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PUSH UP MONITORING SYSTEM USING ESP32 FOR REAL-TIME PERFORMANCE ANALYSIS

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ABSTRACT

Health and physical fitness are great concern to society today. One way to maintain health and physical fitness is by exercising. Recently, people seem very enthusiastic about exercising. We can see this from the frequent appearance of videos and photos of people's sports activities on social media. One of the sports that many people do is push-ups. Many people are familiar with the push-up and often do it to train their arm muscles, or compete in endurance competitions between individuals. Even though they are often done, until now push-ups do not have an integrated monitoring tool so that they can become a credible medium for showing them off on social media. This research aims to create a push-up monitoring tool that can display data in real-time. The push-up monitoring tool is made using an ESP32 microcontroller which is equipped with a VL53L0X distance sensor. By using ESPNOW communication, the special communication between ESP microcontrollers, data can be sent from the push-up monitoring device to a receiver connected to a PC where the monitoring application is displayed. On the PC side, the application is designed to display graphs of distance chest to the ground, average height when the arms are straight, and average height when the arms are bent in real-time. These three aspects are important aspects for observing the validity of a push-up. The results of this research underscore the feasibility of the monitoring system in collecting push-up data. In addition, this research serves as a foundation for future research aimed at simplifying the push up monitoring systems.

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1. INTRODUCTION

Sport is an effective way to maintain health and physical fitness, which is becoming an increasingly important concern in the modern era. Recently, people seem very enthusiastic about exercising. We can see this from frequently appearing videos and photos of community activities on social media. Most of those who share their activities are young people who do sports or exercises such as going to the gym, running, and cycling. This is a progress where society is starting to realize the importance of sport and exercise. Exercise can improve health, help maintain physical fitness, and is essential to physical rehabilitation. Exercise is also defined as physical movement to develop or maintain physical fitness or general health (Elmagd, 2016).

Exercise can be done anywhere, even from home. Some exercise that can be done from home are yoga, push-ups, sit-ups, etc. Push-ups are an exercise that can be done from home and do not require complicated equipment. Push-ups increase upper body muscle strength in strength, mass, and endurance (Abadi et al., 2019; Hassan, 2018). Push-ups are essential because they are active movement exercises that can strengthen the shoulder and trunk muscles in everyday life (Kim et al., 2016).

Almost all people are familiar with the push-up movement and often do it to train their arm muscles, test their endurance, or compete with others in term of endurance. Even though it is often done, push-ups still need an integrated monitoring tool so that they can become a credible medium for showing them off on social media. This is different from some exercise, such as running and cycling, which have special monitoring tools so that you know the location of the trip, the distance traveled, and the average speed traveled. This is also supported by research (Artanayasa et al., 2022), which conducted survey research on 256 respondents consisting of sports and health faculty lecturers and athletes. The results of this research stated that the majority of respondents found it challenging to perform procedurally correct push-ups, and manual push-up tests were prone to human error during calculations. So, all respondents agree with the development of digital technology in instruments to help increase hand muscle strength, such as push-ups.

There have been many applications of digital technology in sports. One of them is the application of digital technology, which is used as a performance monitoring tool in sports. Performance monitoring has been widely used for years in sports, regardless of whether it is an individual or group sport. Performance monitoring is used to carry out the process of evaluating and monitoring athlete performance (Kamarudin et al., 2022). In group sports, the monitoring system has become a tracking system that is often used to help seek competitive advantage, manage the risk of injury, and support the decision-making process (Torres-Ronda et al., 2022). In individual sports, monitoring systems have also been widely implemented and circulated in the community, especially for sports, such as cycling and running.

Push-up counters are actually nothing new and have been marketed widely in society. However, the products on the market still need to follow the latest technology, such as IoT systems, or integrate with applications to create credible value. Based on existing products on the market, this research aims to produce products with the latest innovations and have more features for use. Several studies have also been carried out to calculate push-ups automatically.

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Researchers in Mardela et al. (2023) used an Arduino microcontroller with two ultrasonic sensors placed parallel at different heights. Unfortunately, the reason for determining the height of the sensor is not explained. The research was carried out based on the tool's feasibility level, which several experts tested. The feasibility test results show that the tool is in the "Decent" category. Baumbach & Dengel (2017) define that the correct push up was the push up where the participant bending his elbows till the chest is almost on the ground between hands and on the way up the arms should fully stretched.

