MinBaS

Mineral•Ballast•Sten

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

MinBaS-dagarna 24-25 mars 2011

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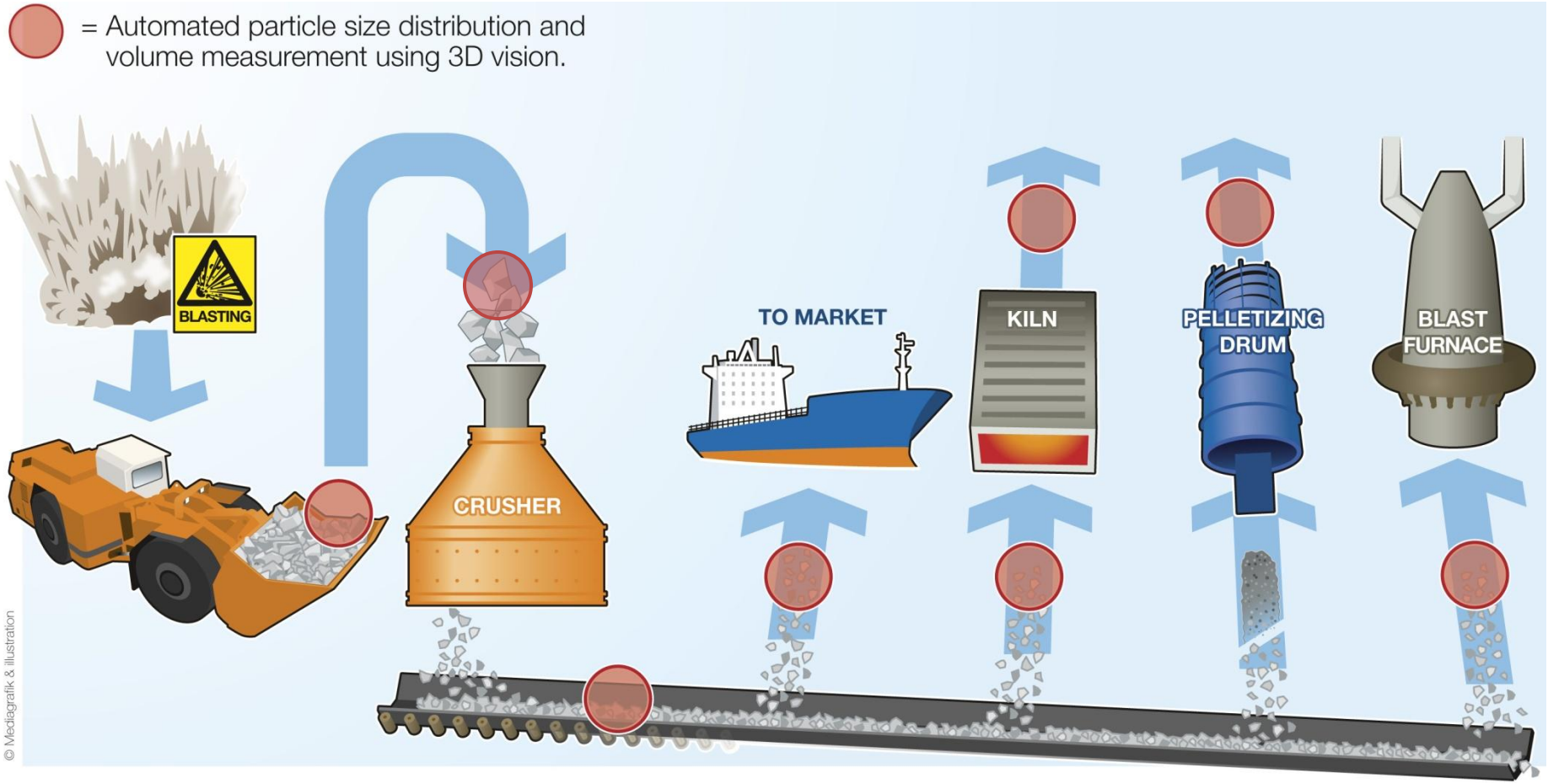
Increased Energy Efficiency and Product Quality through Fast Feedback and Control

