Wearable Technology (2022) Volume 3 Issue 1, *pp.* 56–62.
doi: 10.54517/wt.v3i1.1662

ORIGINAL RESEARCH ARTICLE

Application of embedded accident prevention system for infant crawling stage in intelligent textiles

***I. J. Chico-Morales*[1*], *S. K. Narváez-Pupiales*[1], *A. C. Umaquinga-Criollo*[1], *P. D. Rosero-Montalvo*[1,2]**

*[*1] Universidad Técnica del Norte, Ibarra 170202, Ecuador. E-mail: ijchico@utn.edu.ec*

[2] Instituto Tecnológico Superior 17 de Julio, Yachay, Urcuqui 100102, Ecuador

ABSTRACT

Infant crawling is a method to discover and learn its motor, cognitive, social and emotional functions. Therefore, infants face different risks, such as falls, burns and personal injuries. The most common is that the family is the place where the main event occurs. Therefore, the focus of this research is to develop the embedded system inside the intelligent textile to realize the early warning and prevention of accidents. The system is located in a clothing harness with a crawling knee pad connection including a magnetic sensor. These devices are responsible for detecting security tapes previously placed in the most dangerous location in the home. Therefore, the system gives an alarm with a response time of 7.6 seconds after activation.

Keywords: intelligent textile; magnetic sensor; Internet of Things; infant accidents; Arduino

1. Introduction

Crawling is the displacement of infants through quadruped postures[1]. This exercise enables infants to gain experience of motor maturity[1–3]. As a stage of exploring and learning spatial concepts, they cause changes in infants' perception, cognition, language, society and emotion[1]. In this way, infants can experience their own movement to begin independence[2]. According to García, et al., infants begin the crawling phase at 5 months, while Oldak-Kovalsky, et al.[4,5] takes 7 to 10 months as their initial phase. Therefore, from this stage, the possibility of accidents is greater[6].

The World Health Organization (WHO) defines an accident as: "Accidents, usually unfortunate or harmful, independent of human's will, are caused by external forces acting quickly, manifested as organ damage or mental disorder"[7,8]. According to Mizhquero and Minda[7,9], 54% of accidents of children under 5 years old occur at home. The most common accidents include drowning, falling, poisoning, burns, physical injury, ingestion of foreign bodies, toxic substances[7], etc. The kitchen, bathroom, bedroom, living room and garden are the most accident prone places[10,11].

In 2010, the Saint Vicente de Paul Hospital in Ibara, Ecuador recorded 5,166 family accidents, of

ARTICLE INFO
Received: January 24, 2022 | Accepted: March 2, 2022 | Available online: March 18, 2021

CITATION
Chico-Morales IJ, Narváez-Pupiales SK, Umaquinga-Criollo AC, et al. Application of embedded accident prevention system for infant crawling stage in intelligent textiles. Wearable Technology 2022; 3(1): 56–62.

which 494 involved children under the age of 5. Among them, 422 cases were aged between 1-4 years and 72 cases were aged between 0–1 years[7]. Documented care and hospitalization included fractures, falls, burns and poisoning, mainly men. These accidents are common among children because they are curious about the world around them. Therefore, risk prevention is very important to reduce such accidents.

Generally, there are various electronic security systems, which are mainly responsible for preventing or combating accidents such as home theft and fire, but it is not common to focus on protecting the safety of infants in the crawling stage, but there are various basic auxiliary devices on the market to help to take care of infants at home, including safety barriers, plug covers, sliding door guards, among other things, but in many cases, they are insufficient in the face of many dangers and lack other supplementary functions.

In view of the above, the purpose of this study is to provide input for the prevention and reduction of accidents of crawling infants, and it is suggested to develop an electronic security system on Arduino platform to warn the responsible person of infants by triggering an alarm reaching the mobile device. Similar work, Godoy, et al. and Rosero, et al.[12-14] provides electronic system solutions, but not for infants.

The second section introduces the methods and materials used in this study, and the third section introduces the results achieved. The fourth section analyzes and discusses the main contents. The fifth section puts forward the conclusions and suggestions of this study.

