ECE 445 Senior Design Project Proposal

<u>StoveSense</u>

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1. Introduction

PROBLEM:

In recent years, there has been a concerning rise in the number of house fires attributed to stoves being left unattended. Nearly 50% of house fires are caused by burners being left on and unattended. In addition, being able to control a stove away from the knobs allows for more control while cooking. As a result, there should be an easy solution where a user can remotely control and turn off any burner that is on.

SOLUTION:

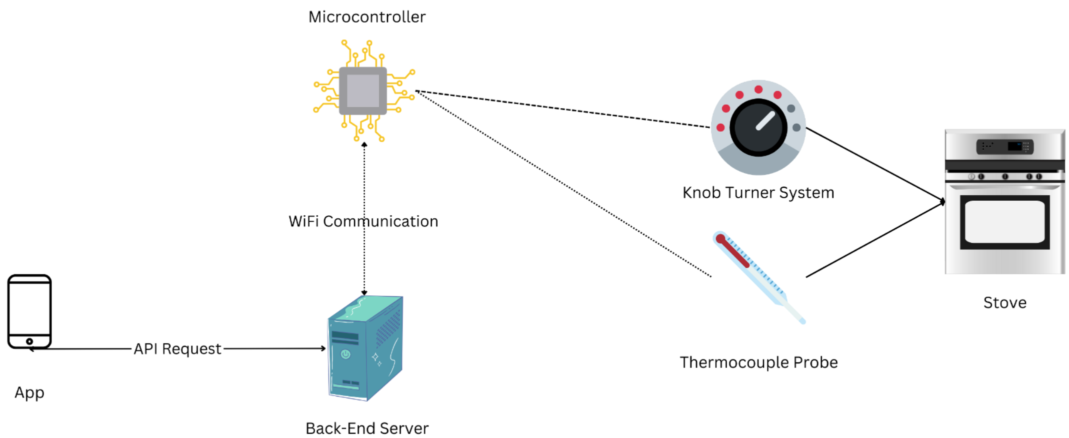
Our solution involves having heat sensors on each of the stoves to determine which burners are on and relay this information to the user via an app. The user will be able to see which stoves are on, and control each stove remotely. Each stove knob will have a coupler over it, which will house our knob turner motor. This coupler will also have the ability to tell what level the stove knob is at, and adjust the stove knob to the desired level according to the user. To ensure the stove functionality isn't impacted, the coupler will attach over each knob and act as an extension. Additionally, all communication between the app and the microprocessor will be done over a network connection. This microprocessor will let us control the knob turner remotely and with precision.

This solution will also have automated features. We plan to add a water-proof thermocouple the user can manually put in pots with soups or other liquids to add boil over protection. This device will monitor the temperature and automatically turn down the temperature of the stove once there is a risk of a boil over (temperature rising significantly above boiling point).

Our app will contain a visual interface which allows users to see which exact burner is on, and change the burner intensity to whatever is desired, including off. Additionally, we will add push notifications to notify the user if a burner is on or if boil over was detected and handled.

If time permits, an additional feature we would like to implement is a separate smoke detecting component to allow for fire detection. This component would detect if a fire is forming and automatically turn off the burner to prevent or reduce the flame. It would also notify users via the app.

VISUAL AID:



PROJECT COMPONENTS:

- ESP-32: Processor to control the robotic knob turners' movements, send and receive signals from app, built-in wireless adapter
- Chassis: Will be fitted over the stove knob and house the servo motor to rotate the knob.
- Gyroscope: to keep track of the rotation of the knob to find initial position and correspond that to a level.
- Servo Motor: Will be responsible for turning the knob to the correct position
- App: Mobile app with front end to display which stove is on and allow users to close stove from app
- Thermistor: Temperature based resistor to detect if a stove is on or not
- LM35DZ: Sensor to check the temperature of liquid in pot, also waterproof

CRITERIA FOR SUCCESS:

Our main goal is making sure that a user is able to remotely turn off a stove. The system should be able display information regarding which stove is one and give the user the option to turn off the stove. All this communication between the system and user will be done through an app.

Our second goal is for boil over protection which should automatically detect when a liquid in a pot is being boiled for too long and either notify the user that their dish is about to boil over or remotely turn down the temperature of that specific burner to prevent the spill over before it occurs.

Stretch Goal: If time permits we would also like to add some sort of smoke detector sensor that would be able to detect if there's a fire on the pan or not. We would probably have to create our own module for this, and look into this further.

