VISION BASED AUTOMATIC FIRE PROTECTION SYSTEM USING SPRINKLER

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ABSTRACT

This paper deals with building an application model of an automated fire protection system in an indoor environment. This model is a highly localized and targeted Fire Extinguishing system. The system consists of an arm which ends with the turret mounted with dispenser. An Infra-Red camera is used to detect the fire using the rays received and the processor inside the camera converts them into an image using various colours for different temperatures. The acquired image is then processed and the sources of heat are isolated. The position of the source of fire is mapped from the camera coordinates to the real world coordinates using a microcontroller and the turret is aimed at the fire by a targeting control system which triggers the servomotor used to move the turret. When the turret is targeted towards the center of the fire source, water is released using the sprinkler controlled by a solenoid valve. Thus the sources of fire in the field of view of the camera are suppressed.

Keywords: Indoor environment, Fire Extinguishing System, Sprinkler, Solenoid Valve

INTRODUCTION

Fire is useful to man only when there is a good control of it. Therefore, it is important to stay away when there is an emergency fire. To prevent or minimize the risks of fire there should be sufficient precautionary measures, such as, immediate warning and notifying the threat. Fire sprinklers are most effective during the fire's initial flame growth stage. A properly selected sprinkler will detect the fire's heat, initiate alarm and begin suppression within moments after flames appear. In most instances sprinklers will control fire advancement within a few minutes of their activation. This will in turn result in significantly less damage than otherwise would happen without sprinklers. Fire sprinklers remain the most reliable and cost-effective measure to reduce or prevent loss of lives and property. In a typical wet system, each fire sprinkler activates independently limiting the number of operating sprinklers to only those near the fire. A properly designed sprinkler system can contain or extinguish a fire before the fire department arrives resulting in less overall damage from smoke and fire. Besides their life property saving benefits, fire sprinkler design and installations can be an economic benefit. Compliance is intended to prevent injury, life loss and property damage. The standard requires at least 10 minutes of sprinkler water on the fire in its initial stage of development.

That controls the fire early, giving residents the time to escape safely and providing sufficient time to the fire department time to arrive. A typical home fire will be controlled and may even be extinguished by the time the fire department arrives. Fires are also fast, they can go from a tiny flame to total destruction in as little as two to three minutes. Fire sprinklers can suppress and often extinguish a fire before the fire department arrives, giving your family to escape. Including fire sprinklers in new home is a great idea that can save family members' lives. Surrounding rooms are protected from fire, heat and smoke damage. Fire sprinkler systems are typically designed to release water droplets of a carefully controlled size large enough to get to the core of a fire before they evaporate. The water flow is strong enough to drop the core temperature of the fire below sustainable levels, effectively dousing it before it has a chance to spread much beyond the point of origin. Fire sprinkler systems are designed to cover a certain range of space as well. The space is meant to be large enough to assure that the water distribution is large enough to effectively control a fire large enough to set off the system using only one sprinkler head. Typically, the water flow will continue until the fire sprinkler system is shut off by the fire brigade a precaution taken to make sure the fire is entirely controlled. The main objective of the project has to suppress the fire produced surprisingly in an indoor environment with a minimum number of sprinklers. The location of the hot spot has to be found from the acquired IR image. The turret in the sprinkler points towards the fire and operate the solenoid valve to open up the sprinkler. Thus the water flowing through the solenoid forces the sprinkler to extinguish the fire. This has been aimed at the pin-pointed area of fire either extinguishing it or keeping it under the control, unlike conventional fire sprinklers delivering water over the entire area and not at localized fire.

IMAGE PROCESSING

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. It is a type of signal dispensation in which input is image, like video frame or photograph and output may be image or characteristics associated with that image. Usually Image Processing system includes treating images as two dimensional signals while applying already set signal processing methods to them. An Infra-red camera is used to detect the fire and gives the image to be processed. Image Processing is done using MATLAB software. The area of fire to be maximum is found by processing the image by the separation of the RGB values. The larger area of fire is only suppressed by fire since it causes too many damages to the environment.

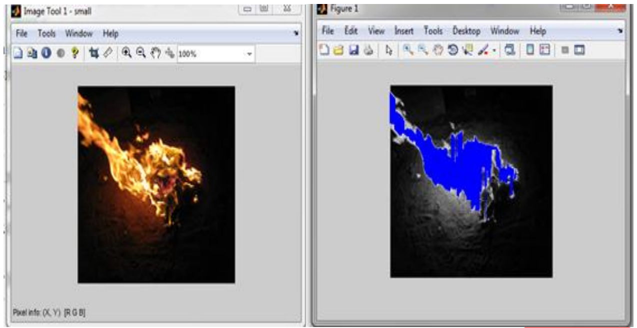

Fig 1.Separation of Fire

The detection and separation of fire is shown in fig 1. The source of fire is found based on the centroid in the separated area and the water is suppressed by the sprinkler.