2. Materials and methods

This section describes the hardware and software resources used in this study and the corresponding process of designing and building a prototype safety system for preventing child accidents in the crawling stage.

These requirements are considered to ensure operation and efficiency in protecting the lives of young children, as follows: The response time for immediate reporting of hazards is very short; The coverage of the WiFi modem to be used; Proper power performance, beautiful, easy to place, does not interfere with the baby's motor activities, except as an independent and easy-to-use system.

2.1. Hardware components

All Smart clothing is a safety mechanism for children under 18 months of age and consists of the following components[11]:

—**Lilypad Arduino control board**: It maintains communication with sensors and usually undertakes the control of system functions.

—**Magnetic spring sensor**: It is connected to the control board and starts as soon as it detects the proximity of the tape that constitutes an obstacle to the exit to the dangerous area.

—**Magnetic tape**: It is coupled to magnetic spring sensors and has similar characteristics to magnets. It is very suitable for changing the state of the above sensors when approaching these tapes.

—**ESP8266 WiFi module**: Allow communication between the home wireless network and the Internet of Things platform, so as to give an alarm when the baby is in danger. It is configured as station mode, allowing communication with any device from the Internet.

—**IoT platform**: Receive and store information about all danger alarm messages provided by the communication block. The project cooperates with the open source thing speak platform[15], which not only analyzes and displays Arduino, rasperry and other components, but also promotes cloud storage.

—**IFTTT (If This Then That) notification platform:** It is installed on smart phones on Android and IOS operating systems, promotes communication with the Internet of Things platform according to received requests, and generates alarm notifications when necessary or dangerous.

—**System power supply**: It includes a rechargeable battery to provide power for the whole system. After proper design, it can provide system operation within 10 hours.

2.2. System programming

The control board programming uses Arduino's own IDE (English integrated development environment) and C language as the programming language. **Figure 1** shows the process of the control block performing different activities of system operation, starting with initialization variables, libraries, serial communication and ESP-01 module. If there is a connection error in the home WiFi network, the system will report the error by activating the buzzer. Otherwise, it will continue the process of sending notifications and initiating data to devices and applications that allow scanning the status of magnetic reed sensors to immediately detect proximity to tapes through the Internet of Things platform, thereby alerting parents or childcare workers to potential hazards.

