THE USE OF ROBOTS IN UNDERGROUND RESCUE ACTIONS

Alin Irimia, *Phd.Student, Eng., INCD INSEMEX Petrosani, Romania*
George Artur Găman, *Phd. Eng., INCD INSEMEX Petrosani, Romania*
Daniel Pupăzan, *Phd.Eng., INCD INSEMEX Petrosani, Romania*
Cosmin Ilie, *Phd.Student, Eng., INCD INSEMEX Petrosani, Romania*

ABSTRACT: During a rescue operation in underground rescue teams face many problems that could affect the capacities to act effectively. Explosions, fires, methane accumulation and toxic gases at high risk during exploration.

The advantages of using robots in these cases are obvious given the ability to intervene in very narrow places, the capacity to analyze the mine air continuously enhanced detection capabilities of victims and survivors even through the atmosphere with smoke and dust using thermal and infrared cameras.Robots can transmit real-time information to the operator about the status of mining, the presence of dangerous gases, providing valuable information to rescuers before they get into the hazardous areas

KEYWORDS: Robot , mining rescue ,explosive danger.

1. INTRODUCTION

Lack of information about the integrity of the geological and environmental conditions raises issues to the underground efforts of the rescue teams. This new technology is a significant potential for improving rescue actions, reducing the exposure to hazards. A robotic vehicle can explore the mine and can provide valuable information to help rescue teams to plan search and rescue operations. Using robots to assist rescue personnel in underground rescue missions is an active area of research.

The first steps were made by using robots converted from military activities or used by emergency teams, the results are rather negative. This has happened in case of Pike River mine in New Zealand in 2010 where was attempted the use of military robots to search the trapped miners after the first explosion but robots were short-circuited when passing through water after just 550 meters and was lost the time that would have allowed the rescue of the miners caught underground, occurring the second explosion

At Crandall Canyon Mine in Utah, USA in 2007 after a failing, six miners remained trapped underground, rescuers tried to collect information using a research robot equipped with cameras placed underground through a drill hole [1;2].

The first robots designed for rescue actions had research role, with the ability to transmit images from their cameras to the operator and to analyze gases from mine’s air.

Groundhog (Figures 1, 2) is a remote controlled robot that has the ability to scan by laser sensors the walls and the obstacles encountered and by a complex algorithm has the ability to convert independent information in a 3D map of the area traversed [3].

Is equipped with camera with night vision, gas detectors, laser distance sensors, diving sensors and a gyroscope.

Fig.1 Groundhog robot

Fig.2 Groundhog robot

MATILDA II Mine Reconnaissance (fig 3). Is a compact robot with dimensions 750 mm x 520 mm x 300 mm, has a mass of 35 kg, 65 kg payload and towing capacity of 115 kg, is controlled by optical fiber at about 500m [4].

Is equipped with auto focus cameras with 300x zoom, incandescent bulbs and infrared lighting, gas sensors duplex communication system. It is easy to carry both the machine as well as the control (Fig. 4)

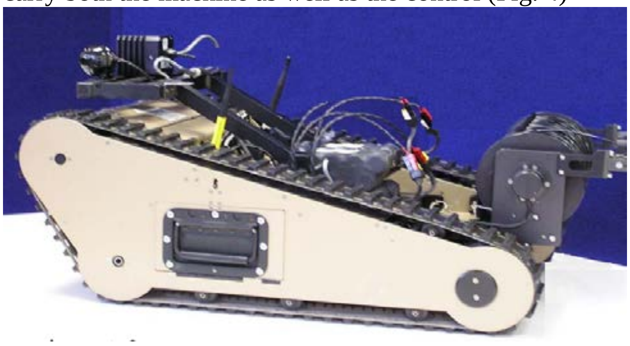

Fig. 3 MATILDA II Mine Reconnaissance

Fig. 4 remote control MATILDA II

With major accidents worldwide in the past decade, mining came increasingly more in the sights of robots manufacturers, exploring the advantages of exploring immediately after an event and the opportunity to provide valuable information about underground conditions to rescuers ,increasing the chances of survival for the miners cought by the event as well as rescuers.

Serious accidents occurring almost annually worldwide underground, public information throughout the media about the event and subsequent investigation lead to pressure to make rescue work more efficiently. In Turkey, because the event from Soma mine in May 13, 2014, as well as high mortality due to work, will be made a fleet of rescue robots and new safety and health at work rules.

The first model already operational is Madrob-1 robot (fig. 5) equipped with cameras and up to eight autonomous plug-and-play different gas detectors, is designed to assist rescuers through research area [5].

Fig. 5 Madrob-1 robot

The three parts, mechanics, electronics and software have to face the unique challenges of underground where difficult terrain resulting from an event, the possible high temperatures, low visibility, low ground traction, the existence of flooded areas to be covered, the need of great distance communication, flameproof enclosure design are just some of the requirements in the design phase.

