SMART AUTOMATIC PASTA / RICE COOKER

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1. Introduction

1.1 Objective

The cultural development of our society has led to an abundance of different cuisines available to us. The two most common food staples in most people's diets are rice and wheat which are the leading food crops in the world. However, a major setback to cooking these important foods is the length of time it takes. Most supplementary foods take less than twenty minutes to cook, while the base of these meals such as rice and pasta take more than thirty minutes to cook. For example, if the pasta is already cooked, adding pasta sauce to it takes a negligible amount of time. The length of time it takes to cook pasta or rice results in a very inconvenient waiting time especially for students or working adults who have unpredictable schedules every day. When one returns home from work or school and wants to eat as soon as possible, starting a rice cooker and waiting for another thirty minutes is unsatisfactory. Using a high-pressure rice cooker still takes twenty minutes and is [1] more expensive than a simple rice cooker. An effective and unique solution to this problem has not been found yet, even though a lot of people face this issue!

Our solution is a fully automatic smart pasta/rice-cooking system that would be an extension on an existing basic rice cooker. Our system would be a module that is connected to a water supply and a rice reservoir. This rice reservoir would be filled when a bag of rice or a box of pasta is bought from the grocery store. The user, while still at school or work, could use our mobile application to prepare the desired amount of rice or pasta. For example, if the user would like to cook 2 cups of rice, the correct amount of rice would be released from the reservoir into the rice cooker along with the correct associated volume of water. The cooker would then be started so that the rice would be ready for when the user arrives home. Since a lot of people (especially college students) have unpredictable schedules, it can often be difficult to plan when they might come home or if they have already eaten by the time they come home. Our system allows you to start the cooking process from anywhere, with no preparation beforehand.

1.2 Background

There are very few “smart” rice-cookers on the market today, but none with the abilities that we are proposing. An interesting device that we found was the [2] Xiaomi Mi Induction Pressure Rice-Cooker. This has the ability to remotely start the cooking of rice through an application but has one issue: it requires the user to have already put in the rice and water, basically rendering the system as a simple on/off smart switch. Our system, on the other hand, would not require the user to prepare for future cooking at all. Since the cooker is already connected to both the rice/pasta and water sources, a user request with the number of cups would begin the cooking process at any time.

1.3 High-level requirements

1. The entire series of operations performs in the correct order successfully using a single start signal provided by the user.
2. The device must be able to dispense the precise number of cups of rice (1 standard cooking cup = 7 oz / 200 g) requested by the user in the mobile application with an error of at most 15%.
3. All operations must be halted at once if an abnormal rise in temperature (>170 ℉) or any form of smoke is detected, with power being cut off to every system of the design.(Normal cooking temperature for a rice cooker is about 150 ℉)

