the smart-phone through the android application.

- Case 2: Send data to the cloud without needing a smart-phone.

Figure 1 represents the hospital rooms where they are portrayed: Case 1, case 2, T.I. room and the real-time health care monitoring room.

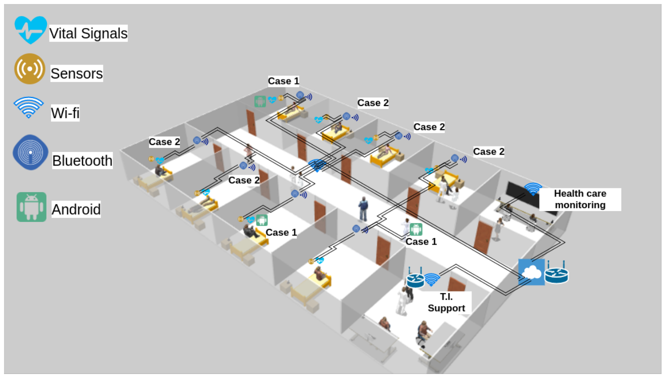

Figure 1: Adapted from this proposed solution.

6 Results

After the development and testing stage the solution was able to capture the data temperature, oxygen level of the blood and the amount of heart rate per minute. It was possible to capture the moment when the patient pressed the button to request the care, and it was also possible to record the moment the patient is treated.

Table 1 showleitoss the monitored vital signs of 3 participants in the testing stage.

	Patient 1			Patient 2			Patient 3		
Sample	HR	SPO2	Temperature	HR	SPO2	Temperature	HR	SPO2	Temperature
1	63	98	36.4	81	98	36.3	67	98	36.5
2	68	98	36.5	78	97	36.2	69	97	36.7
3	65	98	36.5	72	98	36.3	74	97	36.2
4	67	98	36.4	73	98	36.4	68	98	36.2
5	66	98	36.4	72	97	36.4	74	98	36.1
MEAN	65.8	98.0	36.44	75.2	97.6	36.32	70.4	97.6	36.34
VAR	3.7	0.0	0.003	16.7	0.3	0.01	11.3	0.3	0.06
STD	1.92	0.0	0.05	4.09	0.55	0.08	3.36	0.55	0.25

Table 1: Results of the acquisition of 3 patients with interval of 1 min.

Table 2 shows the times when the user requested the service request, showing that all the tests were captured and sent to the server. As well as all the moments in which the key to the service was activated.

7 Discussion

The work [7] has created a solution for patient temperature monitoring. The hardware used consisted of an Intel Galileo second generation plate serving as a gateway to receive data from the LM35 temperature sensors, sent through Xbee S2 transceivers, which formed a mesh network. Already the communication here uses the same network to send data and receive commands like the Figure 1 represents.

No.	Solicitation (datetime)	Treatment (datetime)
1	10/24/2017 08:12:56	10/24/2017 08:13:13
2	10/24/2017 08:14:25	10/24/2017 08:15:09
3	10/24/2017 08:15:36	10/24/2017 08:15:52
4	10/24/2017 08:18:23	10/24/2017 08:19:05
5	10/24/2017 08:19:49	10/24/2017 08:20:10

Table 2: Results of tests from solicitation and treatment

According to the presented data it is noticed that the standard deviation of the means of measurement of the heart beats was not greater than 4,1 or ±5%. In [1], the accuracy presented ranged from ±2% to ±5% for the sensors studied there and here these tests showed the same variation in one single sensor. This means that the captured heart rate varied in the worst case of ±2% of the mean value and in the best case of ±5%. It can be said that the acquisition of vital signs through IoT devices only has to improve the quality of the information captured from the sensors to the health care team.

In [7] argues that the use of health signal sensors, in this case, the use of IoT for health systems, can improve care for hospitalized people, as well as costs involving professionals. [15] argues that monitoring more efficiently through a health team working in a satisfied and motivated way is also very important for the treatment of hospitalized elderly people. Even the protocol and responsibility of health professionals about data collected often have errors in filling it for various reasons, work day, poor compensation, reduced staff and so on. It can then be concluded that IoT, and this particular solution is feasible to aid, decrease costs and improve the quality of patient care.

8 Conclusion and future work

This work was a study of case for a great health insurance company in the trying to improve healthcare assistance and your services with the view to implements/use local knowledge at technology and healthcare. However, even with shelf devices or open-hardware, the sensors and platforms tested by the team of this article, even using members with a great deal of development experience, had a negative impact on the development time of this work since some sensors did not communicate or did not work as promised. The team to devoted themselves to searching for errors in the libraries or in the hardware provided by their manufacturers. Thus, open-hardware technology brings risks costs in this direction. This IoT solution for the acquisition of vital signs using open-hardware was presented in where in experimental way, three people at different times checked their vital signs through the use of temperature sensors, oxygen level of the blood and quantity of heart beats. It was possible to capture and analyze such vital signs to monitor them. It was also possible to monitor requests and services to the health care team.

For future works there is tring compare the data between different sensors and/or mhealth applications. To explorer the architecture elaborated in [9], inserting another heterogeneous element in the data communication with the use of LPWAN, in an attempt to reduce costs and to evaluate communication of long distances and the possibilities to reduce energy consuption.

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