DESIGN OF THE HARDWARE

1.1 Description

The hardware system of the sprinkler consists of pneumatically operated solenoid valve in which one end is connected to the reservoir system and the other end is connected to the stepper motor. Pendant type sprinkler system is used. An Infra-red camera is used for the acquisition of the image. It must be placed in order to get the maximum field of view. A circular disc for mounting this entire setup is used. The reservoir system and the discharge pump are used. The arduino microcontroller has been chosen for the controller system.

1.2 Proposed Design

The design of the entire system is done using the Pro-E software which was shown in fig 2. A circular disc with support on either side is placed on the top of the experimental box in which the controllers are placed. On the top of the disc, a rod is inserted in such a way that it is connected to the stepper motor for the disc to rotate in 360 degrees. Below the disc sprinkler system and the servo motor is connected through the rod. A shaft is inserted to the servo motor which is held by the bearing in which the sprinkler system is placed. The turret of the sprinkler is rotated by 180 degrees. Solenoid valve is placed above the rotating disc. One end of the valve is connected to the displacement pump and the other end is connected to the sprinkler system.

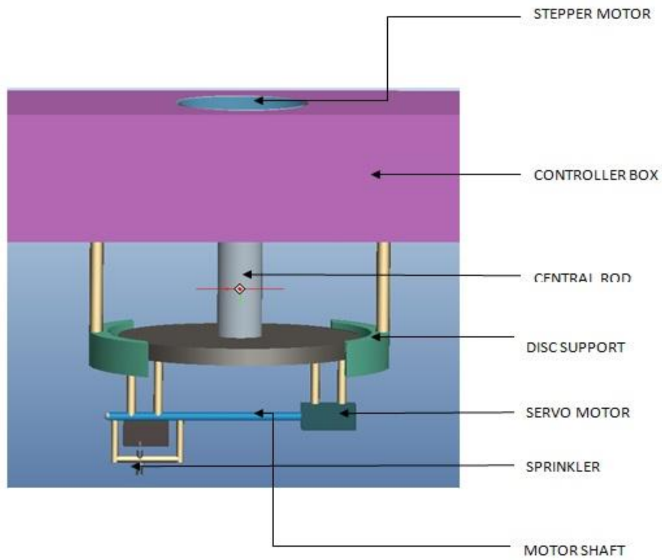

Fig 2.PRO-E model of the system

1.3 Principle of Working

In the case of no detection, the system enters scan mode. In this mode the turret slowly rotates its base 180° back and forth, quickly swinging the turret 180° in order to monitor the surrounding area. The speed of each actuator was adjusted considering the camera aperture and detection speed, the entire semi-sphere in range can be imaged in close to half a minute. When one or more points are detected, the control automatically switches to targeting mode optionally by turning the turret towards the hotspot. The water nozzle and the camera are aligned in such a fashion the water hits the region central to the image. When in targeting mode the points detected by the image processor are ordered by distance to the center of the image, then the two actuators are used to align the nearest point with the center, placing the source of detection right under the effect zone, within the reach of the water nozzle. Once the point is within the effect zone, a solenoid valve is activated releasing the fire extinguishing agent. The flow of the system is as shown in fig 3.

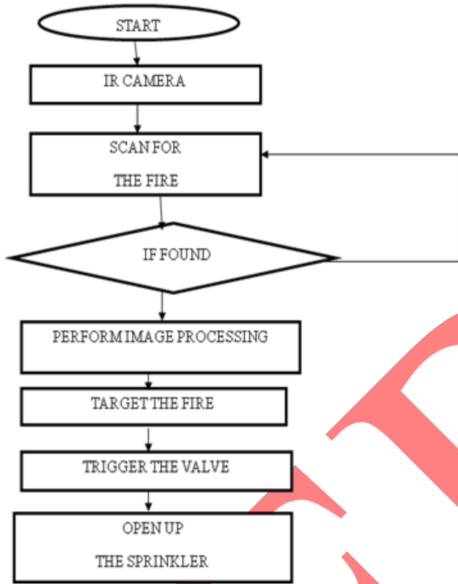

Fig 3.A Simplified Flow Diagram

1.4 Block Diagram

The block diagram of the system as shown in figure 4 consists of two parts, electronic circuits and pneumatic circuits. Electronic circuits consist of the controllers, IR camera and the sprinkler. The entire system is placed in the ceiling.IR camera keeps on monitoring the fire, captures the image and sends to the Pneumatic circuits consist of the reservoir, diaphragm pump for pumping the water and the solenoid valve for triggering is placed on the floor.

