Web Based Weather Responsive Window

By

Fengling Wang

Hanyu Wang

Kaishen Wang

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TA: Zipeng Wang

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1 Introduction

1.1 Objective

People cannot foretell whether the weather is going to be good or bad when they leave the house, so windows can sometimes be left open when bad weather happens, which makes damage to the treasures inside the house, or left closed when good weather happens, in which fresh air and adjust temperature.

We want to have 24/7 control over the windows in our house so that the problem above wont happen. Our solution is to build a weather responsive window which breaks down to two major components: 1. Cloud based weather receiver, which is a microcontroller integrated with a wi-fi receiver. It receives weather data from cloud and controls the window state 2. Window adjustment tool which can open and close the window. It has battery and IF device with highest priority to prevent cat or hands from being damaged.

Sometimes, people may open the window to adjust the room temperature. However, people may not want to make the window fully open or fully close all the time due to a lot of reasons like power saving. Additionally, if there is little rain or wind outside, and people may not want to fully open the window. Our project will adjust the window automatically.

1.2 Background

Window is an essential part of our home. Sometimes we open windows to let fresh air come inside the house or to adjust the room temperature, sometimes we close them because of bad weather, like raining, snowing, temperature being too hot or too cold, etc. One of the problems is that people are not always staying in the house, so people cannot always control the window state. Things can end up not what we want while we are absent in the house. For example, rain damages our treasures through open windows; sunlight and fresh air cannot go into the house in a nice weather day because of closed windows.

1.3 High-level requirements list

- The weather receiver can analyze online and sensors data, interpret it into weather situations, and assign corresponding action correctly.
- The window can open or close to change mode in multiple degrees nicely in a steady speed when it receives the voltage signals from microcontroller.
- The batteries, temperature sensor, and FIR sensor function normally.

2 Design

2.1 Block Diagram

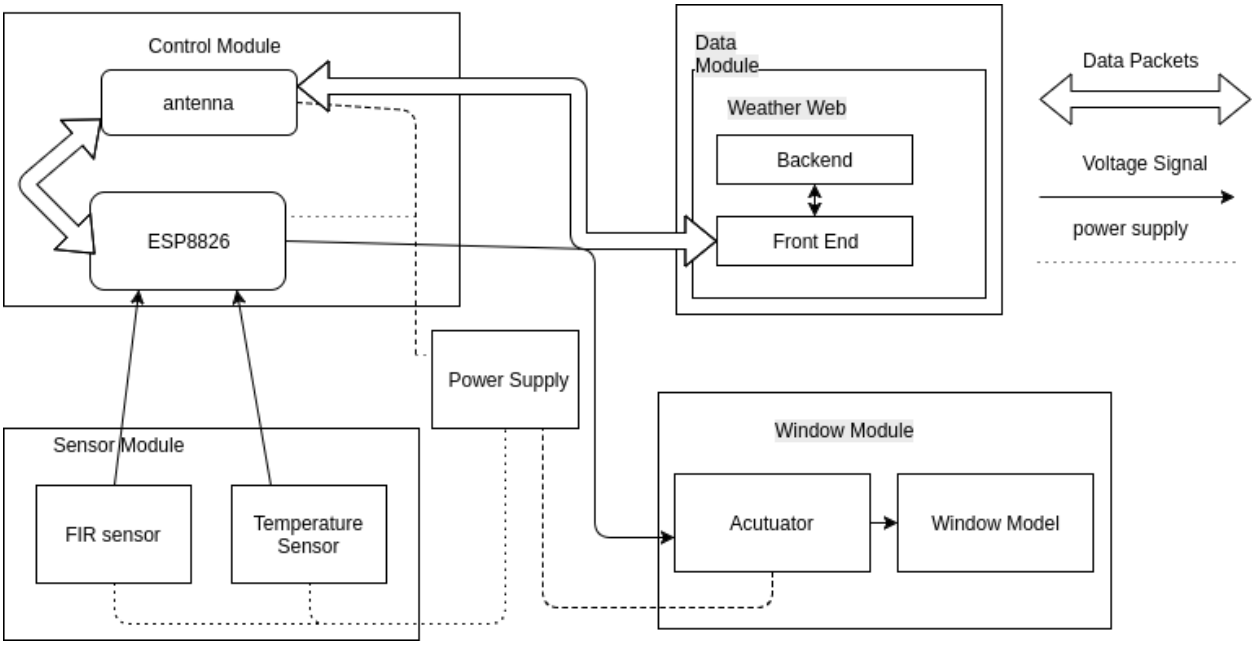

Figure 1: Block diagram with four modules and power supply.

