Steam Heat Controller Retrofit

Project Plan v1

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Team # 2

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℉ - Degrees in Fahrenheit

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1. Introductory Material

1.1. Acknowledgement

Our client and faculty advisor, Leland Harker, will be our point of contact for any equipment we need. This is especially convenient as he runs ETG who normally orders parts for ECpE students that are working on various projects. Additionally, he will provide technical advice on various parts of the project.

1.2. Problem Statement

As with many buildings on ISU's campus, Coover relies on steam to heat the building. The issue with we are facing is the values that control the steam are often hidden behind miscellaneous furniture or equipment making it very hard to adjust the temperature in the rooms. Additionally, there is no reliable way to control the exact degree of temperature in the room. This means that the only way to adjust the temperature is to open/close the valve manually and wait to see if it gets too hot.

Our solution is a system consisting of two main parts; a valve controller and a thermostat. The valve controller has a motor that opens and closes the valve without any manual interaction with the valve itself. This will be controlled by a Raspberry Pi that will communicate with the second part of the system. The thermostat will be mounted on a wall in the same room as the valve, and wirelessly communicate with the valve controller to open/close the valve. It will have an LCD display to show the current temperature as well as buttons to increase/decrease heat.

1.3. Operating Environment

Our product will be used in a standard classroom or lab. The thermostat will only be exposed to standard room temperatures. There may be a bit of dust in the air from being in the labs with drills and saws. Therefore, the end product will have a protective casing covering the circuitry. The motor and circuits controlling the motor will be above the valve on the steam pipe.

1.4. Intended users and intended use

Our intended end users for our steam valve retrofit project are any students or faculty in Coover. The thermostat will be placed in an easily accessible location so whoever is using the room or lab should be able to change the temperature. This is our base requirement that needs to be met. Ideally, we would like to create a network interface that ETG could use to monitor and manipulate each individual thermostat in Coover. This could be used to automatically decrease the temperature during breaks were minimal people will be using the building to save money.

The design plan is to solely rely on the thermostat for collection of data. This being the actual temperature in the room and the desired temperature given by the user. This data will be transmitted to the valve controller which will handle all the logic. Logic being determining which way and how much to change the position of the valve. As well as detecting any issues with the valve and sending the error to the thermostat to display to the user.

1.5. Assumptions and limitations

Assumptions

- The product will only be used in Coover.
- It will be installed in one room with the capability to replicated in an unlimited amount of rooms.
- There will be a single thermostat per valve.
- The temperature in Coover will be within 60 ℉ to 80 ℉.
- There is a wall outlet near the steam valve to power the motor control circuit.

Limitations

- Our product has a $500 budget for building and testing our whole project.
- The thermostat must be battery operated and be able to last for at least one semester.
- The valve controller must be fitted to the valve with little to no change to existing setup.

1.6. Expected end product and other deliverables

The thermostat will be delivered at the end of the second semester. The thermostat will monitor the temperature of the room and take in user input of the desired temperature. The thermostat will then send both of those variables to the motor control circuit. It will also display any error the motor control circuit sent to it to display to the user.

The motor control circuit will be delivered at the end of the second semester. It will take the variables of current temperature and desired temperature. It will then do computation to determine which way and how much to turn the steam valve using a motor connected to a gearbox to increase its torque to the required amount to turn the valve. It will also detect if the valve is stuff and various other possible errors and report them back to the thermostat to display to the user.

The webpage interface will be delivered at the end of the second semester. The webpage will be able to monitor the thermostat temperature for all thermostats in the building. It will display the errors back to the user as well as have options to control temperatures remotely.

2. Proposed approach and statement of work

2.1. Functional Requirements

- Maintain room temperature within ± 1 degree from setpoint
- Thermostat must be battery powered and last for one semester
- Thermostat must communicate with valve controller wirelessly
- Valve controller must detect stuck or broken valve and report error
- System can receive administrative commands to control all valves remotely
- A method to send administrative commands and monitor status of valve controllers

2.2. Constraints considerations

Our approach to this project will be influenced by several constraints, including the client specified set-up, budget, testing period, and time. Our client, Lee Harker, has given us the directive to implement our system with a single thermostat per valve. The steam valves in Coover are responsible for heating the rooms they are in, as well as the adjoining rooms, so changing the valve position will have a varied temperature effect on the rooms. Since we are only able to measure the temperature in one room (the one with the steam valve), this means we have to collect data and try to account for the temperature variance in our feedback system.

