Project Statement

Bluetooth Enabled Coffee Machine

ECE 4901 - Senior Design I

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Summary:

Traditional coffee machine designs are outdated and inefficient. As a result, the purpose of our project is to Bluetooth enable a coffee machine. This will allow users to operate their coffee machine from the convenience of the next room, or another area in the vicinity. A recent survey taken by UConn students has shown that out of 402 students 52% of them prefer to use a Keurig while only 23% prefer a drip coffee maker and the remaining 25% use other forms of coffee makers. As a result, a Keurig Single Cup Coffee Machine will be used the purpose of this project.

This coffee machine will have many features that a regular coffee maker does not. Through Bluetooth enabled, the user will be able to control various features from their smartphone or other handheld device. Some of these features include: commanding it brew on command, commanding it to brew at a specified time, selecting a flavor of coffee to dispense, and selecting a volume of coffee to dispense.

Background:

Our project is sponsored by iDevices LLC. iDevices is a company that is located in Avon, Connecticut, and was founded in 2010. iDevices is an App-enablement and consulting company creating products that incorporate wireless connectivity to popular smartphone and tablets. Using Bluetooth and Wifi technology, iDevices can work with other companies to app-enable their products or offer electrical engineering consulting services.

Project Specification:

Hardware

- A Keurig B40 coffee maker
- AC, zero-cross solid state relay (Input 3-8V DC, Output 0-220V AC)
- Atmega328 Microcontroller (Operating Voltage 5-12V, Output 5V, 30mA)
- Broadcom bluetooth module
  - Bluetooth Classification : 4.0 Bluetooth low energy
  - Dimensions : 6.5mm x 6.5mm
  - EEPROM Size : 512K
  - Antenna Type: PIFA
  - Analog Inputs : 8
  - GPIO : 15
  - Footprint :48 Pin LGA
  - Range : 50 meters
- Temperature Sensor (Operating Voltage 1.5~5V, Range -50°C~150°C)
- Interface between Bluetooth module and Microcontroller via UART

Software
Develop an application on a smartphone by using Java

Minimum Requirements:
- Basic UI layout with buttons to control the coffee machine
- Uses Bluetooth communication
- Froyo (2.2 OS) and compatible with current (4.4 OS)
- Interpret received data and notify user.

Figure 1: Basic layout of the Android application.

Figure 2: Basic layout of the Android application displaying Bluetooth enable prompt.

Solutions:

To improve the functionality of the coffee machine the following aspects of the coffee machine will be controlled via a Smartphone application (table 1).
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>On/Off</td>
<td>The coffee machine will be turned on and off by Bluetooth</td>
</tr>
<tr>
<td>Brew</td>
<td>Send control to brew coffee</td>
</tr>
<tr>
<td>Brew Complete</td>
<td>Informs the user when the coffee has finished brewing</td>
</tr>
<tr>
<td>Water Level</td>
<td>Will indicate when the water level is low</td>
</tr>
<tr>
<td>Flavor</td>
<td>Choose a flavor for brewing</td>
</tr>
<tr>
<td>Volume</td>
<td>Select volume to dispense (8oz, 10oz)</td>
</tr>
<tr>
<td>Time</td>
<td>Set a time to brew coffee</td>
</tr>
<tr>
<td>Stop/Cancel</td>
<td>Stops current brewing</td>
</tr>
</tbody>
</table>

Table 1: Coffee machine functions.

The Keurig coffee machine already has all of these features, with the exception of being able to select a flavor and being able to sense the presence of a coffee cup. Therefore a circuit will be developed to interface with the pre-existing components to monitor and/or control the features mentioned in table 1. The circuit design can be separated into two categories - one section will of the design will be dedicated towards the sensor aspect and the other will focus on more of the physical controls portion.

![Design Flowchart](image)

**Figure 1:** Design Flowchart for the system. The phone will send/receive signal to/from the Microcontroller via Bluetooth. The Microcontroller then controls the Motor (flavor choosing), Relay (turn on/off the Coffee Maker) and the Infrared sensor to determine if the is a cup (dispense coffee if there is a cup).