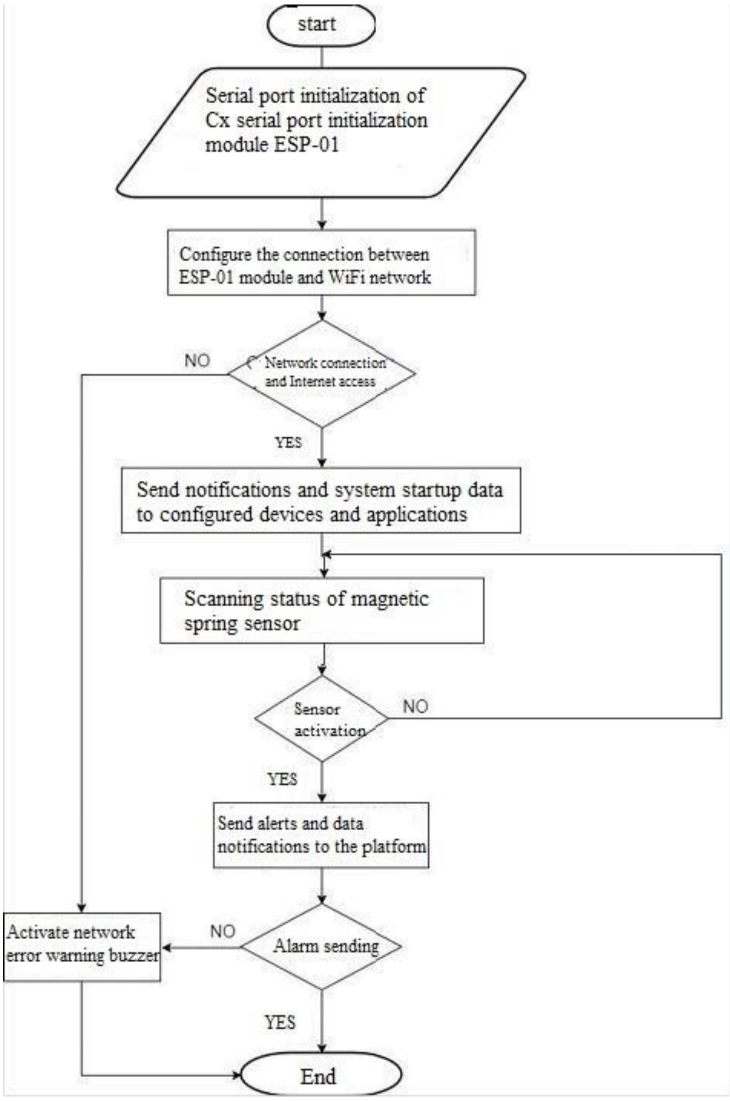

Figure 1. Process control board.

2.3. Construction of intelligent clothing

An important prerequisite for the proper operation of smart clothing is that the personnel responsible for crawling baby care determine the dangerous area, because it depends on the location of the tape. If the baby is close to the tape, the tape will produce activator when detected by the sensor. The sensor is part of the knee pad and is connected to the control board.

With regard to the communication of alarm prevention, the system uses WiFi module through serial communication with Arduino board to make the system part of home and internet wireless network, and stores data and alarms on the Internet of Things website, which interacts with the push notification application installed on smart phone. The construction process of smart clothing is described in detail below:

Complete system connection circuit

Figure 2 shows the electrical connection diagram of the control block, sensor, communication and power supply of the whole system.

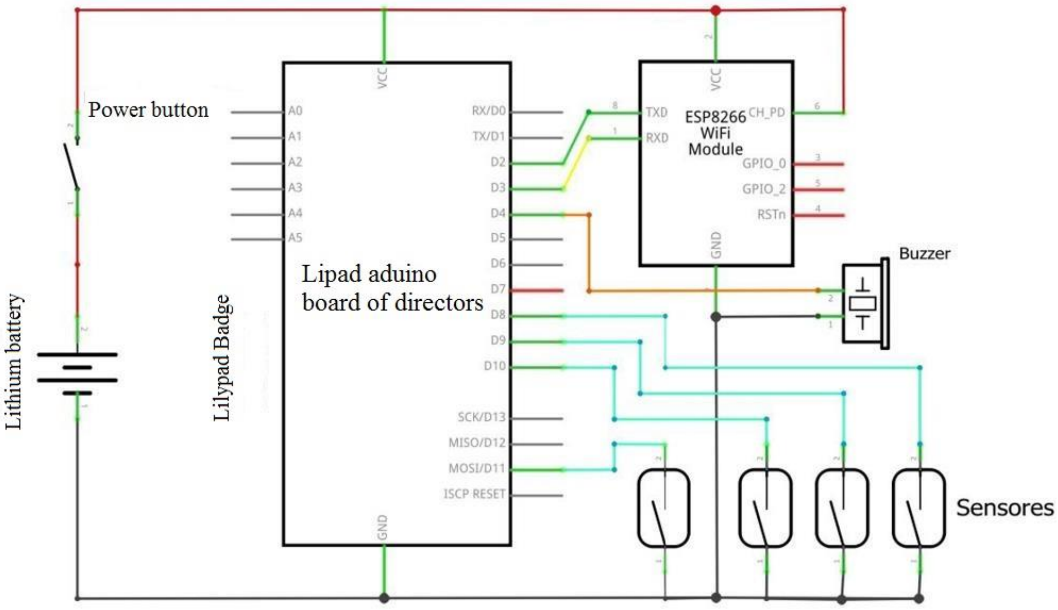

Figure 2. Schematic connection of hardware components.

Integrated WiFi module and power module

Initially, a badge was made with Eagle software, and its pin is similar to the LilyPad badge (**Figure 3**) to sew it on the fabric through wires. The components of the new board include: WiFi module, buzzer, micro USB connector for charging, jumper connecting battery, switch button, resistance, led charging indicator and rectifier diode of charging circuit. The needles to be stitched are: RX and TX of WiFi module, power supply (positive and negative) and pin of buzzer.

