The Design and Implementation of an Integrated and Autonomous Fire Detection System (FireBot)

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The Problem

There are two main types of household fire: fast flaming fires, and slow smoldering fires. Smoke detectors are typically only optimized for detecting one of these types of fires and perform poorly in detecting the other type. In worst case scenarios, some smoke detectors have been found to only detect fire types they aren't optimized for after upwards of 30 minutes.

Fast Flaming and Slow Smoldering Fires

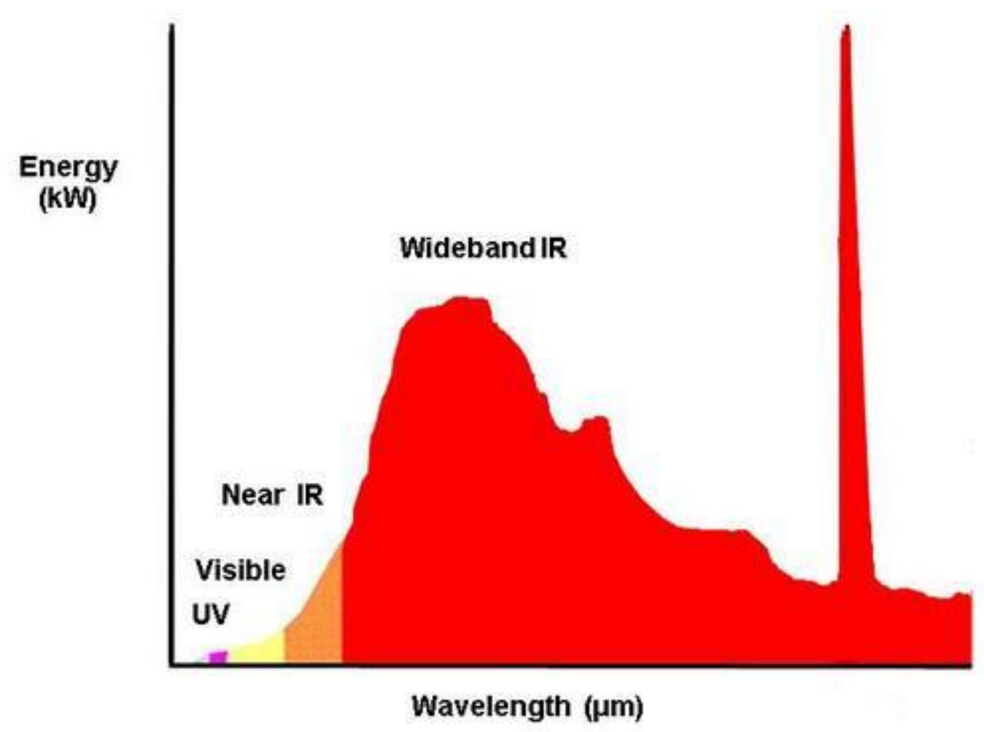
Objectives

Firebot has mainly two objectives:

1. Detect both fast-flaming fire and slow-smoldering fire using a camera, IR sensors, UV sensors, and a thermometer.

1. Notify the user in the case of fire by communicating via WiFi with user's personal device (I.e. PC, laptop, phone), and sending the type of fire and a picture of the fire.

