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ScienceDirect

Procedia Computer Science 105 (2017) 93 – 98

Procedia Computer Science

2016 IEEE International Symposium on Robotics and Intelligent Sensors, IRIS 2016, 17-20 December 2016, Tokyo, Japan

A Fuzzy Decision in Smart Fire and Home Security System

Kunal Kumar*, Navneet Sen, Sheikh Azid, Utkal Mehta

School of Engineering & Physics, Faculty of Science, Technology & Environment, The University of the South Pacific (USP), Suva, Fiji.

Abstract

There has been a major rise in the fire incidents occurring over the past few years in the Pacific Island Countries (PICs) and especially property fires are a major concern. Often it is noticed that these usually lead to loss of homes, personal belongings and even lives of people. Objective of this paper to present a monitoring device that is able to detect the presence of a gas leak and take action before there is an actual fire. To optimize the decision of the system, a fuzzy logic based smart rules are developed to avoid false alarming. The prototype system is designed considering cost, simplicity and reliability. Further, the proposed system helps to reduce fire accident by triggering alarm well-in advance and therefore it can react as an early warning system.

Peer-review under responsibility of organizing committee of the 2016 IEEE International Symposium on Robotics and Intelligent Sensors(IRIS 2016).

Keywords: Fuzzy decision; Safety device; Early warning system; Pacific Island Countries

1. Introduction

A lit cigarette, a burning lantern, an overheated electrical appliance or any of these can cause a fire [1]. Fire incidents hardly need a few minutes to make people helpless even before they realize what is happening. Similarly, a crime known as theft which is a general term embracing the massive variety of misconduct which also leaves a person improperly deprived of his property. Fire incidents and theft cases such as burglary and house breaking are both increasing in the households and office buildings in the Pacific Island Countries (PICs) and has become a major concern especially for the people of Fiji. The companies that deal with security systems offer products such as intruder alarm and fire alarm systems. The fire and intruder alarm systems that have been designed by these companies are highly sophisticated, expensive and both do not come integrated in one system. These systems require more

*Email address: kunalkkumar93@gmail.com

Peer-review under responsibility of organizing committee of the 2016 IEEE International Symposium on Robotics and Intelligent Sensors(IRIS 2016).
doi:10.1016/j.procs.2017.01.207

maintenance work which can only be carried out by authorized company personnel and causes delay with increase in costs.

Property fire incidents in the PICs, especially in Fijian households, are a disturbingly common occurrence. According to the National Fire Authority (NFA) of Fiji, there were over 1800 fire incidents in just year 2009 in Fiji alone [2]. Out of these, over 200 were property fires. While these numbers have reduced over the years, they still hover in the double to triple digits annually. With this, second issue which is a raising concern in the PICs is Burglary and House Breaking. According to the Fiji 2012 Crime and Safety report [3], the crime rate in Fiji is "HIGH" by the U.S Department of State which involves 2178 burglary cases and 7321 theft cases in the year 2012 [4] and the numbers are increasing.

Firstly, fire hazards and accidental fires are a serious concern in the Fijian communities and in the pacific nations in general, especially due to carelessness and lack of fire monitoring systems. According to the fire prevention handbook [5], most fires at home occur in the kitchen as a result of people being careless and getting distracted for some moments while cooking. As stated by National Fire Protection Association [6], 40% of house fires are caused by cooking related incidents. According to the statistics of NFA Fiji [7], about 90 cases of electrical fires are reported each day in Fiji which are mostly caused by overheating from circuit (wiring) and defective or worn out insulation. Not only houses but commercial buildings are also experiencing fires caused by fault in electrical wirings. According to Richard et al. [8], "the danger from smoke is a function of the toxic potency of the smoke and the exposure a person experiences to the (changing) smoke concentration and thermal stress over time they are in the vicinity of the fire".

Secondly, most robberies occur at night when everybody is sleeping or during the day when everybody is in school or at work and the house is left unattended. It was discussed in [3] that houses located near impoverished settlements have a higher rate of breaking and entering and burglaries. Usually most burglars are surreptitious and do not involve violence. However, some burglars do not hesitate in breaking and entering an occupied residence or office building with brandished weapons usually pocket knives, cane knives (similar to machetes) and iron rods. People who tend to engage in criminal activities are often jobless and impoverished [9, 10]. Despite of conventional solutions exist for the house and office fires and burglaries, are quite expensive and this is one of the key reasons why many houses do not install these units. In literature, a simple solution has been developed by Ravindran and Letchamanan [1], which comprises sensing devices like infrared smoke, thermistor heat and infrared sensors. The infrared smoke sensor detects the fire by sensing the smoke at its early stage mimicking the human sense of smell. The thermistor detects the temperature level of the environment and substantial increase in temperature would trigger the alarm. The infrared sensor is for intruder monitor which sounds the burglar alarm when it senses movement. All of these sensors are wired to a PIC 16 micro-controller, which is the brain of the system. This system is cost effective yet is a bit difficult for the end users to understand and carry out maintenance work.

The other existing solution using wireless sensor network for fire hazard detection and monitoring was proposed by Elias et al. [11]. In this system, a wireless sensor was embedded in a micro-controller board and controlled the fire monitoring system. Furthermore, few solutions were proposed utilizing the high end computing systems to monitor fire hazard. The concept is the same as above mentioned solutions but in this system there is less maintenance required; end user can communicate properly with the monitoring system via the computer, stores databases of incidents for future reference. However, this system was developed on 80C31 basic micro-controller [12]. Now, highlighting the second issue which was house and office building robbery, there are existing solutions such as, an intelligent wireless monitoring for home security designed by Jun Hou et al. [13]. A real-time surveillance for the home security was implemented using ZigBee technology and GSM network [14] which was incorporated the Pyroelectric Infrared Sensors (PIR) and ultrasonic sensors. In this embedded surveillance system, signals are triggered by majority voting mechanism. Generally, a PIR sensor detects the temperature changes in human and environment. To overcome the miss rate of PIR sensor, ultrasonic sensors are incorporated to compliment the PIR.

In this work, a user friendly but low cost solution for fire and home security system has been developed. The proposed embedded device is portable and easily adoptable. The application is extended with integrating GSM technology with three main subsystems; monitoring, detection and warning systems. A new decision system is tested with fuzzy logic decision maker to verify the actual threshold levels of fire and gas leaks. The system is first verified using Simulink models to illustrate the potential outputs in various conditions of inputs. A monitoring system incorporates flammable gases and smoke sensor (MQ-2) which constantly monitors the ambient atmosphere for any form of gas leaks or occurrence of smoke. There is a temperature sensor (TMP-36) which monitors the ambient