

EDITORIAL

Mining robotics, a potential catalyzer for technological innovation in Chile

Mining has the characteristics of a suitable application domain for robot technology. Many of the mining jobs are dull, dirty or dangerous for the workers, which would be better off being moved to areas where their skills are put to better use. From the point of view of the mining operation these characteristics of the jobs make salaries high, make the cost of maintaining safety expensive, and maintaining the worker's motivation difficult. Robot technology can be used to address these challenges. Robot technology may not be able to completely replace workers, but may make the jobs more interesting, less dirty and safer. Robot technology may also given time increase efficiency, increase yield, and potentially in the future provide more environmentally friendly ways of extracting ore from the ground and extracting metals and minerals from the ore.

First, it is important to say that robots are not only robot arms. A useful definition is that robots are intelligent machines with autonomous behavior. This means that robots are, but not limited to, autonomous trucks driving in mines, autonomous, small quadcopters (helicopters with four rotors) monitoring underground air quality, walking robots traversing difficult terrain, exoskeletons empowering the workers, and of course the traditional robot arms for small-scale manipulation, and so on. While most of the robots mentioned are yet to be developed for the mining application, robotics is changing world-wide and more and more robots of this type are developed and sold for applications in dull, dirty or dangerous jobs such as vacuum cleaning, lawn mowing, and floor washing.

While the mining robots mentioned above are hypothetical, they are within our technological reach. I believe this presents Chile and other mining intensive countries with a great opportunity. Mining robotics may become a major area of expertise in Chile that can be fueled by and benefit the local mining industry, but also become a major export for Chile. Even wider an increased focus on mining robotics at research institutions may create the robotics knowledge concentration that it requires to develop research and products for other application domains and in time make Chile a technological player on the global market.

While lofty visions are good, the first question to answer is how to get started. The first steps have already been taken. There are strong robotics competencies at Chilean Universities. Personally, I visited Universidad de Chile, Santiago in early 2012 and saw a research environment that was not any different from environments found in the US, Japan or Europe. It is of course clear that not all universities have the same resources as Universidad de Chile, but it actually turns out to be less of a problem than it used to be. I enjoyed a six-month sabbatical at Universidad de Tarapacá, Arica, Chile. Here at this remote university they are taking important steps towards becoming an important player in robotics.

The first step was to make an interdisciplinary education in Mechatronics. Interdisciplinary educations are essential because robot technology is based on electrical engineering, mechanical engineering, and computer science. Implementing interdisciplinary education can be a challenge for a university because this means that institutes that typically do not work together have to work together to produce the students who in time will lead education, robotics research and product development in Chile.

The second step was an investment in a prototyping lab. The cost of prototyping machines have falling dramatically over the last few years and a three-dimensional printer with a resolution of 0.1mm can today be bought for a few thousand dollars and materials for about \$50/kg. It has never been cheaper

or easier to build mechanical prototypes. In terms of electronics there are open-source kits available such the popular Arduino family of electronics. It is also cost efficient to have circuit boards and prototypes ordered online, made cheaply, and returned via mail. In other words, it is difficult to make a financial argument for not doing robotics research. Building full-scale humanoid robots may be costly, but building small application specific prototype robots suitable for further investment and research is not. In fact, highly motivated Mechatronics' students raised the money for the prototyping lab at Universidad de Tarapacá.

From my external perspective, as an internationally recognized robotics researcher, it seems clear there is an opportunity for Chile and other similar countries here. You have an application domain in mining that can relatively quickly make robotics research and innovation profitable. You can create new interdisciplinary educations. You can create the prototyping labs essential to this research for a very small investment. Lastly, while the number of engineering students is in decline internationally there is an abundance of bright and motivated engineering students in Chile who can realize this vision.

What are you waiting for? Mining robotics is ripe for exploitation in Chile!

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