Currently the United States is the best represented state both as producer and as user of rescue robots due to the experience of producers in areas such as military and emergency situations and Mining Safety and Health Agency (MSHA)involvement in the development of this branch of robotics including purchases for their own needs for operating robots with different capabilities.

Andros robot REMOTEC V2 (fig. 6, 7) is designed by REMOTEC Technology Inc. the global leader in robotic vehicles for use in hazardous environments.[6]

The firm has designed robots for different applications with high hazard, eg bomb disposal teams, military teams, SWAT, for remote verification of buildings, etc.

V2 has a height of 130 centimeters and weighs 550 kilograms. can move underground in conditions that are unsafe for rescuers, is powered with engines in flameproof construction. Moving machinery is crawler-mounted.

It is equipped with navigation and surveillance cameras, lighting device, sensors and has the ability to see in the dark. It has a voice communication system in both directions and a mobile arm.

V2 can be operated remotely from a safe place and is able to explore up to 1500 meters, communication of vital information about conditions in the mine is via fiber optic cable. The operator can view real-time information, including video, and concentrations of combustible and toxic gases.

Fig. 6 Remotec Andros V2 robot

Fig. 7 Remotec Andros V2 robot

Another MSHA's endowment robot is Gemini Scout (fig. 8), developed by Sandia National Labs in New Mexico.

It was specifically designed to operate in such an environment, ground traction is made with crawler. It has 1.2 meters long and 0.6 meters wide and a mass of 600 kg, has an infrared camera that can see through the smoke and dust.

Can climb steep slopes and reach narrow places. Andros REMOTEC V2 can cross obstacles even if they are 30 centimeters from the the ground.

The robot is guided by remote. Has gas sensor that warns if toxic or explosive gases. Help rescuers to evaluate gallery walls and ceiling if are damaged before they get in.

Turret of robot is equipped with infrared cameras providing 360-degree visibility of the entire environment. This provides an assessment of the situation on the ground and facilitate release of the robot if it gets stuck.

Infrared camera can locate survivors. The turret also has a video camera light reflector. On the body of the robot are fixed cameras, front and back , relieving its movement in any direction.

Since radio signals can easily lose underground, it provides a dual-frequency signal which automatically chooses the wavelength with the best reception. Optional robot control has a fiber optic cable that lays out automatically behind him.

When the robot reaches the survivors, rescuers could talk to them using the built-in microphone and speakers on the robot. The rescuers can help them reach safe areas, and the robot can provide immediate assistance in the form of reserves of oxygen, water, first aid materials, etc.

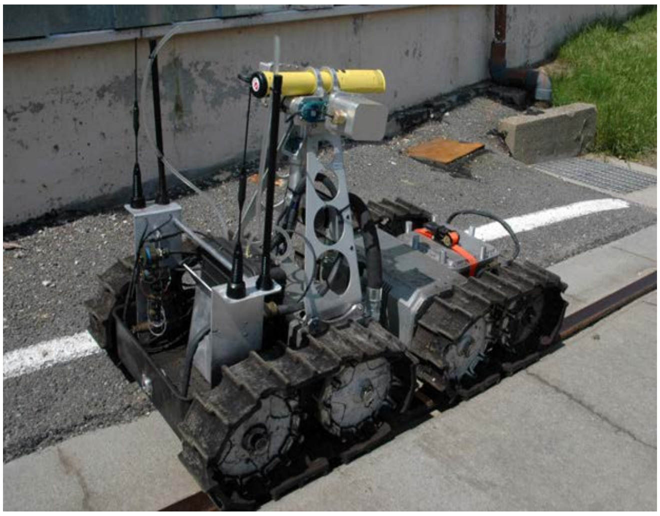

Fig.8 Gemeni Scout robot

Due to the size, the robot can be turned into a rescue car capable of transporting the wounded to safer areas. Due to its size can be transported easily to any vehicle with platform (fig. 9)

Fig. 9 Easy transport of the robot

o explozie internă, în situaţia când are loc un astfel de accident Corpul robotului este format din două părţi It is a machine with electrical supply and the electronics of the vehicle is closed flameproof housings that are specially designed to withstand an internal explosion, in case of the situation when such an accident occurs. Robot body consists of two parts with flexible joint in the middle, offering increased capacity crossing barriers (Figure 10)

The housings are designed so that the front of the fire to be extinguished quickly and not spread. The robot can be damaged but will not trigger a larger explosion.

The robot can cross a ford with water depth of 45 centimeters, without being affected. Is large enough to be able to carry a certain load or save a person.

Fig.10 High ability to overcome obstacles

A thermal camera helps Gemini-Scout to search for survivors and can even be configured to carry food, air supply, and other supplies to the trapped miners. And because mining disasters can happen unexpectedly anywhere in the world, engineers from Sandia wanted to make it operable without too much knowledge. Gemini-Scout is controlled with a standard Xbox 360 remote, so virtually anyone can answer a call in a crisis [7].