Our project will be composed by four essential modules and power supply. The Data Module will be a web server with complete front end and back, which can provide weather information for development and testing. The Sensor Module will have two sensors, which are an FIR sensor which can prevent hand/ cat damage, and a temperature sensor which can provide the room temperature. The Window Module will be composed by an actuator and a small window model. The actuator will drive the window model to different open levels according to the signal it received from the microcontroller. The control model is the most important part. The antenna will help the chip achieve better connection with the Data Module. The chip ESP8826 will handle all the input information from the Data Module and the Sensor Module, and give instructions to the Window Module, and this is how the project will work. The power supply will provide power to everything in the project except the weather web server, which will run on a cloud server.

2.2 Physical Design

To accommodate equipment we have in lab, we will make a testing product first. We will use five thick paper boards to make an open box of size 20*50*20 cm3. The window will be installed at the open facet of size 20*20 cm2 and controlled by a rotating application which is fixed on the upper border of the box.

We will place circuitry along the window frame and fix the chip, infrared sensor and actuator firmly on the ceiling. Lastly, we will seal windows periphery with fiberglass frames. Since fiberglass is made of non-metallic materials, it guarantees that no electricity will be conducted through the borders and keeps people safe. Fiberglass also has stable chemical characteristics therefore has long durability and requires little

maintenance.

2.3 Functional Overview and Requirement

- **Control Module**

  Control unit determines what action the window is going to take and sends instruction to actuator to activate the window. With the help of the antenna, the ESP8826 chip will fetch online data through WiFi connection. Micro-controller interprets keyword string packets in the data, and use all the other information including the room temperature from the sensor, the value from the infra red sensor, the expected room temperature and also the last time that the window is open to make a choice on which mode to turn on. The whole logic will be explained below. The ESP8826 chip will give instruction (voltage signal) to the Window Module.

  To adjust the temperature efficiently, we will consider two factors. The first will be the difference between the outside temperature (read from the web) and the room temperature (read from the sensor), and the second will be the difference between the room temperature and the expected temperature (which will be configured in development).

  Requirement for Antenna: The 2.4 GHz PCB trace antenna will be added. It should be matched at 50 +/-20% between 2402-2484 MHz and will proved $> -75dBm$ access at 800ft open-field with +19.5 dBm input power. [1]

  Requirement for Microcontroller: The ESP8826 chip will be able to communicate IEEE 802.11b/g/n at ¿100kbps with a 50 nominal RF connection. It also must sink or source 10mA on each of two GPIOs at 5V +/- 5%.[1] The control logic should be correct such that once received.

  Requirement for Software Logics: Basically, our project will set the window to four levels, which are 0 degree(close), 10 degree, 30 degree and 45 degree. There are strict rules with highest priority apply to them, like if there is heavy rain or strong wind outside, the window will not open. If there is little rain or medium wind outside, the windows will at most open to level of 10 degrees. To adjust the temperature efficiently, we will consider two factors. The first will be the difference between the outside temperature (read from the web) and the room temperature (read from the sensor), and the second will be the difference between the room temperature and the expected temperature (which will be configured in development). If any of the difference is large, we should open the window to a greater extent in order to make the temperature change quickly. And also, if the any of the difference becomes 0, there is no need to open the window for temperature adjustment. So we will take the product of the two differences, and decide which level will the window be open. Lastly, the window cannot give up the responsibility of refreshing the air. So our project will record the last time the window was open. Every morning at 10 AM (normally people have get up and the air condition is good after a night), our project will decide to open the window for some time if it hasnt been opened in 24 hours. The time it opens will be decided according to the weather condition outside and the temperature difference. (If the temperature difference is large, the molecules will be active, and the time need to exchange the air on both sides will be short.)

- **Power Supply**

  One 24V lithium-ion battery will be provided to the actuator and four 5 V lithium-ion batteries to the antenna, the microcontroller and two sensors.

Requirement:The batteries should be able to supply power (24V or 5V) stably over months and sealed with physical application along windows frame to protect it from external damaging factors like intensive sunlight or high temperature.

- **Window Module**

  The Window Module will be composed by an actuator and a window model. The actuator will receive voltage signals from the microcontroller, and adjust the window model to different open levels. The window model will be a 20cm * 20cm board made by hard paper.

  Requirement:We will use ack4 window actuator, which should be able to drive the window models between 4 different opening levels smoothly: 0 degree(close), 10 degree, 30 degree and 45 degree.

- **Sensor Module**

  FIR sensor will be HCSR501, which detects if theres object outside the windows. The microcontroller will constantly make operation decision firstly based on the sensing result from the sensor, if the FIR sensor senses that an object is blocking, the microcontroller will do nothing and neglect other factors which affect the decision on the window state. The DS18B20 temperature sensor should provide accurate temperature in the room.

