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Design and Construction of an Automatic Dispenser for the Visually Impaired Using Microcontroller Technology

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Abstract. Water is a fundamental need for humans, comprising 70% of the human body. Dispensers are commonly used due to their convenience and hygienic nature for storing drinking water. Visually impaired individuals often face challenges in using conventional dispensers, which can lead to injuries when retrieving water. This study aims to design an automatic dispenser to assist the visually impaired, reducing the risk of injury when using dispensers. The dispenser is designed with two microcontrollers: Atmega32 and ESP8266. The ESP8266 microcontroller has a Wi-Fi feature, enabling it to connect to the internet. The dispenser uses two ultrasonic sensors to detect objects obstructing the sensor's beam, helping control the flow of water. The system communicates between the two microcontrollers and connects to the Telegram app via Wi-Fi, allowing for remote monitoring and control. The Arduino Uno microcontroller serves as the system's control center.

Keywords. Visually Impaired, automatic dispenser, arduino uno atmega32, nodemcu esp8266, ultrasonic sensor.

1. Introduction

Water is a primary necessity for humans since 70% of the human body is made up of fluids [1]. In rural areas, people still boil water for daily drinking needs, storing it in kettles or similar tools. Meanwhile, some people have adopted using gallon water containers and dispensers for drinking and water storage, considering them more hygienic and convenient for dispensing hot or cold water. Although dispensers are considered flexible, they still have limitations, such as requiring the user to manually press buttons for water to flow and needing attention to ensure the water does not exceed the cup's capacity.

The term "blind" refers to individuals with visual impairments. Blindness or visual impairments can interfere with daily activities, such as filling water from a dispenser, which often requires feeling the rim of the cup with fingers to prevent overflow. Designing an automatic dispenser for the visually impaired using a microcontroller can simplify this process by utilizing ultrasonic sensors and timers.

Previous research by Fathoni [1] employed the DS18B20 microcontroller and ultrasonic sensors to measure water entering a glass, automatically stopping the water

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flow when it reached the ultrasonic sensor's range limit. Similarly, Philip [2] designed an automatic dispenser using the ESP8266 microcontroller with ultrasonic sensors to detect the presence of a glass and measure the water's height in the glass. An AC pump was used to control the water flow. Ta'ahal [3] employed the NodeMCU ESP8266 microcontroller in combination with the BLYNK app for mushroom watering systems monitored via the internet.

This study uses a different method, combining two microcontrollers (Arduino Atmega32 and NodeMCU ESP8266), making the system internet-connected. Ultrasonic sensors detect the presence of a glass, and the water flow stops automatically after three seconds. The HC-SR04 ultrasonic sensor is used as an input to the Arduino Uno, and a water level sensor monitors the water level in the dispenser's tank. An electric faucet, controlled by a relay, replaces conventional taps, ensuring automatic water control. Additionally, an MP3 module provides audio commands to assist the visually impaired in daily water retrieval from the dispenser.

2. Theoretical Framework

2.1. IOT (Internet of Things)

IOT is a concept where every object in the world can communicate with each other, connected via the internet. IOT is based on sensors that collect data, which is communicated through the internet, and the information generated is stored on servers [4].

2.2. MySQL

MySQL is a database management system that anyone can use as long as it is not for commercial purposes. MySQL is a relational database server that supports SQL as the database language (Structured Query Language) [5]. In MySQL, the terms used include tables, rows, and columns.

2.3. Arduino Uno ATmega32

Arduino is a microcontroller board using the ATmega32. Arduino Uno provides everything needed by the microcontroller. To connect Arduino to a computer, only a USB cable is needed, or alternatively, it can be powered by a battery or an AC to DC adapter. The ATmega32 is equipped with a bootloader, allowing new code to be uploaded to the ATmega32 without external hardware programmers [6].

2.4. Relay Module

A relay is an electronic module that, when receiving electromagnetic input, can activate a contactor composed of an electronic switch. Using DC current, it can channel AC power. The relay consists of two main parts: the coil (electromagnetic) and a set of switch contacts (mechanical) [7].

2.5. MP3 Module

The MP3 module is a device used to play music and can be connected to various types of microcontrollers. As its name implies, it can read audio file formats like WAV and MP3 [8].

2.6. Solenoid Valve Pneumatic

A solenoid valve pneumatic is a valve operated by electrical energy through a solenoid [9]. The actuator is driven by a coil that moves a piston, generating AC or DC current. The solenoid valve pneumatic has both an inlet and outlet port.

