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Behaviour of a novel algorithm for fragmentation analysis based on 3D images from photogrammetry

Background

LKAB is an international and high-tech mining and minerals group that mines and processes the unique iron ore of northern Sweden for the global steel market.
You will find more information on our website, https://www.lkab.com/eng/.

3GSM is a Graz-based software company and develops and markets easy-to-use systems for generating three-dimensional images of rock and terrain surfaces for assessments and surveying. The main application of its products and services are in the tunnelling and mining industry. You will find more information at http://www.3gsm.at.

Sustainability is the core of LKAB's business, and our ambition is to be one of the industry's most innovative, resource-efficient and responsible companies. The group had sales for more than SEK 16 billion (USD 1.8 billion) in 2016 and employs about 4,200 people in 13 countries. Further group business includes industrial minerals, drilling systems, rail transport, rockwork services and property management.

In our underground mines sublevel caving (SLC) is used as mining method. Fragmentation in SLC is vitally important. Both, gravity flow of broken rock and any downstream process are affected. However, to date there is still no reliable full-scale fragmentation measurement system existent. Both, 2D and 3D algorithms are obviously not flawless yet (Wimmer et al 2015). For this reason, LKAB initiated together with 3GSM the development of a new 3D image based fragmentation algorithm. The main difference of the proposed approach to previous ones is that analysis starts in 3D from the surface geometry, determines particle borders by curvature analysis of the surface, and improves the results by using 2D image information from known methods, e.g. gradient images for edge detection.

Project idea

The newly developed fragmentation algorithm should be thoroughly tested based on lab tests and full-scale data (the latter is supplied by LKAB).
The actual full-scale data comes from a recent measurement program in which blast function, fragmentation and gravity flow are studied. Hence, the fragmentation analysis will also be a valuable input for the overall project.

Specific goals

The project is split in three parts described below:

A) Preliminary assessment and parameter study of selected examples of the muck pile at the draw point, and the muck transported in the LHD bucket. Investigations should focus on the influence of input parameters on the particle delineation results. The preliminary assessment should at first hand, lead to a working set of input parameters, and at second hand, to early detect shortcomings in the algorithm.

B) Validation of algorithm by lab tests

- *Qualitative evaluation of segmentation data. Are there any obvious errors in delineation of particles? If so, when and why?*
- *Comparison with 2D algorithm SplitDesktop software (Split Engineering 2010, supplied by LKAB) applying the evaluation strategy (amongst others an image sharpening filter is used) developed by Righetti (2015)*
- *Comparison with sieve results of homogeneous material*
- *Comparison with sieve results of inhomogeneous material. Can the algorithm reliably describe the surface of a pile? A method needs to be developed to "freeze" and "peel off" the surface of a pile for sieving or vice versa to add an already sieved surface skin to a 3D pile.*
- *Investigation of the influence of the sizing hypotheses and its parameters on the obtained particle size distribution.*

C) Evaluation of full-scale data

In an on-going project LKAB assesses the present-day functionality of large-scale SLC in a multi-year, comprehensive measurement program (Nordqvist & Wimmer, 2016). It will be the basis for possible future changes in the mining layout and working procedures. As part of this program, a 3D image acquisition system is used to document the draw point and the LHD bucket for each mucking cycle.

Data from field test II is available during autumn 2017 and should be evaluated in this thesis. Depending on the complexity of task A) and B) the work load (number of images to evaluate) is adjusted. Main focus should be to verify the functionality of the algorithm for 3D images from production. Moreover, it is expected to discuss the results in general but also in context with findings from field test I (Wimmer et al 2015).

Project formalities

A close cooperation with 3GSM in Graz is expected during the course of this project. Important results should be communicated on a regular base, whereas meetings are organized on demand. If a site visit to LKAB is required, travel expenses can be reimbursed.

It is required that the MSc thesis is written in English.

Publication of results in e.g. journals or at conferences needs to be approved by LKAB and 3GSM. A joint publication (TU Graz-LKAB-3GSM) is pursued for the upcoming Fragblast 12 conference in Luleå/Sweden (June 2017).

A final presentation for LKAB representative is required.
LKAB will sponsor the finalized MSc thesis with 35000 SEK (~ 3600 €).

References

Nordqvist, A and Wimmer, M, 2016. Holistic approach to study gravity flow at the Kiruna sublevel caving mine. In *Proceedings 7th International Conference and Exhibition on Mass Mining (MassMin 2016)*, pp 401–414 (The Australasian Institute of Mining and Metallurgy: Melbourne).

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Wimmer, M, Nordqvist, A, Righetti, E, Petropoulos, N and Thurley, M, 2015. Analysis of rock fragmentation and its effect on gravity flow at the Kiruna sublevel caving (SLC) mine. In *Proceedings 11th International Symposium on Rock Fragmentation by Blasting* (ed: A T Spathis, D P Gribble, A C Torrance and T N Little), pp 775-791 (The Australasian Institute of Mining and Metallurgy: Melbourne).

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