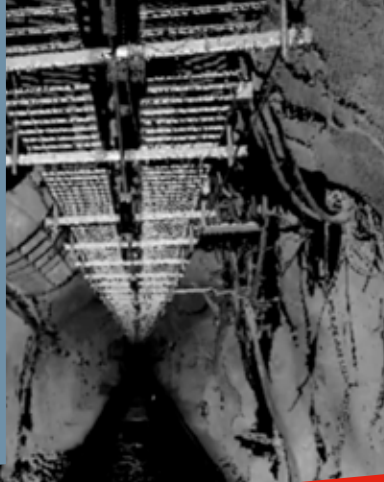


GROUP 04

AUTOMATION IN MINING



LABORATORY OF ROBOTICS AND AUTOMATION IN MINING

MISSION

The Laboratory aims to contribute to develop the next generation of mining systems and to design and construct smart and environmentally friendly equipment.

TEAM

Principal Researchers:

- Javier Ruiz del Solar, PhD.
- Martin Adams, PhD.

Associate Researchers:

- Marcos Orchard, PhD.
- Paul Vallejos, PhD.
- Isao Parra, PhD.
- Mauricio Correa, PhD.
- Mauricio Mascaró, Eng.
- Carlos Tampier, Eng.

FIELDS OF EXPERTISE

- Automation and tele-operation of mining vehicles and equipment.
- Application of technologies to sensorization, data gathering and real-time decision making in underground and open pit mines.
- Development of technological solutions to ensure productivity under optimal safety and health conditions.
- Development of UAV technology for mining application.
- Design and application of pattern recognition methods to relevant problems in mining: rock classification, granulometry, people counting, accident prevention-oriented surveillance, access control to mine facilities
- Design and application of fault diagnosis systems and critical conditions prognosis in mining machinery.

FIELDS OF APPLICATION

- Analysis of semi-autonomous LHD systems technologies.
- Development of an autonomous loading system for LHD.
- Enhanced perception systems for operating machinery in low-visibility conditions.

- Support for operation of autonomous/tele-operated systems in open pit mining under adverse weather conditions.
- 3D mapping and tunnel inspection using aerial platforms.
- State-of-Charge estimation and prediction in lithium-ion batteries.
- Oil quality estimation and prediction in mining machinery.

PROJECTS

1. ENHANCED PERCEPTION SYSTEM FOR OPERATION UNDER LOW-VISIBILITY ENVIRONMENTS

Associate organization: Codelco

Fundamentals

Adverse environmental conditions, such as snow during the winter or excess of dust, interrupt open pit operations. This interruption is due to the high risk of exposure of the operators under these conditions. Tele-operated equipment removes this risk, but the lack of visibility does not allow for a safe operation. Therefore, it is imperative to develop a system that enables operators to see the working environment even in low-visibility conditions.

Goals

The project aims to develop an enhanced perception system that provides information to the operator to compensate for the loss of visibility due to weather conditions, thus allowing a safe tele-operation.

Results

- A system that acquires information from different types of sensors was developed.
- A software that fuses sensor information into an intuitive and robust visualization was created.
- Validation of the system in extreme winter conditions.

2. CONCEPT STUDY ON INTEROPERABILITY FOR TELE-OPERATION AND AUTOMATION OF MINING MACHINERY

Associate organization: Codelco

Fundamentals

Mining companies currently face a problem of incompatibility between the different automation technologies used in their mining facilities. This incompatibility affects the extraction stage of the mining process, specifically in the operation of ore transportation machines (automated and/or tele-operated). As a consequence, a particular mine facility is often restricted to certain proprietary technologies and/or suppliers, since the cost of replacement once the equipment is working in the mine is very high. In addition, each mining workplace approaches the problem differently, without a centralized effort. So, there is a redundancy of efforts and resources to make the suppliers' capacities and available technology compatible. To solve those operational difficulties, the concept of developing an interoperability standard arises.

Goals

The project aims to establish the theoretical and conceptual bases upon which an interoperability standard should be based. The goals are:

- Carry out studies on standards currently applied to autonomous/tele-operated systems in mining.
- Develop an interoperability conceptual model.
- Define requirements for a future standard and evaluate the necessary efforts to implement an interoperability standard that can be adopted by the mining industry and its suppliers.

Results

- A state-of-the-art study, identifying relevant existent standards for interoperability of autonomous/tele-operated systems and identifying areas in which it is necessary to create new standards was completed.
- A generic, conceptual model of interoperability, applicable to all types of vehicles in all types of mining projects was developed.
- A roadmap for an upcoming implementation of an interoperability standard was established.

3. AUTOMATION OF THE LOADING PROCESS IN LHD

Fundamentals

The most advanced LHD systems in the world are semi-autonomous. Transportation and unloading are autonomous, while loading is still tele-operated. The process of autonomous loading is the missing piece to achieve a fully autonomous production level with continuous operation.

The project aims to develop an autonomous loading system for LHD and to validate it in an industrial-based trial.

Results

- The project developed a laboratory prototype of the autonomous loading system, using granulometric and geometric information of an extraction point, along with internal information of the LHD about its interaction with the material (September 2015-September 2016).

Future work

The autonomous loading system will be installed in a real LHD. Two suppliers have shown interest in collaborating with this test (2017). The installed system will be validated in an industrial trial run. A model for technology transfer will be developed, aiming to a commercial implementation (2018).

4. AUTONOMOUS NAVIGATION SYSTEM FOR LHD IN MEDIUM-SIZED MINING

Associate organizations: GHH and GIZ

Fundamentals

Automation is often considered as a key factor to increase safety and quality of work life in underground mining, along with higher productivity and lower operation costs.

Currently available autonomous LHD systems have a cost and complexity custom-made for massive mining operations and, therefore, do not adjust to the needs of medium-sized mining.

In the medium-sized industry, to count on the benefits in safety and productivity of semi-autonomous LHD systems, it is necessary to develop a custom-made system, considering their requirements.

Goals

The project aims to develop a robust automation system for LHD. As part of this concept, the operator station will be located in a safe location outside the mine, from which one or more machines can be operated.

Results

- An autonomous navigation system for LHD was developed in collaboration with GHH (March 2015-Nov 2016) to provide the following characteristics:
 - The system will be remotely operated from a safe location.
 - The system will autonomously navigate in stoping-type mines, with a robust obstacle-detection system.
 - The productivity of the system will be equal or superior to those manually or tele-operated with line of view.

Future work

- System's validation scheduled in a trial field. (Nov. 2016- Feb. 2017)
- Industrial validation will be made in a sub-level stoping mine. (2017)