Self-Sufficient Early Warning Fire System

By Alexia Savage

How can I using affordable technology create a system to detect wildfires before they become uncontrollable?

Why wildfires are such a huge problem

“AccuWeather estimated the total economic cost of the 2018 wildfires at $400 billion”

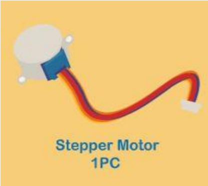
Other Systems Out There

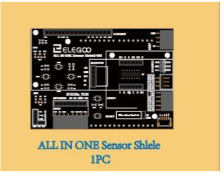
- Limited early warning systems on the market.
  - IQ fire watch
    - On the device there are sensors and a camera; raised in the air. This is not accessible for everyday people it is only meant for wildfires. Very expensive.
    - Uses algorithms to identify smoke
  - United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER)
    - Data provided is meant specifically for fire managers and decision makers
- My prototype of an early warning system
  - Everyday individuals can access the data for their area
    - have in high risk areas(i.e. Campsites, farmers, homeowners, etc..)
    - Self Sufficient, Very Affordable

Overview of Project

- **The benefits of the device**
  - Self-sufficient
  - Able to connect to internet
  - Affordable
  - Sensors, solar panels, a Raspberry Pi, and other systems to allow this to work
  - Camera for digital lookout
- **The device location**
  - Would be placed in spots that are more susceptible to fires
  - Sit on a pole or a treetop so that it has direct access to sunlight and an unobstructed view of smoke
  - Systems data would be compared to the other devices, this would catch abnormalities in the data. For example a temperature spike in the same general area would create an alert.

Prototype 1 Materials





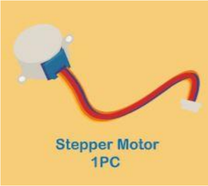
- Arduino, Raspberry Pi
- 3D printed box to hold object
- Sensors(temperature, combustible gas, humidity)
- Camera sensor
- Cellular Modem and SIM
- Solar Panel and Pijuice hat
- Sensor Shield

Prototype 1 Prices

- Arduino Uno R3 with wiring ~ Around $25
- 3D printed box just requires 3D printer - 400g ($0.03/gram) ~ $12
- PiCamera~ $12.99
- Sensors ~ Temperature Sensor $2.99
- Sensor Shield ~ $7.50
- Nova Modem Cellular Modem and SIM ~ $83.00
- PiJuice Hat and Solar Panel ~ $79.95 and $34.81

Total price of the prototype: **$258.24**

Prototype 2 Materials



- Raspberry Pi
- 3D printed box to hold object
- Sensors(temperature, combustible gas, humidity)
- Camera sensor
- Cellular Modem and SIM
- Solar Panel and Pijuice hat

Prototype 2 Prices

- Raspberry Pi 3 Model B ~ $35
- 3D printed box just requires 3D printer - 400g ($0.03/gram) ~ $12
- Picamera ~ $12.99
- Sensors ~ Temperature Sensor $2.99
- Nova Modem Cellular Modem and SIM ~ $83.00
- PiJuice Hat and Solar Panel ~ $79.95 and $34.81

Total price of the prototype: **$260.74** (per system)

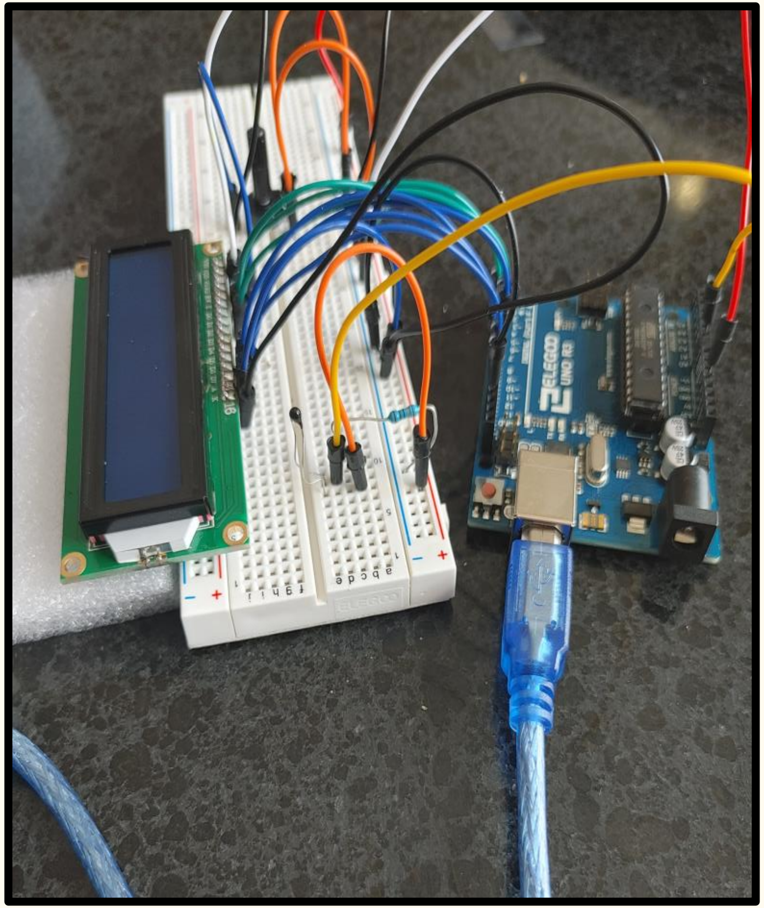
I changed some of the materials so the system worked better. This led to the price decreasing.

