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Applications of Robotics in Mining Industry

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ABSTRACT

The advance of robotics and the increase in robot use have raised the need for computer simulation of robots, among the aims of which are the design of new robots, task planning of existing robots, performance evaluation and cycle time estimation. For mining environment, both the opencast and underground mining needs seriously application of robotics. In deep mining, the room and pillar or bord and pillar method progresses along the seam, while pillars and timber are left standing to support the mine roof and highly equipped machineries used To maintain safety and reduced the human activity, it is very much essential to adopt robotic technology in underground mines. It is proved that, robots will be doing jobs like laying explosives, going underground after blasting to stabilize a mine roof or mining in areas where it is impossible for humans to work or even survive. This paper highlights the need and uses of robotic applications in mining industry environment.

Keywords: Mine Environment, Mine Navigation, Mine Rescue Robot

The advance of robotics and the increase in robot use have raised the need for computer simulation of robots, among the aims of which are the design of new robots, task planning of existing robots, performance evaluation and cycle time estimation. As the proper mapping of each and every mining operations need a special attention in order to reduce the chances of any kind of accidents, an effort has been initiated to carry out this task without human intervention using the latest developments in the field of robotics, aided with the domain specific information. The related information would also be tried to be collected and analyzed for judging the status of the level of hazard prevailing at any given point of time. This operation is expected to help the mine authorities to remain prepared with all the possible rescue measures.Furthermore, the lack of knowledge regarding the geological integrity and environmental condition of the mine also hinder rescue and recovery efforts. Robotic technology offers significant potential to improve the plight of the rescue workers by reducing exposures to hazardous conditions. A robotic vehicle can explore the mine and provide valuable information to the teams to assist in planning and implementing search and rescue operations. Industrial robots have been made a significant contribution toward automating the manufacturing processes.

The efficient use of robots shows productivity increase, production cost reduction, and product quality improvement. However, most robots currently in use perform simple repetitive jobs, such as pick-and-place, machine loading and unloading, spry painting and spot welding. A basic approach has been assumed for the testing of the performance of the semi-autonomous robot. It has been seen that this performs well under the simple assumptions of the conditions established at the underground mining excavation sites. The recent fatality statistics for both underground as well as opencast mining operations worldwide point out that the most serious risks to the personnel are from different mining

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conditions especially that from the inaccessible areas of the mines where regular systematic monitoring and maintenance operations are difficult and hence, none of these operations are not carried out on a systematic basis. It is true that there is no control of the human operators on such unwanted happenings. In general, underground and opencast mining conditions are a cooperative enterprise of powerful, mobile equipment and the workers who operate it. If mining equipment could be automated to function without a worker's full attention, the mining industry could enhance productivity, access unworkable mineral seams, and reduce human exposure to the inhospitable environment of dust, noise, gas, water, moving equipment and roof fall. The critical missing link to enable mine automation is the capability of equipment to estimate its position relative to its surrounding. The lack of accurate maps of inactive, underground mines poses a serious threat to public safety. According to a recent study, tens of thousands, perhaps even hundreds of thousands, of abandoned mines exist today in the United States. Not even the U.S. Bureau of Mines knows the exact number, because federal recording of mining claims was not required until 1976. Hazardous operating conditions and difficult access routes suggest that robotic exploration and mapping of abandoned mines may be a viable option. For maintain the working environment safety, it is now essential to implemented robotic systems in underground mines. This paper highlights the need and uses of robotic application in mining industry

APPLICATION OF ROBOTIC SYSTEM AND ITS NEED

Robots will be doing jobs like laying explosives, going underground after blasting to stabilize a mine roof or mining in areas where it is impossible for humans to work or even survive. Examples of the trend to mining automation include: w Tele-operated and automated load-haul-dump trucks that self-navigate through tunnels, clearing the walls by centimetres w The world's largest robot, a 3500 tonne coal dragline featuring automated loading and unloading w A robot device for drilling and bolting mine roofs to stabilize them after blasting w A pilot less burrowing machine for mining in flooded gravels and sands underground, where human operators cannot go w A robotic drilling and blasting device for inducing controlled caving

Fig.1. A few mining vehicle-related accidents

NEED OF ROBOTIC SYSTEMS IN OPENCAST MINES

As in opencast mining industry, more number of high earthmoving machineries and man power is used, hence robotic systems were used for maintain the safety and enhancing the production capacity. Machinery automation is the major area in opencast mines, where robotic systems were needed to implement.

Machinery automation

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Mining machines are characterized by multiple, articulated joints using hydraulically or electrically powered elements. Many tasks require a human operator to coordinate the movement of several machine links by simultaneous control of numerous joysticks or other control devices, Robotics used in the manufacturing industry cannot be aptly used for the support of mining machinery operations for three reasons: the complexity of mining operations, variability of the tasks, and the changing environment that is unstructured and requires adjustment during operation.Fig.2. shows the block diagram of robotic control architecture in mining equipment.

