WILDFIRE DETECTION SYSTEM

Mevin Ansa, Michael Zebe, Josh Hornsey, Kelli Templeton

SYSTEM AND SUBSYSTEM VALIDATION

20 November 2019

WILDFIRE DETECTION SYSTEM

Mevin Ansa, Michael Zebe, Josh Hornsey, Kelli Templeton

FULL SYSTEM VALIDATION

FULL SYSTEM VALIDATION

Method of Validation: We tested the full system by having it loop multiple times, checking the output string created by the microcontroller, ensuring that the sensor values are as expected, and checking that the values displayed by the website match.

Trial	Time	Output String from Microcontroller	Values as Expected	Display on Website
1	2:01	4000;1;23.4;1;42.2;1;0;1;0;1;0;1;63.9;30.6;-96.7;0;0;0;0	Yes	Correct
2	2:06	4000;1;23.6;1;42.8;1;0;1;0;1;0;1;53.2;30.6;-96.7;0;2;0;0	Yes	Correct
3	2:11	4000;1;24.1;1;43.4;1;1;1;0;1;0;1;40.1;30.6;-96.7;0;0;0;0	Yes	Correct
4	2:16	4000;1;23.6;1;42.7;1;0;1;1;1;0;1;0.00;30.6;-96.7;1;0;0;0	Yes	Correct
5	2:21	4000;1;23.4;1;44.1;1;0;1;0;1;1;1;0.00;30.6;-96.7;0;0;0;1	Yes	Correct
6	2:26	4000;1;23.4;1;43.2;1;1;1;1;1;1;1;99.9;30.6;-96.7;0;2;0;0	Yes	Correct
7	2:31	4000;1;23.7;1;42.7;1;0;1;0;1;0;1;99.9;30.6;-96.7;0;0;0;1	Yes	Correct
8	2:36	4000;1;24.2;1;41.3;1;0;1;0;1;1;1;99.9;30.6;-96.7;0;0;1;0	Yes	Correct

FULL SYSTEM TIMING VALIDATION

Method of Validation: We tested the timing of the full system by measuring the process from start to finish, i.e. from the microcontroller reading values off the sensors to the data being displayed on the web application

Trial	Time (min:sec)
1	3:32
2	4:13
3	3:28
4	4:22
5	3:17
6	4:23
7	3:21
8	3:41

FULL SYSTEM START ON BOOT VALIDATION

Method of Validation: We tested the reboot functionality by restarting the ODROID, making sure that the script started successfully, looped successfully, and that the GSM module reset immediately upon reboot.

Trial	Main Script Start on Boot	GSM Reset at Start on Boot	Loop After Initial Run
1	Successful	Successful	Successful
2	Successful	Successful	Successful
3	Successful	Successful	Successful
4	Successful	Successful	Successful
5	Successful	Successful	Successful
6	Successful	Successful	Successful
7	Successful	Successful	Successful
8	Successful	Successful	Successful

WILDFIRE DETECTION SYSTEM

Michael Zebe

SENSOR SUBSYSTEM VALIDATION

RAIN SENSOR VALIDATION

Method of Validation: Incrementally added .10 ml of water to the surface of the rain sensor and checked the sensor output.

RAIN SENSOR VALIDATION	
Water Amount (ml)	Sensor Reading
0.10	0
0.20	0
0.30	0
0.40	0
0.50	0
0.60	0
0.70	0
0.80	0
0.90	1
1.00	1
1.10	1
1.20	1

REMOTE MODULE VALIDATION

Method of Validation: Set RF transmitter to transmit a high signal and checked to see if the RF receiver signal matched at increasing distances. The RF receiver signal was reset to low in between each trial.

REMOTE MODULE VALIDATION			
Distance (m)	RF Transmitter Signal	RF Receiver Signal	Accurate Transmission
2	1	1	Yes
4	1	1	Yes
6	1	1	Yes
8	1	1	Yes
10	1	1	Yes
12	1	1	Yes
14	1	1	Yes
16	1	1	Yes
18	1	1	Yes
20	1	0	No

FIRE SENSOR VALIDATION

Method of Validation: Incrementally increased the distance of the sensor from the large fire source by one meter and checked the sensor's output.

