Ouster LiDAR deployed on mining truck in China as part of automation solution from WAYTOUS

Sight beyond sight

Autonomous haulage and other operations in mining rely on positioning, cameras and sensors. Paul Moore focuses on the key sensors used – LiDAR & radar – and how they are evolving as autonomous system capabilities evolve such as better sensor fusion

In the world of sensors for mining, including LiDAR and radar in particular, it still is a case of using the best available. But as **Hexagon**'s Andrew Crose, VP - Autonomous told ***IM***, it depends on what 'best available' means in terms of range, durability, price, etc. "Technologies are still evolving and improving rapidly, especially for the automotive industry which invests billions into better capabilities, robustness and lower cost. Some of these sensors are pretty well suited for the mining environment. Nevertheless, to make them work 24/7, worldwide, in any mine remains a formidable challenge and requires a significant effort in adaptation and testing."

But at the same time it is well known that most on-road autonomy deployments stay in areas with good weather, visibility and road conditions. "This is not a limitation we can accept in mining, not even initially," says Crose. "We therefore have to choose both the sensing technologies and the actual sensors very selectively to ensure they work in mining. In addition, and most importantly, we have to adapt the sensor processing and fusion to our needs."

He adds: "It's tremendously helpful that we have already equipped more than 40,000 mining vehicles with V2V technologies, as these share valuable information, such as trajectory and vehicle type, which is valuable when fusing the data with LiDAR or radar and helps avoid false alarms." And of course positioning plays a key role. How has GNSS positioning evolved with mining autonomy? How has that improved? "It is probably more accurate to say that machine guidance has evolved to become more and more precise as GNSS positioning has become more precise. Now, with the availability of high-processing power, and better and cheaper motion and orientation sensors to fuse with high-position GNSS, machine guidance becomes autonomous."

Crose points out that most of us are familiar with GPS, starting with satnav in cars where it is just another part of daily life. Phones provide a good enough position for driving location most of the time and navigating in most cities. "In normal conditions you can expect to be within a few metres horizontally of where you actually are and that is good enough. We can usually determine when the GPS map is telling us we are somewhere we know we are not. However, that is not nearly good enough for high-precision machine guidance and autonomous vehicles: here you need centimetre-level precision. GNSS precision has improved over time with techniques like real-time kinematics, wide-area augmentation systems and so on. These techniques mostly address the factors that lead to errors in GNSS, providing signal correction information without changing the technology or making the actual GNSS signal more accurate or precise."

Multiple constellations, such as Glonass, Galileo and Beidou (up until recently, consumer equipment like satnav, fitness trackers and phones used only GPS satellites) and higher-powered processing, have allowed for more satellites to be used to calculate position which does increase precision and accuracy and potentially reduces the time it takes to determine position. "GNSS is the technology used to determine the 'true or absolute position,' whether that is the surveyed marks or cues the autonomous system uses to initialise itself; or if GNSS is part of the systems' sensor fusion algorithms."

On AI, Crose commented: "One of the challenges for AI in mining is the high diversity of mining environments worldwide and creating suitable training sets for them. We are also much more limited in compute power than on-road vehicles, as we try to avoid active ventilation due to dust and reliability issues. Nevertheless, AI is ideal to solve some hard problems which classic algorithms would struggle with; but the use is more local than in a Tesla, for example." Worldwide 24/7 operation is hard to achieve, and the automotive industry has not yet reached the goal of full autonomy (SAE Level 4/5). However, the challenge in mining is different and by wisely choosing the scope of the autonomy operations can gain productivity and safety with the latest technologies and developments.

He concludes on the overall improvement of automation-related sensing in mining: "It's a combination of much better sensors, more compute power and increased knowhow and experience of how to process all that data in real time. Ultimately, it's essential to design and manufacture it all with (functional) safety as the top priority; these systems do not just inform the operator, they make essential safety decisions. Hexagon's vehicle intervention technology, for example, is mining's first Level-9 collision avoidance system for mining. It helps save lives and protect equipment by automatically taking control of the propulsion system of the truck in defined situations if the operator fails to do so."