Technology News

From the Bureau of Mines, United States Department of the Interior

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Navigation and Control of Continuous Mining Systems for Coal Mining

Objective

To provide accurate navigation and control of continuous mining systems.

Background

The primary focus of the U.S. Bureau of Mines (USBM) is to make mining safer and more healthful for mine workers. The USBM research program is developing technology that will allow computer-assisted operation of mechanized equipment normally used in underground room-and-pillar coal mining, while permitting workers to be located away from the hazardous coal extraction area (the face). Advanced navigation and control technologies are being developed for underground room-and-pillar and highwall coal mining that can be applied to commercially available mining equipment. The technology being developed uses off-the-shelf components, minimizing the effort required to adapt it to mining equipment. Because the new developments are completely modular, only the modules required in a particular application need be used on the system.

Navigation

The most important requirement for a computer-assisted mining system is an accurate, reliable navigation system that is mounted on the mining machine, to provide the continuous miner's (CM) location at all times. The navigation system provides information allowing the mining machine to cut to a predetermined mine plan. For room-and-pillar mining, entries and crosscuts can be cut to required dimensions and location. In highwall mining, a constant rib can be maintained between parallel cuts. Many different navigation devices have been evaluated in an effort to identify the best one for use on the CM's. After much research, the USBM has decided the Honeywell ring laser gyro,[1] (previously known as MAPS (modular azimuth and positioning system), now known as HORTA (Honeywell ore recovery and tunneling aid)) to be the best navigation device for the application (figure 1). Under a contract with Honeywell, the USBM conducted many hours of underground testing of this gyro on a CM while cutting coal.[2] Many accuracy improvements were made and at the termination of the underground tests, a complete reevaluation of the gyro and its implementation for the mining machine control process was performed. A list of desired improvements including increased accuracy, sharing of navigation data between multiple computer systems, simplified navigation data interpretation, and a simplified user interface for operating the gyro, was prepared and each of the improvements were implemented. The navigation data provided by the gyro includes position of the mining machine in state plane coordinates (feet); position of the appendages of the mining machine in state plane coordinates (feet); heading of the mining machine (degrees); pitch, roll, and yaw of the machine (degrees); altitude above sea level, cross-track and along track.

The Control System

Continuous mining machine manufacturers offer radio or umbilical cord control for their mining equipment. This

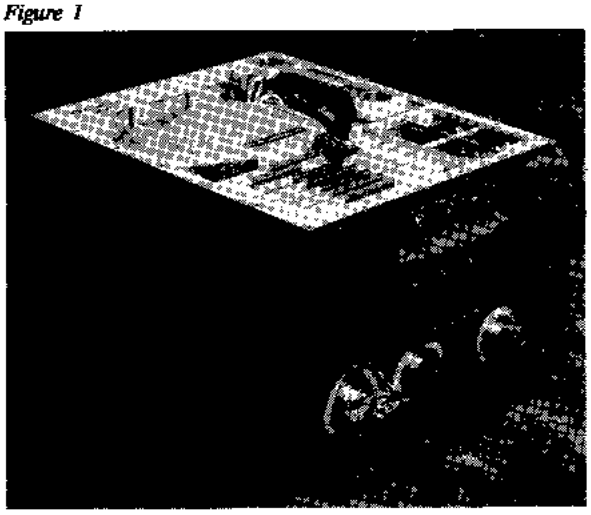
[1]Use of specific products is for identification only and does not imply endorsement by the USBM.

[2]Sammarco, J. J. Field Evaluation of the Modular Azimuth and Positioning System (MAPS) for a Continuous Mining Machine. USBM IC 9354, 1993, 14 pp.

provides line-of-sight operation from close proximity to the machine. Rather than using a radio link, the USBM developed a fieldbus style of control network based on BITBUS[3] standards that allows non-line-of-sight control of all the mining machine's moving parts. The control network consists of a microcontroller board on the CM, and a single microcontroller board in a 19-in rack in the control center that attaches to a single board PC that plugs into a passive PC backplane. The two ends of the control network are connected with a twisted pair cable. The USBM uses a second fieldbus network to provide data collection of the positions of all the moving parts of the mining machine, as well as the status of the machine's critical parameters such as motor currents, hydraulics, pressures, temperatures, and other relevant parameters. This network consists of sensors, signal conditioning modules, and a microcontroller board on the CM, and a PC card that plugs into a passive PC backplane in the 19-in rack. The two ends of the data network are connected with a twisted-pair cable. The separation of the control network from the data collection network allows the fastest system performance. The third connection between the CM and the 19-in rack is two twisted-pair cables that connect the machine-mounted gyro (HORTA) to a PC card that is plugged into the 19-in rack-mounted PC passive backplane. The control network, the data collection network, and the HORTA, are each hosted on their own 486-class single-board PC mounted in a passive PC backplane in the 19-in rack. All three single-board PC's share a common monitor and keyboard using a video/keyboard switcher. One of the key elements of this application is the introduction of a shared-memory box (MEM) and hardware that allow the single-board PC's to intercommunicate with each other through extended memory. The controller (CONTROLLER) software is the key element for providing advanced coal mining operations. By using the data collected from all the CM sensors and the gyro and by executing commands on the CM, the controller is able to do complete coal-cutting scenarios.

[3]BITBUS is a standard developed by the INTEL Corp., Beaverton, OR.

Figure 1



HORTA.

An Expanded Control System

Many modules can and have been added to the design. Each module adds another level of sophistication to the system. Using this method, the USBM is capable of adapting its technology to the most primitive or most sophisticated application, simply by adding the modules required for the application. Figure 2 shows the system's capabilities. The visualization system (VISUALIZATION) uses the collected machine data to provide accurate 3-D graphic representation of the mining machine and associated hardware and its movements relative to the mine surroundings. The user's interface permits the operator to zoom around the scene to view any part of the process of interest. Additionally, top down and side views of the CM for present and previous cuts can be dynamically displayed. Software called MINENAV is being developed to provide navigation information to the CONTROLLER computer that will execute a completely orchestrated mining plan from start to finish, using navigation and sensory data. The simulator application (SIMULATOR), also being developed, will generate a steady stream of data to all the computers in the system that corresponds to data that would normally be provided by the mining machine sensors, including the gyro. This will allow studies to be done without turning on the CM. The haulage application (HAULAGE) will provide for control and monitoring of whatever haulage system is used in the system. The coal interface detection application (CID) will provide information about the thickness of the coal on the roof and floor, and can also provide information about the thickness of a rib of coal. A remote camera system both on and off-board the machine can provide visual information on any part of the process that the operator desires.

For More Information

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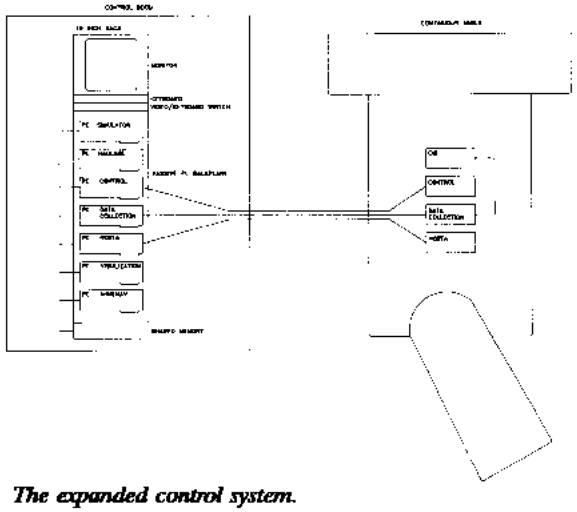
Figure 2



The expanded control system.