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A CASE-STUDY VISION

Prototype device for monitoring vital signs during transportation of accident patients, preliminary results

Prototipo de dispositivo para monitoreo de signos vitales durante el transporte de pacientes de accidentes, resultados preliminares

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ABSTRACT

Approximately 1.3 million people die on the road and between 20 and 50 million suffer non-fatal road traffic injuries worldwide. Natural or man-made disasters claim the lives of thousands of human beings in these cases rescue teams intervene to safeguard the lives of the people affected. The objective is to build a prototype device for monitoring vital signs in the transport of patients in disaster or accident areas, performing initial tests on people in good physical condition to verify its operation. The agile methodology ICONIX process for Embedded Systems allows the modeling and construction of the hardware and software, thus obtaining a device that captures vital signs with sensors and a web application for synchronous monitoring of the current physical state of a person. The IoT applied in the field of rescue enables closer and safer monitoring from the place where a trauma patient is located to the monitoring center over long distances.

Palabras clave:
Accidentes
Monitoreo
Pacientes
Prototipo
Zonas de desastres
Signos vitales

RESUMEN

Aproximadamente 1.3 millones de personas mueren en carretera, entre 20 y 50 millones padecen traumatismos no mortales por accidentes de tránsito en todo el mundo. Las catástrofes naturales o causadas por el hombre cobran la vida de miles de seres humanos en estos casos intervienen los equipos de rescate para salvaguardar la vida de las personas afectadas. El objetivo es construir un prototipo de dispositivo para monitoreo de signos vitales en el transporte de pacientes en zona de desastre o accidentes, realizando pruebas iniciales en personas en buenas condiciones físicas para la verificación de su funcionamiento. La metodología ágil ICONIX process for Embedded Systems permite el modelado y construcción del hardware y software obteniendo así un dispositivo captador de signos vitales con sensores y un aplicativo web para el monitoreo sincrónico del estado fisco actual de una persona. El IoT aplicado en el campo de rescate posibilita realizar un seguimiento más cercano y seguro desde el lugar donde se encuentre un paciente con traumas hasta el centro de monitoreo a grandes distancias.

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1. Introduction

Approximately 1.3 million people die on the road, between 20 and 50 million suffer non-fatal trauma from road traffic accidents worldwide [6]. Earthquakes cause high mortality rates due to trauma, asphyxiation, dust inhalation or exposure to the environment, the survival of a person usually does not exceed 48 hours when trapped in destroyed buildings [5]. The most destructive earthquakes in the world have compromised the lives of thousands of people (see Table. 1). There is great earthquake activity all over the world as indicated by Volcano Discovery (See Fig. 1).

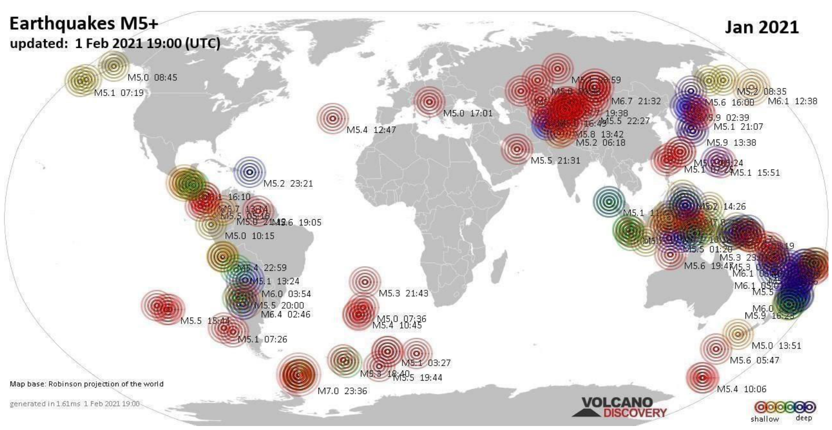
Man-made disasters are: climate change, bioterrorism, chemical agents, pandemics and diseases, radiation, war, terrorism and social disasters [10] in these cases rescue teams intervene to safeguard the lives of the people affected.

The urban search and rescue teams of Bomberos de Colombia have actively participated in emergency response and urban search and rescue tasks such as: the earthquake in Popayán, the eruption of the Nevado del Ruiz volcano, the earthquake in Armenia, the terrorist attack on the El Nogal Club in Bogotá and the collapse of the Space Building in Medellín [1].

