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Designing an IoT-based footstep counter for sports shoes

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ABSTRACT

Shoes are general footwear that can be used when exercising, working, formal events, or just to sweeten your appearance. Shoes used for sports have a slightly different shape from shoes in general, in terms of covering the left and right sides, the base, and the design, but most shoes do not have a device to count the steps taken. To overcome this, researchers have created a tool in shoes that can count the user's footsteps while exercising. A step counter on shoes based on the internet of things uses NodeMCU and an IR sensor which functions to detect every step of the shoe wearer. The result of the detected step count will be displayed in the blynk application. NodeMCU and IR sensors will be connected to the Blynk application using the internet network. When the step counter on the shoe and the hotspot are turned on, the results of the foot count will appear on the Blynk application on the smartphone. Footstep data detected by the IR sensor corresponds to the number of steps counted manually. The test results from a 150-meter step counter, obtained results of 207 steps in 3 minutes when walking casually, 223 steps in 1 minute 30 seconds when walking fast, and 264 steps when running in a period of 1 minute 15 seconds.

INTRODUCTION

Shoes are everyday footwear. Shoes can be used when exercising, working, or just to sweeten your appearance while indoors or outdoors. The function of sports shoes is to withstand the pounding of the feet when running or walking casually. Exercising in shoes can keep the arches on the soles of the feet functioning normally (Chouw et al., 2020). But most who do sports activities often do not know the number of steps taken. To overcome this, we need a tool that can calculate the number of footsteps of shoe users who exercise either by using a smartphone, smartwatch, or other devices. In previous research, several steps have been designed, including the design of a Footstep Meter with an Accelerometer Sensor and 2.4 GHz Wireless Communication Facilities (Abadi & Saleh, 2011). Microcontroller-based running speed measuring device (Hidayat et al., 2019). Microcontroller-based running speed measuring device (Wisnurahutama et al., 2010). Design of a Running Mileage Measurement Tool Using a Microcontroller-Based Inertial Measurement Unit (IMU) Sensor (Yunidar et al., 2022). Footsteps and calorie counter using accelerometer sensor (Fadhlurrahman, 2019). Development of a Power-Saving Footstep Counter System Based on Wemos D1 Mini (Khalif et al., 2018). Development of Footstep Monitoring System with MPU6050 Sensor to Calculate Weight Loss Based on Android (Ubay et al., 2020).

From previous research, the researcher wants to make a tool to count steps that are attached to sports shoes using an infrared (IR) sensor that functions to detect each step, NodeMCU which functions as a circuit controller, and the blynk application to display the results of counting steps on the user's smartphone. The working principle of this step counter tool is that when the user swings step by step, the sensor will detect the distance from the heel counter (the heel of the shoe) to the ground where they are stepped on and count the steps to be sent to NodeMCU and then sent to the blynk application to be displayed on the smartphone user, how many steps have been taken.

LITERATURE REVIEW

Sport shoes

Sports shoes are shoes that are specifically used for sports and active physical activities because they are made with light and soft materials. On the other hand, it is also designed as a fashion shoe. The design of sports shoes when viewed from their anatomy with items that pamper the feet, shows that sports shoes prioritize comfort. The development of sports shoes is always assisted by famous people behind them, like artists, athletes, and even kings (Azhari et al., 2015).

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Figure 1. Sports shoes

Infrared Sensors

IR sensor is an electronic device that can detect objects when infrared light is blocked by objects. The IR sensor consists of an infrared Light light-emitting diode as a transmitter and a phototransistor as an infrared light receiver, made of Gallium Arsenide (Gas) which can emit infrared light and heat radiation when given electrical energy. The process of emitting light due to the presence of electrical energy given to a material is called electroluminescence (Desmira, 2020).

Figure 2. Infrared Sensors

NodeMCU

NodeMCU is an open-source tool that can be developed by anyone and is an Internet of Things platform consisting of hardware in the form of a system-on-chip ESP8266 made by Espressif System. NodeMCU can function like a microcontroller as an Arduino board that can be connected to wifi and NodeMCU has also wrapped ESP8266 into a board that already has various features for its users and also a communication chip in the form of USB to serial. Because the main source of NodeMCU is ESP8266, especially the ESP-12 series which includes ESP-12E (Suryana, 2021). (Ilham et al., 2021). (Nursila et al., 2021).

Figure 3. NodeMCU

METHOD

The tools that will be used in building an IoT-based step counter design include:

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Hardware

The hardware used in this research method is as follows:

Table 1. Hardware and Specifications

No.	Hardware	Specification	Function
1	Shoe	Sport shoes	The media where the components of the tool are installed
2	NodeMCU	*Amica version 3*	control components of the entire set of tools
3	IR Sensors	3,3-5v	component for detecting footfall
4	*Breadboards*	Mini	media components assembling other components
5	Jumper Cable	*Male to Female*	cable connecting all components
6	Alkaline Battery	9-12v	the energizing component for the system

Software

The software used in this research method is as follows:

Table 2. Software and Specifications

No.	Software	Version	Function
1	Blynk app	2.27.15	Controls Arduino and displays step count results.
2	Arduino IDE	1.8.5	Create, edit, verify and upload programs to Arduino.
3	Fritzing application	0.9.2b	The initial design of the overall tool sketch

Schematic Design / Block diagram

Block diagrams are made to simplify the process of designing step counters for shoes based on the Internet of Things. The circuit of this tool system consists of three circuits, namely the input section, the control section, and the output section.