THREE HIGH LEVEL REQUIREMENTS:

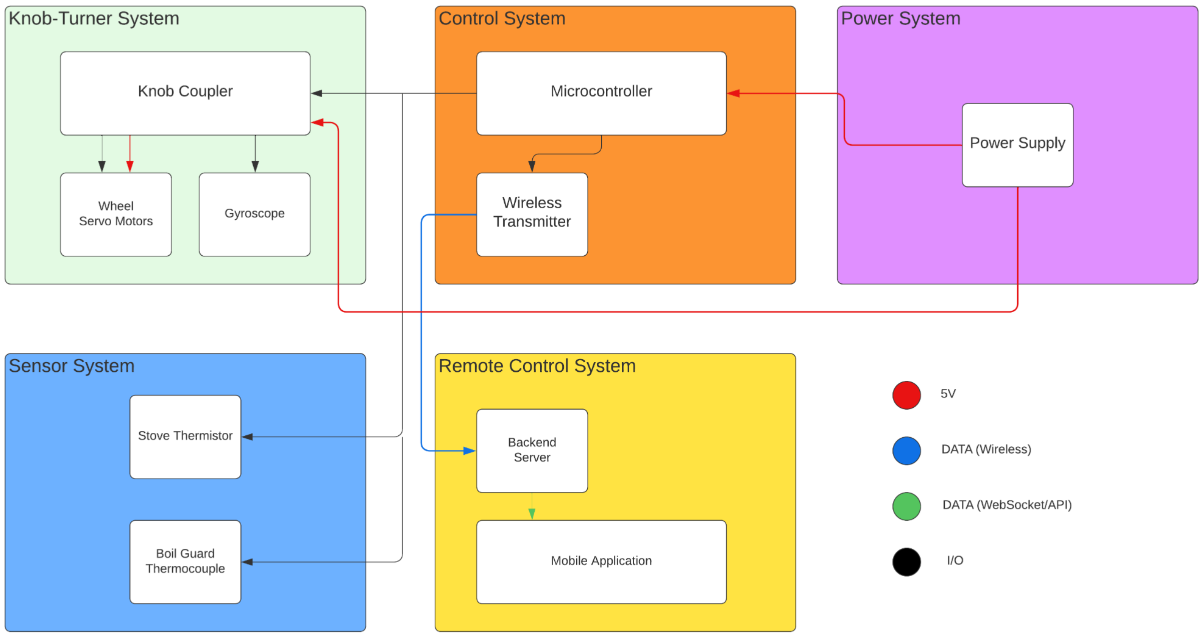
1. Product must be capable of maintaining water temperature at 100 degrees celsius to prevent over-boiling and spilling out of the pot. This will be made possible by constant monitoring of the data relayed by the LM35DZ in the pot of water. When the temperature surpasses 100 degrees celsius, the stove knob turner will slightly dial back the knob to lower the temperature back down.

2. Product must be able to turn corresponding knob kX degrees to turn knob to desired level, where X corresponds to the amount of degrees required to turn the knob a level, and k corresponds with the amount of levels the user desires to change by.

3. Users must be able to communicate with the microcontroller via the app with a latency of less than 1 second. The physical system should be able to complete the operation (e.g turn down stove, turn up stove) in less than 10 seconds. In total, end-to-end operation time should be 11 seconds or less.

2. Design

HIGH LEVEL BLOCK DIAGRAM:



SUBSYSTEMS:

1. Sensor Subsystems:

   Our sensor subsystem consists of two sensors, a thermistor and a LM35 Temperature Sensor. Our thermistors will be connected to the PCB and attached near each stove to check the status of the stove. We will use an analog to digital converter on our PCB to convert the data voltage highs of lows from our thermistor to digital temperature values. The circuitry will be encased in a heat resistant material such as thermal pads while the ends of the thermistors will be open and exposed to the heat of the stove tops. Our LM35 Water Resistant Temperature will also be connected to the PCB and held in a pot of a liquid. Users will be able to manually put the LM35 in desired items (e.g soup, sauces). The LM35 will constantly relay its data to the microcontroller so that the stove knob turner can regulate the temperature of the desired liquid. This can be done by converting the voltage read into a temperature value.

2. Knob-Turner System

   For the knob-turner system we are planning on having a chassis that surrounds the knob and the knob will be rotated by a rotary actuator. This clasp will be adjustable to account for differences in knob size. The rotary actuator that we are using should be able to rotate a 5-pound object which results in about 2 pound-force inches of torque. The knob-turner system should be aware of how much the knob is turned from its initial position and upon receiving a signal from the app should be able to rotate to its newly desired position. To account for this we will need to map its initial position and then calculate the number of degrees from its initial position the knob has rotated.

3. Control System

   Our control system will primarily be run through a microcontroller. We decided to go with an ESP32 microcontroller unit with Wi-Fi enabled communication. The primary communication protocol that we decided to go with is a web socket connection between the board and our app. By establishing a web socket connection we can ensure bidirectional communication between our app and the microcontroller. The microcontroller will be relaying information regarding whether the stove is on or not and the temperature of the liquid on the stove to the app. Additionally, the microcontroller will be responsible for handling user inputs and sending the signals to the knob-turner system if the user wishes to rotate the knob.