Example Fire Emission Spectrum and Sensors Used

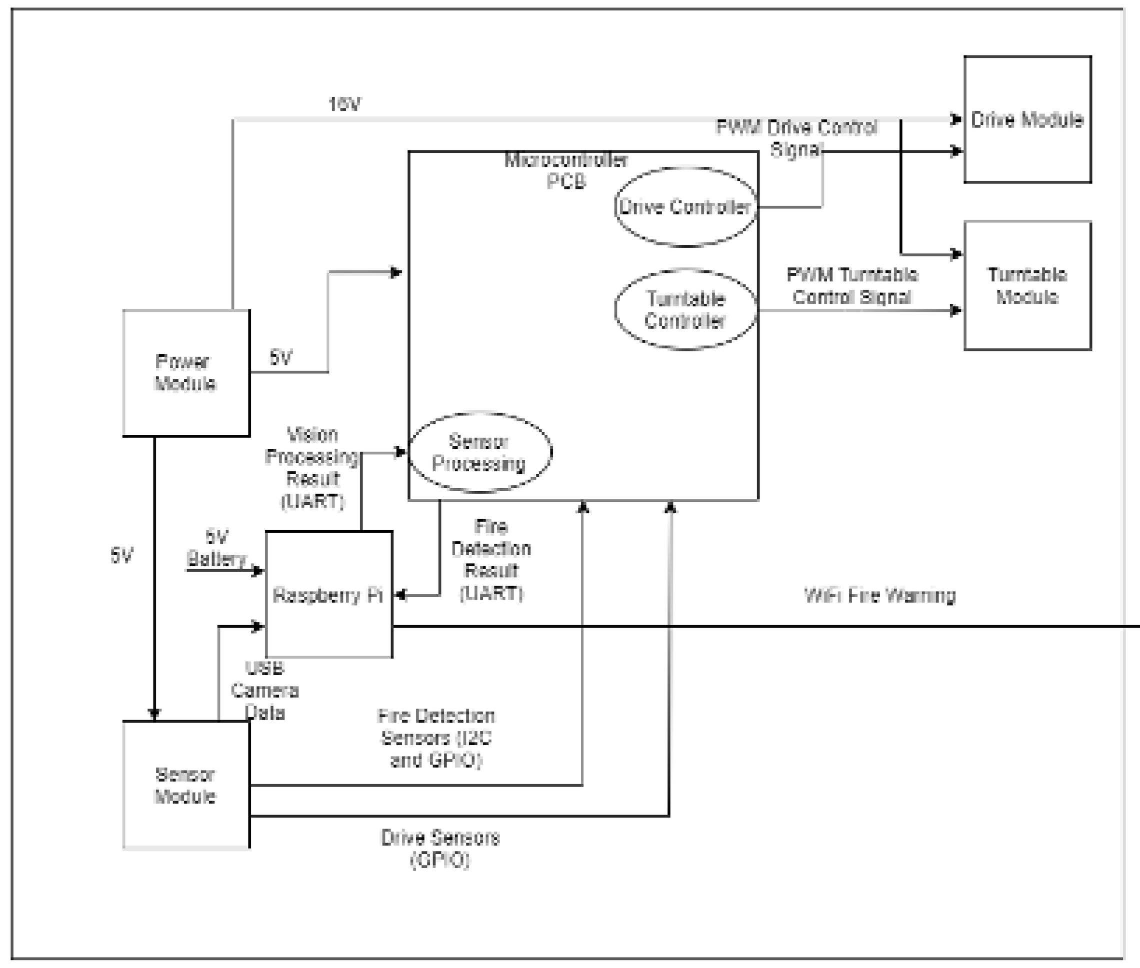


IR thermometer: MLX90614	
Voltage	4.5V - 5.5V
Temperature	-70C - 382.2C
Spot Ratio	1.25
Signal	I2C

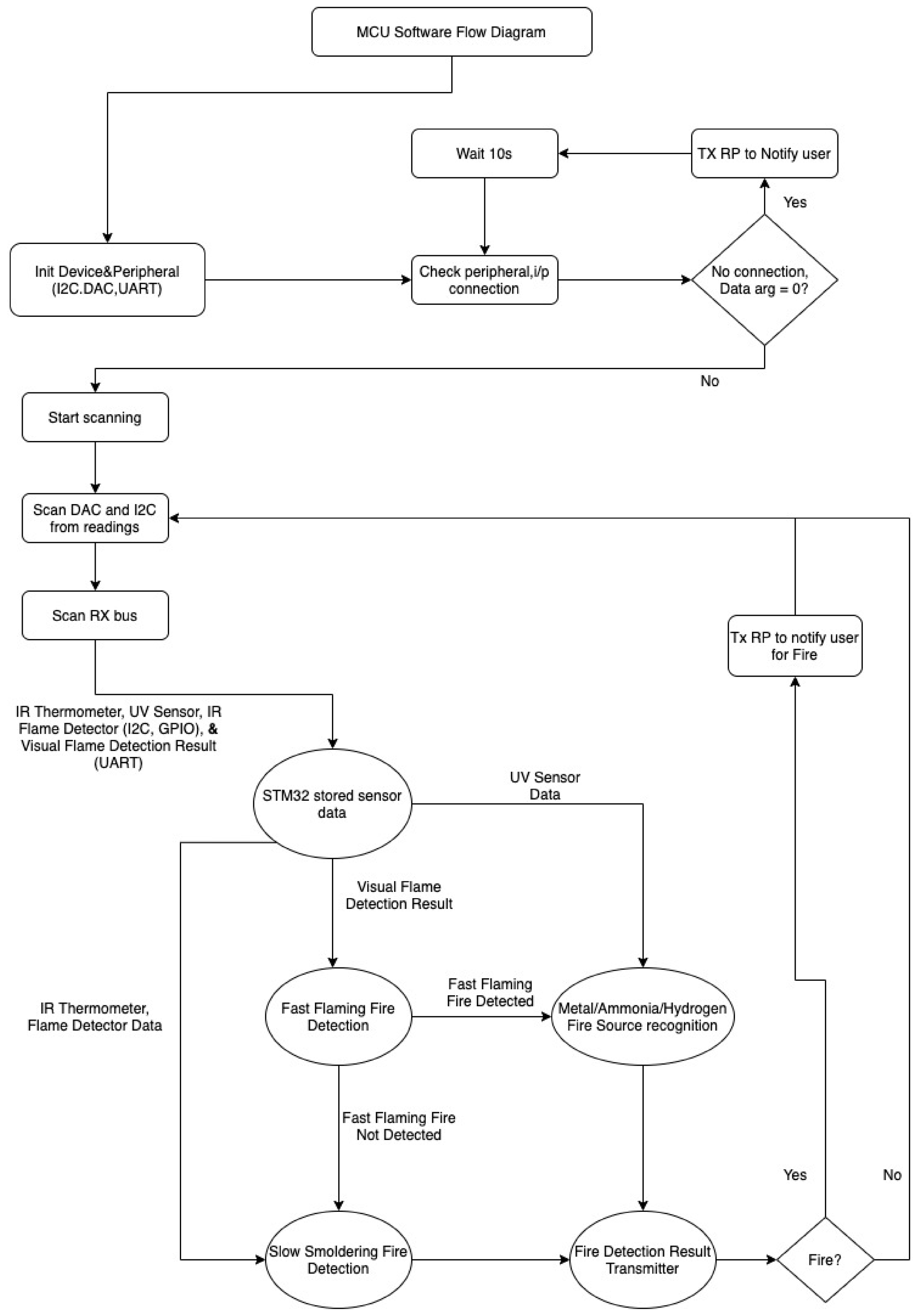
IR Flame Detector	
Voltage	3.3V - 9V
Wavelength	700nm - 1100nm
Distance	0.70m - 1.20m
Signal	Analog/Digital

