Flame Detection : A Data Driven Approach

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Motivation

Fire monitoring and detection forms one of the key elements of any safety system. The purpose of a fire detector is to sense the presence of fire and provide the earliest warning possible such that appropriate actions can be taken to avoid/mitigate the damage caused. A variety of fire detectors are available in the market today based on technologies like smoke detection, heat detection, flame detection etc. A flame detector can often respond faster and more accurately than a smoke or heat detector and hence are widely used for detection of fire.The need for new and improved fire/flame detection algorithms is always justified by the need to lower the existing false alarm rates and to achieve greater sensitivity to the starting fires.

Problem

The problem statement given to us was to study the characteristics of the signals collected from the flame detector and design an algorithm maintaining a balance between the early warning issued during a fire outbreak and minimum false alarms. A total of 8 different signals (including AC and DC) were provided covering the spectral range from visual to far-infrared spectral bands.

The challenge in reliable flame detection arises because of the varied/changing ambient operating conditions like

presence of sunlight; presence of friendly fire—welding; presence of modulating /un-modulating light sources halogen lamp, strobe light; presence of heat radiating sources electric heaters etc. In addition to this, the success of flame detection is also governed by factors like size of fire, distance from fire source, field of view of the flame detectors installed etc.

Solution

We approached the problem by closely analysing each of the signals collected from the flame detector. All data sets from fire and false-fire sources were grouped and their characteristics were studied individually in different spectral ranges —visual, near-IR, far-IR etc. In case of false-fire sources, data sets were further sub-grouped based on the source of false-fire like sunlight, modulating light source strobelight, un-modulating light source —halogen lamp, sodium vapour lamp etc. Signal behaviour in presence of each of these false-fire sources were studied and characterized.

Algorithms were designed to detect and confirm the presence of flame based on principles like power spectral analysis, flicker frequency analysis, radiation intensity thresholds, correlation analysis etc. A completely data driven approach was used to get to the solution by exploiting the signal behaviour/pattern observed in the presence/absence of a fire source.

The algorithms developed were validated for their response time and immunity to false alarm sources on a variety of experimental data. This includes data collected with varied fire size, varied distance from the fire source, varied field of view of the fire detectors and data from varied false-fire sources.