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



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ProcessIT Innovations

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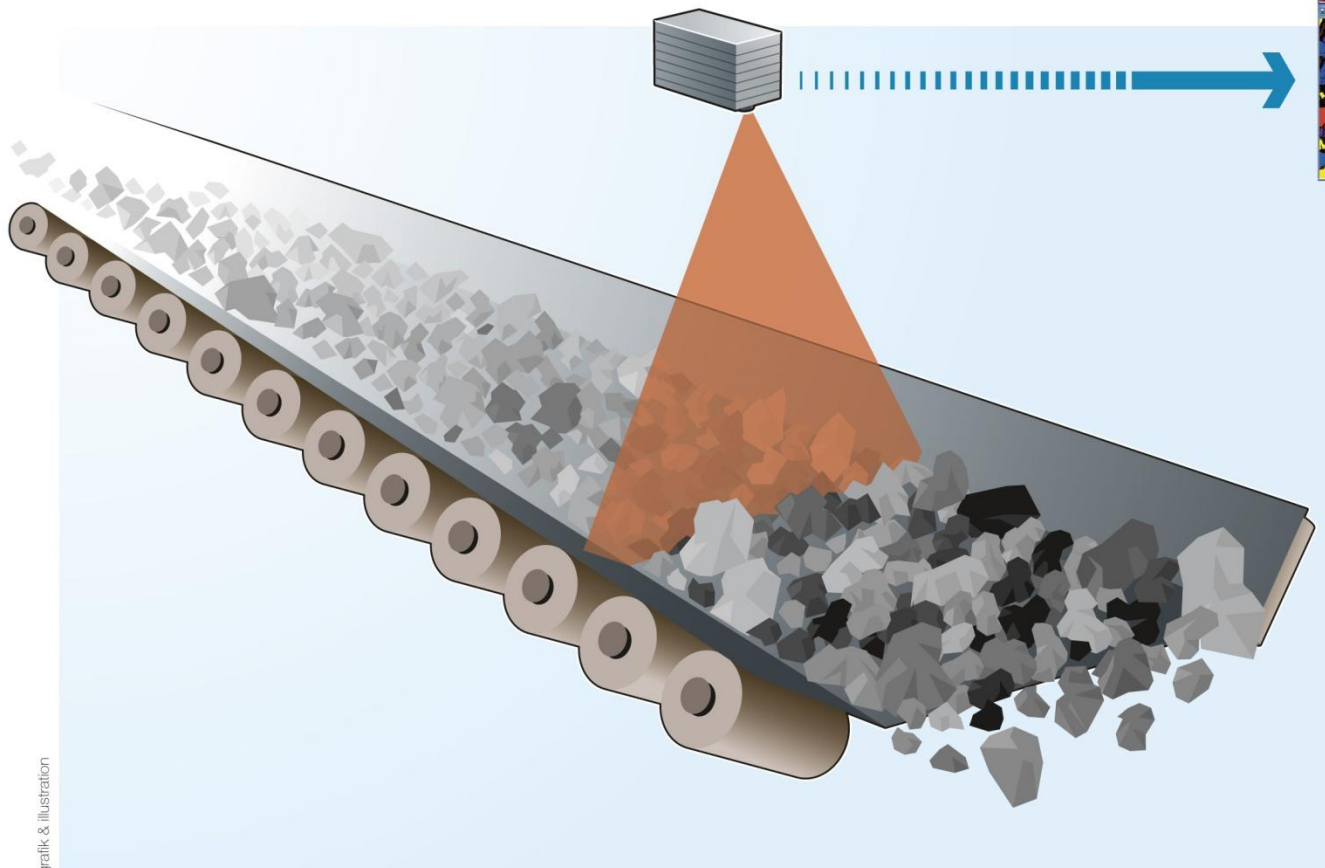
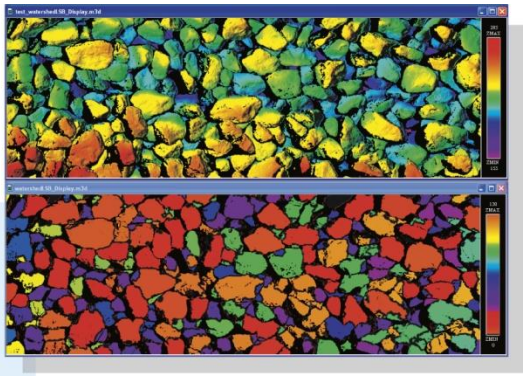
Automated sizing on conveyor – rocks

Nordkalk – Gotland Limestone Quarry (Projekt 1.5.3)





Thurley, M.J. Automated online measurement of limestone particle size distributions using 3D range data, Journal of Process Control 21 (2011) 254-262

Requirements

- Fully automated measurment
- 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.

