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Solar Powered Drying and Hygienic Shoe Rack

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Abstract: This study presents the design and evaluation of a solar-powered closed shoe rack for drying and deodorizing shoes that are wet due to heavy rain or sweating. The shoe rack utilizes airflow to eliminate moisture and odors. The rack is powered by solar panels and is confined in the closed rack to trap heat for more efficient drying. The design includes an automatic fan system that turns on which creates airflow and heating the shoe rack when the shoes are placed inside. The study includes a detailed examination of the design, materials, and functionality of the shoe rack, as well as a comparison of its performance to traditional methods of drying shoes. The study includes an evaluation of the solar-powered closed shoe rack's performance, energy efficiency, and durability. The shoe rack is also able to be controlled via IoT by the application of Blynk Console. It can control the operations of the fans and monitor battery percentage and the duration of the drying process. The results show that the solar-powered closed shoe rack is a convenient and eco-friendly solution for drying and deodorizing shoes, with the added benefit of being energy-efficient and durable. It is also convenient for users as it can be controlled and monitored remotely from their smartphones. Based on this project, the solar-powered closed shoe rack can dry the shoes without the risk of bad smell as well as protect shoes from thieves and avoid being stolen. The study suggests that this technology has the potential to be used in various settings such as homes, gyms, and sports clubs. After several tests, it is found that the shoe rack is effective at drying wet shoes over some time. The drying starts at 10 p.m. with the condition of the shoe being wet at very high humidity (60% $g.m^{-3}$ or more) and the temperature inside the shoe rack is at 27°C. Considering ideal conditions (normal weather, good indoor air circulation, and optimum shoe rack performance), the shoe will be in a completely dry state at 9 a.m. where the inner shoe rack temperature is 29°C and the estimated humidity of the shoe is below 30% $g.m^{-3}$ or less. On top of that, the solar charging and battery capabilities are promising as well.

Keywords: Solar Power, Drying and Hygienic and Drying Shoe Rack, Blynk Console

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1. Introduction

Malaysia is in the equatorial region and has a tropical rainforest climate. Located near the equator. Malaysia's climate is categorized as equatorial, being hot and humid throughout the year. The average rainfall is 250 centimeters in a year and the average temperature is 27°C [1]. Rainy days can be a challenge for people who want to keep their feet and shoes dry. Wet shoes and feet can lead to several problems such as discomfort, odors, and the growth of bacteria and fungi. The prolonged exposure of damp shoes to warm and moist environments can create an ideal breeding ground for bacteria and fungi, leading to skin infections and unpleasant odors. Moreover, walking in wet shoes can cause blisters and other foot problems, leading to discomfort and reduced mobility.

To avoid these issues, it is important to have a method of drying shoes effectively after they get wet. A normal shoe randomness and ones typically found in homes and apartments, might not provide adequate protection from dampness, and could even contribute to the growth of mold and bacteria. A normal shoe rack typically exposes shoes to the open air, which can cause slow drying and promote the growth of mold and bacteria. Because of the ubiquitous nature of dermatophytes and a lack of an adaptive immune response in the nail plate, recurrence and relapse rates associated with superficial fungal infections are high (10%–53%). Cured or improved dermatophytosis patients could become reinfected if exposed to fungal reservoirs, such as an infected shoe, sock, or textile. To prevent this, footwear, sock, and textile sanitization methods can be used [2].

A closed shoe rack, on the other hand, offers a more controlled environment for drying shoes. A closed shoe rack typically has a lid or doors that keep shoes isolated from the open air, which can help to prevent moisture buildup and the growth of bacteria and fungi. Additionally, closed shoe racks often have ventilation systems or air circulation fans that promote faster drying. Drying operations use warm, dry air to lower the moisture content of horticulture produce. Although there are many set-up methods for drying [3]. The controlled environment offered by a closed shoe rack is a much better option for people who want to keep their shoes dry and avoid the problems associated with wet shoes and feet.