FIRE SENSOR	
Distance from Large Fire Source (m)	Sensor Reading
1	1
2	1
3	1
4	1
5	0
6	0
7	0
8	0
9	0
10	0

SMOKE SENSOR VALIDATION

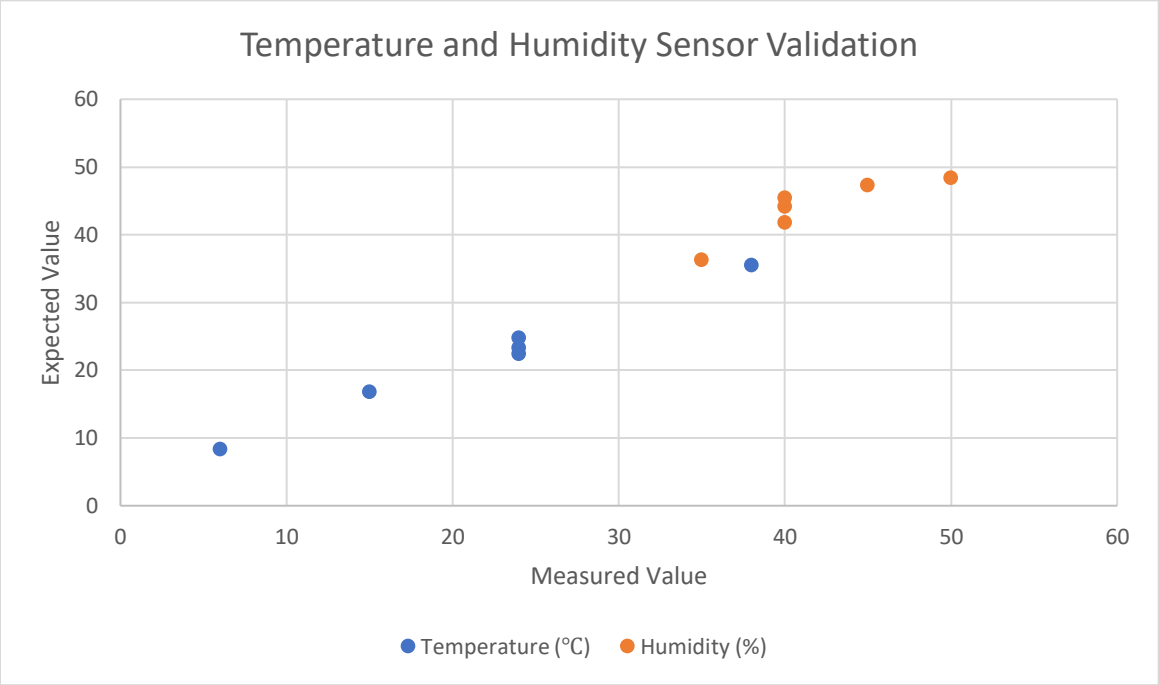
Method of Validation: Incrementally increased the distance of the sensor from the large smoke source by 0.25 meter and checked the sensor's output.

SMOKE SENSOR VALIDATION	
Distance from Large Smoke Source (m)	Sensor Reading
0.25	1
0.50	1
0.75	1
1.00	1
1.25	0
1.50	0
1.75	0
2.00	0

TEMPERATURE AND HUMIDITY SENSOR VALIDATION

Method of Validation: Placed the sensor in areas where the temperature and humidity were relatively controlled. Identified the expected temperature and humidity and compared it to the reading from the sensor.

