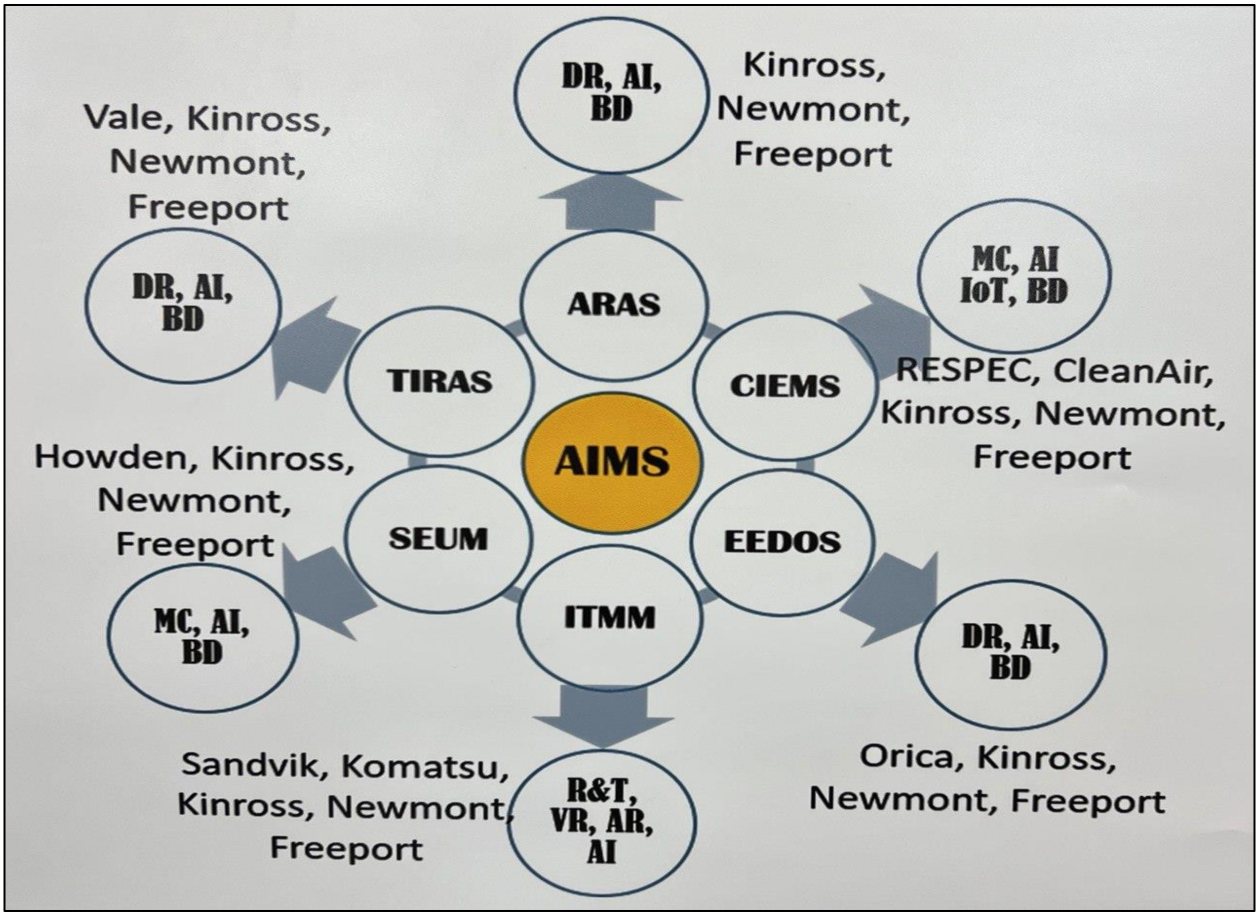
Synopsis

A recent study by Ernst & Young [1] on Digital Mining reveals that the industry will be highly influenced by (i) Robotics and automation through drones, autonomous vehicles, and remote-controlled operational systems, and evolving human-machine interface, (il) Increasing need for Data and Digital literacy across all phases of the mining value chain, and (ill) Integrated operating centers using cloud computing, information sharing, and big data to take employees away from hazardous sites to enhanced workplace conditions. Accordingly, there is a consensus that the skills requiring a greater degree of task creative intelligence will gain more attraction by the impact of technology enhancement and automation. The current project team and industrial partners believe that the path to safer and healthier mining operations crosses only through the development of academic/industrial human resource capacity with a greater understanding of emerging technological infrastructures such as Artificial Intelligence, Internet of Things, Big Data, Cloud Computing, Robotics, Teleoperation, Immersive Technologies (Virtual/Augmented Reality), Drones, and Mobile Crowdsourcing.

With a strong team of multidisciplinary professionals and teaming up with the world's largest mining companies, we are conducting collaborative research on several challenging and safety topics, such as ground failure, exposure to hazardous emissions, and collision avoidance, by developing artificially intelligent tools. In this regard, with the help of our industrial partners, six major missions have been carefully chosen for the project, and each individual mission aims at developing capacities in multiple emerging technological fields.