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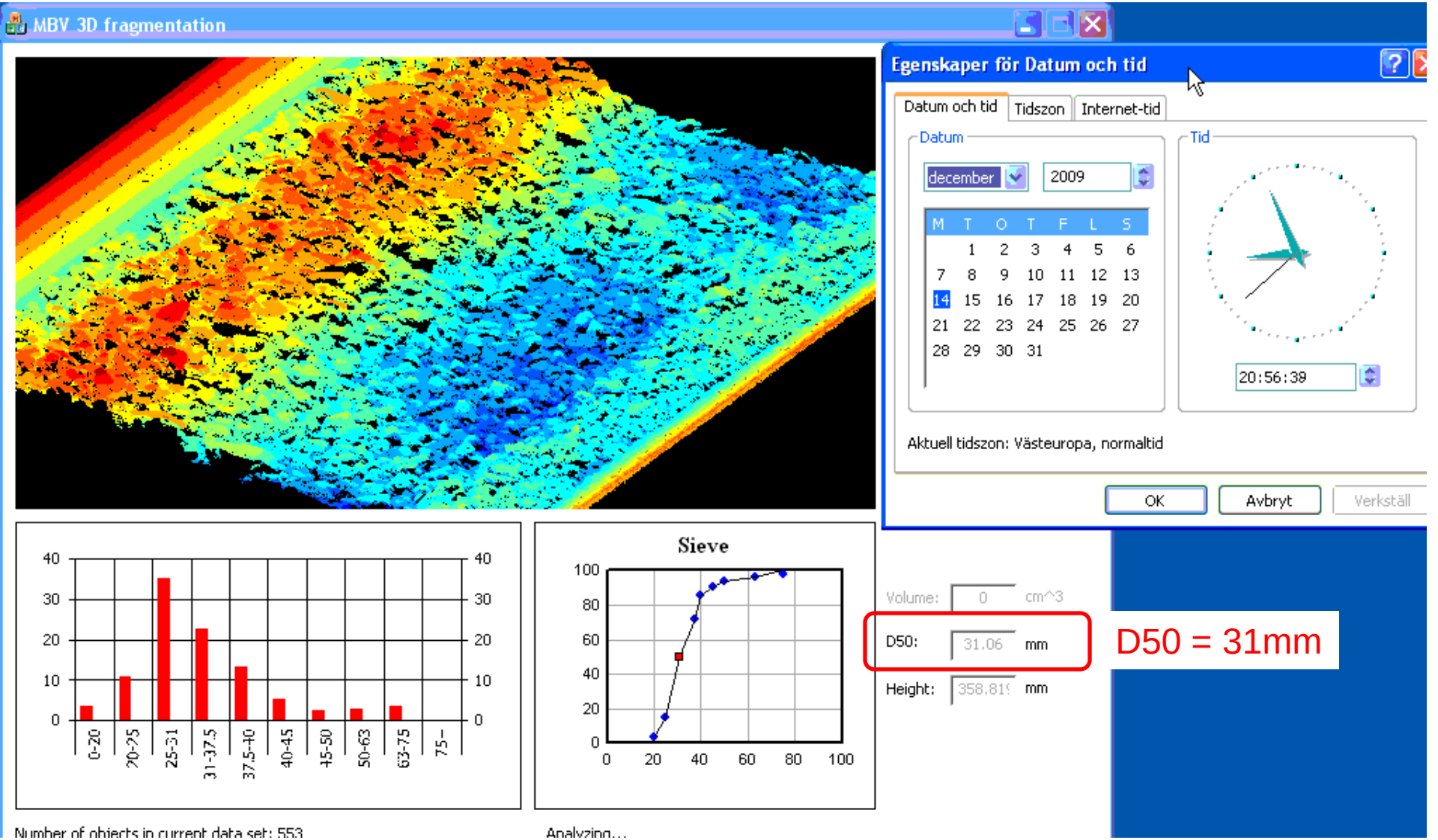
Laserstrålning