Procedures

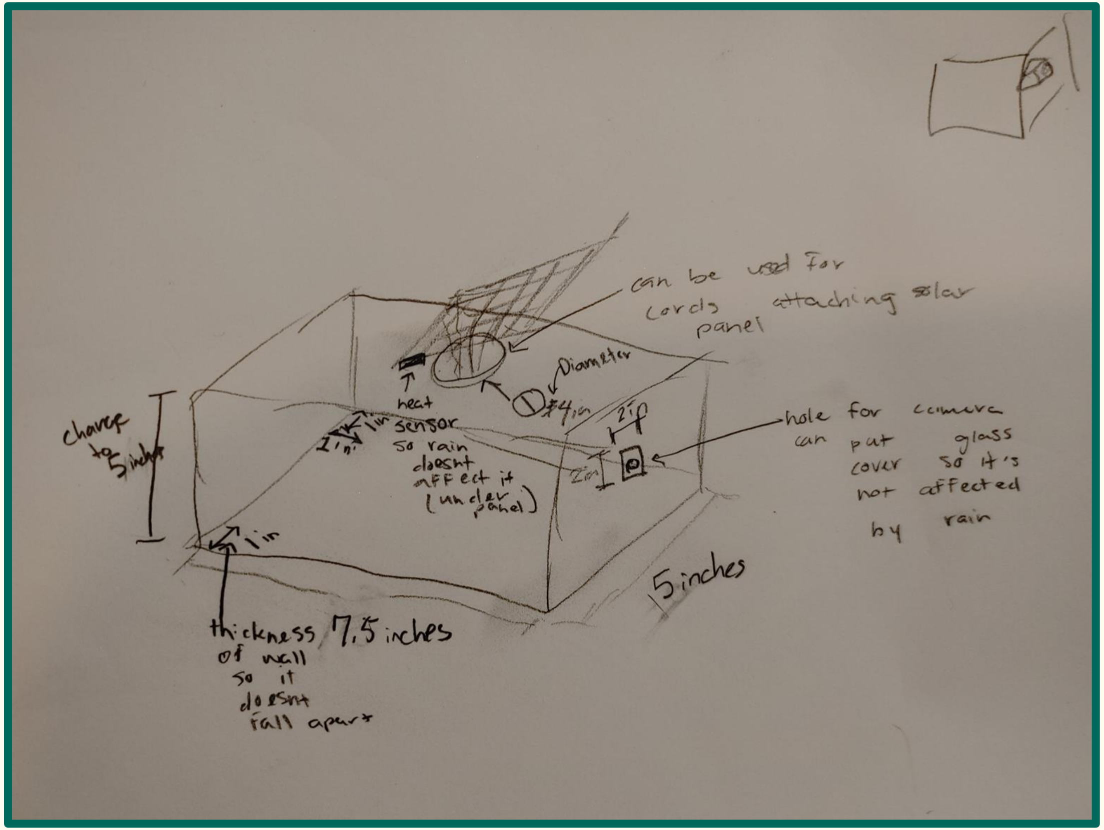
- **Prototype 2**
  - Wiring the sensors to the Raspberry Pi
  - Find and use Python code for heat detection and upload to Raspberry Pi
  - Find and use code for time lapse photo capture
  - Test code / make edits to ensure the code works
- **Data collection**
  - Data was collected using a fire pit as the fire source.
  - Tested the prototype for temperature detection over a 25 foot span. In Trial 1 the device was moved 5 feet away from the fire every minute. To test consistency I then moved it back 5 feet every minute in Trial 2.
  - Tested the Camera range / distance to determine how far the camera can see smoke
  - I recorded my data to make sure the prototype works efficiently
  - I will test methods of data transmission.