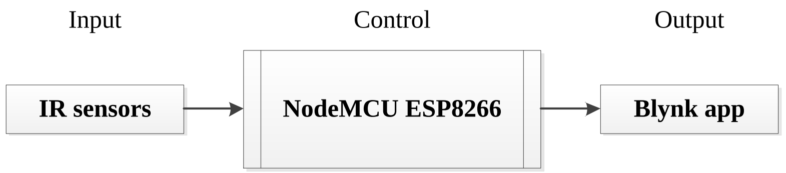

Figure 4. Block Diagram

Information:

1. Input Section

The input section consists of an Infrared Sensor which functions as a sensor to calculate each step of the movement of the foot

2. Control Section

The control section consists of Nodemcu which functions as a controller for the entire circuit so that the circuit can work optimally.

3. Output Section

The output section consists of the Blynk application which functions to display data from the calculation of the number of steps on a smartphone.

Tool Design

The design of a step counter device on shoes based on IoT is by connecting the GND pin and VCC pin on the IR sensor to the GND pin and 3-volt pin on the NodeMCU, then pin D0 on the IR sensor is connected to pin d1 on the NodeMCU.

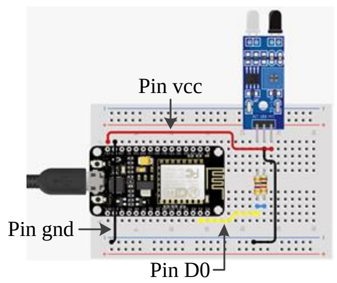

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Figure 5. Tool Design

System flowchart

The following is a step counter flowchart on shoes based on the Internet of Things:

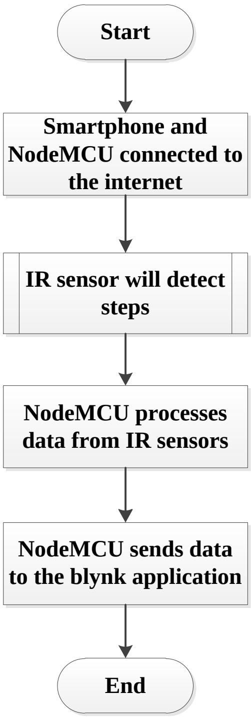

Figure 6. Flowchart of Program Flow

The flowchart above explains the flow of how the program works: The Blynk application on smartphones and Nodemcu must be connected to the internet so that NodeMCU can send data from near and far. The infrared sensor will work automatically if it detects the movement of footsteps and will process the data sent from the sensor to be sent to the blynk application.

Tool Sketch

This tool sketch is needed to provide a temporary description of the tool to be made, but this sketch also requires an appropriate design so that later the tool made will match the description that has been made.

Figure 7. Sketch Tool

RESULT AND DISCUSSION

The Whole Range of Tools

The series of all components are connected and have been placed on the shoe. NodeMCU is on the inside of the shoe. The IR sensor is facing down and is on the outer heel of the shoe. While the battery is in the heel of the shoe. To set the on and off of the tool, use the switch located on the outside of the shoe.

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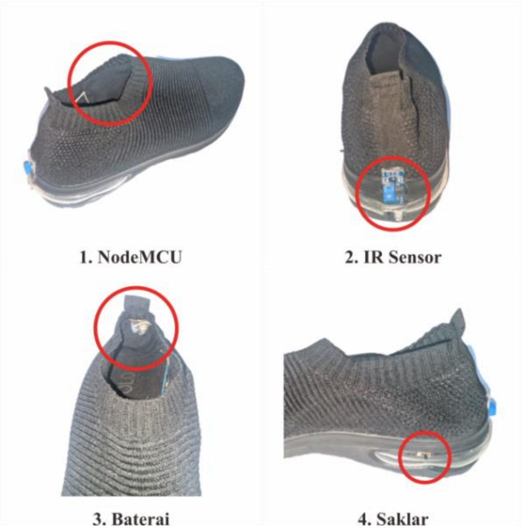

Figure 8. The Whole Range of Tools

Test Table Results

After the system has been created, it is necessary to test the system. This test was carried out in three stages and carried out on four different types of surfaces. Each test was performed ten times and compared to the step count on the smartwatch.