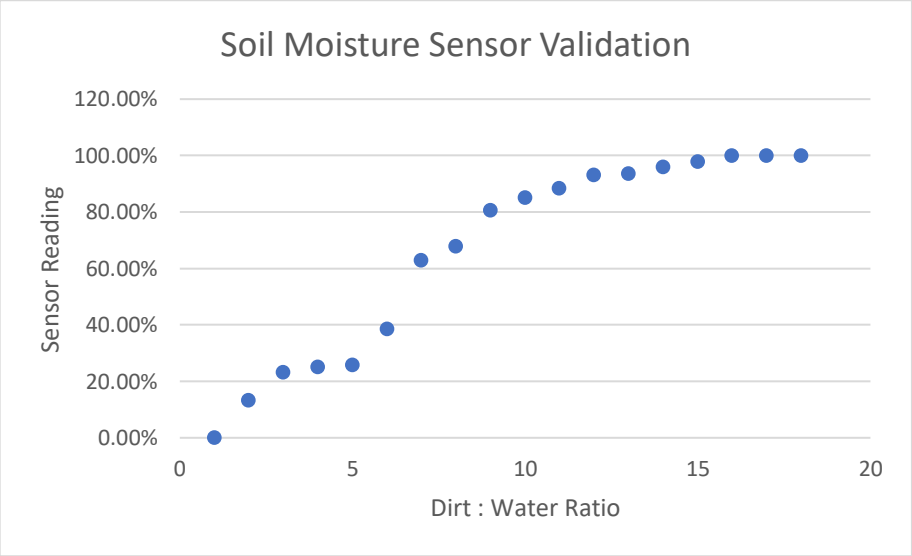
TEMPERATURE AND HUMIDITY SENSOR VALIDATION					
Expected Temperature (℃)	Measured Temperature (℃)	Temperature % Difference	Expected Humidity (%)	Measured Humidity (%)	Humidity % Difference
6.0	7.3	9.2	50.0	48.3	3.5
15.0	16.4	8.9	45.0	47.2	4.8
24.0	24.7	2.9	40.0	41.7	4.2
24.0	22.39	6.9	40.0	44.1	9.8
24.0	23.2	3.4	40.0	45.4	12.6
38.0	35.4	7.1	35.0	36.2	3.4



SOIL MOISTURE SENSOR VALIDATION

Method of Validation: Incrementally increased the amount of water in the cup of dirt that the sensor was placed in and checked the sensor's output

SOIL MOISTURE SENSOR VALIDATION	
Dirt : Water Ratio	Sensor Reading
30:0	0.00%
30:1	13.20%
30:2	23.10%
30:3	25.10%
30:4	25.90%
30:5	38.60%
30:6	62.90%
30:7	67.90%
30:8	80.60%
30:9	85.14%
30:10	88.50%
30:11	93.05%
30:12	93.70%
30:13	95.89%
30:14	97.90%
30:15	99.90%
30:16	99.90%
30:17	99.90%



COMPONENT INPUT VOLTAGE VALIDATION

Method of Validation: Measuring the input voltage of the system's components and comparing it to the expected voltage.

COMPONENT INPUT VOLTAGE VALIDATION		
Component	Expected Input Voltage (V)	Actual Input Voltage (V)
Rain Sensor	5	5.04
Fire Sensor	5	5.04
Smoke Sensor	5	5.04
Temperature /Humidity Sensor	5	5.04
Soil Moisture Sensor	3.3	3.28
RF Receiver	5	5.04
GSM Module	5	4.75

ADDITIONAL SUBSYSTEM VALIDATION

GPS VALIDATION:

- Highly dependent on satellite view count (maximum 7.8 meters)
- During testing, measured latitude and longitude matched expectation based on Google Maps dropped pin

POWER SUPPLY VALIDATION:

- Remote fire sensor powered via 4 AA batteries
  - Initial Voltage Level → 6.04 V
  - Partially Drained Voltage Level → 5.85 V
  - Fully Drained Voltage Level → 4.8 V

DC-DC CONVERTER VALIDATION:

- Input Range 4.5 V – 6 V
- Measured Output Voltage 3.33 V

WILDFIRE DETECTION SYSTEM

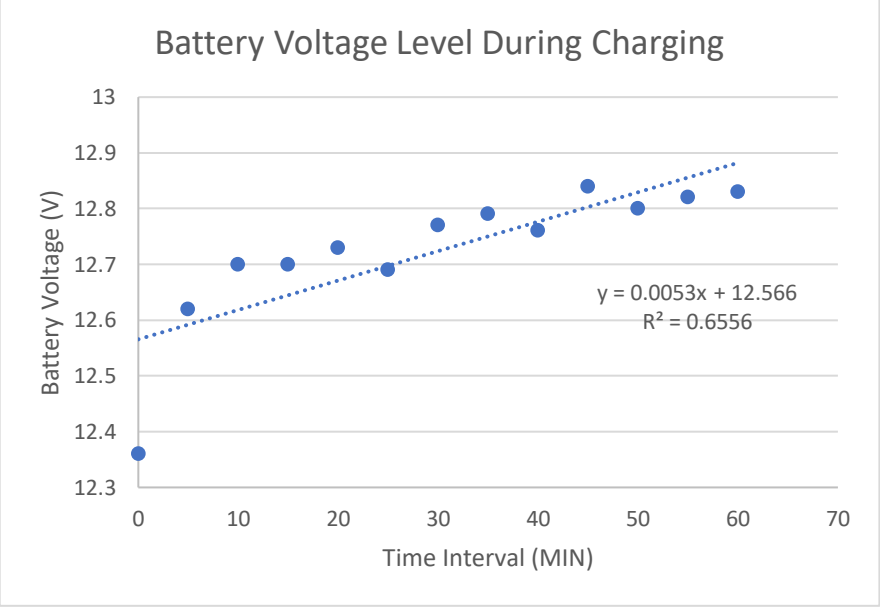
Mevin Ansa

POWER AND MICROCONTROLLER SUBSYSTEM VALIDATION

SOLAR PANEL VOLTAGE OUTPUT VALIDATION

Method of Validation: Measured the voltage output of the charge controller every 5 minutes for an hour while the solar panel was charging the battery. The solar panel was set in direct sunlight at a 20° angle. The voltage was measured in parallel with the battery terminals.

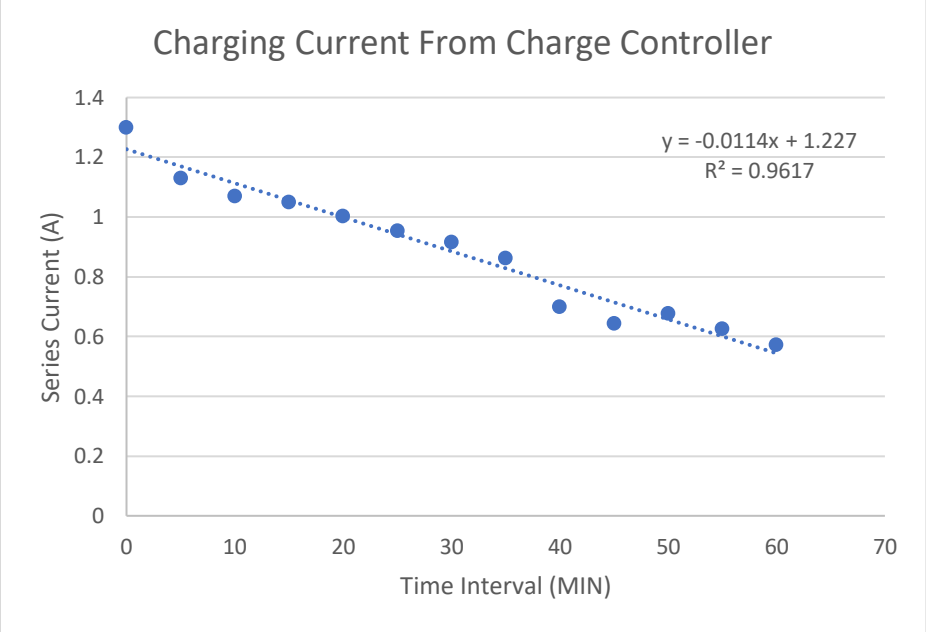
Time (MIN)	Voltage (V)
0	12.36
5	12.62
10	12.7
15	12.7
20	12.73
25	12.69
30	12.77
35	12.79
40	12.76
45	12.84
50	12.8
55	12.82
60	12.83



SOLAR PANEL CURRENT OUTPUT VALIDATION

Method of Validation: Measured the current output of the charge controller every 5 minutes for an hour while the solar panel was charging the battery. The solar panel was set in direct sunlight at a 20° angle. The current was measured in series in the charging circuit.

Time (MIN)	Current (A)
0	1.3
5	1.13
10	1.07
15	1.05
20	1.003
25	0.955
30	0.917
35	0.864
40	0.699
45	0.644
50	0.678
55	0.627
60	0.573



ADDITIONAL SUBSYSTEM VALIDATION

BATTERY VALIDATION:

- Fully Charged Battery Voltage Output: 13 V
- Dead Battery Voltage Output: 11.4 V

DC-DC CONVERTER VALIDATION:

- Expected Voltage Input Range: 11.4 – 13 V
- Voltage Output for Expected Range: 5 V ± 25 mV

WILDFIRE DETECTION SYSTEM

Joshua Hornsey

IMAGE PROCESSING SUBSYSTEM VALIDATION

MODEL ACCURACY VALIDATION

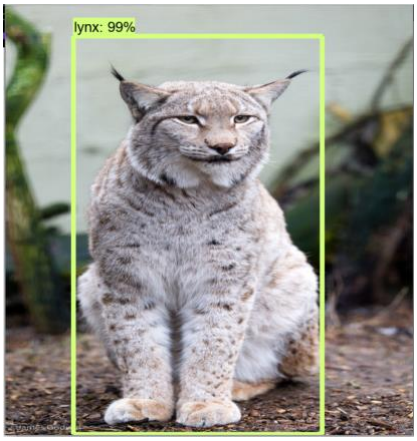
Method of Validation: In order to validate the object detection model's accuracy, I took 400 images and put each one through the model and calculated the percent difference and took the cumulative average.