2. Design

2.1 Block Diagram

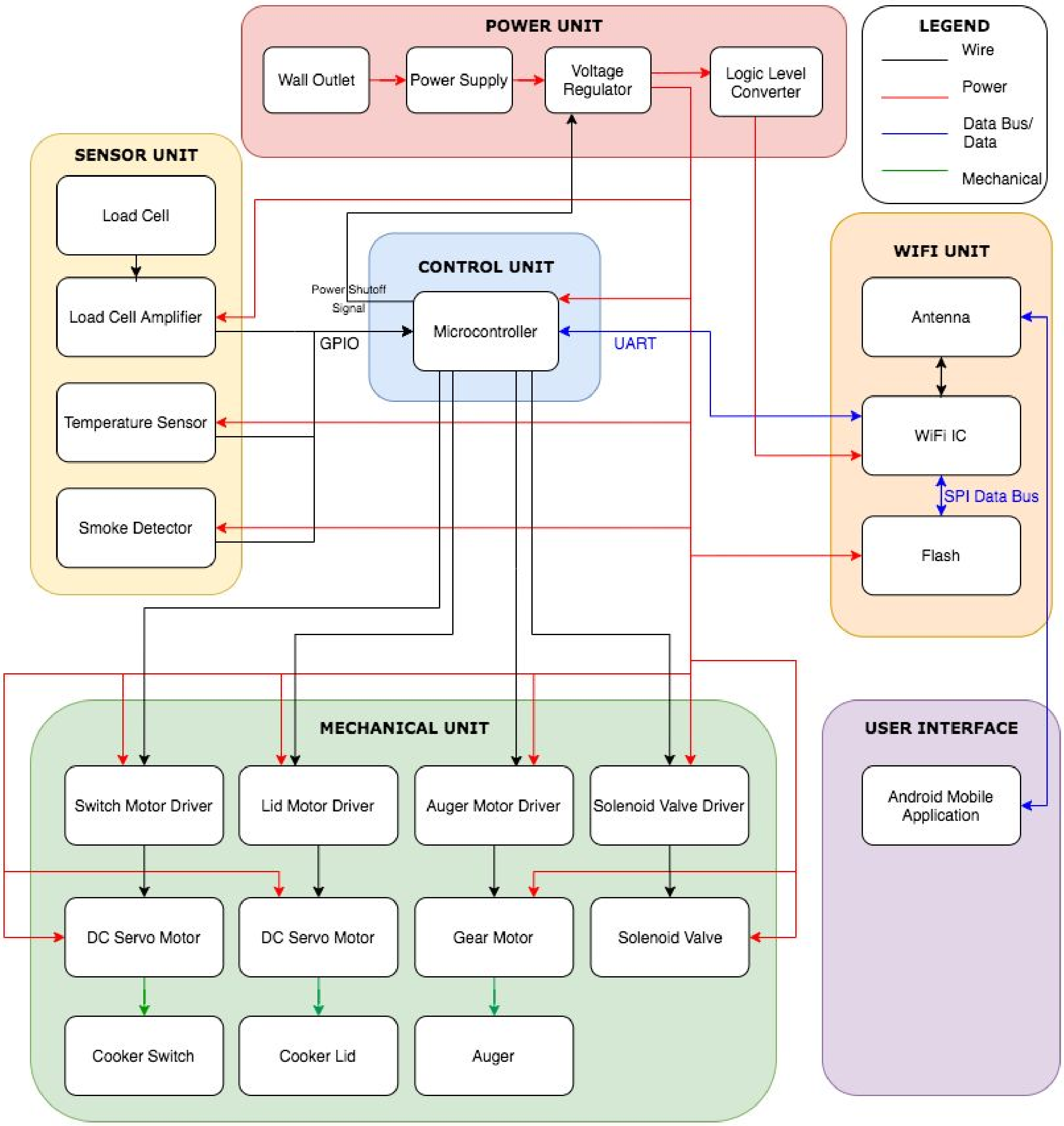

Figure 1: Block Diagram for our proposed design of the smart automatic rice cooker