Table 3. Tests when walking relaxed

No.	Testing	Traveling time	Mileage	Land Type	Calculation Method	
					Step Counter Tool	Smart Watches
1	First	2 minutes	98 meters	Asphalt	140 steps	142 steps
2	Second	1 minutes	46 meters	Asphalt	69 steps	68 steps
3	Third	5 minutes 10 seconds	251 meters	Cement	356 steps	356 langkah
4	Fourth	8 minutes	387 meters	Asphalt	554 steps	556 steps
5	Fifth	2 minutes	102 meters	Grass	146 steps	151 steps
6	Sixth	1 minutes 30 seconds	80 meters	Land	128 steps	128 steps
7	Seventh	3 minutes	150 meters	Grass	205 steps	208 steps
8	Eighth	1 minutes 40 seconds	70 meters	Cement	133 steps	133 steps
9	Ninth	5 minutes	240 meters	Cement	320 l steps	323 steps
10	Tenth	7 minutes 20 seconds	352 meters	Asphalt	494 steps	494 steps

The first test by walking casually was carried out on Wednesday 11 January 2023, Thursday 12 January 2023, and Friday 13 January 2023. The test time was between 1 minute and 8 minutes, with a distance of 46 meters to 387 meters. The comparison of the results of the step counter with a smartwatch ranges from 1 to 5 steps.

Table 4. Tests when running fast

No.	Testing	Traveling time	Mileage	Land Type	Calculation Method	
					Step Counter Tool	Smart Watches
1	First	1 minutes	82 meters	Cement	130 steps	133 steps

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2	Second	4 minutes	350 meters	Asphalt	537 steps	535 steps
3	Third	3 minutes 30 seconds	330 meters	Cement	470 steps	470 steps
4	Fourth	1 minutes	93 meters	Grass	140 steps	144 steps
5	Fifth	1 minutes 25 seconds	135 meters	Grass	154 steps	158 steps
6	Sixth	1 minutes 30 seconds	150 meters	Cement	223 steps	222 l steps
7	Seventh	3 minutes 45 seconds	370 meters	Asphalt	488 steps	490 steps
8	Eighth	2 minutes 10 seconds	205 meters	Land	270 steps	270 steps
9	Ninth	2 minutes 12 seconds	208 meters	Cement	295 steps	295 steps
10	Tenth	1 minutes 5 seconds	112 meters	Land	143 steps	142 steps

In the second test, walking fast was carried out on Wednesday January 11 2023, Thursday January 12 2023, Friday January 13 2023, and Saturday January 14 2023. The test time is from 1 minute to 4 minutes, with distance of 82 meters to 370 meters. The comparison of the results of the step counter with a smartwatch ranges from 1 to 4 steps.

Table 5. Testing when running

No.	**Testing**	**Traveling time**	**Mileage**	**Land Type**	**Calculation Method**	
					Step Counter Tool	**Smart Watches**
1	First	2 minutes 30 seconds	366 meters	Grass	511 steps	522 steps
2	Second	1 minutes	130 meters	Cement	209 steps	214 steps
3	Third	3 minutes	441 meters	Cement	620 steps	616 steps
4	Fourth	2 minutes	320 meters	Land	428 steps	431 steps
5	Fifth	2 minutes 46 seconds	437 meters	Land	620 steps	624 steps
6	Sixth	1 minutes	147 meters	Cement	220 steps	226 steps
7	Seventh	1 minutes 15 seconds	150 meters	Asphalt	264 steps	265 steps
8	Eighth	1 minutes	112 meters	Land	190 steps	194 steps
9	Ninth	2 minutes	287 meters	Asphalt	350 steps	349 steps
10	Tenth	3 minutes	450 meters	Cement	626 steps	623 steps

In the third test, running was carried out on Saturday January 14 2023, Sunday January 15 2023, Monday January 16 2023, and Tuesday January 17 2023. The test time is between 1 minute and 3 minutes, with a distance of 130 meters to 450 meters. The comparison of the results of the step counter with a smartwatch ranges from 1 to 11 steps.

The step counter tool on shoes based on the Internet of Things has been tested 30 times for 7 days. This test is carried out on several types of surfaces, namely asphalt, cement, soil, and grass. Testing time between 1 minute to 8 minutes, with a test distance of 46 meters to 450 meters. From this test, the number of footsteps detected by the tool while walking leisurely was 69 to 554 steps, the number of steps detected by the device when walking fast was 130 to 537 steps, while the number of steps detected by the tool while running was 190 to 626 step. The difference in step count using a step counter with a smartwatch is not much different, namely 1 to 11 steps.

CONCLUSION

After designing a step counter tool on shoes based on the Internet of things and then testing the tool, both testing each circuit and overall sensor readings. Then it can be concluded as follows:

1. Footstep data detected by the IR sensor corresponds to the number of steps counted manually;
2. NodeMCU can work optimally using the internet network;
3. Blynk application to monitor and display the results of the step counter;
4. The test results of the step counter on asphalt, cement, and soil surfaces are well detected. Meanwhile, on the surface of the grass, it is not detected properly.

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