

Design of Automated Guided Vehicle System for Industrial Surveillance and Plant Safety

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Abstract - In an automated manufacturing industry, material handling is an unavoidable process. That requires proper and efficient material handling equipment. This paper deals with the possibility of the Automated Guided Vehicle (AGV) which is a material handling equipment, acting as a firefighting equipment too. According to most recent fire statistics from National Fire Protection Association (NFPA), an average of 37,000 fire accidents occur at industrial and manufacturing facilities every year. The main objective is to utilize scope of AGV in firefighting with an intelligent camera surveillance, a well programmed master controller and the AGV equipped with launcher and fire extinguisher ball. The master controller will get an input signal from the thermal image monitored by the camera surveillance regarding the fire accident in the plant and then it gives the output signal consist of route map to the nearest AGV with the source of fire outbreak. Then the launcher in the vehicle will shoot the fire extinguisher ball towards the fire till it extinguishes. The main advantage of this are there is no need of separate fire safety system, it can extinguish all classes of fires, it will normally perform the material handling works as per the program coded in the master controller. This will help to increase the work efficiency, quick response to fire outbreaks and indirectly confirms the plant's safety.

Key Words: Thermal Imaging Surveillance, Fire Detection, Master Control Unit, Automated Guided Vehicle, Fire Extinguisher Ball

1. INTRODUCTION

A master controller with a database containing information regarding the plant layout location in the plant, routes to reach each work station and other departments. It will be in contact with the thermal image monitoring surveillance cameras equipped in the plant. When fire is detected in any part of the plant these cameras will detect and send a signal regarding the location of the accident to the master controller. Master controller will make a decision on which AGV is to be employed to the accident site based on the distance between AGV and the target location. Once that decision is made it will send a signal to an AGV regarding its need for extinguishing fire and also the optimal route to reach the target location.

The AVG is equipped with an optical guidance system to reach the location and a fire extinguishing ball with a polymer cover encasing the Monoammonium Phosphate (Furex) which can be used for type A,B,C fire, a launcher to shoot the ball at the target point with higher accuracy, thermal sensors to detect the point. Once this AGV receives a signal from controller, it rushes to the location through the optimal route provided by the controller, sets the coordinates to shoot the ball by the thermal sensors and launches the ball. Considering the probability that fire may still persist in the location the cameras are made to continue sending signal to controller and controller to the other nearest AGVs till fire goes off. The findings of this research will enable the use of AGVs not only for material transporting but also to ensure the plant safety from fire accidents.

2. PROBLEM STATEMENT

A big fire broke out in a fertilizer plant in Nanning on December 2, 2014. In the accident, few tons of fertilizer were burnt out and the equipment were heavily damaged [1]. The main reason of the accident was lack of proper firefighting equipment inside the plant. So, the fire can't extinguish until the fire fighters arrived.

The main problems faced in the above incidents are late detection of fire outbreak, lack of proper firefighting equipment inside the plant. The fact which should be noticeable is that, the plant is equipped with camera surveillance and material handling is done by AGVs. Here the importance of this "Automatic Guided Vehicle System for Industrial Surveillance and Plant Safety" reveals. This system can utilize the camera surveillance and AGVs for fire detection and extinguishing process in response to the fire outbreak within less time.



