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Wearable Health Monitoring Device Based on IoT Application for Forklift Driver

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Abstract: A factory is a complex building where various house equipment is used to produce various products. Health is very important because it needs to do the daily work. One of the health services applications is the monitoring system of heart rate and body temperature. Examination of the heart rate and body temperature is a common parameter for medical at the workplace to maintain the safety and health condition of the forklift drivers. However, the problem that occurs at the workplace is that forklift drivers are fatigued during work. To solve this problem, a wearable health monitoring device by using IoT application was proposed to monitor the forklift driver's health condition. This study aims to reduce the factory's rate of accidents and injuries at the workplace. We measured the fatigue level or health condition by using pulse sensor, LM35 and a force-sensing resistor. These sensors are interfaced with the ESP-32 microcontroller. Wireless data transmission is done by wi-fi modules that are used on IoT platforms such as ThingSpeak. So that the data can be monitored over the period. The test results showed that the success rate of the system in detecting heartbeat of 93.75% and body temperature of 99.01%. The overall accuracy of the system to measure the fatigue level or health condition of the forklift driver is 92.76%. In the future, the heart rate sensor could be used to increase the accuracy of the heart rate. Furthermore, the sending notification system through a mobile could be used to notify the supervisor when out of the coverage area.

Keywords: Health Monitoring Device, Heart Rate, IoT Application

1. Introduction

A factory is a complex building that has various equipment to produce various products. They are often used as part of modern economic development. An accident happened in the factory due to fatigue such as heavy lifting products and driving a forklift. Apart from that, working hours for workers in the factory industry is between 10 to 12 hours per day and have a one-off day for work. As the result, they

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cannot focus well when performing work because of the limited time for resting. According to statistics released by the National Institute of Neurological Disorders and Stroke, 13 percent of all workplace's injuries are caused by fatigue[1].

A study by Miah et al. [2], discussed a portable monitoring device consisting of heart rate and temperature that can be used to recognize their actual condition when there is no doctor or clinic nearby. The system provides real-time information on heart rate and body temperature acquired on the portable device and displays it via the linked Android application[2]. Thus, the system gave comparatively better performance than the old hand-measuring system.

According to the project conducted by Selvanayakam et al. [3], the authors used an LM35 and a pulse sensor to develop a system that provides body temperature and heart rate. These sensors were connected to an Arduino UNO board that serves as a controller. Arduino uses a wi-fi module to transmit data wirelessly. On IoT platforms, such as ThingSpeak. The ESP8266 was used for wireless data transmission. Things speak is used to visualize data. So that a record of data can be kept for a long time, this information was saved on a web server and can be viewed by anyone who has logged in[3].

Parihar et al. [4] describe the operating principles of a microcontroller-based wireless heartbeat and temperature monitoring system (Arduino UNO). Sensors that measure a patient's heart rate and body temperature are controlled by a microcontroller in the suggested approach. On the LCD panel, both readings were displayed. Wireless technology was used to transmit the measured data from a faraway place. The temperature sensor monitors the temperature, while the heartbeat sensor counts the number of heartbeats in a certain time interval and calculates the number of Beats per Minute (BPM). Both sets of data were transmitted to the microcontroller to be forwarded to the receiving end. The data was successfully shown on the receiving end. This solution might be produced inexpensively and have a significant impact.

Although there are no specific OSHA requirements on fatigue, it is nonetheless a significant workplace safety hazard. Fatigue is not only a significant issue, but it is also widespread. More than 43 percent of workers, according to the National Safety Council of America, are sleep deprived. The issue is worsened for workers who work shifts or work the night shift, with 62 percent of them complaining about sleep deprivation [5].

Health care is changing from a traditional hub-system to a more customized one thanks to the Internet of Things [6]. This health monitoring system also alerts the patient to take cautious strides to avoid being penetrated [7]. These biological signs can accurately identify tiredness and sleepiness because the sleep rhythm is tightly associated with brain and heart activity. In driver health status monitoring, fatigue, and sleepiness [8]. All the reason above supports the need to develop a device as a solution for the health condition of forklift driver.