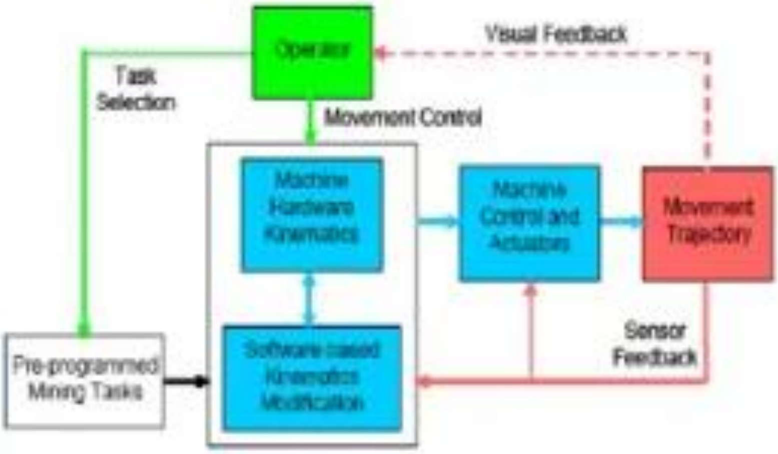

Fig.2. Functional Block Diagram of the New Robot Human Control Architecture

The world's largest robot has been strutting its stuff in a Queensland coal pit, demonstrating how open-cut mines of the future may work. The 3500-tonne monster, which featured on NASA's Cool Robot of the Week website, is a 75-metre tall dragline (Fig.3.) that has been automated to turn the business of shifting millions of tonnes of rubble and rock into a highly precise operation needing 80 per cent less operator involvement. This massive beast, which can devour 120 tonnes of rock in a single bite, has essentially been fitted with a brain to remove the stress and judgment needed by a human operator when controlling its 100-metre boom and swinging load. The semi-automated dragline was used to demonstrate the role that robotics could play in mining operations

Fig.3. World's first robotic system based dragline

Pilania, and Chakravarty (2008) developed Visual Sensor for Semi-Autonomous Mine navigation System for both opencast and underground mining environment. Their work

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represents the efforts undertaken for the development of a semi-automatic robot that may be used for various post- disaster rescue operation planning and their subsequent execution using one-way communication

Fig. 5 The complete robot unit with the pan-and-tilt mechanism for better navigation

NEED OF ROBOTIC SYSTEMS IN UNDERGROUNDMINES

Due to safety purpose in underground mines, the need of robotics is very much essential. The followings are highlights the role of robotic application in underground mines. w Underground mine navigation or mapping using robotics w Position estimation w Machinery automation w Mine Specific Issues research. On the left is a cart, equipped with four 2-D laser range finders. The laser range finders provide information about the mine cross section ahead of the vehicle, and the ground and ceiling structure. The center panel in Figure6 shows the Groundhog robot, a tele-operated device constructed from the chassis of two ATVs. The robot is equipped with two 2-D laser range finders, one pointed forward for 2-D mapping and one pointed towards the ceiling for 3-D mapping. The right panel of this figure shows Groundhogs descent into an abandoned mine in Burgettstown, PA. Unfortunately, neither of these systems possess odometers or inertial sensors. Thus, the location of the vehicles relative to their points of entry can only be recovered from the range scan data

Fig.6. Mine mapping cart with four laser range finders, pushed manually through a mine. Groundhog robot used for breaching difficult mine environments. Position estimation The simplest position estimator for mobile equipment is dead reckoning, in which the robot estimates its current position by step counting (integrating its combined steering and propulsion history). This approach is vulnerable to bad calibration, imperfect wheel contact, upsetting events, and it provides, at best, only a rough position estimate. This estimate generally gets worse as the distance travelled (i.e., the length of the integral) increases. Inertial navigation system (INS) position estimators use multiple gyros (mechanical or ring laser) and accelerometers (one for each axis) to provide an acceleration history that is integrated to estimate position. Although an INS is generally more accurate then reckoning,

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an INS is subject to gyro drift, calibration problems, and sensitivity limitations. Fig.8. and Fig.9 represents the position estimation by the robotic system Object detection and path finder Robotics is also seen as a way to resolve productivity issues. For example, industry estimates put the savings from clawing back some of the time lost during shift changeovers and by reducing the workload on operator sat $300 million a year.

Fig.10. Robotic system for path finder in undergroundmines

Groundhog [12], a 1,600-pound mine-mapping robot(Fig.6) created by graduate students in Carnegie Mellons Mobile Robot Development class, made a successful trial run into an abandoned coalmine near Burgettstown, Pa. The four-wheeled, ATV-sized robot used laser range finders to create an accurate map of about 100 feet of the mine, which had been filled with water since the 1920s. The state-run Korea Coal Corp. (KOCOAL) [13] signed a memorandum of understanding (MOU) with three Korean engineering institutions and companies, including the Korea Institute of Machinery & Materials, for the development of intelligent coal-mining robots in the science complex in Daejeon. The robots will not only drill in mines but will up- and offload coal onto conveyers for transportation, with operators outside to control them remotely using a three-dimensional scanner attached at the back of the robots.

The introduction of mining robots will raise productivity by 30 percent. The robots will increase productivity by working around the clock and going deeper, which will reduce the risk of human losses from conventional mining, if the project is completed, intelligent coal-mining robots will be put to working 2013 after six months of trial operation. Mine Specific Issues The underground mine environment imposes several requirements on a position estimation system. Using dead reckoning alone is ruled out because of the irregular surface of the mine corridor floor, the often jerky motions of the mine machine, and especially, the large amount of slippage of the machines tracks. Long-term autonomous operation of mine equipment precludes the use of an INS since errors from the gyro drift quickly exceed acceptable levels. It is desirable to work in newly mapped areas without first installing the

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necessary beacons (especially if the mapping is done automatically in conjunction with the position estimation). Furthermore, since the environment is cluttered with machines and people not in the model, a significant number of optical beacons could be occluded. Therefore, optical beacons alone are not viable in an underground mine environment. Because mining equipment is mobile, a relevant position estimator must have a reasonably short cycle time. The jerky motion of tracked mining machines and the subsequently poor dead reckoning preclude good position estimates by simple means

CONCLUSION

This paper highlights the importance of robotics system in mining industry. Some applied system also discussed and the need of the robotic system in underground mine was also pointed. Though very few works have been done in this area and still the research work will continue, the need of the robotic system was only highlighted and getting concluded that it is essential to adopt robotic system in underground mines to reduce the human power and enhancing safety.

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