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Study of Unmanned Vehicle (Robot) for Coal Mines

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Abstract: In India from last few decades, coal mining has witnessed a phenomenal growth in production and demand of coal, according to 12th Action plan, demand of coal to the power utilities, power captives, steel industries, cement industries and others, with 8% growth of GDP. With this scenario, technology for coal production (opencast mining, underground mining), during this process many of fatal accident may happen, to prevent these accident, some technological face mechanisms is required with geo-mining atmosphere and its awareness to the mining industry. In this paper we suggest an unmanned machine to check the geo-mining atmosphere through wireless control for Rescue team.

Key words: ZigBee, UGVs, UAVs, USVs, Robot.

I. INTRODUCTION

Safety is a prime intension of a coal industry for proper functioning. It's not only for employees and workers but also for the environment and nation. Coal mines are the most critical challenge for safety, health and environment compared to other industry due to the complication in its operation and maintenance with wide range of hazardous. Due to huge technological progress, the safety culture and safety at work still serious issues. That's why maintaining of high standards of health, safety and environment in coal mines is of immense significance.

To save the fatalities life of coal mines workers, due to unfortunate natural accident or unknowingly human made disaster, demands sophisticated and organized rescue planning from a government or rescue team [12]. The intension is to get out to the accident areas, find the affected workers and help them as fast as possible. Accident comes with many obstacles for the rescue team that makes it hard for them to reach the victims, for example rainstorms, collapsed roof or side walls, obstructions, explosion and dangerous gases and different substances. The rescue team must rapidly and securely collect information of the accident areas, a task that is both difficult and dangerous [18]. Rescue robots, that are a type of field robots, can serve as appreciated tools for human teams under disasters [17]. They can reach places between rubble and hazardous places that humans cannot, and effectively gather crucial information. The robots can also reach victims through narrow spaces and apply them with fluids and medication. To be useful tools the rescue robots must be smart and dynamic so they do not become obstacles for the rescue team. Because of the unstructured and dynamic environment that occurs during disasters, the robots are nowadays in a degree teleported [12], which demands that the robots have a good communication with the rescue team.

There are several rescue robots still under progress and some of them have even been used in some emergence situations. The challenge facing to get perfect rescue robots working on the different field is to make them advanced or intelligent in software and reliable hardware to work in critical zone in the way that it can handle all possible obstacles [17]. The significance of this paper is to get a valuable introduction of rescue robotics or unmanned machines, their challenges, how they are used today and what improvements could be in future of rescue robots for coal mines.

II. BASIC ROBOT STRUCTURE

Its structure configured in five sections such as supply system, communication system, control system, sensor system, drive system.

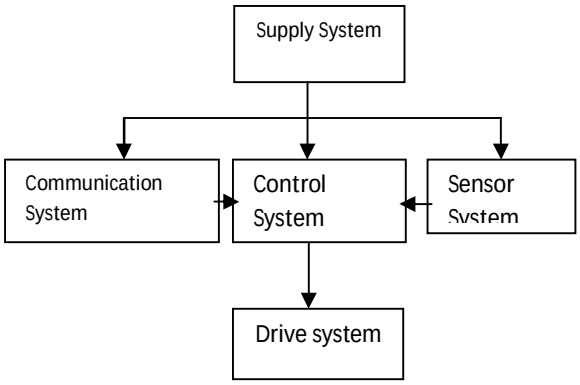
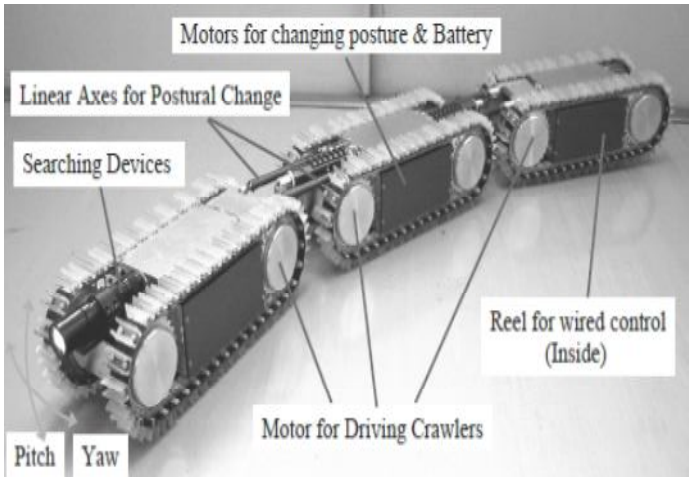