Table 1. World's most destructive recorded and known earthquakes with 50 000 or more deaths, as of September 1, 2009. [9]

Fecha	*Lugar*	*Núm de muertos (estimado)*	*Magnitud*
1556.01.3	*shaanxi(shensi),China*	*830000*	*~8*
1976.07.7	*Tangshan,China*	*255000(oficial)*	*7.5*
1138.08.09	*Siria, Aleppo*	*230000*	*ND*
2004.12.6	*Sumatra*	*227898*	*9.1*
856.1222	*Irán Damghan*	*200000*	*ND*
1920.12.16	*Haiyuan, Ningxia (Ning-hsia),China*	*200000*	*7.8*
893.03.3	*Irán, Ardabil*	*150000*	*ND*
1923.09.01	*Kanto (Kwanto), Japón*	*142800*	*7.9*
1948.10.05	*Ashgabat (Ashkhabad), Turkmenistán (Turkmeniya, USSR)*	*110000*	*7.3*
1290.09.27	*China, Chihli*	*100000*	*ND*
2008.05.12	*Eastern Sichuan, China*	*87587*	*7.9*
2005.10.08	*Pakistán*	*86000*	*7.6*
1667.11	*Caucasia, Shemakha*	*80000*	*ND*
1721.11.18	*Irán, Tabriz*	*77000*	*ND*
1908.12.28	*Messina, Italia*	*72000*	*7.2*
1970.05.31	*Chimbote, Perú*	*70000*	*7.9*
1755.11.01	*Portugal, Lisboa*	*70000*	*8.7*
1693.01.11	*Italia, Sicilia*	*60000*	*7.5*
1268	*Asia Menor, Silicia*	*60000*	*ND*
1990.06.20	*Irán Occidental*	*40000 a 50000*	*7.4*
1783.02.04	*Italia, Calabria*	*50000*	*ND*

Figure 1. Worldwide earthquake report for January 2021. [14]



Therefore, monitoring the health status of a patient is important if he/she is in a life-threatening condition. Various devices have been built for monitoring patients inside a medical center [3], with the Internet of Things (IoT) in the health area have proposed wireless devices to monitor vital signs [4], wearable vital signs monitor for monitoring patients with chronic diseases or home hospitalization [12], remote monitoring of body signs and transmission of data and alerts to an application installed on a smartphone [13], system for displaying vital signs with mobile devices using Bluetooth technology [11], and the application of medical telemetry for three vital signs [7].

On the other hand, medical telemetry systems, due to their complexity and cost, have the disadvantage of being unaffordable for populations in remote locations. Proposing a prototype of medical telemetry of vital signs for rescue teams in difficult access environments would help the medical team to monitor the patient from the place of the accident or area of affectation to the hospital collecting important information for diagnosis.

The general objective of this research is to build a prototype device for monitoring vital signs in the transport of patients in disaster or accident areas. And as specific objectives: to build a prototype hardware device for the acquisition of vital signs from disaster or accident areas; to develop an application for monitoring vital signs; and to perform tests with the prototype device and application in operation in people in good physical condition.

2. Methodology

The general methodology of the project is based on a model based on requirements gathering, analysis, design, development, implementation and evaluation (development tests) and pilot validation, both for hardware and software.

2.1. Construction of a prototype of a hardware device for the acquisition of vital signs from disaster or accident zones.

The agile methodology ICONIX Process for Embedded Systems [8] will be applied for the modeling and construction of the prototype device will be composed of an Arduino Uno microcontroller programmed with C++ connected to the sensors for the acquisition of vital signs: heart rate, oxygen saturation, body and environmental temperature. Transmitting the data serially (COM4) to the main server.

2.2. Development of an application for monitoring vital signs.

The agile methodology ICONIX process for Embedded Systems [8] incorporates the XP (Extreme Programming) methodology. The development of the application will be web server-side using the NodeJS framework and libraries such as: Express, Bootstrap, HighCharts and Chart.js. The use of libraries to graph the data obtained from the patient will allow the visibility in synchronous time of the patient's vital signs through the web application.

2.3. Testing of the prototype device and application in operation with people in good physical condition.

The prototype device and synchronized web application will allow access to monitor patients' vital signs. To perform the tests with the device, a person with good physical conditions will be selected, such as young people between 14 and 23 years of age. The person will place his left hand on the prototype device, once the heart rate, oxygen saturation, body and environmental temperature [2] have been captured, the device will send the information to the main server, indicating each set of data sent by means of a row of colored LEDs. When entering the application it will allow to visualize its behavior by vital sign through a graph, the application will have help information to verify the normal physical conditions within the normal ranges of the values of each vital sign.

3. Results and discussion

3.1. Prototype device (hardware) for the acquisition of vital signs

The prototype device built allows obtaining information about vital signs such as: heart rate, oxygen saturation, body and environmental temperature (thermoregulation). The microcontroller used was an Arduino Uno that is connected by serial (COM4) to the main server. When the left hand is placed on the device, the vital signs will be detected and the colored light bulbs will immediately start to light up, indicating the sending of data for monitoring. If the hand is moved away from the device, the device detects and does not send any more data, Fig. 2 and 3.