Several past projects come into play such as an ergonomic evaluation of a shoe rack in a CAD environment. To improve their usefulness, the majority of shoe racks on the market must adhere to ergonomic standards. In light of this, an effort was made to create an ergonomic multifunctional shoe rack for a small family of 5–6 people, with members ranging in age from children to grandparents, to fit modern apartment-style homes. After some user research and brainstorming, it was decided that the intended design should be functional for the entire family, with all shoes in each rack visible to someone standing in front, easy to move, straightforward to use (take shoes/socks, put on shoes, tie laces, etc.), compact, and aesthetically pleasing. Dust resistance, the availability of enough clearance dimensions, and the incorporation of safety elements were also thought of as extra benefits. The current research illustrates a virtual ergonomic evaluation approach to determine whether a shoe rack's design will be acceptable to its intended users and meet their needs in a practical setting. Readers should be able to see how easy it is to utilize digital human modeling tools for virtual ergonomic evaluations and will likely promote their usage for various applications as and when necessary [4].

Next is a project on a shoe rack for effective sterilization and deodorization of the shoes contaminated by various bacteria. The purpose of this study was to determine the ideal circumstances for developing a shoe rack that could efficiently deodorize and sterilize footwear infected with different germs. The creation and assessment of a shoe rock took place from October 2014 to September 2015 over the course of a year. JIS Z 2801:2010 used Escherichia coli and Staphylococcus aureus to test the antibacterial efficacies. The Korea Air Cleaning Association SPS-KACA002-132:2006 standard technique for evaluating an indoor air cleaner deodorization effectiveness was used to determine the deodorization efficiency. After being exposed to ultraviolet (UV) light for 30 seconds, Escherichia coli and Staphylococcus aureus revealed more than 99.9% of the sterilization effects, according to the results of the antibacterial assessment. For the test gases, the average deodorization effectiveness was 42.5%.

When the UV light was periodically switched on for 5 minutes and off for 25 minutes, the temperature inside the shoes and in the shoe rack was less than 40 degrees Celsius and 25 degrees Celsius, respectively. The UV lamp on/off switch was used to regulate this and keep the shoes at the right temperature. Because the interior capacity of the shoe rack was less than the test chamber used to assess the deodorization efficiency, the true deodorization efficiency is anticipated to be greater than the measured value. The sterilization of the microorganisms that produce offensive odors in shoes may further enhance the deodorization effect [5].

Many people encounter dry problems today, particularly those who frequently engage in activities in sweaty environments, resulting in moist and damp shoes. As a result, the shoes are both unpleasant to wear and induce leg skin diseases. Therefore, the purpose of this project is to design and implement a functional Automatic Shoe Dryer that can help people speed up the drying process of shoes in a brief amount of time and can be located inside a building, thereby preventing the loss of shoes, which is convenient for the user. The created product is a combination of programmed software and hardware. This system uses Arduino UNO as a microcontroller substrate and a DHT 11 temperature sensor to measure the relative humidity within the shoes. Arduino UNO will send a command to the relay to activate the AC hot bulb and fan to distribute the heat. The System operates by calculating the drying time of shoes based on the temperature and time [6].

2. Materials and Methods

This section explains the materials and method that is utilized in this system to achieve the listed objectives. The focus of this section revolves around developing and designing a solar-powered drying and hygienic shoe rack.

2.1 Materials

The material used as components to the Solar Powered Drying and Hygienic Shoe Rack:

- 20V Solar Panels as the main source of energy.
- 12V Lead-Acid Battery acts as the energy storage.
- PWM Solar Charge Controller is used to regulate solar charging for the battery.
- ESP8266 Microcontroller for the application of “Internet of Things”.
- DS18B20 Temperature Sensor as the main information input.
- 5V Mini Fan as the main output and to generate airflow.

2.2 Software

The material used as components to the Solar Powered Drying and Hygienic Shoe Rack:

- Proteus is used to design circuits and schematics.
- Arduino IDE is applied to design the coding.
- Blynk Console acts as the mobile user interface and monitors and controls the system.

