Multifunctional aromatherapy humidifier based on ESP8266 microcontroller and controlled using Android smartphone

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Abstract. The purpose of this study is to create a multifunctional aromatherapy diffuser device that is controlled and monitored using an Android smartphone application through the MQTT protocol. This device also includes an ultrasonic sensor for measuring the water level within the diffuser's tank by calculating the distance between the sensor and the water below it, RGB-enabled LED lighting, and an audio player that can play relaxing natural sounds for the user. The research method is comprised of problem identification, literature review, system development, implementation, and evaluation. This device can achieve the objective of being able to be operated through MQTT using an Android smartphone to control all components within the system with an average response time of 731.91 milliseconds and being able to measure the water level within the diffuser's tank with a typical accuracy of 99.26% during testing.

Keywords: ESP8266, ultrasonic sensor, Internet of Things, water monitoring, aromatherapy, MQTT, Android

1. Introduction
Aromatherapy is a holistic healing treatment involving scented oils used to improve health alongside well-being and is popular method to cope with stress as it can also improve the physiological and cognitive functions of an individual who is experiencing stress [1]. When combined with the appropriate audio or music, it can also help create a calming atmosphere [2]. Currently, there are 4 methods available for diffusing essential oils: ultrasonic vibration, nebulization, evaporation, and heat. The market for essential oil diffusers is also expanding rapidly [3]. Meanwhile, the number of IoT (Internet of Things) devices is expected to increase in the coming years [4] with home automation being the best example for applying IoT at a domestic level allowing users to control and monitor various devices such as home water tanks, air conditioners, microwaves, and many more via a smartphone [5]. In this paper, the research is focused to develop an innovative multifunctional aromatherapy diffuser lamp and audio player based on the ESP8266 microcontroller that is controlled and monitored using an Android smartphone through the internet. Internet connection is used in order to allow the user to control the device easily and from both inside and outside the home network.

The system developed in this paper features multi-coloured LEDs which adds esthetical value, an audio player that playsbacks relaxing natural sounds, as well as an ultrasonic rangefinder used to
monitor the remaining water inside the diffuser’s tank. The ultrasonic has been used in the past to monitor water levels inside a tank [6] and its accuracy can also be further increased [7]. Communication between the smartphone and the device is achieved using the MQTT protocol through the internet with the MQTT broker placed within a cloud-based server. MQTT was chosen as it is efficient for live data [8] and allows the user to both control and monitor the device seamlessly [9].

2. Research Method

The network design for the system developed in this research is shown in Figure 1. The transmission of data from smartphone to the device is done by using MQTT over TCP with the MQTT broker located within a cloud-based VPS (Virtual Private Server). The smartphone will send a command via the MQTT broker which in turn will forward the command to the device while the device will send water level data back to the smartphone in the same fashion.

![Figure 1. Network Communication Design](image1)

![Figure 2. Block Diagram of Aromatherapy Device](image2)

Block diagram of the aromatherapy device can be seen in Figure 2. The device itself consists of the ESP8266 microcontroller as the main processing unit, a programmable multi-coloured LED matrix, an ultrasonic rangefinder, a diffuser module, and an audio player alongside its speaker to
playback the audio of natural sounds. There are three inputs in this system, namely the audio player, the LED matrix, dan the diffuser module. The ultrasonic water monitor serves as an input in the form of distance data. There is an integrated Wi-Fi module present within the ESP8266 microcontroller which is used to send and receive data from the smartphone.

This research also developed an Android-based application that is used to both monitor and control the aromatherapy device. The application consists of 3 pages corresponding to the diffuser, the LED, and the audio respectively. Water level monitoring is embedded within the diffuser control page. Figure 3 shows the flowchart of the Android application.

![Android Application Flowchart](image)

**Figure 3.** Android Application Flowchart

![Diffuser Page](image) ![LED Page](image) ![Audio Page](image)

**Figure 4.** (a) Diffuser Page, (b) LED Page, (c) Audio Page
In the application, the user can control the device’s multiple features which are toggling the diffuser on and off, adjusting the colour and brightness of the LED, and choose from a variety of natural sounds in the library as well as adjusting its volume.

![Completed Device](image)

**Figure 5. Completed Device**

### 3. Result and Analysis

In this research, several tests have been conducted to measure the reliability of the developed system. The first test is the accuracy test. The tank within the device has been designed to hold water up to 5 cm from the bottom of the tank. Measurements from the ultrasonic rangefinder were taken from a water height of 0 cm (empty), 1 cm, 2 cm, 3 cm, 4 cm, and 5 cm with each point having 100 samples measured from it therefore giving a total of 600 samples. Figure 6 shows that the system can achieve an accuracy in the range of 98% to 99% with the accuracy gradually declining the more water there is inside the tank. This system achieved an average accuracy of 99.26% during this test.

![Water Monitoring Accuracy Graph](image)

**Figure 6. Water Monitoring Accuracy Graph**
The second test involves measuring the response time of the system. This test is conducted by measuring the time required by the smartphone to send a command to the device until it receives a feedback from the device. A total of 100 samples were taken during this test and the results can be seen in Figure 7. During this test, the system is able to achieve an average response time of 731.91 milliseconds with a minimum of 609 milliseconds and a maximum of 972 milliseconds during testing.

![Figure 7. Response Time Graph](image)

In the third test, the system is assessed for its reliability by testing its ability to perform actions based on commands sent by the smartphone. Tests are conducted to the diffuser and the audio player. Table 1 and Table 2 show that the system responds to commands very well. This is shown by the success rate of the actions based on the commands received by the system from the smartphone. Table 1 lists the successful activation of audio playback chosen from the smartphone. This test is conducted 8 times for each audio choice. Table 2 shows the successful toggling of the diffuser with 20 repetitions of toggling.

| Selected Music | Success Count | Success Rate |
|----------------|---------------|--------------|
| Rain           | 8             | 100%         |
| Storm          | 8             | 100%         |
| Fireplace      | 8             | 100%         |
| Waterfall      | 8             | 100%         |
| Forest         | 8             | 100%         |
| River          | 8             | 100%         |
| Night          | 8             | 100%         |
Table 2. Successful Diffuser Toggling

| Diffuser Status | Success Count | Success Rate |
|-----------------|---------------|--------------|
| On              | 10            | 100%         |
| Off             | 10            | 100%         |

4. Conclusion
An innovative aromatherapy diffuser developed by adding additional functionalities, namely multicoloured LEDs, diffuser tank monitoring, and control system based on Android smartphone. The multifunctional aromatherapy device is developed by using a Wi-Fi enabled microcontroller and a cloud-based broker for communication between the device and the smartphone. This system is able to be controlled and monitored from an Android smartphone from within the same network as the device as well as from outside the network with a reasonable response time. The monitoring system also works well which is indicated by the accuracy of the water level monitoring feature that measures the remaining water inside the tank.

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