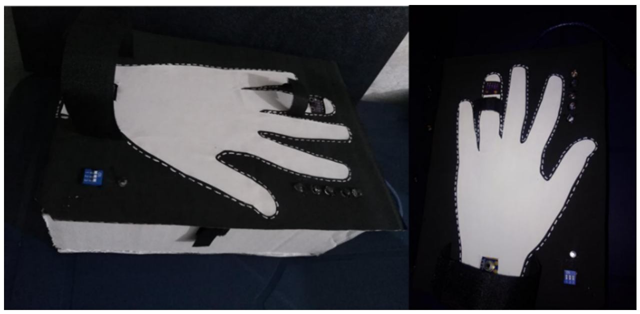
3.2. Web application for monitoring patients in good physical condition

The web application allows the monitoring of a serially connected device. For security reasons, it has a login interface that allows to identify the connected device and log in to monitor people in normal conditions.

Upon entering the system, the following vital signs are available for monitoring: heart rate, oxygen saturation, body temperature and ambient temperature. When the system identifies that the device is not connected, it informs the user about the lost connection. The application has current GPS location of the system and a real-time clock.

Each vital sign monitored has information attached about normal and abnormal values so that the user (health personnel) can be guided and make decisions based on the behavior of the graphs.

Figure 2. Prototype device - Hardware.



Source: own

Figure 3. Prototype device in operation.

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Figure 4. Web application - software.

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Figure 5. Web application interface.

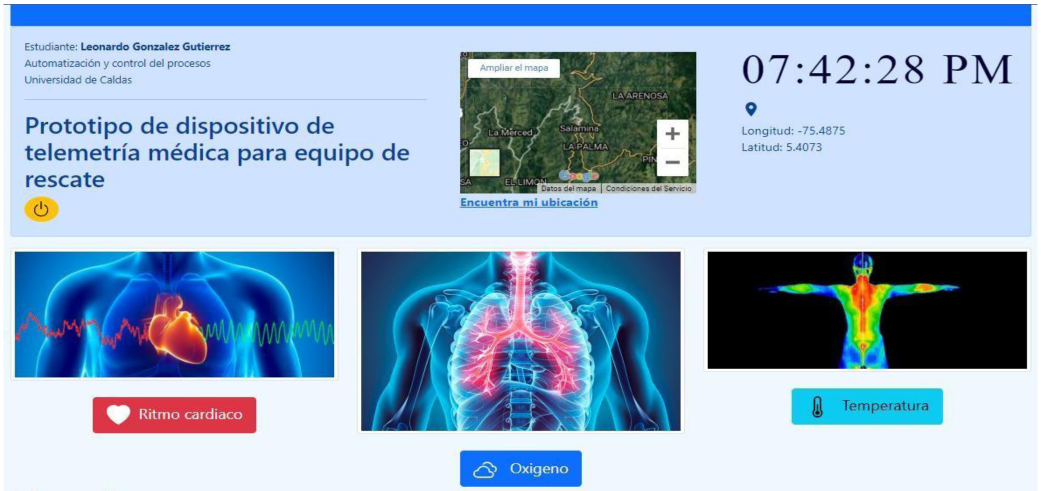

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Figure 6. Heart rate monitoring.

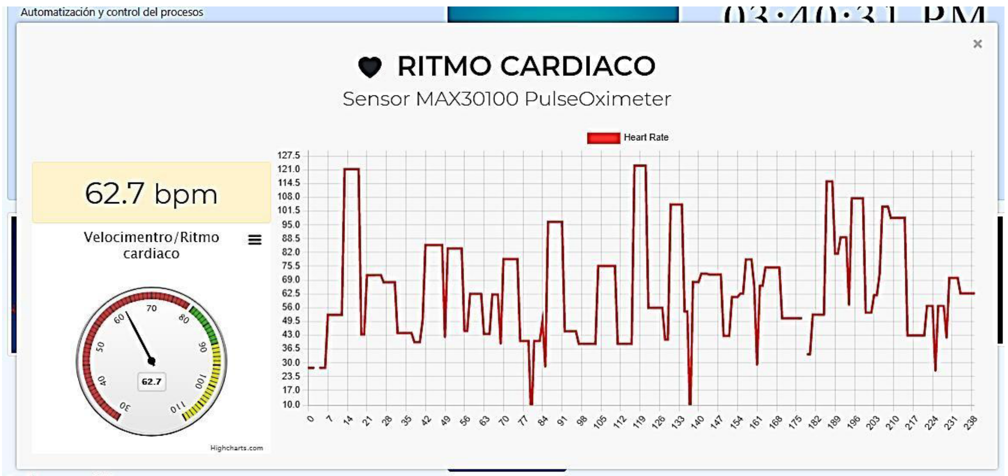

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Figure 7. Oxygen saturation monitoring.

