Sensor Network Forestry Fire Detection System

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Background

- The National Interagency Fire Center's (NIFC) reported a total of 58,733 wildfires across the country that had burned more than 7.13 million acres. This brings the average year-to-date ration was 61,524 fires burning 7.47 million acres[1].
- Year after year, it has become widely known that there now exists a fire season in California.
- Such frequent wildfire causes a rise in greenhouse gases that eventually lead to global warming.
- Among various techniques to detect wildfire, towers equipped with sensors are considered one of the cost-effective and accurate techniques.
- We present a research project on a forestry fire detection system sensor network, specifically within the programming aspect of the project.
- We are able to achieve a sensor network forestry fire detection system by utilizing a Raspberry Pi, Python, and multiple other sensors.

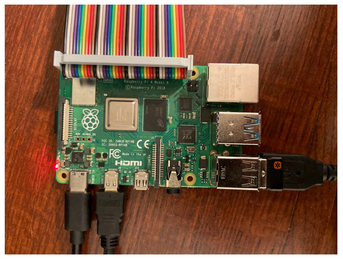

Figure 1: Raspberry Pi 4

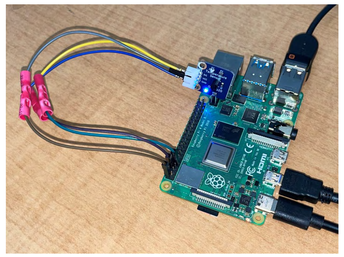

Figure 2: Temperature Sensor

Methods

Global Materials:
- Raspberry Pi 4
- 3 Female-to-Female jumper cables

Infrared Flame Sensor Materials:
- Infrared Flame Sensor

Temperature Sensor Materials:
- Temperature Sensor

Thermal Imaging Camera Materials:
- FLIR Lepton 3.5, 160x120, 57* with shutter
  - (Thermal Imaging Camera [T.I.C.])
- FLIR Lepton Breakout Board V2.0
- 8 Female-to-Female jumper cables

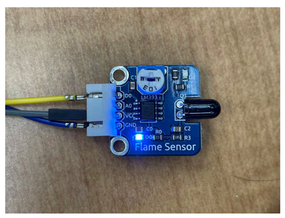

Figure 3: Infrared Flame Sensor

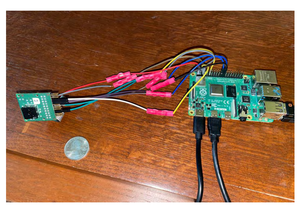

Figure 4: Thermal Imaging Camera

Flame Sensor:

- The Flame Sensor module detects infrared light with a wavelength ranging from 700nm to 1000nm[2].
- The far-infrared flame probe converts the strength changes of the external infrared light into current changes.
- First we connected the 3 plugs on the sensor to the Raspberry Pi
  - VDO to GPIO 4, the Ground to GND and the VCC to 5V[3].
- Then write an 18 line script within the Raspberry Pi application, Thonny Python IDE[3].
- Afterwards, save the script as a file, named "Flame", onto the Raspberry Pi within the Documents folder
- Now we can go to the terminal and type in "ls", "cd Documents", "ls", "python3 Flame.py"[3].
- Now that the program is running, when the sensor detects a flame, it lets us know by printing, "Flame Detected"[3].

Methods

Temperature Sensor:

- First we connected the 3 plugs on the sensor to the Raspberry Pi
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  - SIG to GPIO 21, the Ground to GND and the VCC to 5V
- Then write a 17 line script within the Raspberry Pi application, Thonny Python IDE.
- Afterwards, save the script as a file, named Thermal, onto the Raspberry Pi within the Documents folder.
- Now we can go to the terminal and type in "ls", "cd Documents", "ls", "python3 Thermal.py"[3].
- Now that the program is running, when the sensor detects a temperature over the specified value, it lets us know by printing, "Flame Detected"[3].

