

Automatic Candle

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1 Introduction

1.1 Objective

The problem that we are addressing is the large amount of damages caused by . According to the NFPA, in recent years candles caused about 2% of household fires. Roughly 11% of these cases happen as a result of the user falling asleep with the candle still burning. In total, damages from candle accidents result in an annual loss of \$268 million in property damages. [1] Of course, this hasn't stopped people from using candles and likely never will.

Our goal is to help reduce these statistics by designing a system which makes it easy to follow recommended candle safety guidelines. Our system will allow the user to place a candle on the base piece, and install a phone application. Once connected to the candle holder via bluetooth, the user can use the app to find and automatically light the wick. After a set timeout, or if the user wanders out of bluetooth range, the candle will automatically be extinguished.

1.2 Background

Candles have been around for a long time, and so of course there are a few key competitors in this market. The closest one would probably be the CandleWatch Automatic Candle Extinguisher [2], which will automatically extinguish a jar candle after about 4 hours by putting a lid on it. Other alternatives include flameless candles, which are recommended by the NFPA. However, our solution is novel because it isn't specifically designed around one type of candle, and it also provides the functionality for automatically lighting the candle. Of course, this approach is not quite as safe as the flameless alternatives, but many people dislike flameless candles because they don't provide the same strong scent that real candles do. Knowing this, we would say that our target audience are the people who want to practice safer candle usage, but don't want to give up using actual candles.

The solution proposed in a previous semester was very similar to the CandleWatch device. It was designed specifically for Jar candles, and only designed to extinguish. Our solution is clearly different from this, because we are trying to take an approach that works for many types of candles. Additionally, we are planning to provide functionality for igniting the candle, which is not possible with the design of the other solution.

1.3 Physical Design

The design will include a base plate for holding the candle. An arm apparatus will be able to raise up above the candle and place the snuffer and arc lighter in position. These arms will need three degrees of motion in order to be able to guide both components to the wick accurately.

1.4 High-Level Requirements

- Must be able to detect if the candle is lit.
- Must be able to extinguish a lit candle.
- Must be able to light an unlit candle.

2 Design

Legend:

Red = power Blue = digital signal Green = analog signal
Black: Physical Manipulation