2.3 Project Flowchart

The whole project implementation flowchart is shown in Figure 1. This project starts with a study of Malaysia's current solar-based product system. The most recent advances in the solar appliance system are studied and analyzed to apply them to this project. In addition, the study of the parameters needed for this project is discussed. Following that, a method to apply solar charge to the battery is created. This system's whole list of materials, both software and hardware, is mentioned, followed by the project's entire procedure. As a result, appropriate hardware is built. After the system is finished, the performance and results are evaluated and analyzed. The system is then put through a series of troubleshooting procedures until it reaches the desired level of perfection. Lastly, based on the results obtained, a discussion and conclusion can be made.

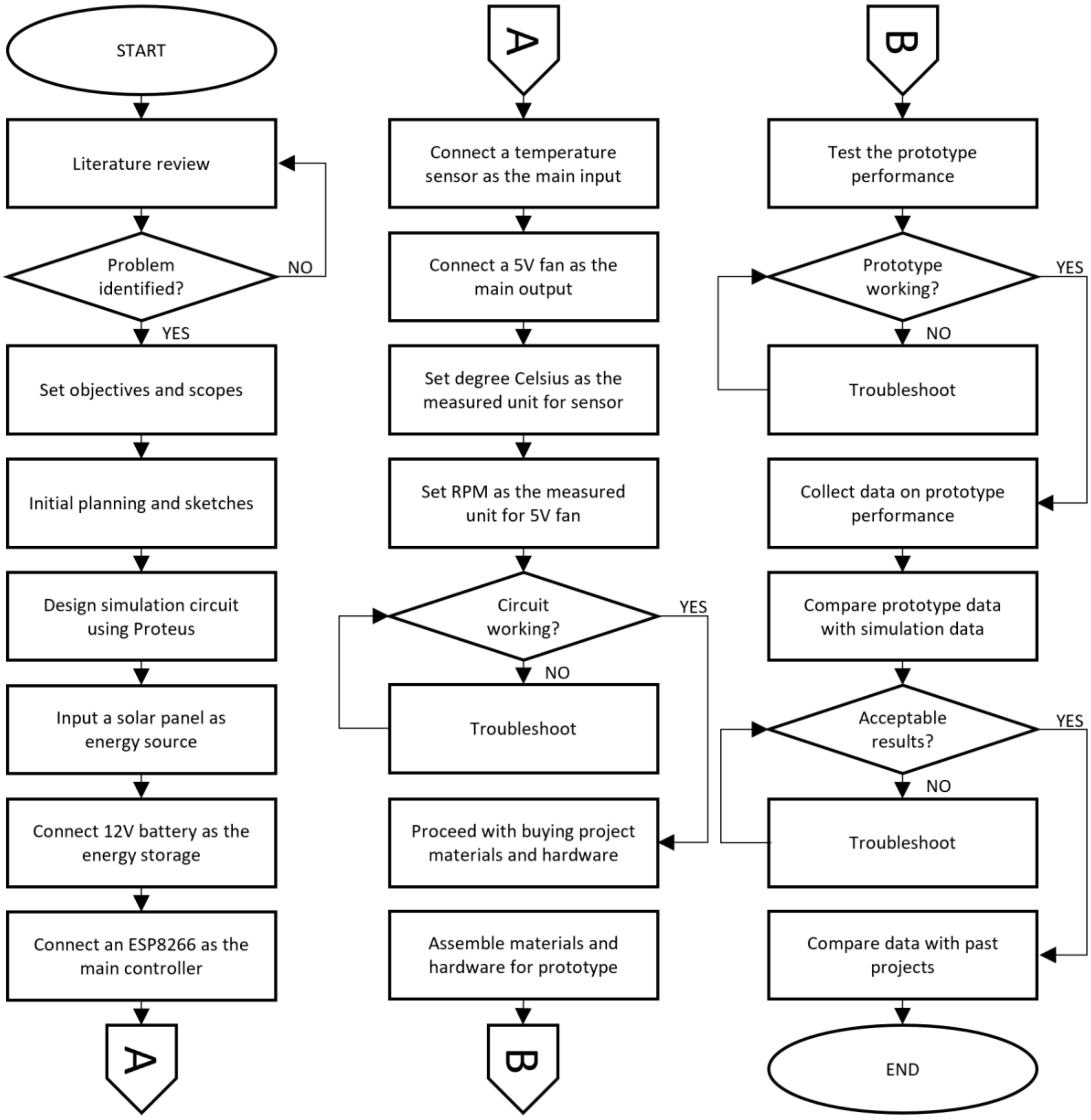

Figure 1: Flowchart of The Project.