Based on previous research, we collected several essential aspects that we must carry out in this research to improve previous research. This research focuses on monitoring systems that use wireless communications and how to display the data in real-time. The monitoring system will be handled by esp32, and the data will be displayed in a self-made application using Visual Studio 2022.

2. METHODS

ESP32 is a microcontroller produced by a company called Espressif. This microcontroller integrates with many peripherals, such as Wi-Fi and Bluetooth modules. Apart from that, it also has 32 GPIOs, making it easier to design a device. By using an ESP32-type microcontroller, many types of communication open up opportunities for use in push-up monitoring. It starts from wired communication, such as UART, to wireless communication, such as Wi-Fi. Based on the goal of ease of monitoring push-ups, we will focus on the type of wireless communication so that it is not limited by the cable length that must be connected. Without using additional modules, the ESP32 can carry out two types of wireless communication protocols: the first is 2.4 GHz Wi-Fi, and the second is the ESPNOW protocol. ESPNOW is a communications protocol developed by espressif, which makes ESP32. The ESPNOW protocol can only be used by microcontroller products from *Espressif*, such as the ESP32 and ESP8266.

Likewise, in every monitoring system, there will always be two parts: the first is reading the situation via sensors and sending it, and the second is receiving data and presenting it. On the sensor reader and sender side, we will use ESP32. Using the 2.4 GHz Wi-Fi protocol requires a router as a data receiver and a personal computer as a data storage and provider. This differs from the ESPNOW protocol, where the data receiver must also be an ESP32 microcontroller.

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ESPNOW

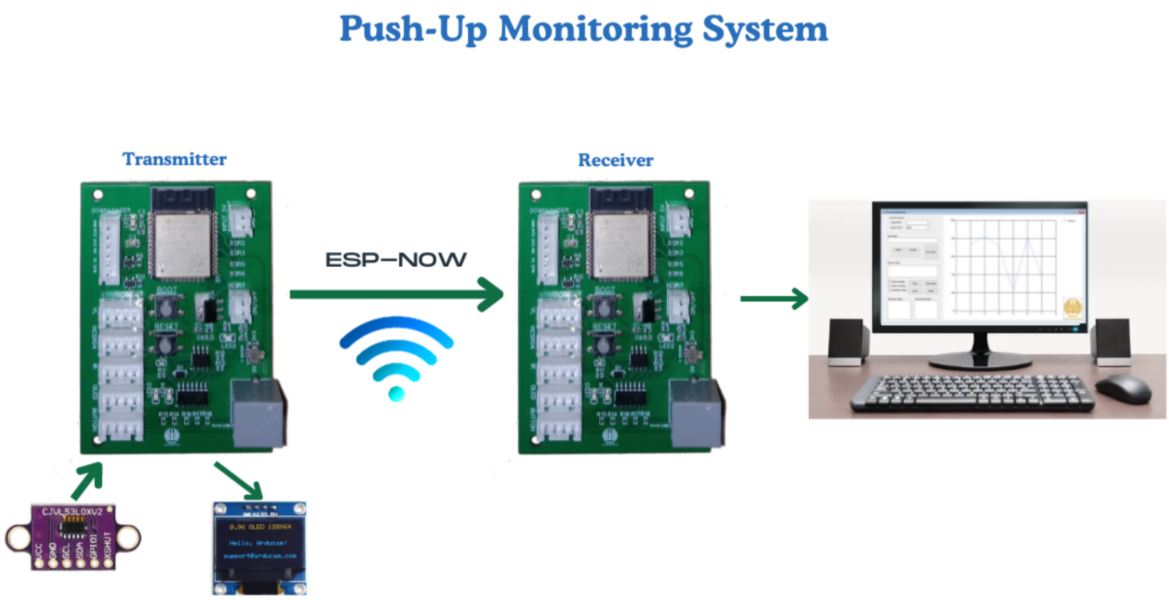

Figure 1. Push-up monitoring system

ESPNOW is a wireless communication protocol specifically for microcontrollers produced by Espressif. This protocol has the advantage because it is integrated with the ESP32, the basic microcontroller in this project. So, there is no need for additional wireless communication modules. To communicate using the espnow protocol, the esp32 on the transmitter must know the MAC address of the esp32 on the receiver. Fig 1 illustrate how espnow communication work.