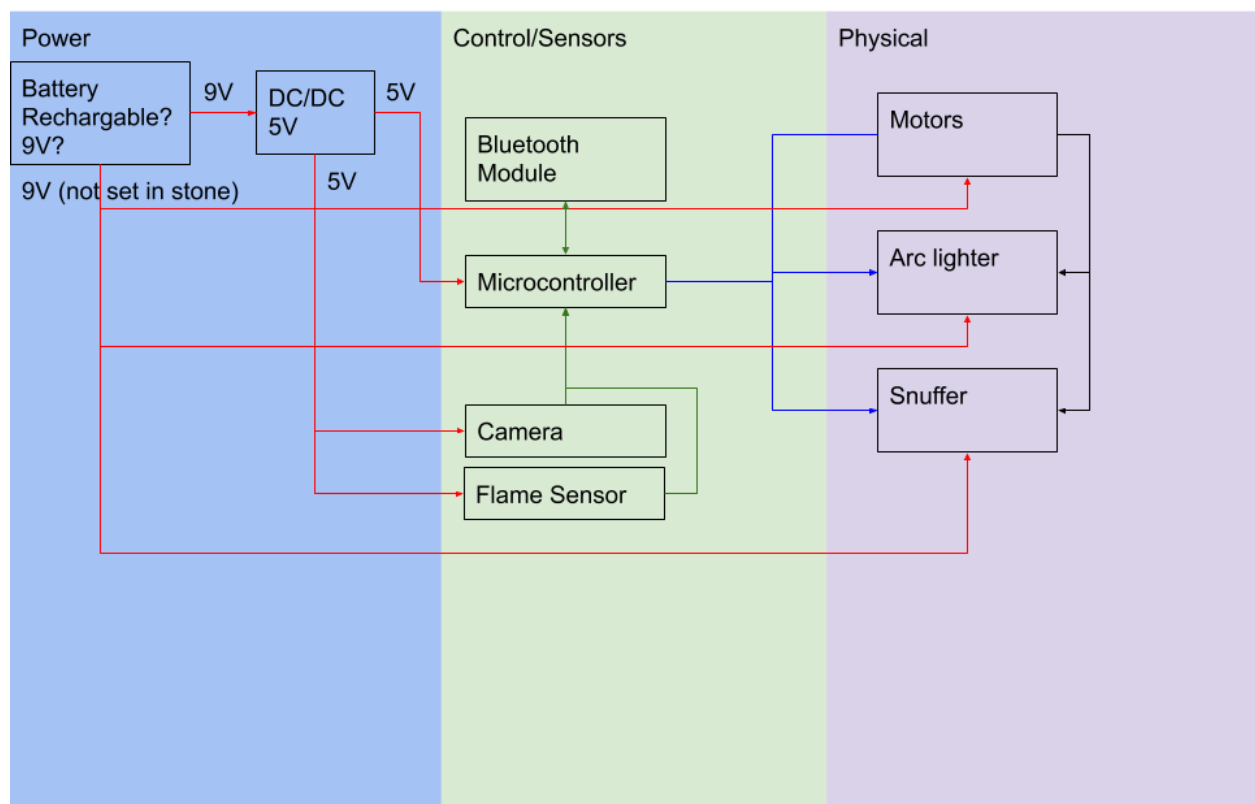


Figure 2. Block Diagram

2.1 Power Supply

A Power supply is necessary to operate all subsystems. The motors, sensors and microcontrollers all need power. Power will come from a battery and will be regulated for each subsystem to use.

2.1.1 Battery

Will provide the power needed to the rest of the system and be (rechargeable/replaceable).
Will be further regulated to usable voltages.

Requirement 1: Provide enough power for voltage regulator, controller, and motors.

Requirement 2: Provide adequate power for X operating hours

2.1.2 Voltage regulator

Will regulate the battery voltage to usable voltages by the sensors and Control unit

Requirement 1: be able to provide 5v +/- 5% to all low voltage components.*

Requirement 2: can provide rated power to each low voltage component while all components are operating*

**low voltage = less than 5V*

2.2 Control Unit

2.2.1 Microcontroller

The microcontroller will interface with the bluetooth module to receive inputs from the user. It will then use user input as well as the sensor data to control the motor arms in order to perform the lighting and snuffing actions. The microcontroller is also responsible for snuffing the candle if the connection to the user is dropped or a timer expires.

Requirement 1: Must be able to communicate via Bluetooth with the user.

Requirement 2: Must be able to communicate via SPI with the camera module.

Requirement 2: Must be able to supply 30mA at 5V for the Bluetooth and camera modules.

2.2.2 Bluetooth Module

The bluetooth module will allow the system to communicate with the users phone application and enable control.

Requirement 1: Must be able to maintain a connection up to 10 meters away with open space between devices.

2.3 Sensors Unit

2.3.1 Flame Sensor

Flame sensors are simply photodetectors which are modified to specifically detect mid-length infrared beams. There are many of these designed for use with Arduinos, which should work well with our project.

Requirement 1: Must be able to detect if a candle wick, placed between 3 and 12 inches from the sensor, is lit, with <0.1% false negatives.

2.3.2 Camera Module

The camera will mostly be used to interface with the user, and to allow us to precisely locate the wick on the candle.

Requirement 1: Must have a high enough resolution that the user can identify the position of the wick in an image taken from up to 12 inches away.

2.4 Arm Assembly

The arm assembly is responsible for bringing the snuffer, and arc lighter to the candle and positioning them so that they can complete their respective tasks.

2.4.1 Arm Motors

The arm motors must be able to accurately and reliably control both the lighter and snuffer so that the candle can be lit and put out in a safe manner.

Requirement 1: Must be able to move the snuffer to wick within .1 in of the center of the snuffer.

Requirement 2: must be able to move arc lighter to within lighting range of arc lighter (will be determined by arc lighter).

2.4.2 Snuffer

The snuffer is a cone shaped piece that will lower onto the wick cutting off its oxygen supply putting out the candle.

Requirement 1: Must be able to reliably put out wicks, with <1% error rate.

Requirement 2: must be able to accommodate different sized wicks(max size will be discussed based on max candle size).

2.4.3 Arc Lighter

The arc lighter will be the component that lights the wick of the candle. It does this by creating an electric arc that can ignite wicks.

Requirement 1: must be able to light wicks of different sizes (max size will be determined by max candle size).