2.2 Physical Design

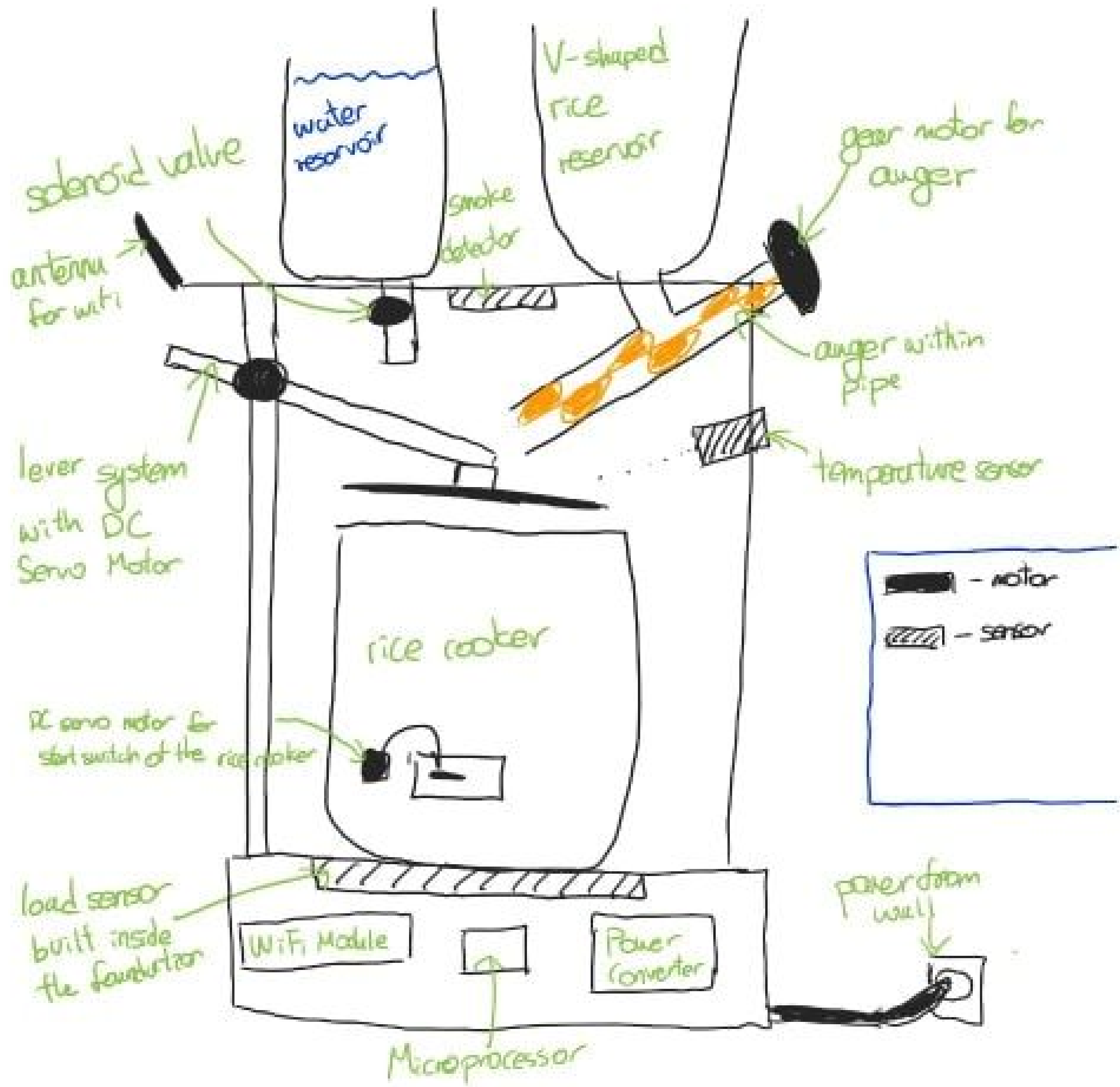

Figure 2: Physical design for our proposed design of the smart automatic rice cooker

The system will make use of a standard simple off-the-shelf rice cooker. For our design, we will use a simple *Black+Decker* rice cooker as shown in Figure 3.

Figure 3: Standard basic rice cooker around which our proposed design will focus

2.3 Functional Overview

2.3.1 Control Unit

The control unit will process the user input received from the user interface, and use the data to run the necessary motors. It is responsible for carrying out the entire cooking sequence by:

1. Running the lid motor to open the cooker lid.
2. Running the auger motor and solenoid valve to release the rice and water respectively.
3. Stopping the release of these materials when the desired load has been reached based on the data collected from the load sensor.
4. Closing the lid, and switching the cooker into “Cook” mode.

Additionally, the control unit is responsible for cutting off power to the entire system in the event of the detection of smoke or an abnormal rise in temperature.

2.3.1.1 Microprocessor

We will use the ATMEGA328P microprocessor. This microprocessor will be a part of our PCB and will be responsible for conducting all of the essential functions of the system. It will also be critical that all of the functions are executed in a sequential manner in the right order. Our microprocessor will also be responsible for communicating with the WiFi module using UART.

2.3.2 Power Unit

This power unit will provide all of the necessary power requirements for the components of the system.

2.3.2.1 Power Supply

This will step down the standard 120V power line to 12V for use in our design. It will be a basic AC/DC converter.

2.3.2.2 Linear Voltage Regulator

The linear voltage regulator provides the necessary voltage level signals to the various components of the system.