Fig -1: Fire accident in fertilizer plant in Nanning

3. COMPONENTS

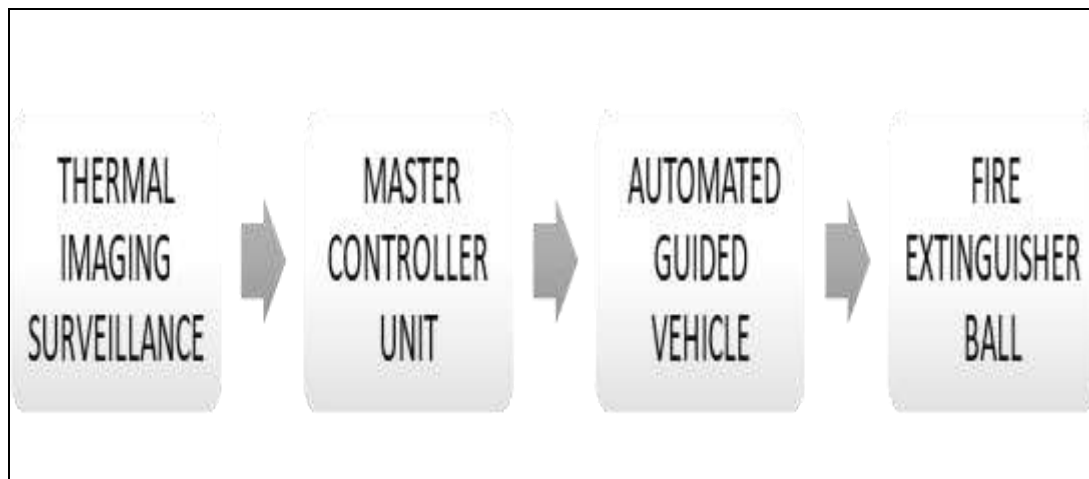


Fig -2: Components of Automated Guided Vehicle System for Industrial Surveillance and Plant Safety

3.1 Thermal Imaging Surveillance

The Thermal Imaging Camera Surveillance is equipped so that it can monitor each and every corner of the total plant. The real time images recorded by the camera processed using a thermal imaging software. This software can detect the fire accident by analyzing the temperature in every pixel of the snaps shot by the camera. If temperature of any pixel is more than the assigned value it is considered as a fire accident and initiate the process to extinguish the fire in the source itself. For that, the corresponding pixel where the fire detected will send to the master controller unit. The pixel value obtained from the thermal imaging software reveals the corresponding coordinates in the plant where fire accident occurs. Thus, it is easy to identify the exact location of the fire outbreak without any temperature sensor.

The Long-Wave IR falls between $8\mu\text{m}$ - $15\mu\text{m}$ and provides thermal data or heat map of the captured scene in quantified form representing temperature data of the same [2]. The fire outbreak can be identified by using the real time temperature tracking. [3]. Each pixel should represent the positional coordinate of the plant layout. This surveillance system can also track the position of AGVs which is equipped with blinking lights of different colors. For every color of LED, temperature produced will be unique so that we can track and distinguish easily.



Fig -3: Realtime Temperature Tracking

3.2 Master Controller Unit

The Master Controller unit is the brain of the plant. It decides the overall movement of the Automated Guided Vehicle (AGV). Normally the Master Controller aids the AGV to perform the material handling in the prescribed manner which is already programmed in it. It facilitates the AGV to perform the material loading, transportation and unloading. Whenever a fire accident occurs, it immediately stops the normal working of the plant and gives a safety alarm. Simultaneously master controller selects the appropriate AGV by tracking the position of each one and send the coordinates of the fire outbreak in the plant along with the route which has to be taken to reach there.

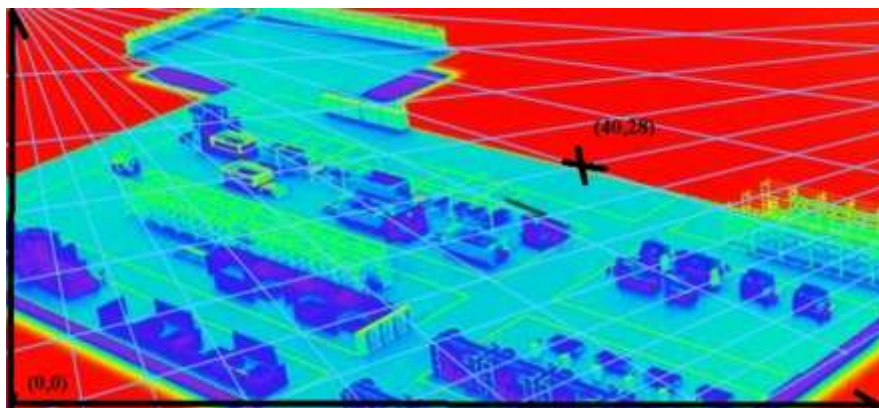


Fig -4: Mapping of Coordinates from Thermal Image

The surveillance system informs about the pixel where fire accident occurs to the control unit. Then it maps the corresponding coordinate of the plant layout and track the position of AGVs. After that it selects the appropriate vehicle and send the route map toward the source of fire.