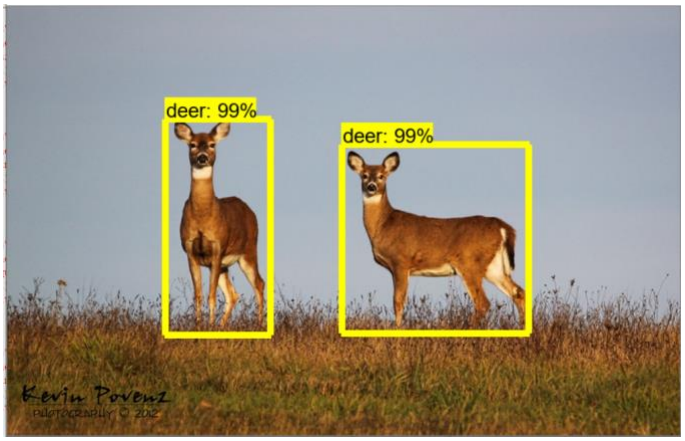
```
: print(acc)
```

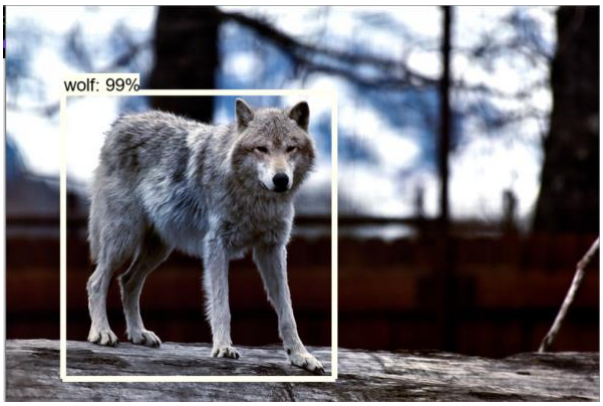
```
0.7903707513922598
```

ANIMAL CLASSIFICATION AND DETECTION VALIDATION

Method of Validation: For further validation, I found four good images for each of the four classes and ran these images through the model in order to demonstrate that it can classify bears, deer, lynx, and wolves and it can do multi-object detection.







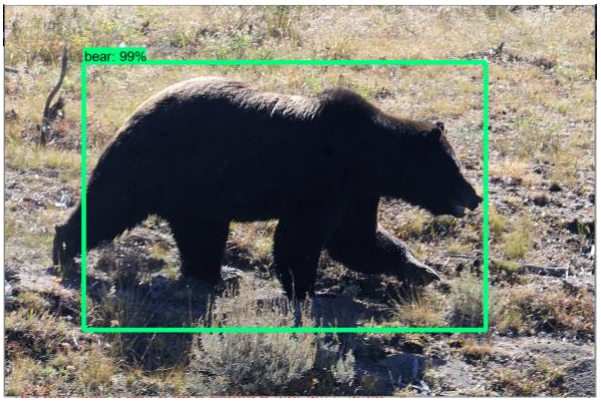


IMAGE PROCESSING MODEL IMPLEMENTATION VALIDATION

Method of Validation: To validate the image processing model implemented on the microcontroller with the camera, I ran the model on the ODROID for multiple trials and recorded the processing time.

Trial #	Image Processing Time (s)
1	42.3
2	41.6
3	45.4
4	38.9
5	40.6
6	46.6
7	39.9
8	47.1
9	43.4
10	44.2

CAMERA VALIDATION

Method of Validation: To validate the camera to the extent that I was able to, I placed the camera at different angles and distances away from a picture that I knew the model could identify accurately.