2.3.2.3 Logic Level Converter

This converter will be used to step down a 5V signal to a 3.3V signal for the WiFi module. The ESP8266 WiFi module we have chosen to use does not have inbuilt 5-3 logic shifting [6] and requires a logic level converter to step down the voltage to the necessary 3.3V.

2.3.3 Sensor Unit

2.3.3.1 Load sensor

2.3.3.1.1 Load Cell

The load cell is able to measure the weight of the object that is placed on it. This will allow us to measure the weight of the rice and water added to the rice cooker. The changes in weight will be used to calculate the amount of rice or water that has been added.

We will use the TAL220B load cell. It has a 5kg weight limit and connects directly to the load cell amplifier with no additional connections.

2.3.3.1.2 Load Cell Amplifier

The load cell amplifier acts as an interface between the load cell and the control module. It transfers the data collected by the load cell to meaningful data to the control module.

We will use the HX711 load cell amplifier. It will be connected to the load cell and the control module using a custom serial protocol specific to the chip. This will be connected to the 5V power supply.

2.3.3.2 Smoke detector

We will have a smoke detector built into the system to detect the presence of any kind of smoke in the vicinity. The data collected in the detector will be processed by the microprocessor and if smoke is detected, power will be cut off to the entire system.

2.3.3.3 Temperature sensor

A temperature sensor will also be part of the design, and send its data to the microprocessor. Any abnormal rise in temperature detected will cause the control unit to cut off power to the entire system.

2.3.4 Mechanical Unit

2.3.4.1 Water Dispenser

Water dispensing will be controlled with a solenoid valve that is going to be connected to the microprocessor through a PCB. The solenoid valve that we are going to use is HFS 12V DC electric solenoid. The valve will remain open until the appropriate weight of water has been dispensed as signaled by the microprocessor. The volume of water added to the cooker will be calculated based on the mass added and the density of water.

2.3.4.2 Rice Dispenser

Rice dispensing will be controlled using a rotatory gear motor on an auger. When the start signal is received from the microcontroller, the auger is rotated to release the rice. Similar to the functionality of the dispensation of water, when the required weight of rice has been released into the cooker based on the signals from the microcontroller, the release of rice stops when the motor comes to a halt. The volume of rice added to the cooker will be calculated based on the mass added and an average density of rice.

2.3.4.3 Lid Translation

A motor will control the movement of the lid on and off of the cooker. Our system will employ a lever mechanism to lift the lid off of the cooker to prepare for the rice and water to be dispensed. When the ingredients have been added, the system will employ the same mechanism to place the lid back onto the cooker before cooking begins.

2.3.4.4 Switch Motor

This motor will be responsible for toggling the “Cook” button on the cooker so as to begin cooking when all of the preparatory processes have completed.

2.3.5 Wifi Unit

Data must be transferred between the user and the control module via UART to be accessed on a WiFi network. Wifi Soc (System-on-a-Chip) operates based on an SPI flash program memory and uses an antenna to communicate with the user.

2.3.5.1 Antenna

Molex 1462200200 PCB trace antenna will be attached to the Wifi IC to gain maximum range. We will aim for 5Mbps access at 20m. This is within the specifications of the product and will allow the user to connect with the product within the boundaries of a household.

2.3.5.2 WiFi IC

ESP8266 Wifi Module is chosen for our project because it is very cost-effective and efficient for our communication. Our product does not require speedy transactions between the user so a cheaper model is used. It can operate at 160MHz when overclocked and has integrated power management units and Wifi transceiver. This module will communicate with the microprocessor via UART.

2.3.5.3 Flash

ESP8266 Wifi module comes with a limited RAM memory of 12kb for user programs and variables/data. A Flash IC will be used, if necessary, to hold the program memory for the WiFi IC. This must operate at 80MHz for the WiFi microcontroller to operate at full speed. Currently, we are not certain of our program size for the microcontroller. We will prototype the size of 1Mb Flash IC and downsize for cost measures.