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



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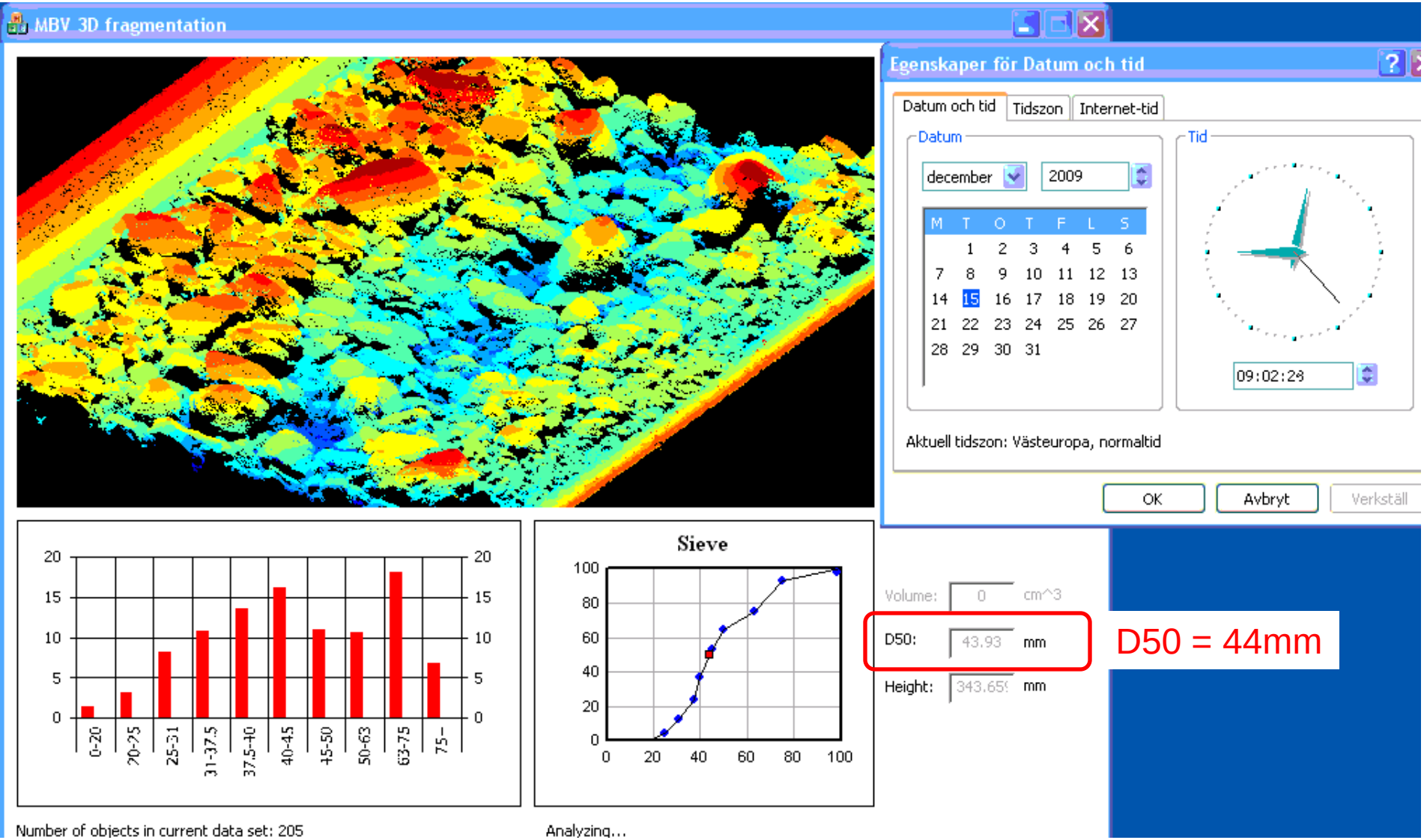
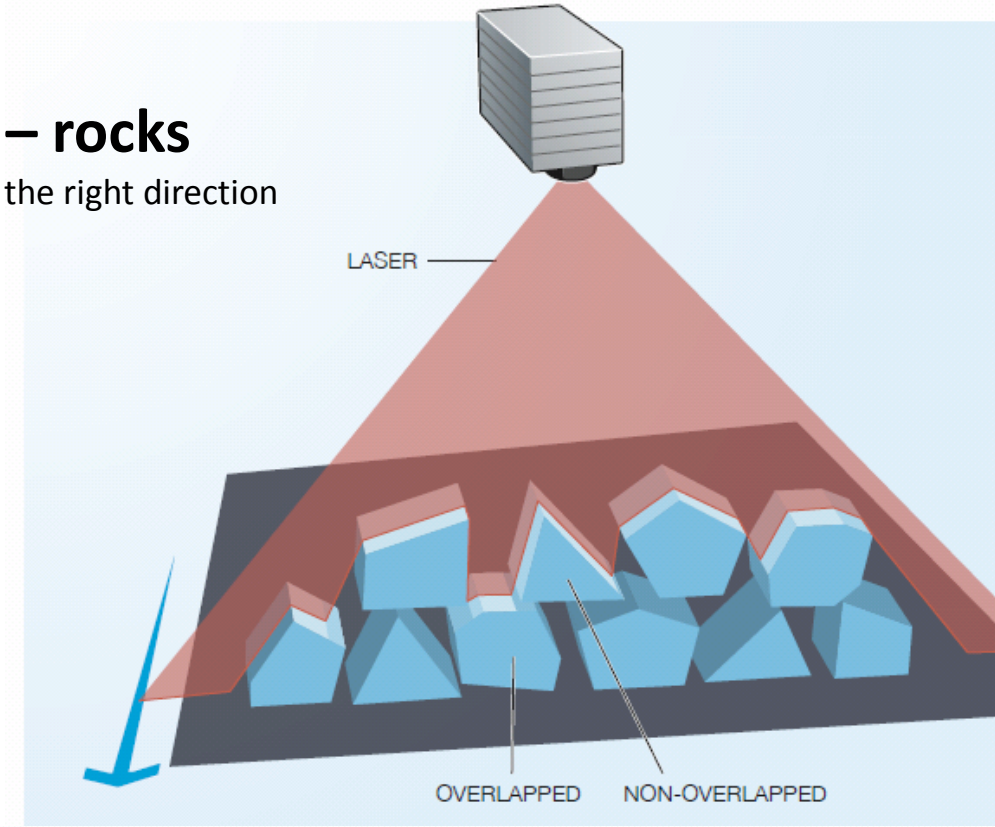
10-90mm being loaded 15.12.2009 9:02