VERIFICATION OF IMAGE PROCESSING MODEL BASED ON CAMERA ANGLE		
Vertical Angle from Image Normal	Horizontal Angle from Image Normal	Accuracy
0°	0°	100%
30°	0°	50%
0°	30°	50%
30°	30°	50%
60°	0°	50%
0°	60°	50%

VERIFICATION OF IMAGE PROCESSING MODEL BASED ON DISTANCE	
Distance from Image (in)	Accurate Reading
1	No
2	No
3	Yes
4	Yes
5	Yes
6	Yes
7	Yes
8	No
9	No
10	No

WILDFIRE DETECTION SYSTEM

Kelli Templeton

USER COMMUNICATION SUBSYSTEM VALIDATION

GSM MODULE – USER'S CELLPHONE CONNECTION VALIDATION

Method of Validation: In order to validate this connection, I tested it with respect to distance by traveling various distances away from the GSM Module while ensuring that I had consistently good LTE signal (-76 to -90dBm) to only measure the effect of distance. I had the GSM module receive data indicating that there was a fire in order for my web application to send an alert message to my phone. I then checked the GSM logs and my SMS message logs in order to calculate the time elapsed.

Distance (mi)	Location	Power Level (dB)	Time to Receive (ms)
0	1811 George Bush Dr.	-81	1094
0.5	112 Redmond Dr.	-83	1103
1.0	1600 Glade St.	-77	1208
1.5	Commons	-88	1068
2.0	Evans Library	-78	1206
2.5	MSC	-76	1208
3.0	PEAP	-77	1189
3.5	Start-Up Aggieland	-83	1204
4.0	Gibb Gilchrist Bldg.	-86	1203
4.5	Easterwood Airport	-77	1443
5.0	Aggie Field of Honor	-85	1415
10	HEB North Texas Ave.	-84	1719

GSM MODULE – USER'S CELLPHONE CONNECTION VALIDATION

Method of Validation: In order to further validate this connection, I tested it with respect to signal strength. I did this by finding locations with different levels of cell strength, all 2 miles away from the GSM Module. I had the GSM module receive data indicating that there was a fire in order for my web application to send an alert message to my phone. I then checked the GSM logs and my SMS message logs in order to calculate the time elapsed.

Power Level (dBm)	Signal Strength	Time to Receive (ms)
-56	Excellent	1534
-64	Very Good	1774
-72	Good	1783
-94	Fair	1938
-102	Poor	2167
-118	No Signal	No Connection

DATABASE STORAGE VALIDATION

Method of Validation: I programmed the GSM Module to send a wide array of inputs to the MQTT Client to store in the database. I checked the Client's logs to see if it was able to store the information in the database. I then checked the database to see if the information was stored correctly.

	Device		Temp		Humidity		Rainfall		Smoke		Correct
Trial #	Expected	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected	Actual	
1	4444	4444	15.5	15.5	20.2	20.2	0	0	0	0	Yes
2	4000	4000	15.5	15.5	20.2	20.2	0	0	0	0	Yes
3	67	67	15.5	15.5	20.2	20.2	0	0	0	0	Yes
4	67	67	0.0	0.0	20.2	20.2	0	0	0	0	Yes
5	67	67	1.3	1.3	20.2	20.2	0	0	0	0	Yes
6	67	67	M	M	20.2	20.2	0	0	0	0	Yes
7	67	67	1.3	1.3	0.0	0.0	0	0	0	0	Yes
8	67	67	1.3	1.3	2.4	2.4	0	0	0	0	Yes
9	67	67	1.3	1.3	P	P	0	0	0	0	Yes
10	67	67	1.3	1.3	2.4	2.4	0	0	0	0	Yes
11	67	67	1.3	1.3	2.4	2.4	1	1	0	0	Yes
12	67	67	1.3	1.3	2.4	2.4	0	0	1	1	Yes
13	67	67	1.3	1.3	2.4	2.4	0	0	0	0	Yes
14	67	67	1.3	1.3	2.4	2.4	1	1	1	1	Yes
15	67	67	1.3	1.3	2.4	2.4	M	ERROR	M	ERROR	No
16	67	67	1.3	1.3	2.4	2.4	0	0	0	0	Yes
17	67	67	1.3	1.3	2.4	2.4	0	0	0	0	Yes
18	67	67	1.3	1.3	2.4	2.4	0	0	0	0	Yes
19	67	67	1.3	1.3	2.4	2.4	0	0	0	0	Yes
20	67	67	1.3	1.3	2.4	2.4	0	0	0	0	Yes
21	67	67	1.3	1.3	2.4	2.4	0	0	0	0	Yes
22	67	67	1.3	1.3	2.4	2.4	1	1	1	1	Yes
23	67	67	1.3	1.3	2.4	2.4	1	1	1	1	Yes
24	67	67	1.3	1.3	2.4	2.4	1	1	1	1	Yes
25	67	67	1.3	1.3	2.4	2.4	1	1	1	1	No