ESP32 as Data Transmitter

The ESP32 that is used as a transmitter data will be connected to the vl53l0x sensor and Oled. The sensor used is a time-of-flight sensor. This type of sensor provides knowledge regarding the distance between the sensor and the object based on the length of time the light reflects. The ESP32 that is used as a transmitter data will be placed on the side of the person doing the push-up to send the push-up data produced by the vl53l0x sensor.

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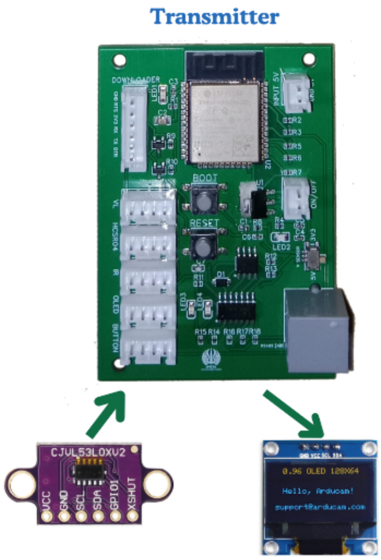

Figure 2. Data Transmitter

The vl53l0x series was chosen because it has a distance range that corresponds to the estimated highest distance of the human chest from the ground. Oled is used to display the number of times push-ups have been performed on the person doing the push-ups.

ESP32 as Data Receiver

The ESP32 that is used as the data receiver will receive data from the data transmitter via wireless communication using the ESPNOW protocol. Data that has been received will be forwarded to the computer. The computer that receives data containing chest distance values from the device will represent the data in graphical form.

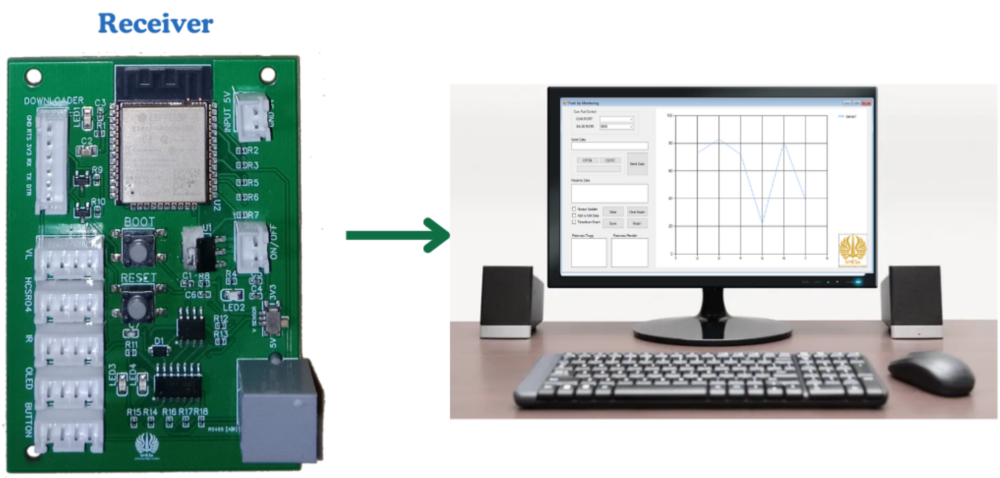

Figure 3. Data Receiver

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Presentation of Data Using Self-made Applications

The data received by the computer is displayed in graphic form using an application. The application used is an application created specifically for this research, which aims to facilitate data representation. Apart from displaying sensor data in graphic form, this application was also created to display the arm's height when straight and bent. When the arms are straight and bent, chest height data from the device can represent whether the push-ups performed are appropriate.