Our budget will need to be managed well; we are only able to spend $500, so we are anticipate needing to make decisions for part sourcing and creation based on this factor. In order to create the feedback system, we will have to collect and analyze data on how valve position affects the temperature of rooms. Due to the spontaneity of weather, we will need to collect as much data as possible in the early stages of our project when heat is still being used in the building. The majority of our prototyping and building phases will be done when heat is not necessary, so it is vital that we collect good and plentiful data early.

Finally, our final constraint is the length of this project. We must complete the project within the 2 semesters of Senior Design, while we take other classes. It is necessary then that we manage our time and set hard deadlines and goals in order to complete the project.

2.3. Technology considerations

Our project will have to control steam valves that could stick or break. We will have to include checks in the software while the motor turns the valve. If the valve is not working properly, we can send error reports to someone who can fix it. For simplicity, we will have to make our user interface as simple and straightforward as possible. This includes system setup when a new room is setup and a user changing the temperature on an existing system.

2.4. Testing requirements considerations

The valve controller and thermostat are expected to maintain a set temperature without the need for maintenance or manual adjustment. With this in mind, we will need to benchmark each subsystem for reliability and usability.

Additionally, our project is composed of several subsystems, so we will need to evaluate how the components interact with each other. In terms of reliability, the system must operate without user intervention indefinitely; in preparation for inevitable failures, the device will be programmed to report its status and alert the appropriate overseer in the case of errors. Every possible condition and error will need to be tested thoroughly. For usability, we will rely on our client's feedback of the interfaces as we create them to gauge their efficacy.

Finally, extensive testing must be completed for each subsystem at every stage of integration into the project in order to guarantee a unified final product.

2.5. Security considerations

We will be working on the wireless network which is open to all students. In creating an interface, we will have to consider the networking protocols we use, and make sure that people that should not have access, do not have access.

Our hardware may also have security considerations as it will be located throughout Coover, inside offices, classrooms, and other public areas that are easily accessible.

2.6. Safety considerations

We will be abiding by all safety precautions throughout this project as we will be working with steam valves, electric drive motors, circuitry, and heavy equipment. Our group has been trained on safety practices for the room we will be installing the product in, as well as operating the equipment contained within to construct it.

2.7. Previous work/literature review

While many companies offer thermostats to control heating control, none offer a thermostat that also controls a steam valve. For example. Honeywell has a digital thermostat, but it cannot control the steam valve, and Danfoss makes at valve to control steam, but it cannot adapt to the temperature in the room.

Our Advisor/Client, Lee Harker, has also informed us of a previous groups effort to solve this problem in 2011. We haven't examined their documentation thoroughly, but we plan to have a good understanding of the direction they chose to go and any complications or issues they faced.

2.8. Possible risks and risk management

The risks we have identified so far include falling behind schedule, running out of budget, equipment failures, and software errors. By outlining clear goals and deadlines at the beginning of our project, we are actively engaged in staying on schedule. We have also broken our project up into several goals, such that we are able to complete basic functionality before working on extra features. This gives us some extra time to complete the project in case we do fall behind.

We are mindful of our budget and have a member of our group in charge of managing it and our resource requests. By setting up a process of requesting and delivering through a single group member, we will be able to stay on budget and keep unnecessary expenses at a minimum. Another risk is that our equipment or software fails, either in development or once its deployed. We will mitigate these risks by researching the datasheets for each component before working with them, and accounting for these constraints in testing. For software, we will ensure exceptions and error reporting are apart of the deliverables of the project. As we encounter risks through the development of the project, we will document them as part of our testing procedures.