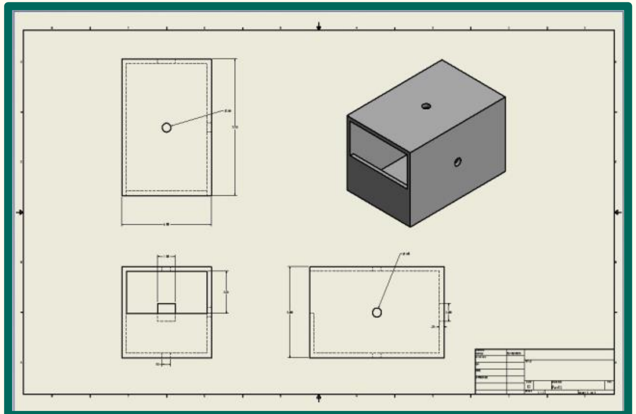
Prototype 1 Design Arduino Based system

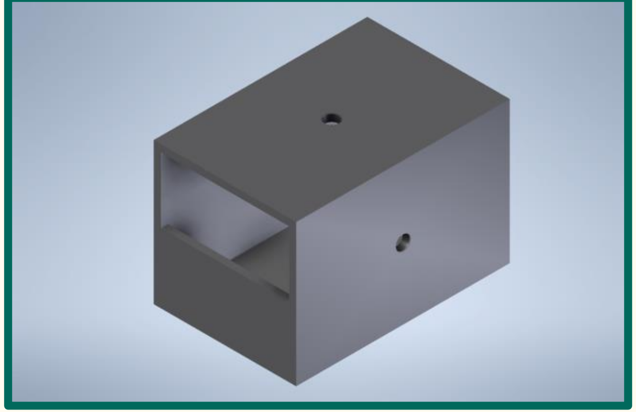
My first prototype involved building around a Arduino system. I studied the programing books but struggled to make the sensors work. After doing more research I learned there was more programming support for Raspberry Pi's and the sensors were interchangeable.



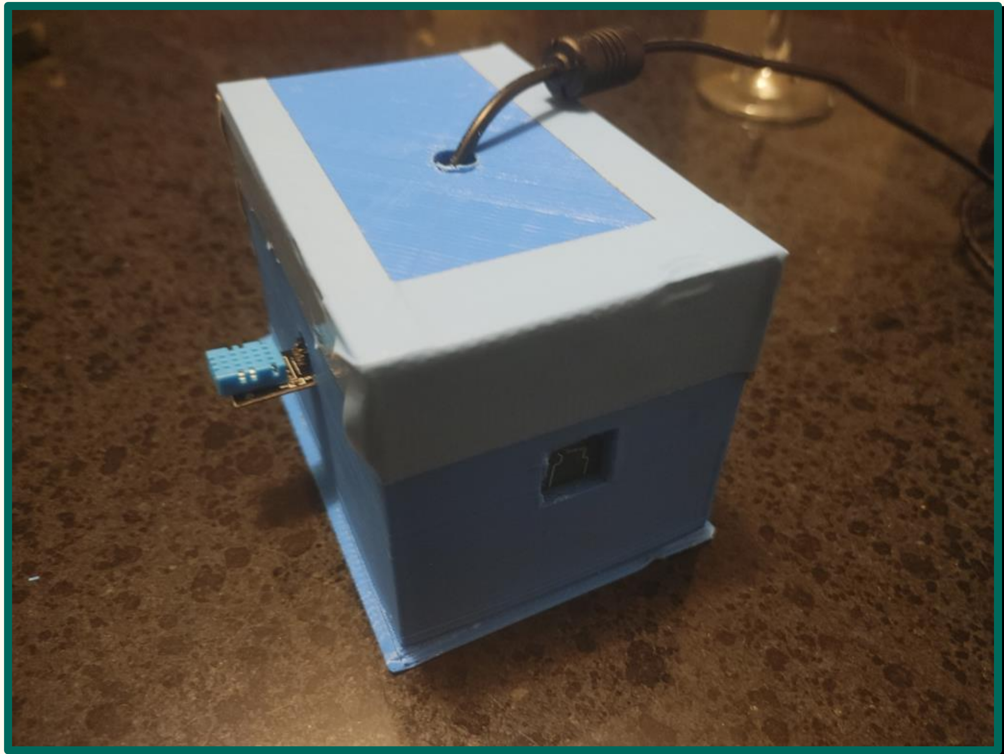
Prototype 2 Design(Box that holds the system)







Final version of Prototype 2



The image shows the final version of the design/prototype. I ended up using a raspberry pi and mostly the same sensors as the first prototype. The box to hold the system was 3d printed. It was made so that the camera could have a window for sight. There are holes for cords like the solar panel and raspberry pi. Even though it’s not in the image there's a hole on the bottom so that in the future I can put the hole system on a pole that spins. This means their will be images of everything around since it will be able to turn 360 degrees.