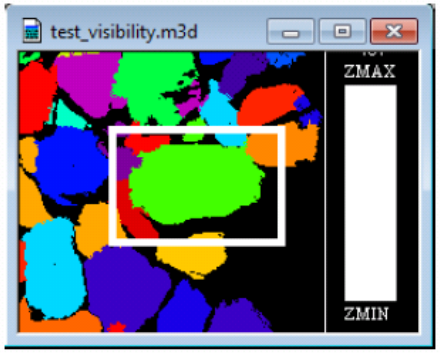


Automated sizing on conveyor – rocks

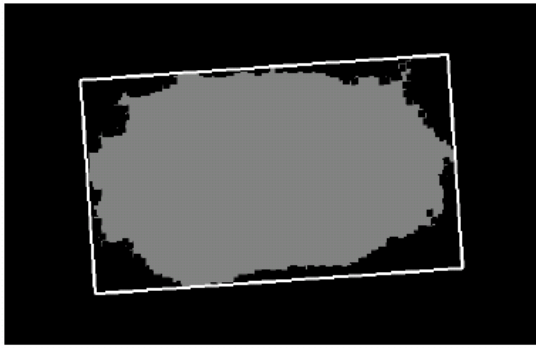
Nordkalk – limestone quarry: Measurement trends in the right direction

- The raw size measurement results trend in the right direction because they are based 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