3. Method

Figure 1 below shows the design flow used:

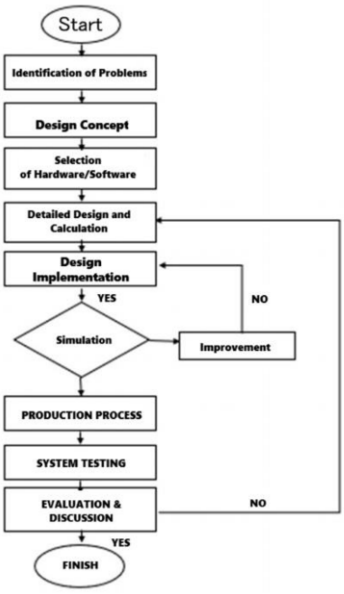

Figure 1. Design Flow

The design of this study is divided into two parts: Hardware and Software design. The hardware consists of several components, namely Node MCU ESP8266, Arduino Uno Atmega32, ultrasonic sensor (HC-SR04), relay module, solenoid valve, MP3 module, power supply, and pump. The required software involves writing a program on the Arduino IDE application, which is stored on the Arduino Uno Atmega32 board. It also includes connecting to the Telegram app to send messages. The water level data is sent to Telegram for monitoring purposes, ensuring that the water in the dispenser is always available. The data is sent to Telegram for the administrators/providers at PSBN Tan Miyat Bekasi, so they can quickly respond to replace empty water gallons. Telegram was chosen as the data delivery method because it is widely used, and it offers a bot feature that allows integration with the data transmission components, i.e., NodeMCU as

the data sender from the water level sensor.

The REST API method used is POST and GET. Data is sent from the water level sensor through NodeMCU to the database using the POST method to add data every 2 minutes. Data received by Telegram uses the GET method, allowing Telegram to read the data generated by the water level sensor. The reading process works such that when the water level drops below 30, a notification is sent indicating that the water is empty, with a notification sent every 2 minutes.

The design process uses the QFD (Quality Function Deployment) method. QFD is a method used to design and develop new products that meet the desires and needs of consumers. It systematically evaluates the product's capabilities and the services provided to meet customer needs [10]. This method is generally used as a planning tool to fulfill consumer demands. QFD aims to identify consumer desires and feedback regarding the design of the automatic dispenser in terms of mechanism, safety, and ease of use [11]. The QFD method is applied in the initial design and product development stages, prioritizing consumer needs and preferences [12]. The QFD method is more effective in this research given the physical limitations of the respondents, which made it difficult to use other design methods. The QFD process generally involves: interviews with customers and questionnaires. Due to the physical limitations of the respondents, the writer only used interviews to collect data.

4. Results and Discussion

4.1. Working Principle of the Device

The automatic dispenser design uses a solenoid valve (electric tap) to replace the conventional tap, placed on the dispenser body. An AC pump connected to the solenoid valve pushes the water. To automatically activate the solenoid valve and AC pump, ultrasonic sensors HC-SR04 are placed on the left and right sides. The ultrasonic sensor reads a glass from a distance of 5 cm, connected to the Arduino Uno microcontroller. The water level sensor is installed to provide information about the water level inside the dispenser tank. This sensor is connected to the Arduino Uno microcontroller and NodeMCU ESP8266. The connection to NodeMCU ESP8266 allows the sensor to send data to the database and ensures the dispenser can connect to the Telegram app via the internet. The flowchart of the dispenser's working system is shown in figure 2.

Figure 2. Flowchart of the Automatic Dispenser System

4.2. Device Design

The device design consists of two stages: hardware and software design. The first stage involves designing the hardware of the automatic dispenser, as shown in figure 3. The system design uses the Proteus 8 Professional application.

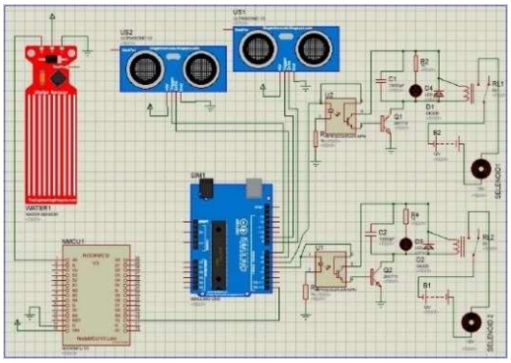

Figure 3. System Design

Figure 4. Hardware Design Results

The hardware design includes a 5–12 V DC power supply, ultrasonic sensor circuit, relay circuit, and water level sensor circuit. Based on figure 3, the components include:

a) Pins used on the Arduino Uno board are GND, 5V, RX, and pins 4 through 11. The Arduino Uno serves as the command center to control other electronic parts.
b) The first ultrasonic sensor uses pins 6 and 7 on the Arduino Uno for the trig and echo pins. It functions as an input to the Arduino Uno for detecting the presence of a cup.
c) The second ultrasonic sensor uses pins 8 and 9 on the Arduino Uno for the trig and echo pins, functioning similarly for cup detection.
d) The relays consist of two modules, each with a 5V pin and GND. Pin IN1 connects to pin 4 of the Arduino Uno, and IN2 connects to pin 5. The COM pin is connected directly to the power supply, and the NO pin is connected to a solenoid valve.
e) Both solenoid valves have one wire connected directly to the positive power supply (12V DC).
f) The mini MP3 module is connected to pins 10 and 11 of the Arduino Uno, with 5V and GND pins connected. The speaker is connected directly to the MP3 module.
g) The TX pin of the NodeMCU is connected to the RX pin of the Arduino Uno, while GND and 5V are connected to the Arduino Uno. The TX and RX pins facilitate serial communication between the NodeMCU and Arduino Uno.
h) The water level sensor has an S pin connected to A0 of the NodeMCU, and its 5V and GND pins are connected to the NodeMCU.

The hardware design results can be seen in figure 4.

The second stage involves software design. Programming is done in C using the Arduino IDE application. The program is saved in the Arduino file format and embedded into the Arduino Uno and NodeMCU ESP8266 microcontrollers. Database connections are managed using PHP programming in Sublime Text 3, with files saved in the XAMPP folder. PHP programming is integrated with Arduino file programming for NodeMCU ESP8266. Data from the water level sensor is automatically connected to the database

and Telegram, as long as the NodeMCU is connected to the internet.

4.3. Database Design

a) Class Diagram

The system design in the class diagram describes the structure and relationships between each class. The database design illustrates the "nodemcu_log" information system. Each variable in the database plays a key role in PHP programming, with data sent to the database every 2 minutes.

b) Station 1 Table

The table 1 below contains data fields such as name, type, action, and description for Station 1, including ID, water level, and timestamp.

Table 1. Station 1

No	Name	Type	Action	Description
1	ID	Int(20)	*PrimaryKey*	Sensor Entry ID
2	Water Level	Int(10)		*Value* from thesensor
3	Time	timestamp		Date and Time the data was recorded

4.4. Device Testing Results

a) Relay Time Calculation Testing

The table explains the test results for relay timing. The timer is used to control the electric switch. The tests use centimeters (cm) and milliliters (ml) as units.

Table 2. Relay Time Calculation Testing

Experiment	Time (seconds)	Type of Glass	Glass Height (cm)	Glass Width (cm)	Water	Amount (ml)	Note
1	3	Ceramic	10,5 cm	7 cm	Cold	190 ml	70% Glass filled
2	3	Ceramic	10,5 cm	7 cm	Hot	140 ml	50% Glass filled
3	3	Glass	8,5 cm	6,5 cm	Cold	200 ml	100% Glass filled
4	3	Glass	8,5 cm	6,5 cm	Hot	140 ml	80% Glass filled

The system timing determines how much water (ml) is dispensed into the glass. Choosing glasses of different sizes is crucial to avoid overfilling. The programmer set limits: 3 seconds for neutral water and 3 seconds for hot water. Table 2 shows minimal difference between the two glasses due to the same relay timing. Glasses with different dimensions (height 10.5 cm, width 7 cm vs. height 8.5 cm, width 6.5 cm) demonstrated differences in space left for additional water.

Testing confirmed that the ultrasonic sensor can detect various glass materials, including ceramic and clear glass.

b) Water Level Sensor Testing

The water level sensor is placed inside the dispenser's water tank to monitor the

water volume. When the sensor value drops below 50, the NodeMCU sends an alert to Telegram. The table 3 below shows the water level tests:

Table 3. Water Level Sensor Testing

Experiment	Sensor Value	Percentage	Conclusion
1	35	35%	Water Empty
2	40	40%	Almost Empty
3	50	50%	Almost Empty
4	20	20%	Water Empty
5	60	60%	Medium Water
6	80	80%	Full Water
7	100	100%	Full Water

5. Conclusions

The conclusions from the design of the microcontroller-based automatic dispenser for the visually impaired are:

a) The automatic dispenser design with Arduino Uno as the main controller facilitates easy use, especially for users with disabilities, by automating water dispensing without the need to touch the glass rim. This minimizes the risk of injury when filling hot water. The system uses a solenoid valve instead of a conventional faucet, operating when the ultrasonic sensor detects an object within 5 cm.

b) NodeMCU facilitates Telegram connectivity via the internet. The microcontroller programming enables data transmission and messaging. Water level checks through Telegram are achievable, and serial communication with Arduino for analog signal sharing is successful.

c) This study's advantage over previous research is the use of two microcontrollers connected to Telegram.

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