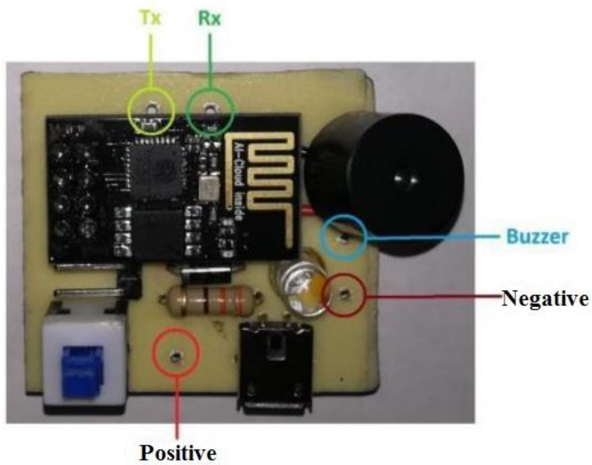

Figure 3. Integrated board of WiFi and power module.

Integrate components into fabric

All hardware (detachable parts) are made of conductive materials. The buttons are integrated into the garment nylon harness and extend the conductive wire to the crawling knee pad where the sensor is located, so as to trigger the alarm in case of danger. In addition, it has an additional pocket behind the removable part, that is, the back of the motherboard (LilyPad and WiFi module), as shown in **Figure 4**.

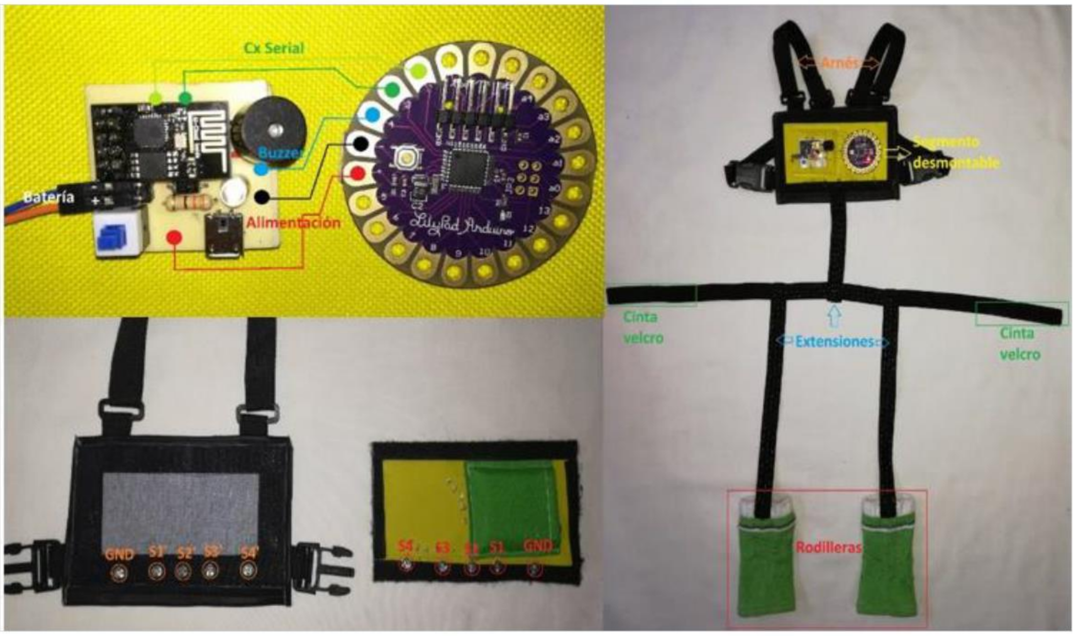

Figure 4. Integrate components into garment harness.

Sensor installation

Sensors fixed to knee pads with elastic features are placed in the lateral areas of the legs below the knee because these areas are close to the ground when the baby crawls, and this area helps to avoid damaging the sensor when the baby moves.