Fig.1: Basic robot structure

III. TYPES OF UNMANNED VEHICLE

These are mainly four types of rescue robots according to [23] that can be categorized like this:
UGVs – Unmanned Ground Vehicles. These robots works on the ground or surface and can help rescuers to find and interact with trapped victims, in areas were human cannot enter.
UAVs – Unmanned Aerial Vehicles. These robots can easily work above the ground surface and transport medical treatments to victims and can give the signal of the situation to the rescue team.
UUVs – Unmanned Underwater Vehicles. These robots can search through water and identify fatalities, hazardous subject or material.
USVs – Unmanned Surface Vehicles. These robots work on the water surface, and can help rescuers to locate and bring the right equipment to the victims.

Picture 1: UGVs Robot



Picture 2: UGVs Robot

Picture 3: UGVs Robot

Picture 4: UAVs Robot

Picture 5: USVs Robot

IV. RESCUE ROBOTS USED IN DISASTERS world trade centre in 2001:- Robots were used for Urban Search and Rescue [23] activities in the aftermath of the WTC attack on 11 September 2001. The robots were on site from 11 September until 2 October 2001. This was the first known actual use of robots for USAR. The robots were used for Searching for victims, searching for paths through the rubble that would be quicker to excavate, Structural inspection, Detection of hazardous materials.

Picture 6: Robot used at WTC

V. HOW UNMANNED VEHICLE ARE USED IN FATAL ACCIDENTS

Compared to natural accident, fatal accidents occur in a smaller area. Examples like fall of roof, Fall of side, Rope haulage, other transportation machinery, Machinery other than transportation machinery, Explosive inside coal mines, serious accident, leak of dangerous substance, radioactive leak and so on. The areas afflicted in the danger zone [8]. The challenge here is not to look at the entire external extent of the damage, but rather to see the interior of the garbage, location and condition of the survivors and state any potentially danger. Visibility is difficult due to no lighting and gray dust [8]. Recognize the fatalities, potential danger and accurate mapping is more important here. The survivors in the defected zone are often in directly needed of medical treatment or migration within 48 hours [8]. Therefore the challenges are to be able to search through all possible obstacles found in the mine collapses and reach the sufferers as fast as possible. UGVs are recommended for this type of fatal accident, and it is strongly suggested that the UGVs should be waterproofed or highly water resistant, because there are usually some water present that comes from damaged sprinkler and dirt systems. These robots should be man-packable, as small as possible for driving through the debris. Rescuers can supposedly interact with the fatalities when found, so there is no need for larger size robots in human-robot interaction.

VI. PROBLEMS FACED BY UNMANNED VEHICLE

The immense motivation is to save life. Robots can aid in meeting this goal by interacting directly to the fatalities or structures or automating support activities toward rescue team [17]. Compared to military platforms, a rescue robot has quite same structure, because they are using the same technology for searching, navigation and control. But the difference that makes rescue robots unique from military robots is that the rescue robots have more human-robot interaction for inhabitant response. The strategy of rescuing for rescue robots is highly similar to the human way of rescuing. The rescue robot strategy has several important categories that has to be covered to be able to work as they should. Therefore following categories are divided according to [12] as Searching, inspection and mapping, dirt removal, Structural inspection, Medical sensitive release and evacuation of casualties, Acting as a mobile encouragement or repeater, Serving as a substitute for a team member and Providing logistic support.