Thermal Imaging Sensor:

- Program by utilizing the Raspberry Pi Terminal
- The First step in getting the T.I.C. to work is to plug in the wires on the breadboard in their correct locations[4].
- After doing this we can connect the Raspberry Pi with the breadboard by utilizing the male to female GPIO ribbon cable 40pin[4].
- Then we plug the T.I.C into the breadboard[4].
- Afterwards, we download the program from GitHub and put it onto the raspberry pi[4].
- Ran into the issue of the Raspberry Pi system being on an outdated operating system.
- Updated to the Legacy operating system. Then could not access the internet.
- To solve this, we needed to set the correct date and time.
- Downloaded the LeptonModule file.
- Tried to open the file but got a hardware error message
- Rewired the camera to the Raspberry Pi, to by pass the breadboard.
- Then ran the code within the Terminal in order to open the Thermal Image[4].

Figure 5: Thermal Imaging Camera Hardware Error Message

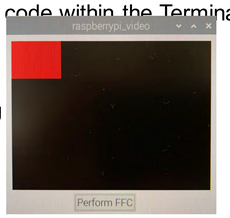

Figure 6: Thermal Image of person

Results

- The Flame sensor has a successful detection within a 16 inch range.
- The Temperature sensor works and detects a fire when over a specified temperature, 55 C (131 F).
- The Thermal Imaging Camera successfully displays the image on the screen.

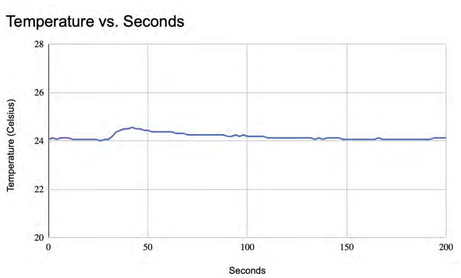

Figure 7: Temperature Vs. Seconds

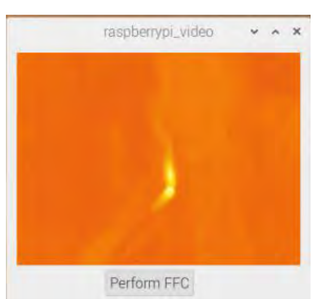

Figure 8: Thermal Image of Flame

Conclusion

- In conclusion, the Flame Sensor is capable of detecting fires within a 16-inch range.
- The Temperature Sensor is capable of detecting fires as soon as the temperature exceeds 55 °C (131 °F).
- The Thermal Imaging Sensor successfully displays the Thermal Image on the screen through the Raspberry Pi / Linux operating system.
- The display changes the color range depending on what is the hottest subject within the frame.

Future Work

- After the completion of this project, the fire detection system is to be utilized within a forestry environment.
- Not only this, but it is also necessary to have it become a part of a solar powered system.
- Additionally, it is going to be beneficial to combine this fire detection system with other fire detection systems, in order to have an increased level of accuracy.
- We plan to progress research on this project by discovering a superior method to program the Raspberry Pi in order to have an increased level of accuracy regarding fire detection.
- This will be done by combining the sensors to have a heightened level of accuracy.
- It will be important to move forward by writing a code that analyzes the Thermal Image and turns it into an array of temperatures.
- Then once a temperature is detected that exceeds a specific temperature, 65 C (150 F), it will inform us that a fire has been detected.
- This will help the Thermal Image be correctly processed through the Raspberry Pi / Linux operating system.

References

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3. https://learn.sparkfun.com/tutorials/flir-lepton-hookup-guide/all
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Acknowledgements

- Project supported by Project RAISE, U.S. Department of Education HSI-STEM award number P031C160152
- Project RAISER U.S. Department of Education HSI-STEM award number P031C2100118.
- Dr. Marianne Smith

Alternate text

Luke Esperiquette

CSUF- Project Raise

'Sensor Network Forestry Fire Detection System'

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References:
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