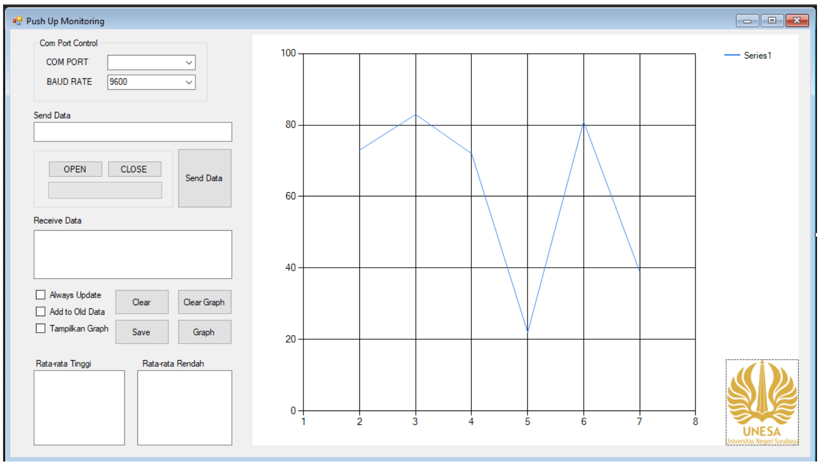

Figure 4. Application for displaying data in graphic form

3. RESULTS AND DISCUSSION

In the first test, we carried out tests on the transmitter device regarding the suitability of the distance reading. We do this by displaying sensor reading data using the tera term application. The data we produced from this trial is as follows:

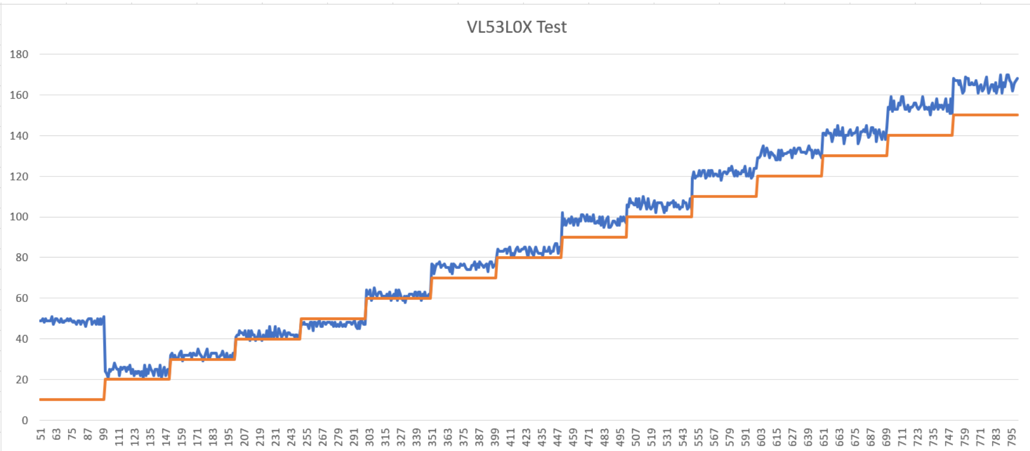

Figure 5. Sensor Test

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Table 1. Error range from sensor

Distance	MAX	MIN	Error Range
500	543	515	28
400	408	387	21
300	314	299	15
200	218	205	13
190	211	183	28
180	201	187	14
170	189	180	9
160	179	167	12
150	170	161	9
140	159	150	9
130	145	136	9
120	135	128	7
110	125	118	7
100	110	102	8
90	102	95	7
80	87	80	7
70	78	72	6
60	65	58	7
50	50	44	6
40	46	39	7
30	35	29	6
20	28	21	7
10	51	46	5

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Figure 5 presents data from the VL53L0X sensor test results which calculate the distance of an object by changing its distance. The blue color is the result of the sensor reading and the orange color is the supposed value. From this data it can be seen that not all sensor reading values are on the correct line, but this can be overcome by recalibrating the sensor using software. Apart from that, what is needed to carry out performance analysis on push-ups is the stability of data reading. Table 1 presents data on changes in reading data for reading values from 50 cm to 1 cm. From this table it can be seen that the range of changes in sensor readings starts from 5 mm to 28 mm. Another thing to pay attention to is that when the sensor takes readings below 2 cm, the error that appears is very large. This is the limitation of this device where the lowest distance that can be read is 2 cm.

(a) (b)

Figure 6. (a) data transmitter (b) Process of collecting data

We carried out the second test by doing real push-ups and recording the data using tera term. Then, we processed the data results from tera term using Microsoft Excel. So, the push-up graph data is obtained as follows.