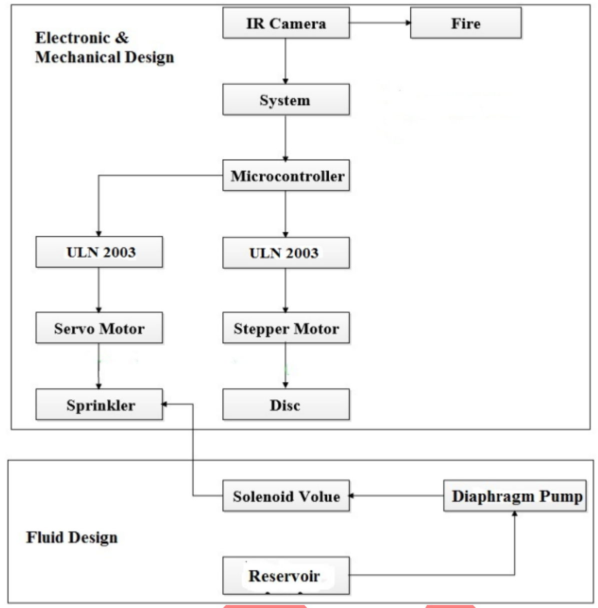

Fig 4.Block Diagram of the System

RESULTS AND DISCUSSIONS

1.5 Experimental Setup

The controller system where the program is loaded is shown in fig 5a. The whole setup is balanced with the help of this controller box. Below this the sprinkler setup placed is shown in fig 5b. A sprinkler is connected to the frame of the aluminium shaft.

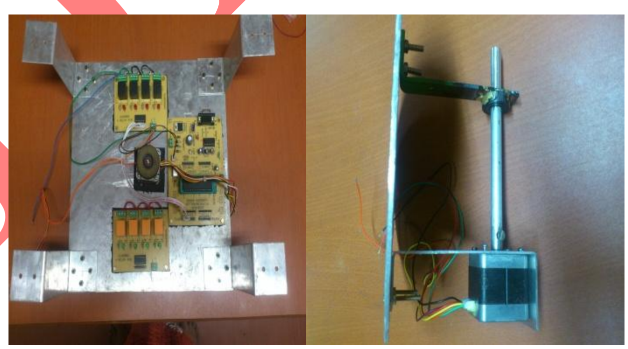

Fig 5.a)Controller Setup b)Sprinkler Setup

1.6 Calculation of Sprinklers

The pressure at the orifice of the sprinkler depends on the header of the source. In this project the source is the over tank whose vertical height is approximately measured as 12ft(144 inches).

27.71inchesH_2o=1psi 144inchesH_2o =5.20psi

$1kg/cm^2$=14.22psi

Therefore 5.20psi=$0.36kg/cm^2$≈0.5bar

According to NFPA,

If the pipe used is of half inch diameter, For a water pressure of 0.5bar and density of 5 litres/min per ft^2 .

One sprinkler is required for every $180ft^2$

The area taken for this project has dimensions of 12ft x 15ft ($180ft^2$).Hence one sprinkler is required for this project.

1.7 Limitations

Sprinkler system cannot be used in an open environment since the radiation of the sun may disturb the reception of IR rays from the fire. Requirement of water has to be clean and free from sand. The storage of flammable or combustible liquids is generally not allowed. Flue spaces between storage pallet loads within storage racks must be maintained. Electrical fires cannot be extinguished using the sprinkler system since it is water controllable.

CONCLUSION

In this project ,employed control systems and actuators as well as digital imaging to propose a new solution to an old problem. A prototype was assembled (presented in figure 2), demonstrating successfully the suitability of the proposed alternative to replace conventional fire sprinklers. Upon activation the water damage in minimized in opposition to the extensive water damage caused to electronic equipment, furniture, books and paperwork by conventional sprinklers. The numbers of sprinklers were reduced to a particular area. The tilting of the sprinkler can cover about a larger area which provides an additional advantage. The proposed model is expected to respond quickly in controlling fire thus having an outright advantage over other systems which are in use.

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