2.4 Project Block Diagram

The solar panel is the component that captures solar energy, which is then sent to the charge controller as shown in Figure 2. The charge controller regulates the power from the solar panel and sends it to the battery, which stores the energy for later use. The inverter converts the stored DC power into AC power, which is then sent to the shoe rack and fan. The fan is connected to the shoe rack to help dry and deodorize the shoes.

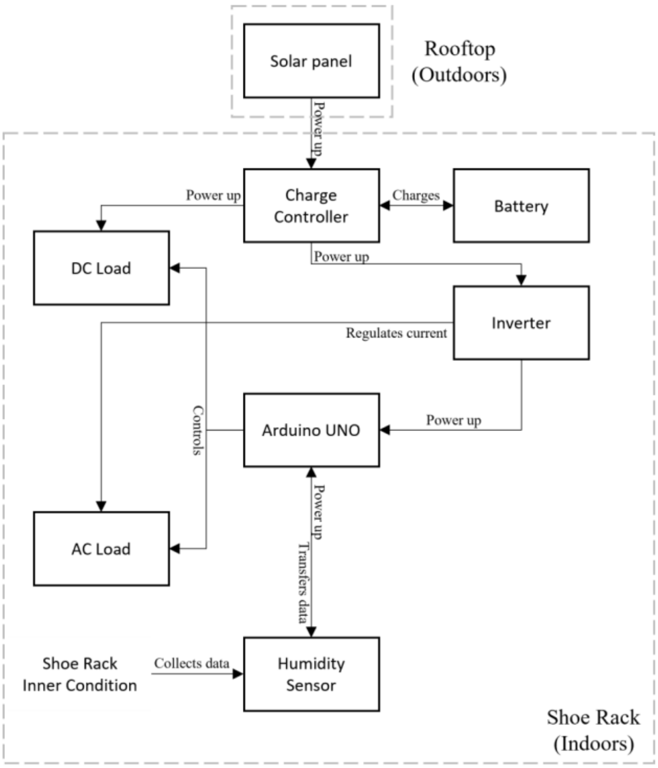

Figure 2: Block Diagram of The Project

3. Results and Discussion

This section consists of six parts representing all explanations throughout the completion of this project. The result and analysis of the functionality of the solar panels, functionality of the solar charge controller, and functionality of the battery are deeply explained.

3.1 Results

The findings obtained for battery charging results are shown in Table 1. The data taken is to show how much solar energy can be taken and charge the battery. All these data are taken from 11 a.m. to 4 p.m. on a sunny day. Table 1 shows the results that were obtained. It is proved that at 11 a.m., a weak battery voltage condition which is 12.4 V, increased by 0.1 V at p.m.. It further increased to 12.7 V, which is an increase of 0.2 V at 1 p.m. Later, the final recorded battery voltage was 12.9 V at 4 p.m.

Table 1: The results of battery charging

Time	Battery Voltage (V)
10.00 a.m.	12.4
11.00 a.m.	12.4
12.00 p.m.	12.5
01.00 p.m.	12.7
02.00 p.m.	12.8
03.00 p.m.	12.9
04.00 p.m.	12.9

The results for the shoe drying capability of the Solar Powered Drying and Hygienic Shoe Rack are shown in Table 2. These experiments are carried out from 10 p.m. to 9 a.m. After running some tests, the average temperature inside the shoe rack and shoe condition is obtained. At the start of the experiment which is 10 p.m., the initial temperature is at 27 °C and the condition of the shoe is very wet. At 12 a.m., the temperature has increased to 27.5°C and the shoe is no longer very wet and not dripping any water. At 3 a.m., the temperature is now 28.3°C and the shoe's condition has changed to damp. After a while, the temperature only slightly increases to 28.7°C but the shoes are now dry at 6 a.m. Finally, the shoes are completely dry at 8 a.m. with a temperature of 28.9°C to 29°C. The input fan is turned on from 10 p.m. to 3:59 a.m. to boost the drying efficiency and turned off until 9 a.m. to reduce battery usage.