A) Searching: The robot may have to handle searching in coal mines, opencast mining, underground mining, formless and dynamic environment to find fatalities or dangerous hazard. It is important that the robot can do it with speed under complete control without increasing the risk for the rescuers, victims or other living creatures. For UGVs the challenge is the complexity of the environment, the robot needs to handle unpredictable combination of vertical and horizontal objects. One mechanical problem in searching is that robots can get stuck in the debris and can only work for a limited time because of the lack on power supply [10]. Even though it's hard to get an overall picture of debris because of its unpredictable conditions, it is clear that more work is needed for the robots mechanical design in order to act to the atmosphere.

B) Inspection and mapping: This is broader than searching because the robot have to provide the human rescue team with general information about the situation and create a reference of the destroyed surroundings. It is important to coverage large area as fast as possible. The goal is to have a multi-agent [16] system to predict any catastrophes and disaster trough software. To let UAVs mapping the area will be much faster rather than waiting for the information from the pilots flying helicopters [12]. For UAVs the challenge is to handle the different wind conditions, and at the same time trough trees, power lines and any obstacle in its path it may collide with. The software should also handle mapping and detect fatalities. In areas where it too dangerous for human to enter UAVs is sent first before any other UGVs are sent [10].

C) Debris removal: The robot should be able to move heavier debris faster than it can be done manually, but of course with a small framework and without risking the lives of the fatalities or the human rescue team. Rescue robots can be used in the way that it sense the situation using sensors to decide which rubble can be moved or what pieces are in too much danger to move. Rescue robots are also used to test stability and of several conditions and decide if it is safe for a rescue team to enter [15].

D) Structural inspection: It is important that the robot can find a optimal path into a debris structure in order to prevent collapses. The sensors must be able to read the area from many constructive viewing angles to make it easier for the robot to find the optimal path into the rubble. UGVs are focusing in this part, but it needs even smarter solution in both software and hardware to maintain better navigation.

VII. MULTI-ROBOTS AND SWARMS

New concepts like multi-robot [21] teams or swarms are robots that extend the communication and sensor network. Small parts that work together in a team, with a high communication and synchronization between them, can take the robotics into a higher level. Even if one robot gets lost or destroyed, other robots can still work together. But its hard to accomplish this idea, though there are some research and investigation on multi-robot teams.

An intelligent group of swarm robots would effectively improve the search of a disaster area and save lives [15]. To be able to use this concept a reliable communication must be available between the robots. With a reliable communication they can collaborate with each other to get over an obstacle or to report to other robots that a certain area already has been covered and thereby save time and energy. The swarm robots should be able to enter a collapsed structure by their own and from there give general data to the human rescuers. In [18] it is proposed that the system must contain sensors, network communication protocol, user interface for the human and a database management system for collecting the information. Due to that the disaster area is assumed to be both broad and unpredictable, the robots should be adaptable, scalable and easy to use by a human that gathers the data the swarm sends [18]. The system proposed in [18] contains mobile robot platforms, a wireless ad hoc network called, a user interface for controlling multiple robots, and a Geographic Information System (GIS) data server.

OBJECTIVES FOR FUTURE WORK

To eliminate risk of disasters and accidents in coal mines through detailed analysis of accidents and dangerous occurrences using rescue techniques; A controlled automatic unmanned machine (robot) designing for assisting rescuers. This system works even when a ZigBee, RF, Wi-Fi, Gi-Fi, 2G, 3G, 4G etc. Whenever any accident occurs, the robot automatically detects the accident, finds the location and enters the coal mine tunnel well before the arrival of rescuers. It finds the location of accident, searches for survivors to give them first aid treatment at right time and informs the rescue team about environmental conditions and about the survivors inside the coal mine.

VIII. CONCLUSION

The Indian coal mining is changing very fast with the increasing demand for coal, to meet the countries energy security from fatal accidents. The expectation of the society is also increasing day by day and the accident is not accepted anymore. The coal mines needed improvement in terms of reduction of accident and occupational safety and health in totality.

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