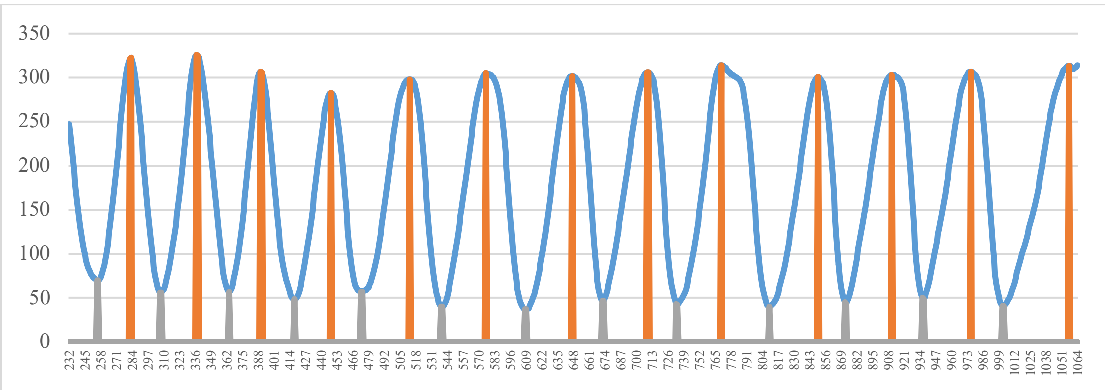

Figure 7. Push-up data

This data shows the push-up movements performed and the numbers based on the many mountains and valleys recorded. Apart from the number of push-ups, we can also see the average highest peak during the push-up and what the difference in distance should be. Likewise, at the lowest movement, we can observe whether the push-up is done how close to the ground. These two high and low average values can show our performance in doing push-ups.

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From the data that has been previously processed in Microsoft Excel, then we can design an application to display the data in real-time. We used the Microsoft Visual Studio 2022 in creating the application. In this application, we focus on showing the best graphs so that performance in push-ups can be directly observed.

The following displays the application that we have created. This application can observe in real-time the push-ups being performed as well as the average high and low push-ups. With this application, observation of push-up performance can be done quickly and easily.

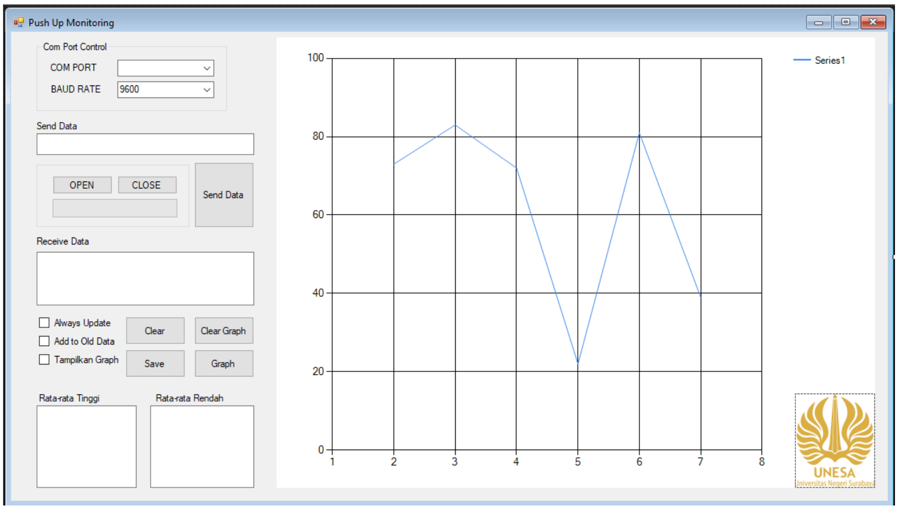

Figure 8. Application for displaying data in graphic form

5. CONCLUSION

The push-up monitoring system based on esp32 was successfully designed and developed. Using the ESP32 microcontroller, the push-up counter can be made smaller, and data can be sent via wireless communication. So, using the push-up counter is easier. The data sent is data on the distance between the chest and the push-up counter when doing push-ups. From this distance data, an application is created on the receiver side to display the distance data in graphical form. The application is designed to display graphs of distance chest to the ground, average height when the arms are straight, and average height when the arms are bent in real-time. These three aspects are important aspects for observing the validity of a push-up. The results of this research underscore the feasibility of the monitoring system in collecting push-up data. In addition, this research serves as a foundation for future research aimed at simplifying the push up monitoring systems.

Suggestions for further research on push-up counters are to pay attention to the biomechanics of push-ups and create a tool that automatically counts the number of push-ups based on the correct push-up movement. From this research, the software can also be added to automatically show the highest and lowest values of the push-up movement so that you can directly observe the quality of the push-ups.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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