Experiment 1 - Identifying Smoke

The first experiment I did, once I had finished completing and uploading the code, involved testing how well the camera could capture smoke. The system I designed takes a photo every 10 minutes, however for this experiment I modified the code so that it took a photo every minute. This allowed me to speed up the process while still testing the range. As you can see from the photo of smoke from a campfire many feet away, the camera works pretty well. It was fairly easy to spot the smoke from the images. I also would like to note that the fire I used in the experiment is a small campfire, and the fire that this system protects against would be much larger and easier to see. I would say that overall the camera worked extremely well. Also, I believe that this camera can show distances much further than where the fire was. If you look closely at the photo you can even see that details of the clouds miles away. This suggests that the camera range stretches super far.

Experiment 1 - Identifying Smoke

Experiment 2 - Trial 1: Identifying Temperature Change

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Python 3.5.3 (default, Apr  5 2021, 09:00:41)
[GCC 6.3.0 20170516] on linux
Type "copyright", "credits" or "license()" for more information.
>>>
============ RESTART: /home/pi/dht11-raspberrypi/dht11_example.py
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Temp: 21 C Humid: 38 %
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This second experiment involved testing the temperature and humidity sensor to see how well it worked. This first trial was tracked by moving the system back 5 feet from the fire after a minute. I did this for 5, 10, 15, 20, and 25 feet. Like I said with the camera the fire used was a small campfire and a wildfire would produce much more heat.

Experiment 2 - Trial 2: Identifying Temperature Change

```
Python 3.5.3 (default, Apr  5 2021, 09:00:41)
[GCC 6.3.0 20170516] on linux
Type "copyright", "credits" or "license()" for more information.
>>>
============ RESTART: /home/pi/dht11-raspberrypi/dht11_example.py
============
Temp: 19 C Humid: 58 %
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Temp: 19 C Humid: 48 %
Temp: 19 C Humid: 51 %
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Trial two of the second experiment was testing it moving the system from far away and getting closer to the fire. I used that same distances but I went from 25 feet to 0 feet away. The results were similar to the first trial there were only a few degrees of temperature change.

Experiment 2 - Identifying Temperature Change

The results showed a 5 degrees(celsius) of temperature change. Also, the other measurement the systems sensor tracks is humidity. During the trial the humanity went up and down but tended to get lower percent wise when closer to the fire. To sum it up this temperature sensor works, but not as well as the camera and is not as accurate. With that being said it still could be helpful data for this system. In the future I will evaluate the system and more specifically the sensor to see if there's any changes I can do to make to more accurate.

Challenges I faced while creating this system

Building this prototype came with a lot of challenges. One challenge that occurder was during trying to code the Arduino, I had little experience and coding it was extremely hard. I could not get the temperature sensor to work properly. My solution was to instead use a raspberry pi which I had a tiny bit more experience with, I found that coding that was much easier for me with the raspberry pi. Another challenge was coming up with the design. The reason this was challenging is because it needs to be able to support the system but not be to big and I also had to figure out what material to use. I decide 3d printing the box holder would be the best to use since I would have specific measurements so that it wasn't to big or small.

Future Works

- Evaluate the prototype design and find things that could be improved without affecting the cost too much.
- Determining additional usage for the system.
- Coding the system so that data can be transmitted and the information from it can be received. I would also need to delete files that got too big.
- Add solar panel to the prototype so that it is self sufficient.
- Find a way to connect the raspberry pi to the internet.

Abstract

The problem addressed in this project is very important especially right now, as I previously stated many people each year lose their lives and homes to fires. Also, because of other factors the wildfires are getting worse. When the fires get worse, they cost more, more people lose their homes, and it destroys the trees. I decided my solution was going to be creating a prototype that works well, is self-sufficient and built from affordable materials. I obtained my results and finished most of the building for the prototype. My next step is to add the solar panel and figure out how to transmit data so that my prototype is completely finished.

Sources

DHT11 Temperature Sensor and Adruino System - Purchased at Amazon.com

MQ2 Gas Sensor - Purchased at Aliexpress.com

IQ firewatch - IQ Firewatch System (iq-firewatch.com)

Wildfire statistic - Vicki Stein, PBS New Hour, 8 numbers that tell the grim story of California's wildfires.

UN-SPIDER - The Global Early Warning System for Wildland Fires, UN Office for Outer Space Affairs.

The Geek Pub - Assistance programming the DHT11 Sensor

Raspberrypi.org - Assistance programming the PiCamera