Tape installation

As mentioned above, the tape is placed near the dangerous area and kept at a careful distance so that the baby caregiver has time to respond and arrive at the scene. In order to determine the distance between the tape and the dangerous area, the data in the climbing Evaluation Dynamic Model were used to obtain the average climbing speed of infants aged 8 to 13 months, which is 0.21 m/s. In addition, the average time between triggering the sensor and establishing communication with the Internet of Things platform to send a notification is 7.36 seconds. According to these data, the safety distance is given by the principle of $x = v * t$, i.e. 1.54 m.

Optimized storage of data in Internet of Things network platform

The Internet of Things platform to use is thing speak, which needs to create an account on your official website to enable it. When working with the security system, the platform will receive data and store data when the sensor is started[16]. The data is sent to ESP-01 module (WiFi module) through HTTP request. The information to be received could be a value of 100 indicating that an alarm has been activated and a value of zero as well as the start of the system.

Notice

When the baby is close to the dangerous area, it is alerted through the caregiver's smartphone, which corresponds to the alarm mechanism. Applications used in mobile IFTTT work through links to the Internet of Things platform. To access IFTTT services, you need to register from an official page or even an application.

3. Result

The During the implementation, corresponding tests were carried out to verify its function, including the minimum safe distance for tape installation is 1.54 meters, away from the dangerous area.

The average system startup time of system startup test with network speed of 2Mbps is 18.7 seconds, and the estimated alarm notification time on tapes installed at different distances is 7.49 seconds: It is 4 meters away from the router (stairs), another 2 meters (bathroom), and the last 3 meters (kitchen). It is further away. It successfully attempts to send notifications at 13 meters in 6.8 to 7.8 seconds. The notification text sent when the sensor is activated is “alarm! Your child is in danger.”

The battery life is 12 hours and 10 minutes. It is recommended to charge the battery 1 hour before use.

The data is collected on the Thing Speak platform, the system sends a 0 (zero) when the system is started and 100 (one hundred) as an indicator that an alarm has been triggered which immediately communicates to the caregivers’ cell phone via the IFTTT platform.

4. Discussion

The intelligent system was evaluated in a controlled environment and then in the actual situation. The results showed that the average response time was 7.36 seconds within 1.54 meters from the dangerous area, which was initially considered prudent so that the baby caregiver could reach the scene and help the baby. It should be noted that the average response time of the system depends on the Internet connection speed, access point distance and wireless signal quality.

With regard to the possibility of affecting children’s daily and normal activities, a flexible system was considered in the construction process. The system consists of a standard seat belt that can be adjusted to the average weight of infants aged 6 to 18 months, minimizing the possibility of affecting children’s motor ability.

With the future work, it is expected that the system will be able to expand its coverage through machine to machine platform. In this way, the mobile communication antenna can be used more flexibly for communication.

5. Conclusions and recommendations

Crawling is one of the most important stages of infant development. It enables them to explore and develop the abilities of movement, balance and touch. Therefore, it is inevitable to restrict infants from using this movement mechanism between the ages of 8 and 13 months. However, there may be dangerous environments or places at home, such as stairs, bathrooms, kitchens, etc., which may become dangerous. Therefore, the purpose of this study is to help reduce the number of infant accidents by warning and reporting that minors are approaching an area defined as dangerous, and combining embedded systems with textiles with the help of software and hardware technical tools, Internet of Things and reporting platform.

Hardware and software components are selected from a set of similar tools, so the construction of the system needs to be evaluated and compared in advance to ensure the performance and efficiency of the system. However, for further work, it is recommended to optimize battery consumption and improve system response and communication time.

Conflict of interest

The authors declare no conflict of interest.

References

1. García MH, Zúñiga MES, Ayala DV, et al. Modelo dinámico para valoración del gateo [Dynamic model of reptile evaluation]. Rev Mex Med Fis Rehab 2016;