The objectives of this study are to develop wearable fatigue or health condition monitoring device for forklift drivers to maintain safety and health in the workplace. It also developed a notification system for the forklift driver, supervisor, and nearby workers to alert the health condition of the forklift driver that can cause any potential incident via the Internet of Things (IoT) platform and analyze the performance of the developed device.

2. Materials and Methods

2.1 Materials

This section contains the electronic component that completes the entire functionality of a wearable health monitoring device for forklift drivers based on an IoT application. Based on their principles and capacities to work in the system, the electronic components in this project are divided into three

categories which is processing, input, and output. The following are the electronic components that were used:

- Input: Power supply, Pulse sensor, Temperature sensor, and Force sensing resistor
- Process: ESP-32 (main controller)
- Output: Buzzer, OLED, and ThingSpeak (IoT)

Figure 1 illustrates the classification of electronic components included in this project's flow process depending on their capability.

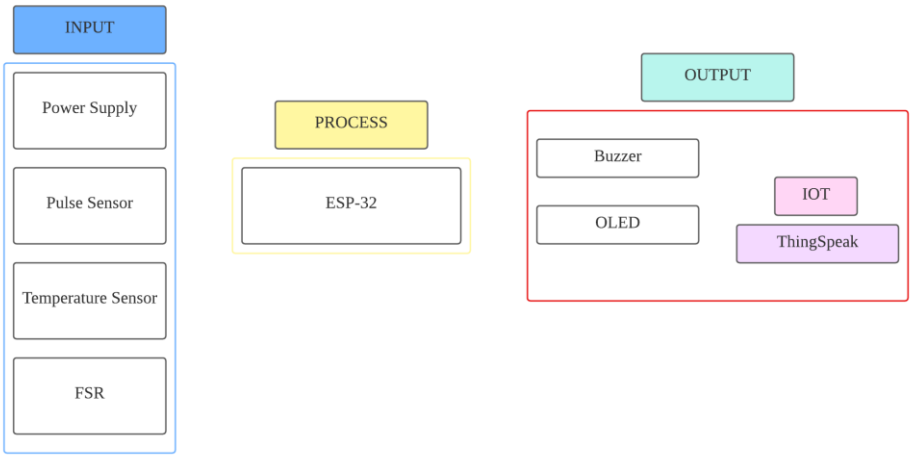

Figure 1: List of hardware and software components that were utilized

2.2 Methods

A. Device design

The input, process, and output are all designed and implemented to achieve the design strategy. The power source also supplies 3.5V, which is utilized to power the sensors, microcontroller, and output. All of the input sensors are connected to the ESP-32 main control to execute operations on the outputs, which include an OLED display and a buzzer to warn the driver. As an access point, the ESP-32 is also used to link the computer by transmitting data to an IoT platform called ThingSpeak, which allows the supervisor to keep track of the forklift driver's health. The block diagram of the complete system is shown in Figure 2.

