Unattended Candle Notifier: An IoT Solution for Candle Safety

Yazan Sawalhi†
Mechanical and Aerospace Engineering
The George Washington University
Washington DC, USA
ysawalhi@gwu.edu

Abstract

This project proposes an IoT-based solution to the problem of unattended lit candles and the associated fire hazard. The developed device uses a flame sensor that gets triggered at the presence of a flame along with an ultrasonic sensor to monitor room occupancy. Email notifications will be the method of communicating to the user when they have left a burning candle unattended. In the event that the user is unable to return and extinguish the candle, a motorized fan has been incorporated that will blow out the flame after a certain amount of time. The aim of this project is to ensure candles are being used safely and reduce any risks of a potential fire.

Keywords

IoT, Fire Safety, Candle Monitoring, Ultrasonic Sensor, Flame Sensor, Automation, Home Safety

I. INTRODUCTION

Lighting a candle can improve the ambiance and aroma in a room, however, there are greater risks involved when the proper practices are not observed. The tiny flame can end up posing a major fire hazard if left unsupervised. To solve this issue, an IoT device has been developed to identify a lit candle and send an email notification to users when they have left the candle unattended. An additional safety measure has been incorporated to extinguish the candle after a set amount of time. Through the use of a RaspberryPi with Python, the integration of sensors and motors, as well as a reliable network connection, this project seeks to innovate candle safety practices.

II. BACKGROUND AND LITERATURE REVIEW

Candles are a staple in most households when it comes to setting a tone and improving the scent of a room, as well as a must for birthday celebrations. However, they are no stranger to starting a dangerous fire in households. The National Fire Protection Association (NFPA) reports that between the years 2018 to 2022, "U.S. fire departments responded to an annual estimated average 5,910 home structure fires started by candles. These fires cause an annual average of 74 civilian deaths and 558 civilian injuries, as well as $257 million in property damage" [1]. These harrowing statistics serve as a calling to engineers to find solutions to this issue that can remind users of their responsibility to the candle that they lit.

Additionally, the NFPA states that "over one-third of candle fires (36%) started in the bedroom. Sleep was a factor in 10% of home structure candle fires, 15% of candle fire deaths, and 18% of candle fire injuries" [1]. These results from their numerous studies are a key factor for urging people to "extinguish all candles when leaving the room or going to sleep" [2]. For this reason, the project will also feature an extinguishing mechanism that gets triggered after an allotted time from when the candle is lit. The National Candle Association recommends that a candle should not burn for more than four hours [3]. This will inform the default setting for the duration of the timer.

There is a product that resembles this concept on the market, MyAiryFairy, which uses an adjustable arm to blow out a candle [4]. The unattended candle notifier expands on this by providing notifications to the user when a lit candle is left unattended, giving them the opportunity to address the situation before the extinguisher intervenes. This approach helps to provide a more comprehensive solution that gives the user more control, in addition to helping preserve the life of the candle.

III. METHODS USED FOR IOT DEVICE IMPLEMENTATION

The Unattended Candle Notifier encapsulates hardware components like sensors and motors (Figure 1) alongside the software provided by the RaspberryPi in the form of Python.

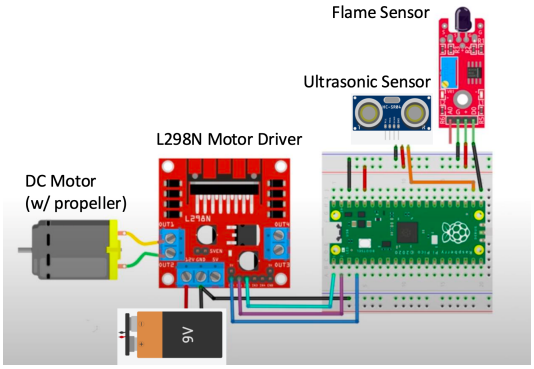

Figure 1. Schematic of the IoT device

A. Hardware Components:

- **Flame Sensor:** Indicates when a candle has been lit.
- **Ultrasonic Sensor:** Monitors the room entrance to detect when a person leaves.
- **DC Motor with Propeller:** Extinguishes the candle when necessary.
- **L298N Motor Driver:** Connects the DC motor to the Raspberry Pi to control its speed.
- **9V Battery:** Powers to the motor driver.
- **Raspberry Pi Model 4B:** Processing unit that allows the code to interact with the sensors.
- **WiFi:** Method for connecting to the internet to send email notification.

B. Firmware and Front-end Development: The device's logic is implemented using Python. Key software components and strategies include:

- **Python:** The programming language used to control the sensors, timer, and motor, and to send email notifications.
- **Yagmail Library:** Sends email notifications to the user when a lit candle is left unattended.
- **Time Library:** Sets the delays for the ultrasonic sensor readings and the timer for the motor to extinguish the flame.
- **Threading:** Allows the motor timer and the ultrasonic sensor trigger to run concurrently.