2.3.6 User Interface

2.3.6.1 Android Mobile Application

We will use an Android application to get the user's input on the amount of rice and water desired to be cooked. We will have a custom option as well as a preset option for the amount of water. However, there will also be a limit on what the user can input into the application as there is a physical limit on how much rice can be cooked in any given rice cooker (Ex: More than 6 cups cannot be cooked in a 6-cup rice cooker). Most importantly, the user may begin the cooking process by pressing the "Start" button.

2.4 Block-level Requirements

Unit	Requirements
Control Unit	1. Must connect to and support communications with the sensory unit, dispensing unit, wifi unit and switch unit in both SPI and UART.
Power Unit	1. The power unit must be able to transfer the correct amount of power to different parts of the project. 2. Power unit must be prepared for the following safety hazards: a. A spike in the voltage or current from the power source. b. Fire hazard from the cooking
Sensor Unit	1. The sensor unit must be responsive to transmit data to the microprocessor. 2. Sensors must effectively carry out their respective functionalities while transmitting accurate data back to the microprocessor.
Mechanical Unit	1. There are numerous mechanical parts of the project moving in the same designated space. Different parts must carry out their respective functions without interference from other potential obstacles. 2. Parts of the mechanical unit must remain unaffected when met with pressure and heat from the steam of the rice cooking.
Wifi Unit	1. The WiFi unit's antenna must be omnidirectional to support a signal from any direction thereby avoiding poor performance from any single direction. 2. Both UART, as well as SPI must be viable with the WiFi unit.
User Interface	1. The application must be simple and easy to use. 2. The application must have a preset value as well as a custom option for the user to input their desired amounts of rice and water. 3. A limit must be set on the maximum amount of rice/water entered by the user so as to prevent an overflow of cooked rice.

2.5 Risk Analysis

The greatest risk for this project will be creating the control system. This needs to be individually connected to every single part of the project and operate them in sequential order. Thus the order and timing of each individual step will have to be precise and accurate. Since water and electricity are handled in this project, we have to make sure that it is absolutely impossible for spills and leakages to happen. However, in case there are safety issues, our safety system must halt the process and shut off the voltage source.

There is also the possibility that the amount of rice or water released into the cooker may be too little or too much. Too little water can cause the rice to be burnt and cause a fire hazard, while too much water can lead to spillage of water onto the electrical components. Hence it will be of utmost importance for us to ensure that the sensors are set up in a way so as to maximize accuracy. We have decided to allow a maximum 15% error when measuring the amounts of rice and water and a limit to the maximum amount of rice cooked.

Furthermore, PCB design for the control unit will be a challenge since all three members of our team have not had experience in PCB design. Using both online and departmental resources, we will ensure that we can effectively execute this task of the project. Using the knowledge base of the course staff will also be vital to meet our goals on this front.

3. Ethics & Safety

3.1 Ethics

We would like to build a system that is accurate in dispensing the correct measurements of rice and water. Even though we would like to get the exact measurements perfectly, it is one of our high-level requirements that we aim for an accuracy of eighty-five percent or above. We did this to be realistic and not lie about the efficiency of our product. We are abiding by the [3] IEEE Code of Ethics #3 by doing this.

As our dispensers will be storing food that is primarily for human consumption, it is crucial that we do not harm the quality of the rice or the water. Hence, we will be using food-grade plastics and materials to not contaminate the cooked food. Our device will not introduce any harmful chemicals into the user's food and will prevent any harm to our user, therefore following the [4] ACM Code of Ethics and Professional Conduct #2.

3.2 Safety

We plan to address the safety concerns with a few precautions so that our users are not afraid that their houses might catch on fire. We will be adding a smoke detector and a temperature sensor, which on detection of smoke or heat will send a message to the user's mobile phone and immediately cut off power to the entire device. We will also have an in-built surge protection to safeguard against a potential voltage spike. Additionally, we will be using a converter to change 120 V to 5V for some of our devices which would avoid any potential electrical hazards. All these precautions comply with the lab safety guidelines. As our system contains two plastic dispensers that hold the rice and water, we will be using plastics that are [5] FDA approved for food consumption safety.

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