Bildanalys - Fragmentation Measurement of Bulk Material on Conveyor using 3D Vision

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Tobias Andersson
Industrial Image Analysis Group
Luleå University of Technology
Increased Energy Efficiency and Product Quality through Fast Feedback and Control

In the future, crushing, aggregating, and loading of bulk material will be fully automated

= Automated particle size distribution and volume measurement using 3D vision.

Dr Tobias Andersson
www.ltu.se/staff/t/tobiasa
Automated sizing on conveyor – rocks
Nordkalk – Gotland Limestone Quarry (Projekt 1.5.3)

Requirements
- Fully automated measurement
- Quality control of material size during ship loading.
- Capability to report loading of the wrong size class
- Ability to report deviations in desired material size during loading of the ship in order to detect mechanical failure in the screen decks.


Dr Tobias Andersson
www.ltu.se/staff/t/tobiasa
Automated sizing on conveyor – Preliminary Online Results
Nordkalk – Gottland Limestone Quarry: Measurement trends in the right direction

- By the end of 2009 we demonstrated that the online fully automated results trend in the right direction
- The following two images were taken from the online measurement system during the 14th of December 2009
10-90mm being loaded  14.12.2009  20:56

D50 = 31mm

Dr Tobias Andersson
www.ltu.se/staff/t/tobiasa
10-90mm being loaded

9:02

D50 = 44mm

Number of objects in current data set: 205

Dr Tobias Andersson
www.ltu.se/staff/t/tobiasa
Automated sizing on conveyor – rocks
Nordkalk – limestone quarry: Measurement trends in the right direction

- The raw size measurement results trend in the right direction because they are based on a physically observable property, the Best-Fit-Rectangle (BFR) area of the non-overlapped rocks.

- 20-40mm product
  - Median value 882mm²

- 40-70mm product
  - Median value 1901mm²

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www.ltu.se/staff/t/tobiasa
Identifying the Product
Nordkalk – limestone quarry

- Using this physically observable property, the BFR area of the non-overlapped rocks, we can identify the product being loaded

- For each measurement data set (surface data for approx 1m length of the belt)
  - Identify non-overlapped rocks
  - Calculate the BFR area of each rock
  - Obtain the median and IQR of the resulting distribution of BFR area values

Identifying the Product
Nordkalk – limestone quarry

Product identification probabilities: 98.8 % accurate classification

Calcualted probabilities for product classification.

\[ \hat{p}, \text{ (day 1)} \]

\[ \hat{p}, \text{ (day 3)} \]

Dr Tobias Andersson
www.ltu.se/staff/t/tobiasa
Estimating the Sieve-Size Distribution
Nordkalk – limestone quarry

- Industry standard is to sample and sieve to measure the weight of material in each size interval
- Observe two graphs of the same three sieve samples
- Imaging systems observe the number of visible rocks

Dr Tobias Andersson
www.ltu.se/staff/t/tobiasa
Estimating the Sieve-Size Distribution
Nordkalk – limestone quarry

- Convert number of rocks by size-class to a weight of rocks by size-class
- Calculate the average weight by size-class based on sieving samples
- However, average particle weight for a given size-class can vary depending on the product (Shape varies)
- Use our classification strategy to identify the product first
- Use the appropriate average weights for a specific product.

Presume shape varies between products for the same sieve-size-class. Open research question to characterise shape in the 3D surface data.
Estimating the Sieve-Size Distribution by Weight

Nordkalk – limestone quarry

- Segmentation
- Detection of non-overlapped particles
- Sizing and classification using BFR area
- Into sieve-size classes (by number)
- Identify which product
- Conversion to sieve-size distribution by weight
- Validation against hold-out data
- Overestimating smaller sizes in the larger products
- More work to be done
The next step

- Complete Nordkalk system for product identification
- Continue discussions with Sandvik and Magnus regarding a crusher control project
- Develop a new project for estimation of hidden fines

Dr Tobias Andersson
www.ltu.se/staff/t/tobiasa
Automated Segmentation

1. Raw 3D surface data
2. Fully automated segmentation
3. Fully automated exclusion of overlapped rocks

Dr Tobias Andersson
www.ltu.se/staff/t/tobiasa
## A Broad Range of Applications

Aggregates and Mining Industries

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<th>Material</th>
<th>Location</th>
<th>Status</th>
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<td>Green pellets</td>
<td>Conveyor</td>
<td>Commercial-ready</td>
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<td>Ship loading</td>
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<td>Blasting (underground)</td>
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<tr>
<td>Feeders to Mills</td>
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<tr>
<td>Heap leaching permeability mineral liberation</td>
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<tr>
<td>Blasting (above ground)</td>
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<td>Trucks</td>
<td>Open research</td>
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</tbody>
</table>
Key Research Benefits - Good 3D Data and Smart Algorithms

Good 3D data provides the necessary foundation for smart algorithms that:

- Achieve a sufficiently accurate **fully automatic particle delineation**
- Distinguish between overlapped and non-overlapped particles **eliminating error** due to mis-sizing overlapped particles
- Identify areas of fine material, **eliminating error** due to misclassification as a large particle
- Facilitate fully automated industrial prototype systems
- Provide a new range of automatic control opportunities

This research lets us break the problem down into three separate problems that can be handled in different ways.

\[
\text{The Pile} = \text{Non-overlapped rocks} + \text{Overlapped rocks} + \text{Areas of fines}
\]

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Dr Matthew Thurley  
[www.ltu.se/staff/m/mjt](http://www.ltu.se/staff/m/mjt)
Status and Roadmap

Existing Technology
- Pellets on conveyor belt
- Course fractions on conveyor belt
- Hardware for measurement on conveyor is off-the-shelf

Research
- Using shape to improve estimate particle weight

The Next Step
- Prototype for feedback to blasting (excavator buckets or trucks)
- Prototype for crusher control (measurement before and after a crusher)

Research
- Robust validation of the area-of-fines detection algorithm within a prototype installation
- Outdoor measurement hardware