(a) Identified non-overlapped rock



(b) Calculated best-fit rectangle

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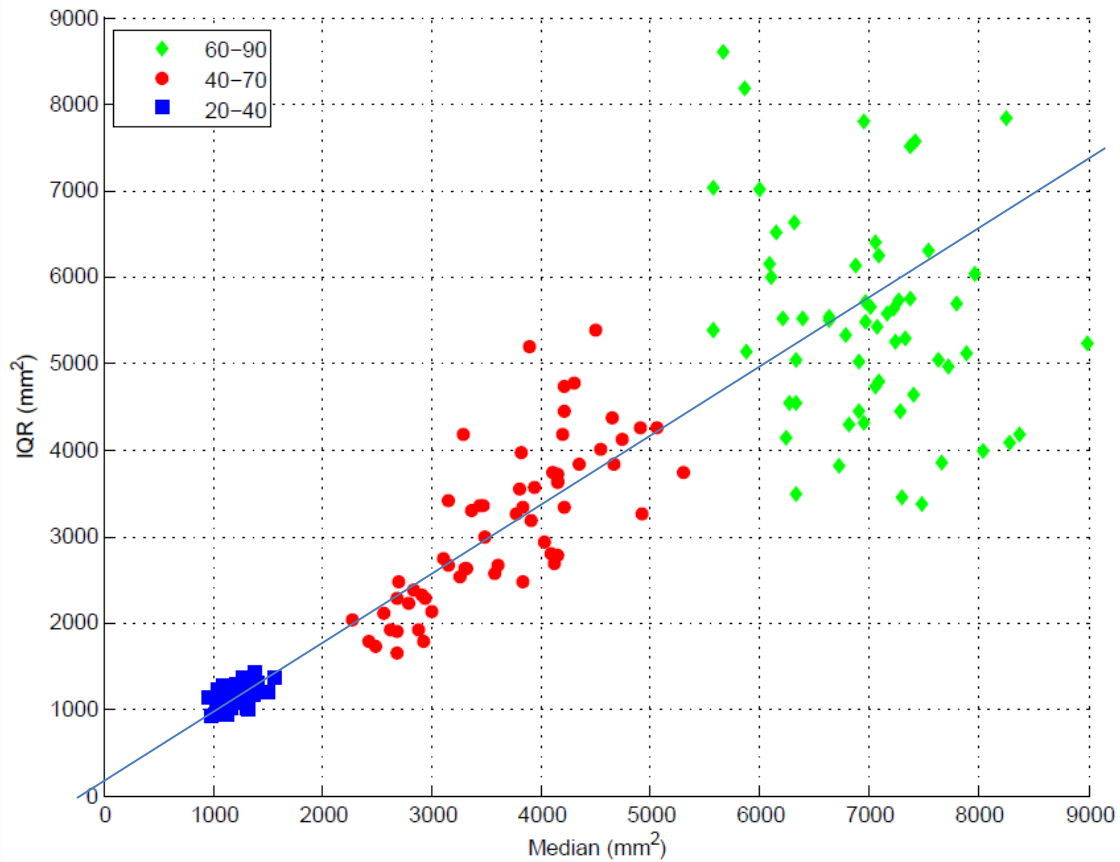
Identifying the Product

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



Anderson, T., Thurley M., Carlson, J.E. Online Product Identification during ship loading of limestone based on machine vision. Machine Vision & Applications 2010 (in submission)