Table 2: The results for shoe drying capability.

Time	Temperature in Shoe Rack (Celcius)	Input Fan (RPM)	Output Fan (RPM)	Shoe Condition
10.00 p.m.	27.0	4200	4200	Very Wet
11.00 p.m.	27.2	4200	4200	Very Wet
12.00 a.m.	27.5	4200	4200	Wet
01.00 a.m.	27.8	4200	4200	Wet
02.00 a.m.	28.1	3150	4200	Wet
03.00 a.m.	28.3	3150	4200	Damp
04.00 a.m.	28.5	3150	4200	Damp
05.00 a.m.	28.6	3150	4200	Damp
06.00 a.m.	28.7	2100	3150	Dry
07.00 a.m.	28.8	2100	3150	Dry
08.00 a.m.	28.9	2100	3150	Completely Dry
09.00 a.m.	29.0	1050	2100	Completely Dry

The results for battery condition and capacity of the Solar Powered Drying and Hygienic Shoe Rack are shown in Table 3. These experiments are conducted from 10 p.m. to 9 a.m. After running several tests, the battery condition and capacity are obtained. At the start of the experiment which is 10 p.m., the initial battery condition is fully charged at 11 p.m., the battery condition is now changed to strong which lasts until around 2 a.m. At 2 a.m., the battery condition has become average which lasts around 4 hours. Then at 6 a.m., the battery condition is now considered weak. Finally, the battery capacity has almost reached its end and is now very weak at 9 a.m. The input fan is turned on from 10 p.m. to 3:59 a.m. to boost the drying efficiency and turned off until 9 a.m. to reduce battery usage.

Table 3: The results for battery condition and capacity

Time	Battery Condition	Input Fan (RPM)	Output Fan (RPM)
10.00 p.m.	Fully Charge	4200	4200
11.00 p.m.	Strong	4200	4200
12.00 a.m.	Strong	4200	4200
01.00 a.m.	Strong	4200	4200
02.00 a.m.	Average	3150	4200
03.00 a.m.	Average	3150	4200
04.00 a.m.	Average	3150	4200
05.00 a.m.	Average	3150	4200
06.00 a.m.	Weak	2100	3150
07.00 a.m.	Weak	2100	3150
08.00 a.m.	Weak	2100	3150
09.00 a.m.	Very Weak	1050	2100

Changes in the weather, such as overcast days or little sunlight during the winter, can have an impact on the efficiency and effectiveness of the solar panels. To avoid operational interruptions and sustain continuous operation, a reliable power supply and energy storage must be optimized. The room temperature for the location of the shoe rack also affects the results on rainy days, the shoes take a longer time to dry while at a hotter room temperature, the shoes dry quickly. Different types of shoes also become a major factor in the duration of drying the shoes. Leather-made shoes take a quicker time whereas fabric shoes take a longer time to dry.

4. Conclusion

As a conclusion, the Solar Powered Drying and Hygienic Shoe Rack controlled by Blynk introduces efficient and sustainable solutions for drying wet shoes caused by rain or sweating. Through the Blynk platform, this cutting-edge system combines the strength of solar energy with the control capabilities of smartphones to minimize both the environmental impact and the need for conventional methods of shoe drying. Moreover, the shoe rack dryer is economical and environmentally friendly because it uses solar energy as its main energy source. Shoes can be dried indoors or over the course of an entire night thanks to solar panels' efficient conversion of sunlight into electricity. Due to the ability to dry overnight, this not only does away with the conventional method but also saves time. By implementing Blynk Console, users can monitor, and control the operating system and also be notified of the battery condition. This creative solution offers a dependable, effective, and convenient replacement for conventional shoe drying techniques and fits with the expanding trend of environmentally responsible practices.

Acknowledgement

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