2.5 Risk Analysis

The mechanical arm is a large risk to the successful completion of this project. Specifically, we expect the control of the arm to be the biggest risk to this project. In order for us to reliably find the wick and light or extinguish it, we will need 2 degrees of motion to place the lighter or snuffer above the wick, and then another degree of motion to lower the lighter or snuffer onto the wick. This requires a lot of moving parts, which significantly increases the chance of failure.

The arm is expected to be very light, so we believe that just using a few stepper motors will be enough to get it into position. In order to light and extinguish the candles, we would normally need to also gauge the depth of the candle. This would require an extra sensor or some kind of parallax calculations. However, we can avoid this by slowly lowering the lighter or snuffer straight down, and stopping as soon as resistance is detected. This will require a torque sensor on the motor or something similar, but this seems to be a cheap, easy, and effective alternative to computing the actual depth of the wick.

We also want to keep the design as non-intrusive as possible, in order to ensure that it can still be placed in the same spots that the user would typically place their candle. This doesn't constrain the problem too much, but we do need to make sure that our design won't risk knocking over the candle or any nearby objects.

3 Ethics and Safety

3.1 Safety

This project has little danger alone, but it is meant to be used with candles, a common household item that presents danger to both property and person. We will analyze the safety of our project when attached to a candle to get the most realistic sense of our project's hazards and how we combat them.

Candles have open flames in all types. Although jar candles and certain candle holders reduce the danger of this flame, they hold the same open flame hazards as other types. This flame can cause home fires. The National Candle Association has safety guidelines directed at customers to prevent many hazards associated with candles. We help address the crucial NCA guidelines [3], "do not burn a candle for longer than four hours and cool for at least two hours before relighting", and , "never leave a burning candle unattended." If a candle is on for too long, it's flame becomes large and hot, leading to combustion of the table it rests on, or nearby flammable items. Our project has timers that will automatically put out candles after 4 hours. This both stops the candle from getting too hot, and ensures the candle is put out after four hours, reducing the dangerous consequences of forgetting about

a lit candle. We also will put a timer on the candle that doesn't allow it to be re-lit by our project until 2 hours have passed after it was last put out. Another cause of fires is the method of extinguishing the candle. Most people blow out candles with air. This is not safe due to the possibility of blowing the hot wax onto something flammable. We follow the NCA recommendation, "Use a candle snuffer to extinguish a candle." Our project uses a small snuffer to extinguish candles.

Open flames can also injure people directly when lighting and extinguishing a candle. Even when following the NCA guidelines of using long lighters or matches [3], a user could still burn themselves by accidentally touching the source of ignition on the lighter. People could also burn themselves on a snuffer since the snuffer usually gets hot when extinguishing a candle. Our project eliminates all that risk igniting the candle automatically with an arc lighter attached to a robotic arm. The user only needs to press a button to ignite the candle remotely, eliminating proximity of the user to the flame or heat. Another risk of injuring when using candles is the heating up of the candle holder during usage. Our project does not directly address this since the point of a candle is to heat wax and provide light. This safety will be left to the user to follow NCA guidelines.

Our device uses an electric arc lighter to ignite a candle wick. This leads to a shock hazard if a user touches the arc of the device when in use. We will address this by including warnings to keep away from the candle wick during ignition. We also will not start the arc lighter until it is in position to ignite the wick.

There is a danger associated with the moving arms of the device. They can knock over nearby objects and things can get caught in the spinning motors. We will address this by having all motors moving at very slow speed, and having covers. We will also limit the amount of required proximal clearance the device needs to operate.

3.2 Ethics

This project has ethical considerations dealing with its function of improving safety. This project claims to reduce the risks of using candles by both eliminating the direct user interaction with the flame, and by providing a safeguard against the dangers presented by forgotten lit candles. This can lead to violations of 2 different IEEE codes of ethics, #3: "to be honest and realistic in stating claims or estimates based on available data;" [4], and #9: "to avoid injuring others, their property, reputation, or employment by false or malicious action;" [4]. Addressing #3, our claims can easily be overstated to be the all inclusive candle management system which requires no oversight. This also addresses #9. These claims can give people the impression that they are completely safe if they just use our project. This can lead to potential injury and damage by false impressions. We will ensure that claims are clearly stated. We will emphasize that candles still require oversight, and are dangerous when used improperly. We will also reference the NCA guidelines throughout our user manual and packaging to promote safe candle usage.

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4 References

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