28(1–2): 28–32.
2. Flehmig I. Desarrollo normal del lactante y sus desviaciones: diagnóstico y tratamiento tempranos [Normal infant development and its deviation: early diagnosis and treatment]. Madrid: Editorial Médica Panamericana; 1988.
3. Trevino CMJ. Neurofacilitación/Neurofacilitation: Técnicas de rehabilitación neurológica/Neurological rehabilitation techniques (Edición: Reissue) [Nerve Promotion/Nerve Promotion: Neural Rehabilitation Technology Rezo]. México: Editorial Trillas Sa De Cv, 2008.
4. Oldak-Kovalsky B, Oldak-Skvirsky D. Revisión de la literatura médica [Medical literature review]. Revista Mexicana de Pediatría, 2015; 144–148.
5. Babycenter. Gatear—BabyCenter. [Cited: 2018 Feb 11]. Available from: https://espanol.babycenter.com/a900442/gatear.
6. Matute Seminario AM, Sarmiento Segovia MJ, Torres Durán AE. Conocimientos, actitudes y prácticas sobre el desarrollo psicomotor dirigido a madres de niños y niñas menores de un año de edad que asisten a la Fundación Pablo Jaramillo Crespo [Provide knowledge, attitudes and practices on psychomotor development to mothers of children under one year of age participating in the Pablo Jalamilo Crespo Foundation]. [Accessed: 2015]. Available from: http://dspace.ucuenca.edu.ec/handle/123456789/23069.
7. Minda Almagor AC. Factores influyentes asociados en la aparición de accidentes domésticos en niñas y niños menores de 5 años, atendidos en el Servicio de Emergencia del Hospital San Vicente de Paúl, de la Ciudad de Ibarra en el período noviembre 2010 a julio del 2011 [Related Factors of Family Accidents among Children under 5 Years Old Treated in the Emergency Room of Saint Vicente de Paul Hospital in Ibara from November 2010 to July 2011]; 2013.
8. Fuentes FJC. Apoyo al soporte vital avanzado [Advanced Life Support]. SANT0108. IC Editorial, 2013.
9. Mizhquero N, Fernanda Y. Determinación de la prevalencia de accidentes domésticos en pacientes menores de 18 años atendidos por el personal de atención prehospitalaria del Cuerpo de Bomberos Quito en el período enero-diciembre 2016 [To determine the prevalence of family accidents among patients under the age of 18 treated by pre hospital nurses of quito fire brigade from January to December 2016] [Bachelor’s thesis]. Quito: UCE, 2017.
10. Facua Andalucía. Facua—Consumidores en Acción [Facua—Consumer action]. Available from: http://www.facua.org/es/guia.php?Id=132. (Cited: 2018 Feb 12)
11. Chico-Morales IJ, Narváez-Pupiales SK, Umaquinga-Criollo AC, et al. Textil Inteligente de Prevenció npara Bebé sen Etapa de Gateo [Wearable textil for accident prevention for babies in crawl phase]. Proceedings of the 2nd International Conference on Information Systems and Computer Science; Quito, Ecuador.
12. Godoy S, Alvear V, Realpe S, et al. Human sitting pose detection using data classification and dimensionality reduction. IEEE Ecuador Technical Chapters Meeting (ETCM); 2016 Nov 24; Guayaquil. NYC: IEEE; 2016. p. 1–5.
13. Rosero-Montalvo P, Jaramillo D, Flores S, et al. Human sit-down position detection using data classification and dimensionality reduction. Advances in Science, Technology and Engineering Systems Journal 2017; 2(3): 749–754.
14. Rosero P, Peluffo D, Godoy P. Elderly fall detection using data classification on a portable embedded system. IEEE Second Ecuador Technical Chapters Meeting (ETCM); Salinas. NYC: IEEE; 2017. p. 1–4. doi: 10.1109/ETCM.2017.8247529.
15. Quiñonez-Cuenca M, González-Jaramillo V, Torres R, et al. Sistema de Monitoreo de Variables Medioambientales usando una Red de Sensores Inalámbricos y Plataformas de Internet de las Cosas. Enfoque UTE [A system that uses wireless sensor networks and Internet of Things platforms to monitor environmental variables UTE method]. [Cited: 2017]. Available from: http://ingenieria.ute.edu.ec/enfoqueute/index.php/revista/article/view/139.
16. Alvear V, Rosero P, Peluffo D, et al. Internet de las Cosas y Visión Artificial, Funcionamiento y Aplicaciones: Revisión de Literatura [Internet of Things and artificial vision, performance and applications: Literature review]. Edición Especial INCISCOS 2016; 8(1).