Abstract

Development of a Modular Flame Detection System for Early Fire Detection in Large Areas

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The increasing occurrence of devastating fires worldwide, including forest fires and industrial fires, necessitates effective early detection systems. Existing technologies often fail to detect fires at their incipient stages or activate extinguishing systems promptly, highlighting the need for improved fire detection methods. This research focuses on addressing the limitations of current technologies by developing a modular flame detection system with high sensitivity and rapid response times.

Infrared (IR) and Ultraviolet (UV) flame detectors based on semiconductor technologies have shown promise in identifying potential fire hazards in critical areas such as fuel storage facilities and factories. UV flame detectors, in particular, offer shorter response times by detecting the electron avalanche induced by ionization of photo-cathode materials interacting with UV-C photons emitted from flames. These detectors are capable of detecting flames within the UV-C photon wavelength range, which is not significantly filtered by the atmosphere.

This work aims to construct a novel modular flame detection system capable of accurately pinpointing the coordinates and origin of flames, including sparks, in open or closed large areas, with a location error of 2-5m. The proposed system, consisting of 36 identical modules, combines conductive-coated UV-C transparent windows, high voltage applied anode wires, and photo-cathode vapor. Each module is responsible for a ten-degree circular field of view. The UV-C photons emitted from flames enter the modules through the detector windows and interact with the photo-cathode vapor, inducing an electron avalanche and generating a signal on the anode wire. The resulting signals from multiple modules allow for the determination of the flame's angular information relative to the detectors. These data are processed using embedded mathematical equations in microprocessors to produce accurate flame coordinates. Additionally, cameras placed on the modular detectors capture images of the flame's origin, which are then transmitted to relevant authorities.

The proposed modular flame detection system has the potential to significantly advance early fire detection capabilities in large areas, contributing to enhanced fire safety and prevention measures.