Improving Energy Management in Coffee Makers with Intelligent Controls

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Background/Purpose

Workplace coffee makers waste approximately 75% of the total energy they consume by keeping coffee at peak temperatures during idle times. Commercial coffee makers are often kept active for more than 8 hours a day. Figure 2 shows the typical operating time of an average workplace coffee maker compared to the Coffee Buddy system. The Coffee Buddy system allows the coffee maker to be switched on and off according to occupancy, time of day, and ambient light.

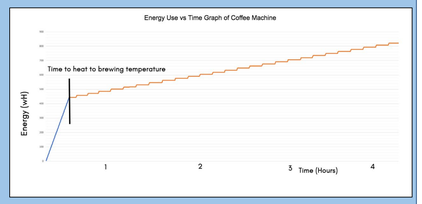

Figure 1: Energy-time relation graph for a coffee machine in typical usage

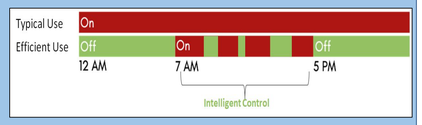

Figure 2: Graph of typical and managed (efficient) use in coffee machine operation.

Operational Goal

Coffee Buddy provides the ability to monitor energy usage and adapt to its surroundings. Motion detectors are used to detect occupancy, ambient light sensors determine if the lights in the room are on, thermocouples and IR sensors record the temperature of hotplates and the coffee itself, and range finders monitor the status of the coffee pot. An algorithm combines all of the data recorded from the sensors to gradually consumption based of use. The can be reprogrammed her increase

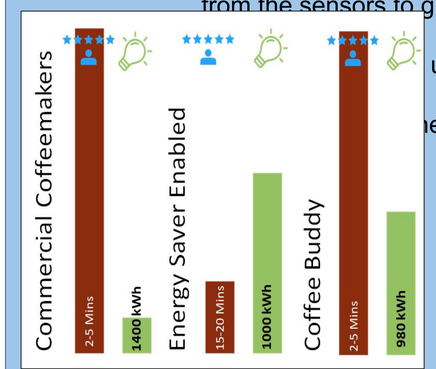

Figure 3: Warmup time, energy savings and predicted user satisfaction for the discussed solution as compared to alternative solutions including default device energy saving mode on Curtis Coffee Maker

Proposed Solution

Coffee Buddy reduces wasted energy by frequently monitoring the temperature of the hot plate and boiler. If the occupancy sensors do not detect anyone present in the room, the temperature will be reduced. It takes substantially more energy to maintain coffee at peak temperatures than to allow it to cool down to a lower temperature and bring it back to drinking temperature on-demand. The dynamic temperature control used in Coffee Buddy is expected to reduce energy consumption by approximately 68%. To accomplish these energy saving, two versions of Coffee Buddy are proposed:

- **Retrofit Device**:
An aftermarket ad-on device that can monitor and control an existing coffee maker based on its environment and detected coffee drinking habits.

- **Energy Management for OEMs**:
Integrating sensors and control components directly into the coffee maker.

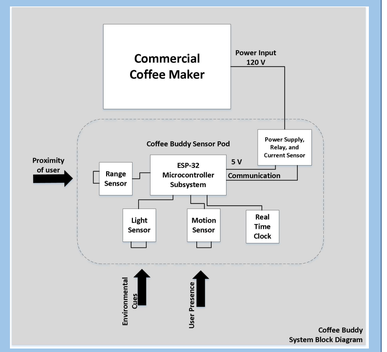

Figure 4:(Above) Block diagram showing the Retrofit version of Coffee Buddy

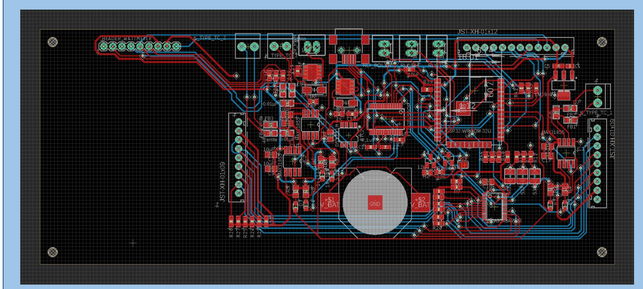

Figure 5: Current PCB design of the main controller. This board is installed inside an existing coffee maker. It is responsible for processing all sensor data and sending control signals.

Acknowledgements

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Operational Algorithm

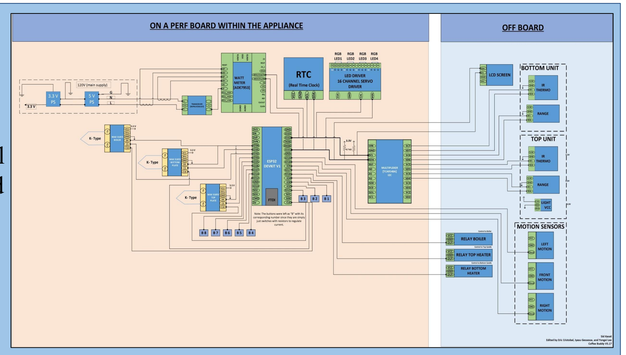

Figure 6: Electronic connection diagram for Coffee Buddy prototype

The ATOM (Active Thermal Observation and Management) methodology in Coffee Buddy allows for intelligent prediction of device use based on previous interactions with the coffee machine, derived from motion and IR sensor inputs correlated with time of use information. In doing so, the coffee machine can lower the heater temperature during times of predicted inactivity and heat up when it expects user interaction. For example, the implementation of ATOM into water heaters in an office would result in dropping from using 1.1 kWh to just 0.233 kWh, saving 79%.

As the desired outcome of ATOM is to allow the machine to operate independently and with minimum energy loss, it's sensors desired outcomes are to deliver inputs indicating any user presence. If the motion sensors do not detect anything, the light sensor will finalize the feedback by verifying if the room is in use. The range finder and IR thermometer work in a similar manner by checking the status of the pot. With the feedback provided from the IR thermometer, the thermocouples will monitor the plates' temperature according to the input. The real time clock (RTC), is used to shut off the machine during after hours, which can always be overwritten if motion is detected.

Future Impact

Coffee Buddy's intelligent control of energy use can also be applied to other office appliances and plug loads, a number of which consume a fair amount of power when left idle or on when not needed. Energy expenditure would be managed by utilizing edge intelligence to predict the user's interactions with the device. This collection of data would also provide a holistic view of the user's energy use to empower the user to make other energy conscious decisions with device usage.

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