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Global Positioning System Application in Mining

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Abstract

The Global Positioning System (GPS) is a satellite-based navigation system that was developed by the U.S. Department of Defense in the early 1970s. Initially, GPS was developed as a military system to fulfill U.S. military needs. However, it was later made available to civilians, and is now dual-use system that can be accessed by both military and civilian users. GPS provides continuous positioning and timing information, anywhere in the world under any weather conditions. Because it serves an unlimited number of users as well as being used for security reasons, GPS is a one-way-ranging (passive) system. That is, users can only receive the satellite signals. GPS has been available for civil and military use for more than two decades. That period of time has witnessed the creation of numerous new GPS applications. Because it provides high-accuracy positioning in a cost effective manner, GPS has found its way into many industrial applications, replacing conventional methods in most cases. For example, with GPS, machineries can be automatically guided and controlled. This is especially useful in hazardous areas, where human lives are endangered.

Introduction

The design of GPS is based partly on similar ground-based radio-navigation systems, such as LORAN and the Decca Navigator developed in the early 1940s, and used during World War II. In 1956, Friedwardt Winterberg proposed a test of general relativity (for time slowing in a strong gravitational field) using accurate atomic clocks placed in orbit inside artificial satellites. (To achieve accuracy requirements, GPS uses principles of general relativity to correct the satellites' atomic clocks.) Additional inspiration for GPS came when the Soviet Union launched the first man-made satellite, Sputnik in 1957. Two American physicists, William Guier and George Weiffenbach, at Johns Hopkins's Applied Physics Laboratory (APL), decided on their own to monitor Sputnik's radio transmissions. Within hours they realized that, because of the Doppler Effect, they could pinpoint where the satellite was along its orbit from the Doppler shift. The Director of the APL gave them access to their UNIVAC to do the heavy calculations required. When they released the orbit of Sputnik to the media, the Russians were dumbfounded to learn how powerful American computers had become, as they would not have been able to calculate the orbit themselves. The following spring, Frank McClure, the deputy director of the APL, asked Guier and Weiffenbach to look at the inverse problem where you know the location of the satellite and you want to find your own location. (The Navy was developing the submarine-launched Polaris missile, which required them to know the submarine's location.) This led them and APL to develop the Transit system. The first satellite navigation system, Transit (satellite), used by the United States Navy, was first successfully tested in 1960. It used a constellation of five satellites and could provide a navigational fix approximately once per hour. In 1967, the U.S. Navy developed the Himation satellite that proved the ability to place accurate clocks in space, a technology required by GPS. In the 1970s, the ground-based Omega Navigation System, based on phase comparison of signal transmission from pairs of stations, became the first worldwide radio navigation system. Limitations of these systems drove the need for a more universal navigation solution with greater accuracy

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Principle of Truck Dispatching System

Truck dispatching system is Global Positioning System (GPS) based application. The GPS is a satellite based navigation system. The system enables a GPS receiver to determine its location, speed, direction, and time. The principles of measurement of location, speed, direction and time we already have discussed. Based on measurement of location, speed, direction and time softwares are developed for truck dispatching system.

Main components of this software are:
An Intel / Risc-based application –cum – database server and clients configured according to requirements. A GPS-based on board instrument called Nirdeshak, developed by CMC for monitoring the vital signs of vehicles, voice/data communication and tracking the location of equipment

Dynamine module Display: Real time display of mining operations Real time display of instantly generated warning messages/ messages sent by the operator to the control room from heavy earth moving machinery A scrolling display of critical production parameters in real time Activates voice communication with HEMM operators Production/availability/utilization/status details of any HEMM in real-time, on double-clicking the icon of the particular HEMM.

Allocator:
Dynamic allocation of trucks to excavators: Opens and closes various dumps. Displays equipment and operator performance as well as various critical production parameters in real-time on client machines, and also on large displays installed at the mines office

Survey:
Edits and updates mine map, based on data from mine planning software or from surveying instruments. Defines blasting zones with blast timings, to generate automatic warning messages in real-time, in case of any HEMM entering the area during those times. Defines and edits profile of dumps-points. Replays the movement of any particular HEMM, in a user-selected time period, with user-controllable speeds for analysis

Maintenance:
Records breakdown details of HEMMs. Records the preventive maintenance activities of HEMMs Maintains a breakdown history of HEMMs, to help in breakdown analysis Automatically generates a preventive maintenance schedule for HEMMs. Monitors critical components of HEMMs, through its interface with the vital signs monitoring system

Administration:
Administers radio communications between the server and HEMMs: Configures communication parameters for voice communications with HEMMs. Configures communication parameters for data communication with HEMM: Configures parameters for the vital signs monitoring hardware Real-time displays of the status of critical communication equipment like network controllers, communication servers, terminal servers, etc.

Application of GPS in High precision machine control and guidance
Mine APSTM Dozer is an advanced machine guidance system utilizing GPS and GLONASS positioning technology. This provides the operator with easy to follow graphical information needed to work accurately to design, simply and with no survey pegs- and achieve final results accurate to just centimeters. mineAPSTM Dozer also includes important safety features, including supporting proximity warnings, fixed and mobile hazard warnings,

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Vol 11 No 05
May 2022

messaging and generally improves operator situational awareness by putting the design on the machine. mineAPSTM dozer improves productivity on a mine site with many applications including push dozing, selective mining, clean up, benching, stock pile dozing, maintenance and remediation projects.

Applications:

• Selective mining
• Stock pile Operations
• Pushing to feed point
• Construction of accurate benches, ramps and pads
• Bulk Earthworks
• Rehabilitation Projects
• Clean up

Benefits:

• Improve ore grading through accurate selective mining
• Improve safety through Fixed Hazard and Proximity Warnings
• Improve efficiency and reduce errors by putting the digital design directly on the machine.
• Achieve results faster, with fewer passes.
• Reduce rework caused by over or under cutting of filling.
• Significantly reduce dependence on survey and grade checking.
• Machine based production reporting removes errors and improves timelines and accuracy of management information.

GPS Based Collision Avoidance System

Types of collision avoidance system: A study of various sites visit revealed that there are two classes of collision avoidance systems in open cast mines. The first and most prevalent, in the USA at least, is close proximity

Close proximity (<= speed < 10km/h):

The intention of these types of systems is to warn the haul truck operator of light vehicles / pedestrians that are in close proximity to the haul truck and possibly in one of the operator's blind spots. Technologies that specifically target close proximity type collisions are radar based, low frequency radio identification (RFID), and high frequency RFID. These technologies are commercially available and are discussed further in this report. Technologies using Mesh Networking and Machine Vision Cameras are currently being developed.

Long range (0m-150m) high speed (0km/h<= speed<= 55km/h) collision warning systems:
The second class of collision warning system is high speed-long range collision avoidance systems. These systems operate on the principle of detecting potential threats (light vehicles, other haul trucks etc.) in the direction of travel and providing sufficient warning time to the operator to allow him/her to take evasive action. Evasive action could include applying brakes to bring the machine to a stop or it may involve slowing the machine to a controllable safe speed before swerving to avoid a collision.

GPS based collision avoidance system: GPS systems for tracking vehicles in mining conditions have a requirement for more sophistication than everyday GPS units that are commercially available for highway driving cars. Open cut mines are generally deep pits. Satellites signals may not be able to penetrate deep inside the pit. In this case constellations of fixed ground based pseudolites are used to extend the coverage of GPS. Phelps Dodge Morenci mine have a constellation of 5 Novariant Terralite pseudolites together with a

ISSN no. 2277-3037
Vol 11 No 05
May 2022

differential base station that enables them to increase GPS accuracy to centimetre level. This cost in the region of US$ 750 0. Centimeter level accuracy for collision avoidance is obviously not needed, but it is a prerequisite for surveying, drilling, blasting etc. In addition to coverage issues such as multipath reflections (Satellites signals bouncing of the pit benches etc.) can cause errors in the GPS calculations although this is not commonly observed. GPS by itself cannot do collision avoidance – it is simply a means to establish position. By knowing the positions of vehicles in a mine and communicating these positions to machines it is possible to start to have the first part of a collision avoidance system based on GPS positioning. The principle of a GPS based collision avoidance system is as follows: - Each machine is equipped with a GPS receiver to obtain its position - In addition a communication system is required on each machine in order to broadcast its position as well as "listen" to the position of other machines in the vicinity (0 – 500m range) around. The communication network is probably where the most differentiation occurs with GPS based systems.

Acumine Proximity Detection System

The company was established by The University of Sydney, CRC Mining (formerly the Cooperative Research Centre for Mining Technology and Equipment) and researchers from the University's Australian Centre for Field Robotics (ACFR). The Proximity Warning System is a GPS based system that operates on Haul trucks, Light vehicles as well as People. Three modules are used: Haul Truck Proximity System (HTPS), Light Vehicle Proximity System (LVPS), Personnel Proximity System (PPS) and a Base Station. The HTPS alarms the haul truck driver when another truck, a light utility vehicle or personnel is within the defined proximity of the haul truck. The haul truck forms an ad-hoc mesh network with these agents, all of which are equipped with GPS, and broadcasts its position and velocity. The HTPS will generate a different alarm according to the threat level, e.g. truck approaching in front, vehicle behind etc. The system uses a dedicated on-board computer for processing and alarming in the haul truck and light vehicles. A Personal Digital Assistant (PDA) is used to warn personnel such as pedestrians etc. Each agent uses a GPS sensor and an omnidirectional antenna for wide area coverage. All these agents are registered in a single ad-hoc network. The area of operation is by line of sight of the agents in the proximity and the area of detection is programmable through a configuration file. This is possibly a limitation of the system. 802.11x systems based on line of sight will typically give ranges of 100m – 500m depending on conditions. However if line of sight is obscured such as on ramped curved roads or possibly at intersections this could become an issue and the system would not detect with required level of fidelity. The operator interface is either a simple audible alarm or a full graphical interface as shown in Figure 34. The system costs are expected to be in the region of US$ 10000 but this has not yet been verified.

Conclusion

With widely developed IT across the world, utilizing the right technology at right place will not only improve the production and productivity but also enhances safety. Switching over from conventional methods to GPS based technologies could be much beneficial for Surface mining system as mentioned above. According to experts, future improvements in the state of the art should be focused on increasing reliability methods, like extensive use of trolley lines and remote truck's parameters monitoring, making possible internet diagnostic and troubleshooting capabilities. Another advance will likely be unmanned haul trucks. It is expected that this feature will increase security levels and allows for more optimized path selection. This means that the use of GPS will be a common tool in most open pit mines.

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References

1. Astronautica Acta II, 25 (1956) "GPS and Relativity". Astronomy.ohio-state.edu. Retrieved 2011-11-06.
2. Guier, William H.; Weiffenbach, George C. (1997). "Genesis of Satellite Navigation". John Hopkins APL Technical Digest 19 (1): pp. 178–181.
3. Steven Johnson (2010), Where good ideas come from, the natural history of innovation, New York: Riverhead Books
4. Jerry Proc. "Omega". Jproc.ca. Retrieved 2009-12-08.
5. "Charting a Course Toward Global Navigation". The Aerospace Corporation. Retrieved 2010-01-14.
6. "A Guide To The Global Positioning System (GPS) — GPS Timeline". Radio Shack. Retrieved 2010-01-
7. Michael Russell Rip, James M. Hasik (2002). The Precision Revolution: GPS and the Future of Aerial Warfare. Naval Institute Press. p. 65. ISBN 1557509735. Retrieved 2010-01-14.
8. http://www.positionpartners.com.au/products/mining-systems/high-precision-machine-guidance/
9. http://www.msha.gov/accident_prevention/newtechnologies/collisionavoidance/ve