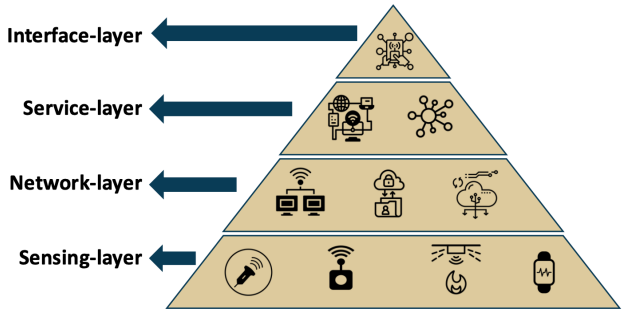

Figure 2. Architecture model used to describe the IoT device [5]

C. IoT Layered Model: The project follows the IoT layered model as shown in Figure 2 and as detailed below:

- **Sensing Layer:** The flame and ultrasonic sensors collecting data about the state of the candle and room occupancy, respectively.
- **Network Layer:** The Raspberry Pi connects to the internet via WiFi and allows it to send email notifications.
- **Service Layer:** Python code is what drives the interaction between the sensors, the motor, and the timer using the various libraries.
- **Interface Layer:** The Yagmail library is the crucial component of reaching out to the internet to send an email notification to the user's phone or computer.

IV. DISCUSSION OF YOUR IOT DEVICE AND RESULTS GENERATED USING THE DEVICE

The development process involved researching hardware components, building the circuit, and writing the necessary code. Additionally, testing and redesign was required to fine tune the sensors and how they interacted with the code. The flame sensor was successfully integrated to detect when the candle is lit. The ultrasonic sensor was implemented to trigger a notification when someone leaves the room. A timer was incorporated to track the burning time, and threading was used to manage the timer and sensor triggers effectively. The Yagmail library successfully sent email notifications to the user. The DC motor with a propeller was implemented as an automatic extinguisher triggered by the timer.

Some of the challenges faced include ensuring the flame detection was extremely reliable to avoid any false positives as well as finding the adequate fan strength to consistently blow out the candle. While the latter challenge was evident in the live demo, other trials have shown that the current fan is strong enough to extinguish the flame. Overall, the project was successful in demonstrating its purpose of notifying a user when a lit candle is left unattended and extinguishing it at the end of a timer.

V. CONCLUSIONS, SUMMARY, FUTURE WORK

This project successfully developed an IoT device capable of monitoring a lit candle, notifying the user when it is left unattended, and automatically extinguishing it after a time limit. The use of flame and ultrasonic sensors, along with email notifications and a motorized fan, provides a multi-faceted device that provides greater safety to candle usage.

Future improvements could include using dweet.io to allow users to trigger the fan remotely. Also, implementing two ultrasonic sensors could improve the accuracy of room occupancy detection by differentiating between someone leaving and entering. This project demonstrates the potential of IoT technology to address everyday safety concerns and promote responsible practices in using household items like candles.

In the long term, the device has potential to be scaled up for larger and more threatening fire-related dangers. An example of this could be in mitigating forest fires by notifying emergency services when a fire has been started, preventing the devastating damages that forest fires can cause.

ACKNOWLEDGMENT

I would like to thank Dr. Kartik Bulusu for providing the necessary hardware and teaching me how to use the software for this project. Also, thank you to the NerdCave YouTube channel for giving me the background needed to utilize the flame sensor and incorporate the motor [6].

VI. REFERENCES

[1] National Fire Protection Association, "Candle Safety," NFPA, 2025. [Online]. Available: https://www.nfpa.org/education-and-research/home-fire-safety/candles. [Accessed: Feb. 10, 2025].

[2] M. Ahrens, *Home Fires That Began with Upholstered Furniture*, Quincy, MA: National Fire Protection Association, Fire Analysis and Research Division, Aug. 2011. [Online]. Available: https://www.nfpa.org. [Accessed: Feb. 10, 2025].

[3] National Candle Association, "Your Foolproof Guide to Burning a Candle Correctly," candles.org, Jul. 27, 2018. [Online]. Available: https://candles.org/your-foolproof-guide-to-burning-a-candle-correctly/. [Accessed: Feb. 10, 2025].

[4] MyAiryFairy, "MyAiryFairy," myairyfairy.com, 2025. [Online]. Available: https://myairyfairy.com/. [Accessed: Feb. 10, 2025].

[5] Bulusu, Kartik V. (2025, February). Week-6 Presentation: MAE 6291 Internet-of-Things for Engineers. [Course lecture notes, codes and presentations]. Department of Mechanical and Aerospace Engineering, The George Washington University.https://gwu-mae6291-iot.github.io/spring2025/

[6] NerdCave, Raspberry Pi Pico Tutorial - Flame Sensor Module, (May 21, 2022). Accessed: Mar. 24, 2025. [Online Video]. Available: https://www.youtube.com/watch?v=y1_scz9I0go