Fig -5: Selection of Path

3.2 Automated Guided Vehicle

Automated guided vehicle (AGV) is used for material handling and fire extinguishing too. It consists of mechanical parts and electronic parts.

3.2.1 Overview of Mechanical Parts

- Vehicle body
- Basket holder
- Launcher
- Storage box

The vehicle body consist of chassis and four wheels. A basket holder is equipped to the vehicle for the material handling. An inbuilt launcher is used to shoot the fire extinguisher ball in a parabolic path. One or two extinguisher balls are kept inside the storage box.

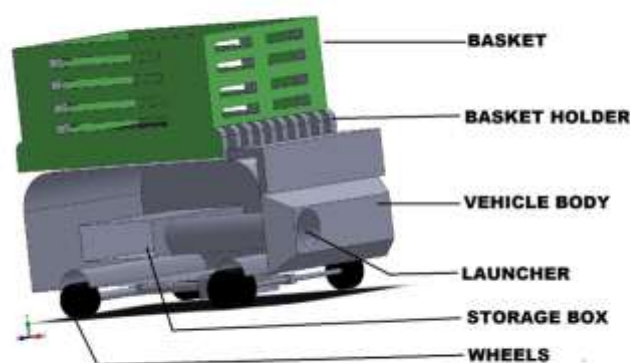


Fig -6: Design of Automated Guided Vehicle

3.2.1 Overview of Electronics Parts

Electronic modules consist of

- Microcontroller
- Motor
- Motor drives
- Thermal sensor
- Ultrasonic sensor
- Tachometer
- Transceiver

The AGVs can receive and transmit data from and to, to the master controller respectively through a transceiver module. Usually the master controller unit gives a predefined program for material handling to the AGVs. Whenever a fire accident occurs, it will stop the normal working of the plant and gives a warning alarm. Then the master controller selects the appropriate AGV and gives a well-defined path including the coordinates which has to be taken by the AGV to reach at the fire outbreak source.

The path guidance of vehicle is done by analyzing the speed and time. Speed of the vehicle is obtained from the tachometer equipped on the wheels. Thus, we can calculate the distance travelled. From the coordinates sent by the master control unit, the microcontroller inside the AGV will process the coordinates and gives the output to the motor drive such that it can reach at the destination. It will give the directions like first move this much distance (already calculated with the help of speed and time) then take right/left, thus it will cover all the coordinates from the master control unit and reach the destination. The ultra-sonic sensor helps to avoid obstacles.

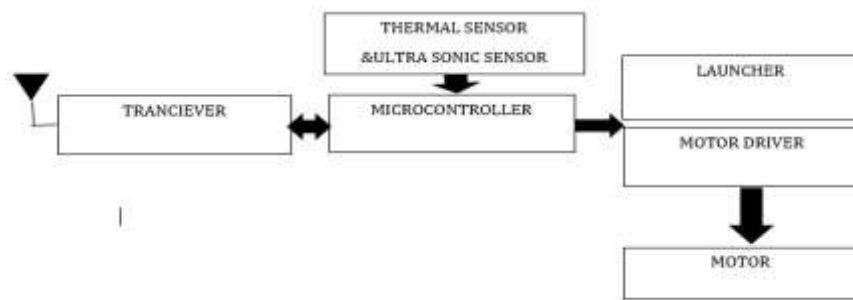


Fig -6: Overview of Electronics Components

Then the launcher will shoot the fire extinguisher ball to the fire from the predefined destination point according to the signal obtained from thermal sensor. This signal determines the range of shooting of the launcher.

