Machine Learning Smart Building

Supervisor: Babak Esfandiari

Name	Student Number	Email
Matthew Maynes	100882216	mattmaynes@cmail.carleton.ca
Cameron Blanchard	100886476	cameronblanchard@cmail.carleton.ca
Jeremy Dunsmore	100889935	jeremydunsmore@cmail.carleton.ca
Peter Mark	100886038	petermark@cmail.carleton.ca

Introduction

Maintaining a comfortable environment within a building such as a home or a school can often be a burden on homeowners and maintenance staff. Adjustment of the temperature and lighting in a room, for instance, is often a repetitive task which it would be convenient to automate.

This report contains a proposal for a project to eliminate these manual tasks. The objective of the project is to build a system to automate control of a building's environment, which uses machine learning algorithms to minimize manual configuration. The proposal presents several motivations for using the environmental control system, as well as a detailed description of the project's objectives. The proposal also includes a timeline for the completion of concrete milestones for the project as well as a technical summary of the proposed solution.

Background

Any home maintenance task which can be automated can save the owner a substantial amount of time and money. Automated environmental control is not a novel concept; devices such as light timers and programmable thermostats have existed for many years. Most of these common devices, however, must be configured manually. The system proposed in this report is able to configure itself based on normal actions taken by the user. By having the system learn the habits of the user dynamically, the configuration is essentially eliminated, leading to an ease of installation that does not currently exist.

One scenario in which a home automation system could be a significant help is in the case of a homeowner with physical limitations that prevent them from independently maintaining their house. A system which controls the living environment without requiring substantial configuration can give these people more independence, or allow their caregivers to focus on other priorities.

There is also a place for automated environment control in a commercial setting. An example of this is in educational buildings, where there are thousands of people in many different rooms at all times of day. Maintaining a single building in this situation requires full time staff. For example, during a lecture at sunset, an instructor may have to adjust the blinds and contact the maintenance staff to adjust the temperature at the same time each day. The cost and effort of this maintenance is multiplied for every building in a given institution. If a system could be installed in each building that learns to handle this activity automatically, it would help reduce the burden and cost of maintenance.

Another benefit of automated environment control is improved energy efficiency. It is not uncommon to leave a room forgetting to turn off a light, or to leave a building with the air conditioning still running. This leads to needless consumption of energy, again increasing the cost of maintaining the building. Removing this responsibility from the building owner also removes this waste of energy. An automated environment control can also improve energy efficiency beyond just removing negligence. Once the desired temperature of a room for a given time is known, options besides air conditioning or heating can be explored first. If the room temperature must be raised, and the temperature outside is warm enough, the system could open the room windows. Once the desired temperature has been reached, the windows could be automatically shut again.

Objectives

Currently, supervised learning algorithms require a complete input dataset and a meticulously configured output to train the system. We want to have the algorithm be trained in a real world environment where users perform live actions and the system determines relevant changes and environmental factors. This automated learning system will be generic and use only the categorical and numerical information provided by sensors and actuators.

Manual adjustment of a building's environment can be tedious. A goal of the project will be to create a system which uses automated learning to adjust the environment based on input from a number of sensors. The system should support simple configuration of any type of sensor, and should not contain detailed knowledge about any sensors or actuators.

This system will support dynamic updates to the configuration of sensors and actuators. Overhead for adding and removing new devices from the system will be minimal. The learning algorithm will then adjust to take these new devices into account when altering or maintaining the environment.

Scenarios

In order to create concrete goals for the project, we have identified a collection of scenarios. Each scenario describes a common situation which occurs in a home's environment, and how the home automation system should respond.

Light Automation

Nearly every room contains several lights which need to be adjusted regularly in response to various stimuli. It is very common for occupants to forget to turn off lights when they are not in use, leading to and unnecessary waste of money and energy. In order to save money and energy, the home automation system should be capable of automating the following tasks:

- Turn on lights at a given time * Turn off lights at a given time * Turn on lights when dark outside * Turn off lights when light outside

Curtain Automation

The home automation system should be able to detect the current temperature and light levels to do the following:

- Open curtains when cool inside and sunny outside
- Close curtains when warm inside and sunny outside

Temperature Automation

The climate of a building can fluctuate throughout the day, and there are multiple possible ways to control it. By automating this process, the desired temperature can be maintained in the most energy efficient way. The temperature automation will be responsible for:

- Raise temperature directly
- Raise temperature by opening/closing windows
- Lower temperature directly
- Lower temperature by opening/closing windows

Schedule

The project has been broken down into several week long iterations. The focus of each iteration is to introduce a useful (demoable) feature to the system. By breaking the project into demoable iterations, we will be able to commit to a set of concrete goals on a weekly basis. The emphasis on demoable increments will allow us to have a product that always in a working state. Iterations have been grouped into larger milestones; each milestone marks the implementation of one of the scenarios described in the previous section.

Iteration 1

> October 5, 2016

- Arduino micro-controller hooked up to a voltage relay
- Relay hooked up to a single light switch
- A single button to toggle the state of the light

Iteration 2

> October 12, 2016

- Light sensor reading values
- Arduinos communicating to central server

Iteration 3

> October 19, 2016

- Light sensor communication to light controller

Milestone: Automated Lighting Control

Iteration 4

> October 26, 2016

- Arduino motor that moves a curtain track
- Button that control Arduino motor

Iteration 5

> November 2, 2016

- Add communication to curtain Arduino

Milestone: Automated Curtain Control

Iteration 6

> November 9, 2016

- Web API

Iteration 7

> November 16, 2016

- Static functioning web interface

Milestone: Functional Web Interface

Iteration 8

> November 23, 2016

- Add temperature control buttons

- Add temperature LED display

Iteration 9

> November 30, 2016

- Add temperature device communication

Milestone: Automated Temperature Control

Iteration 10

> December 7, 2016

- Add basic decision making software

Iteration 11

> January 4, 2017

- Add device discovery

Milestone: Automated Configuration

Iteration 12

> January 11, 2017

- Improved web client

Iteration 13

> January 18, 2107

- Improved decision making

Iteration 14

> January 25, 2017

- Add record and learn

Milestone: Complete System

Team Responsibilities

Responsibilities will change on an iteration by iteration basis. Each team member will rotate and contribute to different elements of the system. This will allow each member on the team to have a good understanding of the entire system.

Required Facilities

4 Arduinos

These will be used for interfacing with sensors and controlling motors. Two different devices were considered for this role; an Arduino and a Raspberry Pi. The size of an Arduino is much smaller than a Raspberry Pi and therefore more applicable to the embedded device use case. Working with hardware from a Raspberry Pi requires more accessories than an Arduino and is therefore more difficult to setup than an Arduino.

Sensors

- Photo Transistor Light Sensor
- Digital Temperature Sensor

Output Devices

- Standard 16x2 LCD
- AC voltage relay

Control Devices

- (10) Buttons