4. Remote Control System

   Our mobile application will be primarily controlled through a backend server. The backend server will be responsible for facilitating communication between the ESP32 MCU and the app itself. The backend server should be able to properly take in user's input and relay them to the app. We envision the app to display each knob on the stove that is supposed to mirror each of the knobs on the stove. Additionally, there should be a temperature associated with each stove to indicate whether it is on or not and also how hot the stove currently is. Finally, if the LM35 is in use the app should display the temperature of the liquid that is currently on the stove. The primary input that our app should take is allowing the user to rotate any specific knob to any degree that it desires. The user will not be able to turn on the stove remotely, but will be able to decrease and turn off the stove via the app. We envision the user rotating a virtual knob on our app that will correspond to the knob on the stove.

5. Power System

   Our power system will simply consist of a power supply. This power supply will deliver power from an outlet to a microcontroller. It is imperative that we do not deliver too much power as the maximum amount of input voltage for an ESP32 MCU is over 3.6V.

Subsystem Requirements

1. Sensor Subsystems
   a. The sensor subsystems are responsible for measuring the temperature of the stove and if there’s a pot of liquid on the stove measuring the liquid temperature. The sensor subsystems will then convey this information to the ESP32 microcontroller. The sensor subsystems consist of a thermistor and LM35 waterproof sensor.
   b. The thermistor will be used to measure the temperature of the stove. Its operating temperature range is between -55 to 150 degrees Celsius.
   c. The LM35 waterproof sensor will be used to measure the temperature of the liquid in a pot. Its operating temperature range is between -55 to 150 degrees Celsius.
2. Knob-Turner Subsystem
   a. The knob-turner subsystem is responsible for rotating the stove’s knob to users’ desired position. It will receive a signal from an ESP32 microcontroller unit and then rotate the knob X degrees. An electronic rotary servo motor actuator will be used to actually rotate the knob.
   b. The rotary actuator must be able to deliver 2 pound-force inches.
3. Control System
   a. The control system will be responsible for communicating with all the peripherals. It should be able to send and receive information via websocket connection to an app. It should be able to take in and understand information from the sensor. It should also be able to relay information to the knob-turnery subsystem regarding the position a specific knob should turn to.

    b. The microcontroller should be able to communicate with all peripherals within 5sec +/- 1sec.
4. Remote Control System
    a. The remote control system should be able to display information regarding the state of the stove and how far the knobs are turned which it will receive from the control system. Additionally, it should send user inputs regarding how much they want to turn the knobs.
    b. The remote control subsystem should be able to send user input data within 1 +/- 0.5 seconds to the remote control systems.
5. Power Supply System
    a. The power supply subsystem is responsible for delivering voltage and current to the ESP32 microcontroller.
    b. The power supply should send 2.2V to 3.6V to the microcontroller. It should also deliver 20mA to the microcontroller.

Tolerance Analysis:

- One aspect of the project that could be difficult is the amount to turn the knob proportional to a change in "level". For example, we plan to have X levels that the user can pick to turn the knob, with 0 being off. The stove knobs we are testing with have a 2" diameter. Therefore, to turn the knob k of the X levels:

  $$T\ (rad)\ =\ 2\pi k/X$$

  Where T is the amount in radians we need to turn the knob. For example, if we had 10 levels, and we wanted to turn the knob from level 3 to 0, we would be moving 3π/5 radians or rotate the knob 108 degrees.

3. Ethics and Safety:

The main safety risk associated with this project is a potential malfunction of the stove knob turner. If this component were to malfunction and turn the heat up too high it could potentially cause a fire. Additionally, having remote control of the stove's level could pose a risk to safety as the user might accidentally turn the stove up too high or even have someone steal their device and turn it up on purpose. One way to remedy this problem is to require the user's face ID or fingerprint ID on their mobile device to confirm that they want to operate the stove. This would make it difficult for someone to forcibly mess with the stove and also for the user to accidentally interfere when they don't mean to. An issue that could arise during the development of this project is if the boil-over protection feature were to fail and cause liquid from the boiling pot to spill across the stove top. We can easily remedy this by keeping a close watch on the pot while testing this feature and ensuring that it never reaches this critical point. Section 1.2 of the ACM Code of Ethics states that unjustified damage to property should be avoided. This is an ethical issue that we must also take into account, as our product has the capability to severely damage property if misused or malfunctioned. This ethical breach can be mitigated by holding the leaders accountable for knowing when to "pull the plug" on the operation. "If leaders do not act to curtail or mitigate such risks, it may be necessary to "blow the whistle" to reduce potential harm" (ACM Code of Ethics). Section 1.5 of the ACM Code of Ethics states to "Respect the work required to produce new ideas, inventions, creative works, and computing artifacts." Smart stove knobs already exist as a product and we will respect this invention by crediting the creators and also identifying how our product differs from the existing ones.

References:

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