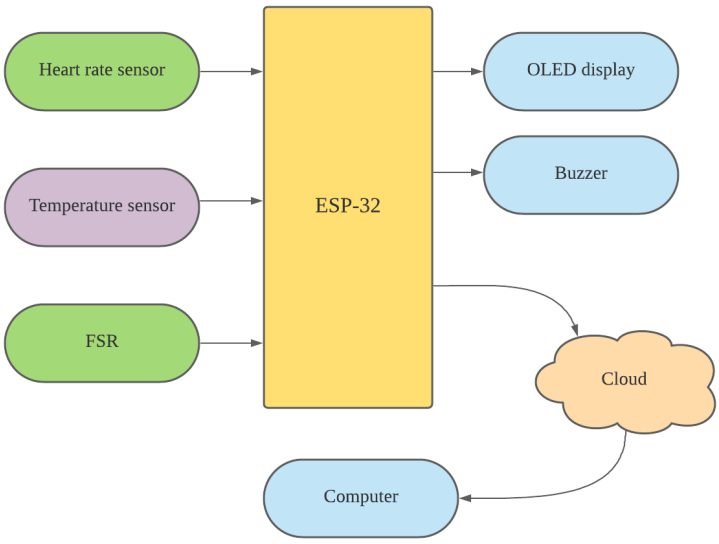

Figure 2: Block diagram of the project

B. Algorithm

Due to the obvious three sensors utilized for these qualities, the beginning of this health monitoring system can be divided into three stages. These features make it simple for the supervisor to keep track of the forklift driver's health. These three sensors have comparable process flows; thus they may be illustrated using the same flowchart. The pulse sensor and temperature sensor are where the procedure for heartbeat and temperature monitoring starts. The driver will wear a wristband that contains a pulse sensor and a temperature sensor. The driver's heartbeat and body temperature will be recorded by the sensors and sent to the controller to be processed. In addition, the readings from both sensors will be forwarded to the ThingSpeak programmed, which will keep track of the supervisor's computer and the health of their driver. Like the force sensor, it is easier to measure by placing the driver's hand on the steering wheel and connecting it to the device. For the monitoring process, the data from the sensor will be delivered to the ThingSpeak application. Health monitoring process is shown Figure 3.

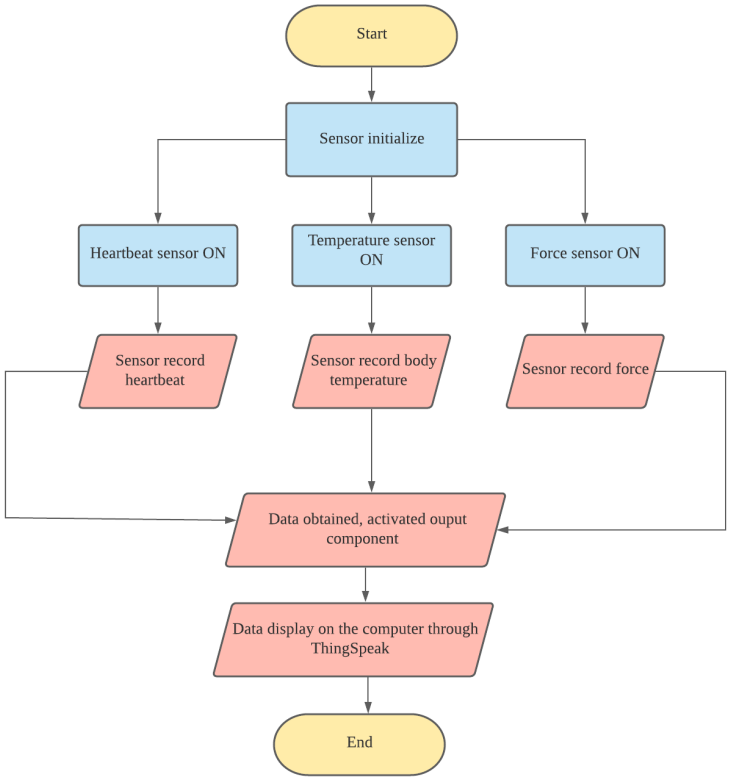

Figure 3: Health monitoring process

3. Results and Discussion

This part would cover the project's outcomes and analysis, as well as the project's final design, which had been completed and tested. Figures 4 and 5 show the top and bottom perspective of the created device's final design. The top and bottom views of the hardware revealed the circuit connection of the system, which included a pulse sensor, force sensor, temperature sensor, ESP-32, buzzer, and OLED.