Acronym	Sub-Project Title	Related Technological Capacities*	Industrial Partners
ARAS	Automated Rockfall Risk Alert System for Open-Pit Mines	DR, AI, BD	Kinross, Newmont, Freeport
TIRAS	Tailings Instability Risk Alert System	DR, AI, BD	Vale, Kinross, Newmont, Freeport
CIEMS	Comprehensive Intelligent Exposure Monitoring System	MC, AI, IoT	RESPEC, CleanAir, Kinross, Newmont
EEDOS	Explosive Energy Distribution Optimization System	DR, AI, BD	Orica, Kinross, Newmont, Freeport
ITMM	Immersive Teleoperation of Mining Machines	VR/AR, R&T, AI	Sandvik, Komatsu, Kinross, Newmont
SEUM	Simulation-based Smart Evacuation of Underground Mines	MC, AI, BD	Howden, Kinross, Newmont



Dissertation

Subproject V: ITMM

Dangerous working environments, Inadequate safety training, low teleoperation, and autonomous systems productivity are major growing problems as surface, and underground mines are becoming wider and deeper. Work efficiency in unmanned operations is less than in boarding operations due to a lack of visual information. The first problem is the difficulties of depth estimation in 2D monitors, reducing the operation's speed. Many researchers and companies have tried enriching visual information by adding multiple views. However, providing excessive visual information can cause "cognitive tunneling" in operators, making them subconsciously more focused on a limited point of view and ignoring others. Hence, the mining industry could significantly benefit from virtual reality (VR) platforms to switch 2D monitors teleoperation systems to an immersive 3D environment to make the teleoperation systems efficient.

The project proposes an approach to solving the challenges of teleoperation. It is an enhanced visualization of the remote equipment by using respective 3D models, whose individual parts move in relation to each other as they would in real life. Spatial data of the machinery's components will be sampled and transmitted in real-time and represented by a corresponding 3D model. The equipment's surroundings are visualized by modeling the inputs from several cameras on the machinery. A high illumination is usually needed on all sides of the machine since underground mines are usually too dark for good-quality video capturing. The offered approach has four major upgrades compared to the similar technologies available in passenger cars. (i) Passenger cars usually have a single integrated body, which needs only a single virtual model to be inserted into the VR environment. In contrast, most mining machines have moving components, such as a bucket, boom, etc., that move in relation to the main part of the body. We have planned to sense the machine's configuration at each instance and project a corresponding 3D model into VR space. The sensing will be implemented using location actuators in the lab scale and Electronic Control Unit output in real machines. (il) We have planned to add a series of 3D guidelines illustrating the prospecting trajectory of the machine's moving components. This will assist the operator in performing a safer operation. (iii) The operational environment of mining machines can be extensively dusty, smoky, or foggy, with reduced visibility for both on-site and remote operators. We have planned to virtually reduce invisibility using visual effects to improve the technology's effectiveness. (iv) It is planned to build a dual application for the proposed technology as another layer of proximity detection. In this module, human objects will be detected on the videos using a deep learning neural network and warned to the operators.

Figure 8 Combining VR and tele-control in ITMM

The final platform will allow operators to work in fully 3D environments remotely. By switching from 2D display teleoperation systems to fully 3D ones and enhancing the speed of teleoperation systems, the operational cost of exploitation will decrease, and the operator will not have to attend to the dangerous working environment.

Industrial Partners

The project is supported by an exceptional list of ten industrial partners. These collaborators are the world's mining leaders. The project has Kinross, Newmont, and Freeport as general collaborators for all subprojects. In addition, we have specialized industries helping each subproject individually. For example, Orca will be involved in EEDOS, Vale in TIRAS, CleanAir in CIEMS, Howden in SEUM, and Sandvik and Komatsu in ITMM. RESPEC is another collaborator that will not only be involved in CIEMS but will also provide extra funding for a graduate student to work on this topic. Moreover, the Big Data team of Freeport and the Artificial Intelligence Center of Vale are priceless partnerships for this project.

Deadline:

The project was a five years contract funded by NIOSH that started in 2018 and was supposed to be finished by 2023, but the Covid 19 changed the deadline. My advisor can provide more information about the project.

References

[1] EY. (2019). The Future of Work: the Changing Skills Landscape for Miners. Minerals Council of Australia, 35 p.

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[3] Rauhala, A., Tuomela, A., Davids, C., Rossi, P.M. (2017).UAV Remote Sensing Surveillance

of a Mine Tailings Impoundment in Sub-Arctic Conditions. Remote Sensing, 9: 1318.

[41 Chen, J., Zhang, Y., & Xue, W. (2018). Unsupervised Indoor Localization Based on

Smartphone Sensors, Beacon, and Wi-Fi. Sensors, 18(5): 1378.