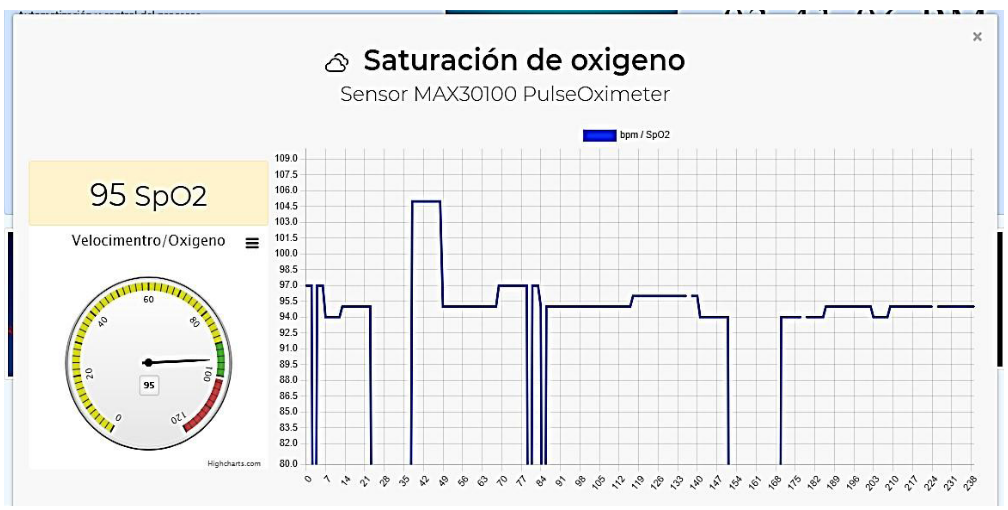

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Figure 8. Body and environmental temperature monitoring.

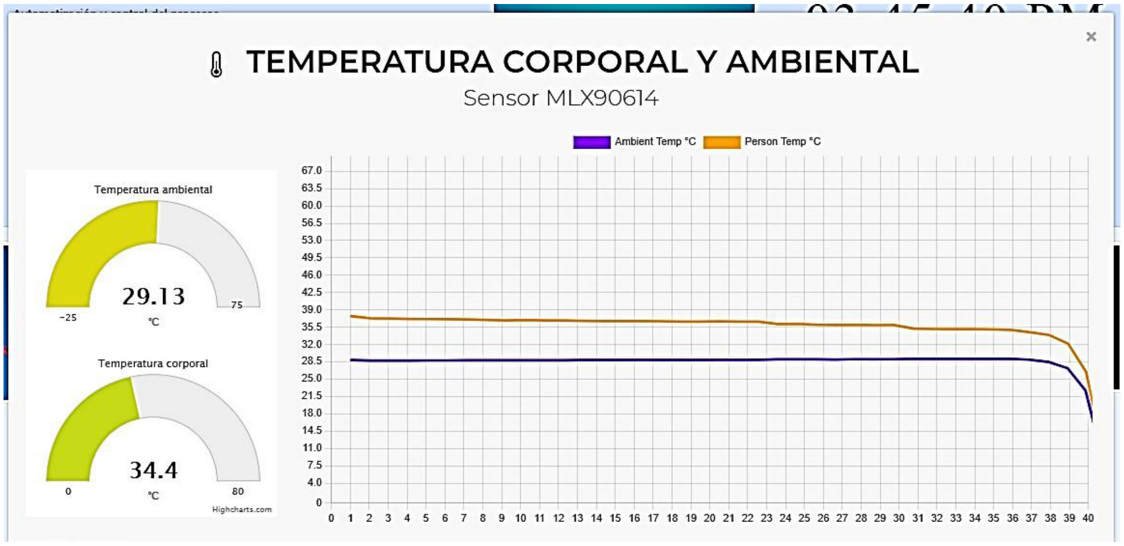

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Figure 9. Decision support information.

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3.3. Discussion

IoT applied to the field of health by integrating microcontrollers and sensors with high precision in capturing information from body signals, helps to define the current physical state of a person, measuring vital signs such as: heart rate, oxygen saturation, body and environmental temperature (thermoregulation). The implementation of devices for monitoring the current state of a patient from a remote location (geolocation) to the medical center will make it easier to provide a health service by telemetry when rescuing the patient from a place of difficult access that puts life at risk and even to the medical center.

4. Conclusions

The use of medical telemetry devices within rescue equipment enables synchronous monitoring of the patient's physical condition from the scene of a disaster or accident. IoT applied in the rescue field enables closer and safer tracking from a trauma patient's location to the monitoring center over long distances.

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