The sensors keep records of the health condition as well as the force applied to the workers. Through the ThingSpeak application, the collected values are presented on the computer. Figure 6 shows how ThingSpeak displays updated heart rate, body temperature, and force applied values, as well as a buzzer that alerts the supervisor and other nearby workers.

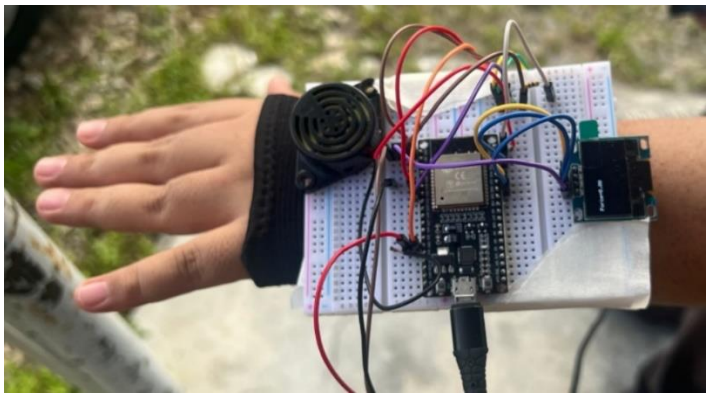

Figure 4: The top view of the hardware

Figure 5: The bottom view of the hardware

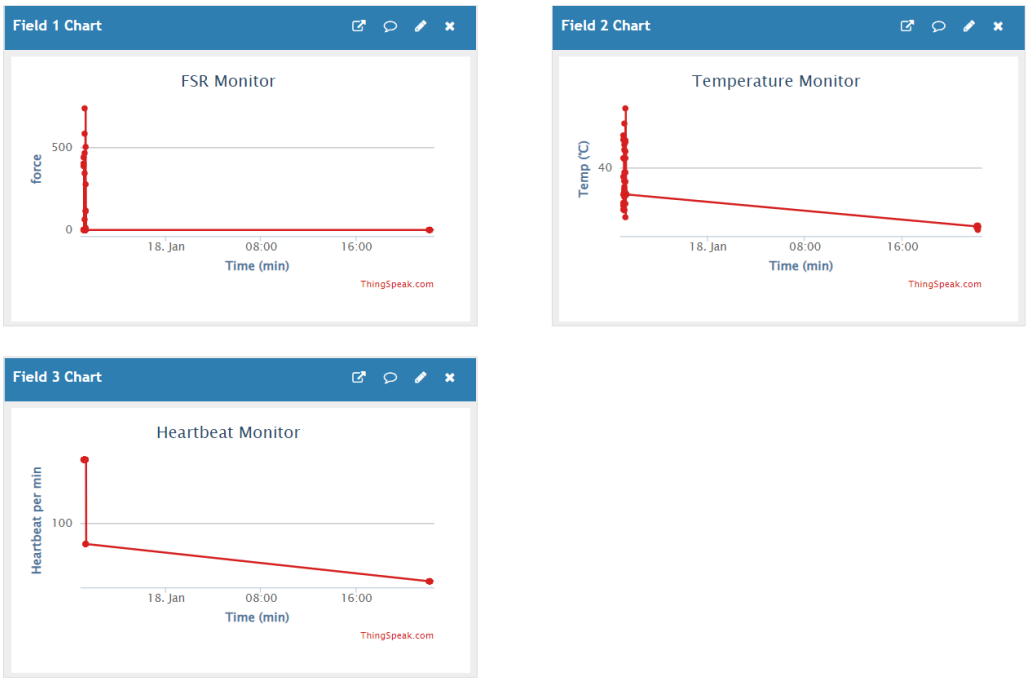

Figure 6: ThingSpeak output display

For the wi-fi limitation of an ESP-32, it has been analyzed which is the range within up to 100 meters. But it also depending on the coverage area of the router wi-fi where the strength connection between an ESP-32 and wi-fi router to display the collected data from the OLED. Some interference that may be affect the strength connection between an ESP-32 and wi-fi router which is the weather environment such as rainy day.