PackBot® 510 (Figure 11) is a platform created by iRobot that can perform a variety of missions from bombs destruction, military tactical missions, suspicious vehicle research, interventions in tight spaces, identification of hazards in buildings, identification of hazardous chemicals and as a result of changes made by South African researchers from the CSIR, in underground rescue missions.

Fig.11 PackBot® 510 platform

The robot is designed as a platform able to be equipped with a variety of sensors according to the type of task:

-sensor for presence of chemical agents

-sensor for radiation monitoring

- video cameras for inspection

- measurements of gases

- audio communication systems

-laser -scanner

It can be operated remotely via wireless or 800 m fiber for longer distances. Can generate maps of the area investigated based on measurements made with their laser sensors [8].

The robot can be operated easily in manual mode using a joystick connected to the laptop (Figure 12) or can work in automatic or semiautomatic if is plot a goal.

The main goal of researchers from the CSIR was to make the robot able to perform reconnaissance missions later underground blasting operations to assess the safety of miners before returning workplaces.

It is good as rescue operations robot too , having the ability to quickly get in the intervention area on autonomous when plans previous has been cofigurate.

Fig.12 PackBot® 510control system

For situations where it is not possible to unlock access routes following massive landslides and bulky robots can not find a way to get people caught underground in the vicinity of the event, a possible option is to drill from the surface and placing in the drill hole of a snake robot. This is a special category of robots, for research operations, motion achieved by highly complex mathematical algorithms are inspired by mooving of snakes.
Such a robot is Uncle Sam (Figure 13) an ultimate achievement of the Biorobotics Lab at Carnegie Mellon University, after a long history in snake robots. High degrees of freedom that it has gives qualities necessary for rescue operations . One of laboratory challenges was to succeed to copy from nature the locomotion with the lowest energy consumption. Can withstand intense mechanical shock, falls from great heights without affecting operation.

Fig.13 Uncle Sam robot

It is designed as a sixteen identical modules that can move in different directions to make the movement of the robot. Even in case of failure of half of the modules the robot can move further.[9]

Movement commands are given via a joystick and yet for rescue operations will be provided outside of the camera with two-way communication system.

Mark II (Figure 14) developed by Raytheon Sarcos is used in the United States Mine Rescue operations can be lowered vertically to 700 m by 10 cm hole drilling has a travel speed of up to 3km / h, can cross areas with water and mud, can detect oxygen, methane, carbon monoxide, can measure temperature, provides bidirectional audio communication, has 60 m lighting, features color camera and infrared, operates both through its own batteries as well by connecting cable to the surface operator.[10]

The project was completed in 2013 and then went through a series of laboratory tests and passed through three underground intervention scenarios, all successfully completed.

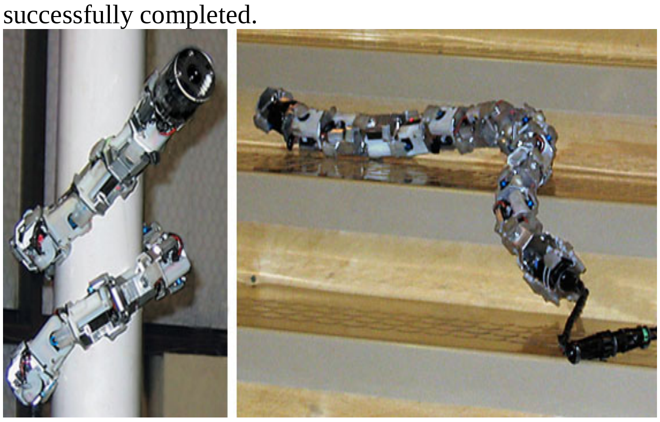

Fig.14 Mark II

2. CONCLUSIONS

Using robots in rescue work at the moment is very limited worldwide for several reasons:- companiile miniere alocă greu fonduri pentru achiziții de roboți

-in short period since their introduction on the market, there were many failures in rescue operations

-the costs of research, development and production of robots able to operate underground are high

-reduced involvement of national fora dealing with health and safety at work except US related financing rescue robots projects.

- Small number of global manufacturers maintain a high price.

These shortcomings will be removed in the coming years because robotics make major advances in related fields, on the basis of successful rescue in emergency situations, the used for law enforcement, research and destroying bombs used by engineers and other areas, there will be a transfer of technology that will make the next generation of mining rescue robots more efficient. The mining industry can not ignore progress in safety and health at work by the use of robots in rescue interventions as long as from the total global disasters in 12 years, 42% of these took place underground.

Global trends require that future robots in mine rescue solve the following requirements:

-Possibility of introducing the robot underground by drilling holes then be handled by the surface providing video information and gas measurements

- Possibility to be operated at several thousand meters in front of the rescue teams that will benefit real-time information from the robot

- Possibility to remove injured from area or transport hazardous materials and heavy equipment underground or at the surface.

3. BIBLIOGRAPHY

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