UV Sensor: GUVA-S12SD	
Voltage	3.3V - 5V
Wavelength	200nm - 370nm
Signal	Analog

Functional and Software Diagrams



Functional Decomposition Diagram



Software Flow Diagram

Acknowledgements

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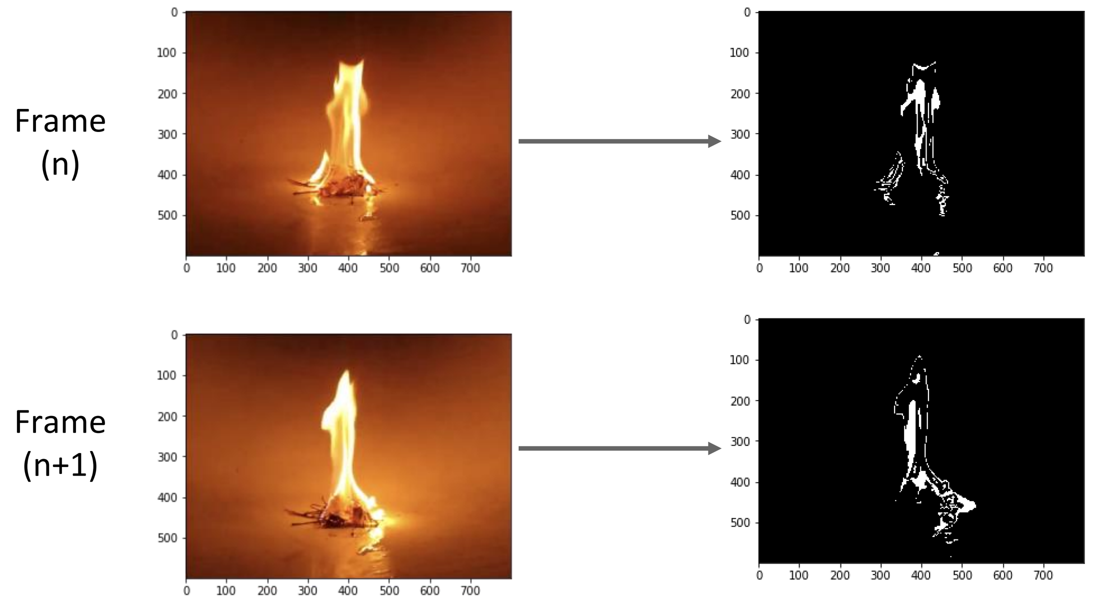
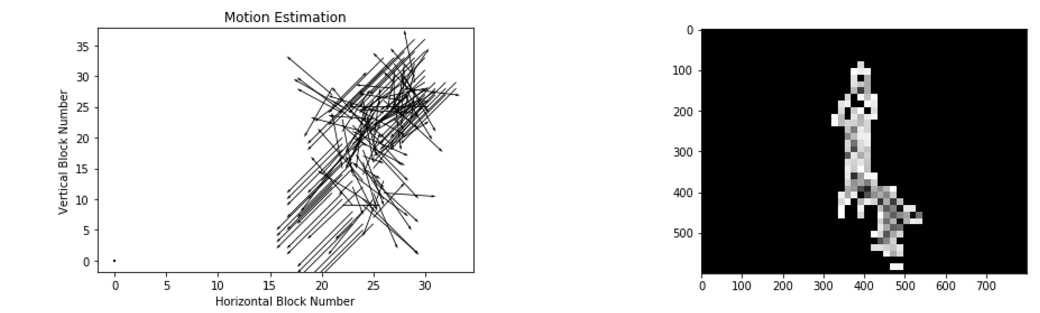
Visual Fire Detection

We implement the visual fire detection algorithm by Processing RGB pixel images to identify points of intensities and motion. This approach utilizes the YUV spectrum of an image to determine intensities, and threshold them to eliminate noise. We may, then, measure the motion in frame to evaluate the difference between different bright objects and distinguish fire. This can be summarized into two main steps:

1) Process two consecutive frames (n and n+1) into intencity points:



1) Estimate motion between both processed frames:



References

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- Kalpana, Y., & Padmaa, M. (2014). An efficient edge detection algorithm for flame and fire image processing. 2014 International Conference on Communication and Signal Processing. doi: 10.1109/iccsp.2014.6949932