**Controlling Components:**

Components of the coffee machine that will be controlled by the circuit in figure 1 are: On/Off, Brew, Volume to dispense, time, stop/cancel and flavor selection.
The Keurig will be able to be turned on and off via the smartphone application. This is achieved by controlling a Solid State Relay. A signal is sent from the phone to the microcontroller via Bluetooth, the microcontroller then output 5V from a GPIO pin which drive a transistor and control the relay.

The Keurig will accept a command to brew via the smartphone application. To do this a signal will be sent to the Microcontroller which activate the GPIO that connected to the built-in microprocessor to enable the punching on the K-cup. Along with the ability to simply brew coffee, there will be a feature on the smartphone application which allows the user to choose a specific type of coffee. This will be capable by utilizing a stepper motor. In essence the stepper motor receives a command from its indexer and converts it to an electrical signal which will then shift the K-cups accordingly using PWM.

*Sensing Components:*

Components of the coffee machine that will be sensed by the circuit in figure 1 are: water level, brew head open and whether a coffee cup is present. The pinout of the Keurig\textsuperscript{s} Display/Interface Board can be seen in table 2 (below).

<table>
<thead>
<tr>
<th>Pin:</th>
<th>Function:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Voltage supply for Vref of Op-Amp</td>
</tr>
<tr>
<td>2</td>
<td>Heating LED</td>
</tr>
<tr>
<td>3</td>
<td>Descaling LED</td>
</tr>
<tr>
<td>4</td>
<td>10 oz Brew LED</td>
</tr>
<tr>
<td>5</td>
<td>Pressure Sensor Voltage Output</td>
</tr>
<tr>
<td>6</td>
<td>Analog Muxed Switches</td>
</tr>
<tr>
<td>7</td>
<td>Add Water LED</td>
</tr>
<tr>
<td>8</td>
<td>VCC (5V)</td>
</tr>
<tr>
<td>9</td>
<td>GND</td>
</tr>
<tr>
<td>10</td>
<td>GND</td>
</tr>
<tr>
<td>11</td>
<td>Not Connected</td>
</tr>
<tr>
<td>12</td>
<td>Auto-Off LED</td>
</tr>
<tr>
<td>13</td>
<td>Power LED</td>
</tr>
<tr>
<td>14</td>
<td>Not Connected</td>
</tr>
</tbody>
</table>
In order to monitor the water level of the Keurigs water reservoir pin 7 from table 2 will be polled by the Microcontroller. Analog to Digital Conversion technique will be used to map the water level to voltage signal and fed into the Microcontroller. If a high signal is intercepted an interrupt will be triggered and in the interrupt a message will be sent to the app via the Bluetooth module.

Prior to brewing it will need to be determined whether the brew head of the Keurig coffee machine is open. Therefore, before accepting the command to brew pin J10 (brew head open switch) of Keurig's main controller board will be checked to determine whether the brew head is open. If the brew head is closed, then the Keurig will brew the coffee, otherwise an error message will be displayed in the application.

Prior to brewing it will also need to be determined whether there is a coffee cup present under the spout. To do this an optical sensor will be used to determined whether anything is beneath the spout. If something is under the spout the coffee machine will be allowed to brew a cup of coffee, otherwise it will not.

**Timeline:**

We plan to have all of the software and hardware designs done in the first semester. The second semester will include implementing and building actual circuitry/components for the prototype. As the circuitry is built, the application will have to be updated accordingly.
Conclusion:

This project is expanding the idea of the Keurig coffee maker to make it controllable via bluetooth. A big part of this project requires the coffee maker to be reliable when sensing water levels, K-cups, etc. and for the application to notify the user; this means the microcontroller and sensors used must also be reliable. The addition of the stepper motor is innovative because it provides an added purpose to the bluetooth controlled aspect of the project - allowing the user the ability to change the K-cup without physically performing the action. The platform for the smartphone application will be on Android but this idea can be expanded to iOS and other bluetooth controlling devices in the future. If this project is a major success there could be room for Keurig to partner with iDevices in the future to expand on the flavor choices and possibly support various devices.

References: