By Nima Nabavi

Keeping Obstacles on Your Radar Vision

Shovels, excavators and most mobile mining equipment have significant blind spots due to their large sizes. While this statement is an obvious fact, the extent of these blind spots may not be as clear. Figure 1 shows the measured blind spot map of a Hitachi EX5500 (John Steele, PhD, PE, "Final Report Blind Area Study Large Mining Equipment", July 22, 2006) hydraulic shovel. The grey areas indicate the blind spots while the shade of yellow indicates the area visible through the mirror.

While Hitachi EX5500 is not the largest shovel used in open pit mines, its blind spots at some points far exceed 24m according to the diagram shown in Figure 1. A multi-camera surveillance system is an effective way of viewing the blind spots and reducing the probability of an accident for large mining shovels. However, due to the lack of distance/depth information in two-dimensional camera images, the operator can only rely on visual cues to guess the distance between objects. Furthermore, quite often accidents occur when the operator is momentarily not looking at the display.

The probability of these cases happening can be dramatically reduced if the machine is also equipped with an active proximity system, which can notify the operator if needed, and the operator can use the camera views to see what caused the warning.

"A system that can effectively combine proximity information with vision could be a valuable addition to heavy equipment in open-pit mining as it can prevent many accidents," says Mark Richards, the Mining Technology Manager at Teck Metals Ltd.

According to the Mine Safety and Health Administration of the US (MSHA), "20 percent of all mining-related deaths in the last 5 years could have been prevented through the use of proximity detection".[1] While fatalities are the most notable consequences of these accidents, the financial losses due to equipment damages and the subsequent down times should also be taken into account.

Some of the more practical sensor technologies such as ultrasound, scanning lasers and radars have been utilized by the industry to address the problem. Each technology is associated with its own strengths and weaknesses, which have to be considered based on the requirements of the application at hand. Ultrasonic technology is one of the most commonly used proximity detection methods. The sensors, while being cost-effective and simple, are limited by their short range, noisy outputs and long response times.[2]

Scanning lasers work by reflecting a beam off of a moving mirror. While providing accurate and high-resolution measurements, they are not suitable for this application due to their planar scans, which creates large blind spots above and below the scanning plane. 3D scanning lasers, on the other hand, provide the proper coverage, but their application is limited by their impractically long response times and high costs. In addition, the internal moving parts of these scanners increase the chances of failure due to shocks and vibrations. Furthermore, being optical devices, these sensors can be heavily affected by dust, fog or snow.[3]

Radar sensors, while typically not able to match the accuracy of laser scanners, benefit from their solid-state construction and faster operation. Additionally, they exhibit a much higher level of immunity to severe weather conditions and small particles such as dust.

Motion Metrics International Corp. (MMI) has developed ViewMetrics™-Radar which analyzes and correlates the

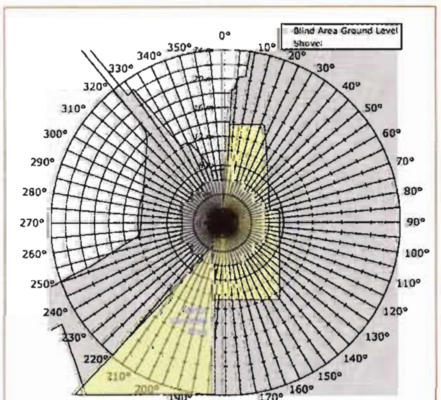

Figure 1. Hitachi EX5500 blind spot map.
(John Steele, PhD, PE, "Final Report Blind Area Study Large Mining Equipment", July 22, 2006.)

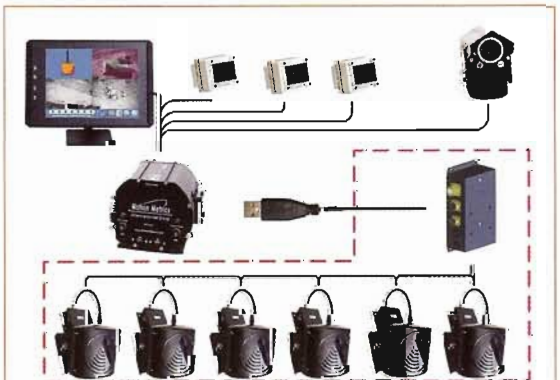

Figure 2. The red dotted line encloses the additional hardware required to augment the camera surveillance system with radar sensors.

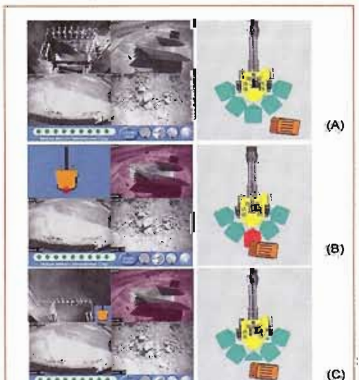

Figure 3 (A) No obstacles detected. (B) An obstacle enters the detection zone. The operator is notified. (C) The operator knows about the obstacle and overrides it.

output from several radar sensors with those of 3 wide-angle cameras, providing a total coverage of about 300 degrees around the mining equipment. The selected radar sensors feature a solid-state construction to withstand the shocks and vibrations incurred in mining operations. While the integration of radar and camera vision in a single product package is new, the individual components including the radar sensors and the camera-surveillance system have been extensively used for mining applications for several years.

The hardware consists of a few radar sensors (typically six for a mining shovel), three or four surveillance cameras, an in-cab junction box, an industrial CPU box, a rugged touch-screen LCD inside the cab and the connecting armoured cables. If the machine is already equipped with MMI's digital surveillance system, ViewMetrics™, the existing hardware can be upgraded using a single USB connection. See Figure 2.

To reduce cabling and therefore the installation time, all of the sensors are placed on a single cable branch on a CAN bus network. CAN bus is the most widely used network for automotive and heavy duty industry due to its robustness and immunity to typical grounding issues. For example, in most modern automobiles, the airbags and the stability control units are all placed on CAN bus networks. Another benefit arising from this hardware configuration is the complete flexibility in the number of sensors that can be added or taken out at the installation site.

To avoid crowding the cabin with another monitor, the user interface blends seamlessly into the previously installed digital camera surveillance system. When there is no close obstacle, the screen is identical to a normal surveillance view (Figure 3A). When an obstacle enters the detection zone, the user is provided with a bird's eye view of the machine with the corresponding sensor locations highlighted. In addition, the corresponding surveillance view is indicated by a red border with its thickness indicative of the distance to the closest obstacle (Figure 3B).

If the operator knows about an existing obstacle, such as during maintenance, he/she can touch the bird's eye view and the warning will stop. By doing this the user has automatically adjusted the range of that particular sensor to ignore that obstacle. Yet, to avoid compromising safety, the system keeps watch for new obstacles (Figure 3C). The detection range is automatically reset once the obstacle is removed from the detection zone. M

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References

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