	Fire		Lat		Long		Animals		Correct
Trial #	Expected	Actual	Expected	Actual	Expected	Actual	Expected	Actual	
1	0	0	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
2	0	0	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
3	0	0	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
4	0	0	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
5	0	0	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
6	0	0	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
7	0	0	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
8	0	0	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
9	0	0	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
10	0	0	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
11	0	0	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
12	0	0	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
13	1	1	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
14	1	1	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
15	M	ERROR	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	No
16	0	0	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
17	0	0	M	M	21.3	21.3	4,4,4,4	4,4,4,4	Yes
18	0	0	0.00	0.00	21.3	21.3	4,4,4,4	4,4,4,4	Yes
19	0	0	1.2	1.2	21.3	21.3	4,4,4,4	4,4,4,4	Yes
20	0	0	36.3	36.3	M	M	4,4,4,4	4,4,4,4	Yes
21	0	0	36.3	36.3	0.00	0.00	4,4,4,4	4,4,4,4	Yes
22	1	1	36.3	36.3	21.3	21.3	4,4,4,4	4,4,4,4	Yes
23	1	1	36.3	36.3	21.3	21.3	0,0,0,0	0,0,0,0	Yes
24	1	1	36.3	36.3	21.3	21.3	1,2,3,4	1,2,3,4	Yes
25	1	1	36.3	36.3	21.3	21.3	M,N,O,P	ERROR	No

WEB APPLICATION VALIDATION

Method of Validation: I imitated all of the actions that a user could potentially perform and recorded my web application's response.

User Action	Website Response	Action Handled Correctly
User Logs in with Correct Password	User Routed to Home Page	Yes
User Logs in with Incorrect Password	User Receives "Invalid Password or ID" Message	Yes
User Logs in with Incorrect Username	User Receives "Invalid Password or ID" Message	Yes
User Registers with Correct Information	User Routed to Log In Page with Access to Log In	Yes
User Registers with an Email in Non-Email Format	User Receives "Invalid Email" Flag	Yes
User Registers with a Phone Number that is too Short	User Receives "Invalid Phone Number" Flag	Yes
User Registers with a Phone Number that is too Long	User Receives "Invalid Phone Number" Flag	Yes
User's Passwords Do Not Match	User Receives "Unequal Password" Flag	Yes
User Enters in Correct Device Number	User Routed to Entered Device Page	Yes
User Enters in Device Number that Does not Exist	User Receives "Invalid Device ID" Message	Yes
User Enters in Device of Another User	User Receives "Invalid Device ID" Message	Yes
User Enters in Number of New Device	User Routed to Entered Device Page	Yes
User Logs Out from Device Page	User Logged Out and Routed to Login Page	Yes
User Logs Out from Home Page	User Logged Out and Routed to Login Page	Yes
User Navigates to Home Page from Device Page	User Routed to Home Page	Yes
User Tries to Access Home Page without Logging In	User Routed to Login Page with "Please Access Page Flag"	Yes
User Clicks "Remember Me"	User Routed to Home Page when Accessing Website and Able to Access Device Data Without Logging In	Yes
User Navigates to User Help Page	User Routed to User Help Page where a User Manual PDF is Displayed	Yes
User Navigates to Home Page from User Help Page	User Routed to Home Page	Yes
User Logs Out from User Help Page	User Logged Out and Routed to Login Page	Yes

FIRE BEHAVIOR AND DANGER LEVEL PREDICTION VALIDATION

Method of Validation: In order to validate the correctness of the prediction models, I entered in varying values for all of the fields that the models use as inputs and viewed the output. I calculated the expected output and ensured that they matched