3.1 Validation of heart rate and body temperature data

The result of the measurement on one man with given time of 6 seconds to collect the data. the aim of validation is to figure out what the sensor's average value is. The digital measurement such as a smartwatch for measure the heart rate and a thermometer for the measure the body temperature, where are used to determine the specified sensor device's error rate. For the heart rate data, the average error rate of 6.25% and the body temperature with an average error rate of 0.99%. Table 1 shows the result of the heart rate and Table 2 shows the result of the body temperature.

Table 1: The result of heart rate data

Time(s)	Pulse sensor	Digital heartbeat	Error (%)
1	90	92	2.17
2	83	87	4.59
3	77	85	9.41
4	80	90	11.11
5	82	82	0
6	79	88	10.22
	Average error		6.25

Table 2: The result of body temperature data

Time(s)	LM35	Digital thermometer	Error (%)
1	37.2	36.8	1.08
2	37.4	36.9	1.35
3	37.0	36.6	1.09
4	37.1	36.7	1.08
5	36.9	36.8	0.27
6	37.2	36.8	1.08
	Average error		0.99

3.2 The force applied to the steering wheel

A series of experiments were carried out within 6 seconds to obtain the force applied to the steering wheel. Based on the data below, the driver has been conducted by the hardware. Table 3 shows the condition when the force applied to the steering wheel. It shows that the force applied to the steering wheel is less than 400g, the driver does not enough strength to hold the steering wheel tightly that could be seen in Figure 7.

Table 3: The condition when the force applied to the steering wheel

Status	Force (g)
Low	1 – 400
High	> 400

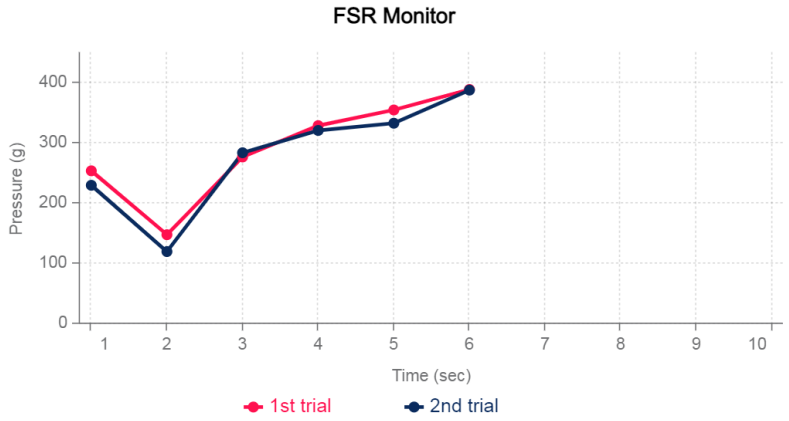

Figure 7: Relationship between the force applied and the time taken for the user attempt to drive a forklift

4. Conclusion

In conclusion, this project has been successfully constructed where it has achieved the main objective for the project. The three main sensors have been successfully tested and it can measure the health condition of the user which is for forklift driver. The hardware components error rate in detecting the heartbeat of 6.25% and body temperature of 0.99% so it could be able to maintain the safety and health condition of the forklift driver at the workplace. But the overall accuracy od the system is 92.76% which that the system can be used in surrounding area within 100 meters because of the limitation of the range between an ESP-32 and wi-fi router where it suitable within surrounding area of the hardware. Apart from that, the hardware has been tested through several times and it is able to conduct the health condition for the forklift driver successfully. In future, the sensors such as pulse and temperature need to improve for ensure that the measurement of the heart rate and body temperature have more accuracy for the medical purposes. After that, the project needs to improve the notification system, where it can notify the supervisor through phone when he is out of coverage area. It is easier to determine or monitor the driver's health condition so that I could prevent any potential incident occur at the workplace.

Acknowledgement

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