  Requirement for FIR sensor: The sensing range is less than 120 degree, within 7 meters. Upon detection of objects like human or pets, the sensors output signal will fluctuate dramatically.[2]

  Requirement for Temperature Sensor: Centigrade Temperature Sensor runs on a 4 30V DC power supply and outputs a voltage signal to the microcontroller thats linearly correlated to temperature calibrated in Celsius degree. Analog output voltage signal displays a 10mV/C scale factor and is able to measure temperature variation of a range from -55C to 150C. [2]

- **Data Module**

  The Data Module will basically be a web server provides the weather information to the control unit. The communication will be hold by TCP connection.

  Requirement: As we are simulating a real weather web server, so our web server will have back-end support and complete front end. It should use HTTP protocol and the front end should provide following information in text form: Time, Temperature, Strength of Rain, Strength of Snow and Strength of Wind. It will enable a TCP connection to fetch the whole page including the information.

2.4 Risk Analysis

1. The difficulties of handling complex logic inside the micro controller. The input will be the weather information (light, temperature, strength of wind, rain, snow) from the web, the room temperature from the sensor, the value from the infra red sensor, the expected room temperature and also the last time that the window is open. The microcontroller needs to consider all these factors and figure out to what extent should the window be open.

2. To successfully test the full functionality, we need to simulate a lot of different circumstances, including all the possible cases that the project can handle in reality. It is possible that some cases cannot be fully implemented in testing.

3. In order to handle different levels when opening the window, the motor control the window cannot be as simple as work versus idle. Besides considering the current level, we need to calibrate the motor to figure out how much power and how much time does it take from one level another. (And the gaps between different levels will be quite different, there will be total of six.)

4. The overall complexity also introduced by the number of components. As it has been demonstrated in the block diagram, the microcontroller, the antenna, the temperature sensor, the infrared sensor, the power and motor to control the window, and the window model itself. Composing the project by so many parts may bring unforeseen obstacles.

3 Ethics and Safety

Since our objective is to control the window to react to incoming weather changes properly, we will take in weather forecasting data. Some numbers and descriptions we obtain may not be raw records, which for example, accurate history temperature or hourly precipitation. What we get is already predictions based on some raw data which we dont know their resources. The website may hire mathematicians and programmers to design a unique algorithm to perform predictions. The algorithm can include an invented regression model. The website may also collaborate with an observatory to get precise measurements and collect massive data in a long time. These procedures involve a lot of intellectual properties and copyrights which are not explicitly claimed.

We should respect other people professional creation. Per Imperative 1.6 in the ACM Code of Ethics, Specifically, one must not take credit for other's ideas or work, even in cases where the work has not been explicitly protected by copyright, patent, etc. [1].

To avoid possibility of violations, we will do some research on whether the website has set up any mathematical modeling which havent been published ever and is owned by itself. If so, we need to contact the website for further discussion. Moreover, we will pay attention to whether the website has clearly annotated their data resource on the webpage. If not, we can contact its developers and inquire for more information. If the datas origins have been listed, we should also cite their work and names as patent and patent owners.

More hazards may come when our project is misused by people who dont know how to manipulate it, or when people trigger any sensors without realization. A possible safety issue we may encounter is that the window will probably take a series of subsequent actions which can bring harm to the user. Imagine situations like a kid was watching a beautiful scenery outside through a slightly open window. Then a strong wind blown by and the window was shutting up; however, the kid didnt notice the changing because windows motion is slow and steady. At that moment, the kid would have danger of being hurt by the window.

Number 9 of the IEEE Code of Ethics says that, avoid injuring others, their property, reputation [3]. We should protect a user's safety in many ways in a greatest extent. We thought of what we learned in another ECE course to be a great analogy to this kind of problems solution. Inside a computer, when user mode programs try to modify things in kernel which is of higher priority, the CPU will generate interrupts to inhibit any detrimental actions going further. Inspired by this way, we have decided to arrange the priority of sensors in a proper order to make sure that people will not be physically hurt at any time. The infrared sensor for detecting human and animal bodies will be set a highest priority among all the sensors. We will also install a manual emergency brake handle beside the window to allow user to take control of the window under any urgent circumstances.

References

[1] "Acm code of ethics and professional conduct," online, acm.org, accessed Feb 2017. [Online]. Available: https://www.acm.org/about-acm/acm-code-of-ethics-and-professional-conduct

[2] J. N. X. Cao and Z. Wan, "Smart window responding system," online, 2016, accessed Feb 2017. [Online]. Available: https://courses.engr.illinois.edu/ece445/getfile.asp?id=8186

[3] *IEEE - IEEE Code of Ethics*, accessed Feb 2017. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html