Trial #	Temp	Humidity	Wind Speed	Rate of Spread		CBI		Fire Danger Level		Correct
				Expected	Actual	Expected	Actual	Expected	Actual	
1	0.00	0.00	0.00	1	1	215.5	215.5	Extreme	Extreme	Yes
2	10.5	40.3	5.21	2	2	30.4	30.4	Low	Low	Yes
3	15.4	31.6	11.5	3	3	51.1	51.1	Moderate	Moderate	Yes
4	20.2	21.2	16.8	5	5	89.17	89.17	High	High	Yes
5	25.4	10.3	25.5	8	8	153.57	153.57	Extreme	Extreme	Yes
6	1.2	0.3	0.1	1	1	214.3	214.3	Extreme	Extreme	Yes
7	40.4	20.5	6.68	2	2	103.8	103.8	Extreme	Extreme	Yes
8	30.3	51.6	12.2	2	2	19.1	19.1	Low	Low	Yes
9	11.6	80.1	55.4	12	12	0.12	0.12	Low	Low	Yes
10	23.2	24.1	33.3	11	11	78.8	78.8	Extreme	High	Yes

WEB SERVER VALIDATION

Method of Validation: In order to validate that the public web server consistently hosts my webpage, I logged onto my web application at least a few days a week for the past month and checked its functionality. For a few of the checks, I restarted the server to ensure that it would continue to display my app if the server crashed and restarted.

Date	After Restart	Web App is Up	Web App is Functional
10/25	Yes	Yes	Yes
10/27	No	Yes	Yes
11/1	Yes	Yes	Yes
11/4	No	Yes	Yes
11/6	Yes	Yes	Yes
11/11	Yes	Yes	Yes
11/12	No	Yes	Yes
11/16	No	Yes	Yes
11/19	No	Yes	Yes
11/20	Yes	Yes	Yes

MICROCONTROLLER – GSM MODULE INTEGRATION VALIDATION

Method of Validation: In order to validate the serial connection between the microcontroller and GSM module, I wrote a script to send the GSM module a new string of expected values every 5 minutes and observed the string received by the GSM module. I also validated the new parsing script run by the GSM module by ensuring that the MQTT Client stored the values in the database correctly,

Trial	Time	String Sent from ODROID	String Received by GSM	Received by MQTT Client	Stored in Database Correctly
1	11:53	4000;1;26.7;1;75.4;1;0;1;0;1;0;1;77.7;33.3;-96.7;0;0;0;0	4000;1;26.7;1;75.4;1;0;1;0;1;0;1;77.7;33.3;-96.7;0;0;0;0	Yes	Yes
2	11:58	4000;1;26.7;1;75.4;1;1;1;1;1;1;1;77.7;33.3;-96.7;0;0;0;0	4000;1;26.7;1;75.4;1;1;1;1;1;1;1;77.7;33.3;-96.7;0;0;0;0	Yes	Yes
3	12:03	4000;1;26.7;1;75.4;1;1;1;1;1;1;1;77.7;33.3;-96.7;5;5;5;5	4000;1;26.7;1;75.4;1;1;1;1;1;1;1;77.7;33.3;-96.7;5;5;5;5	Yes	Yes
4	12:08	4000;1;26.7;1;75.4;1;1;1;1;1;1;1;77.7;-12.2;44.4;5;5;5;5	4000;1;26.7;1;75.4;1;1;1;1;1;1;1;77.7;-12.2;44.4;5;5;5;5	Yes	Yes
5	12:13	5;1;40.3;1;20.2;1;1;1;1;1;1;1;77.7;-12.2;44.4;5;5;5;5	5;1;40.3;1;20.2;1;1;1;1;1;1;1;77.7;-12.2;44.4;5;5;5;5	Yes	Yes
6	12:18	0;0;00.0;0;00.0;0;0;0;0;0;0;0;00.0;00.0;00.0;0;0;0;0	0;0;00.0;0;00.0;0;0;0;0;0;0;0;00.0;00.0;00.0;0;0;0;0	Yes	Yes
7	12:23	0;0;00.0;0;00.0;0;0;1;1;1;1;1;00.0;00.0;00.0;0;0;0;0	0;0;00.0;0;00.0;0;0;1;1;1;1;1;00.0;00.0;00.0;0;0;0;0	Yes	Yes
8	12:28	0;0;00.0;0;00.0;0;0;1;1;1;1;1;00.0;00.0;00.0;1;1;1;1	0;0;00.0;0;00.0;0;0;1;1;1;1;1;00.0;00.0;00.0;1;1;1;1	Yes	Yes