The launcher consists of a rack and pinion. The rack is used to shoot the ball. It is attached with a helical spring which will extend when the rack moves in the backward direction. The backward movement is obtained by rotating the motor in clock wise direction coupled with pinion gear. Then the rack gets decoupled from pinion and it will shoot the fire extinguisher ball. The signal from the thermal sensor depends the backward extension distance of the rack and can adjust the shooting range. If the thermal sensor gives high temperature input then it will shoot only for less distance and vice versa.

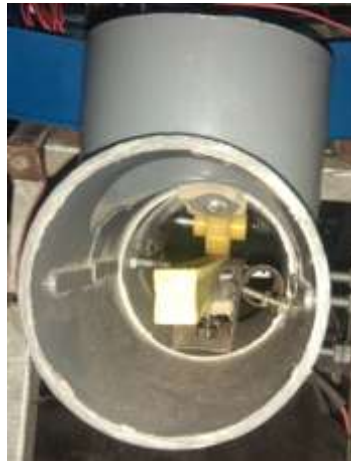


Fig -7: Launcher Prototype

3.3 Fire Extinguisher Ball

The fire extinguishing balls made by a foam casing wrapped in PVC. These products respond to heat and flames quickly, causing the triggers embedded in the unit to respond and disperse the dry chemical fire suppressant locked inside. To actively fight a fire, it must be thrown or rolled into the flames, where it will activate and spread a dry-powdered fire extinguishing agent. Mono ammonium phosphate is commonly used as a non-toxic alternative that extinguishes flames of Class A, B or C fires. They are also passively effective, without human intervention [4]. Advantages are it can extinguish all classes of fire, it doesn't harm human beings, self-activation and low cost.



Fig -7: Fire Extinguisher Ball

4. OVERALL PROCESS

Normally the AGVs carried out the material handling in predefined manner programmed by master controller. If any fire accident occurs, then thermal imaging camera surveillance detect the source of fire outbreak and it sent the pixel information to the master controller. The master controller will convert the pixel information to the coordinate information. And also selects the appropriate AGV with the help of tracking system. It would get the route which has to be taken from the master controller.

The AVG will reach the particular location. It is loaded with a fire extinguisher ball. It encased by a polymer casing and filled with the Monoammonium Phosphate (Furex) which can be used for extinguishing fire of type A, B, C. Once this AGV receives a signal from controller, it rushes to the location through the optimal route provided by the controller, sets the coordinates to shoot the ball by the thermal sensors and launches the ball. Considering the probability that fire may still pertain in the location the cameras are made to continue sending signal to controller and controller to the other nearest AGVs till fire goes off. The findings of this research will enable the use of AGVs not only for material transporting but also to ensure the plant safety from fire accidents.

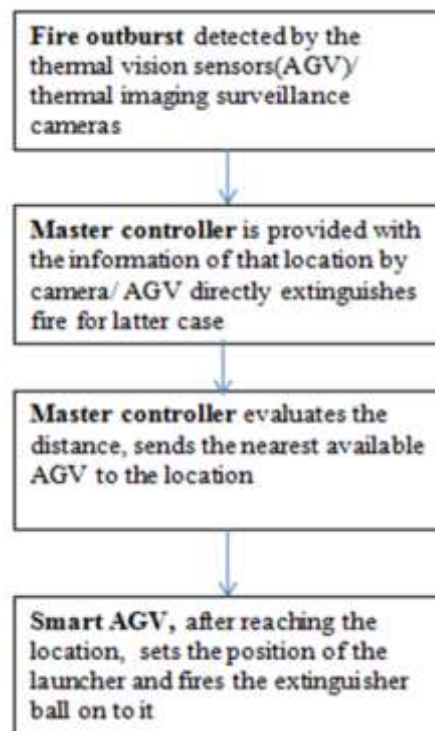


Fig -8 : Block Diagram of Overall Process

5. CONCLUSION

This Automated Guided Vehicle System for Industrial Surveillance and Plant Safety ensures the safety of the plant from any fire accident and can also utilize for the material handling. So, there is no need of implementation of separate fire safety system. This system can avoid the huge damage in the plant due to the fire accidents by early detection and extinguishing of fire in the initial stage itself.

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