2.9. Project proposed milestones and evaluation criteria

- Create a simple valve controller
    - Evaluation: Can it open/close the valve?
- Create thermostat capable of communicating with the controller
    - Evaluation: Can it control the valve controller reliably?
- Configure feedback system to accurately control temperature
    - Evaluation: Can it keep temp in specified range?
- Setup a network to control the system externally
    - Evaluation: Can an admin change the temperature remotely?

2.10. Project tracking procedures

In order to complete our project on time, we must be aware of the deadlines and goals before we miss them. We have established detailed goals for each section of development as a group; each member is cognizant of their responsibilities for reaching the goals by the deadline. We have set meeting dates at least twice a week that are documented by a member of the group; this information, as well as each member's update information, will be included in the weekly status report, and provide us with a benchmark for comparison with the original project plan. These procedures will enable us to stay up to date with our deadlines.

2.11. Expected results and validation

We expect to complete the project within the timeline set out in our plan. This includes a working valve controller and thermostat system. We will consider our project a success when the following functionalities are complete:

- Pressing the temperature control buttons on the thermostat change the temperature on the LCD.
- The temperature change is relayed from the thermostat to the valve controller successfully.
- The valve controller changes the valve position accordingly.
- The temperature is adjusted in the room to maintain set temperature through the feedback system.

We will test each of these sections as we develop them according to our testing considerations. As they pass or fail, we will adapt the project and validate.

3. Estimated Resources and project timeline

3.1. Project Timeline

The timeline for our project is layed out in the form of a Gantt chart in Table 1.1.

3.2. Feasibility Assessment

Many of our group members have extensive knowledge on programming and networking with microcontrollers. This experience will be invaluable when creating the more difficult aspects of the project, such as the communication between the controllers. We have laid out the various challenges we might encounter throughout this project, and have come up with plans to overcome them in a time and cost effective manner. At this time, we believe this project to be feasible in terms of the length of the time given, budget, and requirements laid out in Section 2.

3.3. Personnel Effort Requirements

Due to the diversity of majors in our group, and since the project consists of a major hardware and software portion, we can divide our group into two groups. The hardware group will be tasked with creating the assembly that will fit onto the valve as well as the circuitry contained within. The software group will be handling the communication between the two devices, as well as the programming for the thermostat. We haven't assigned specific tasks at this point in the project, but we plan to have a detailed chart by the end of the semester.

3.4. Other Resource Requirements

For the valve controller, we will need to acquire the following materials:

- Motor
- Motor Gearbox
- Power Supply
- Raspberry Pi

The thermostat will require the following materials:

- Raspberry Pi with LCD display
- Buttons/Switches

Both components will also require a custom casing to protect them from any tampering as well as the high heat conditions next to the steam pipe. In addition to the materials listed, we will require access to the room that the product will be created/installed in.

3.5. Financial Requirements

As previously stated in Section 1.5, our budget for the entirety of this project will be $500. This amount cannot be exceeded, as it would make the cost for the potential expansion of the project not feasible. We have designated one member of our group to maintain this budget and control all purchases necessary for the completion of the project.

4. Closure materials

4.1. Conclusion

Overall, we as a group are excited to work on and complete this project. The heat control in Coover is in dire need of an update, and we are confident that our solution will satisfy the requirements given. Though the application of our individual skills, and using the plan we have laid out, we will

4.2. References

No references are available at this time.

4.3. Appendices

	Semester 1											Semester 2													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Data Collection																									
Thermostat																									
- Temperature sensor - Microcontroller communication																									
- Logging temperature																									
- Fetching log																									
- Battery and Case																									
- Testing and documentation																									
Valve Controller																									
- Mount																									
- Transmission																									
- Motor controller																									
- Microcontroller																									
- Logging torque in software																									
- Error reporting																									
- Case																									
- Testing and documentation																									
Thermostat - Valve controller communication																									
- Integration																									
- Testing and documentation																									
User Interface																									
- Buttons and LCD																									
- Remote control																									
- Error communication																									
- Status Reporting																									
- Testing and documentation																									
Feedback Control																									
- Analyze data																									
- Code																									
- Testing and documentation																									
Final testing and documentation																									