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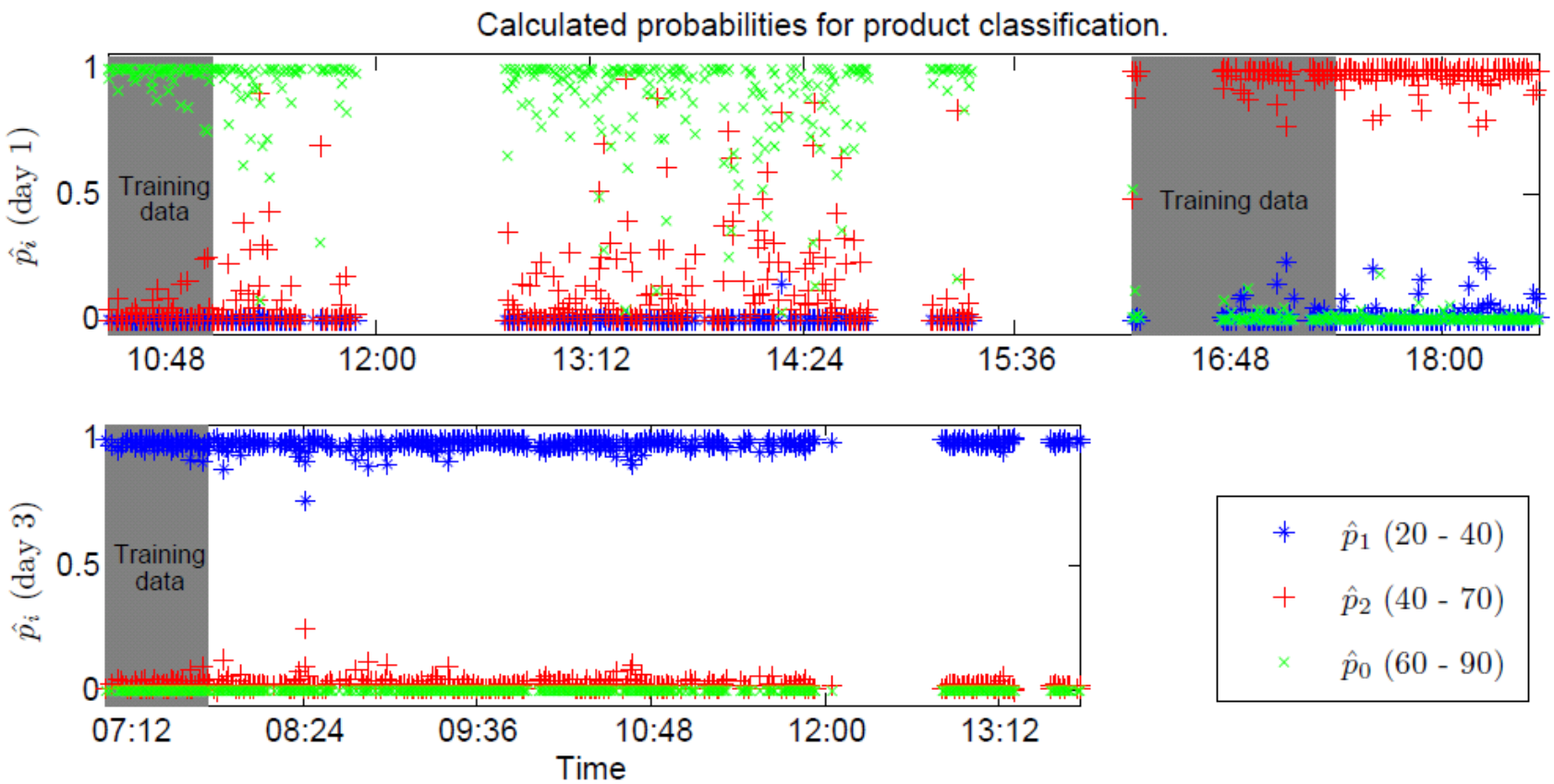
Identifying the Product

Nordkalk – limestone quarry

Product identification probabilities: 98.8 % accurate classification



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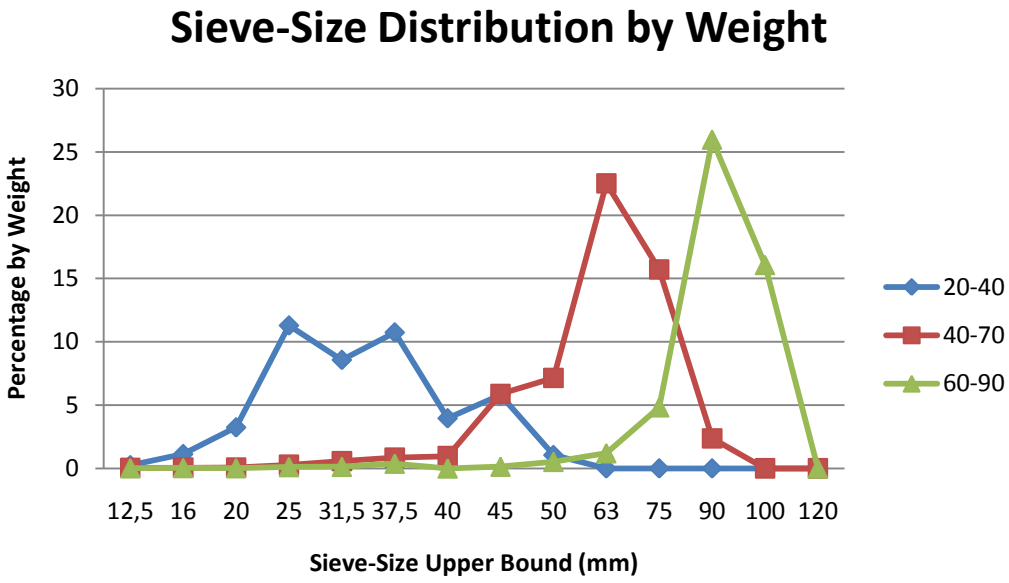
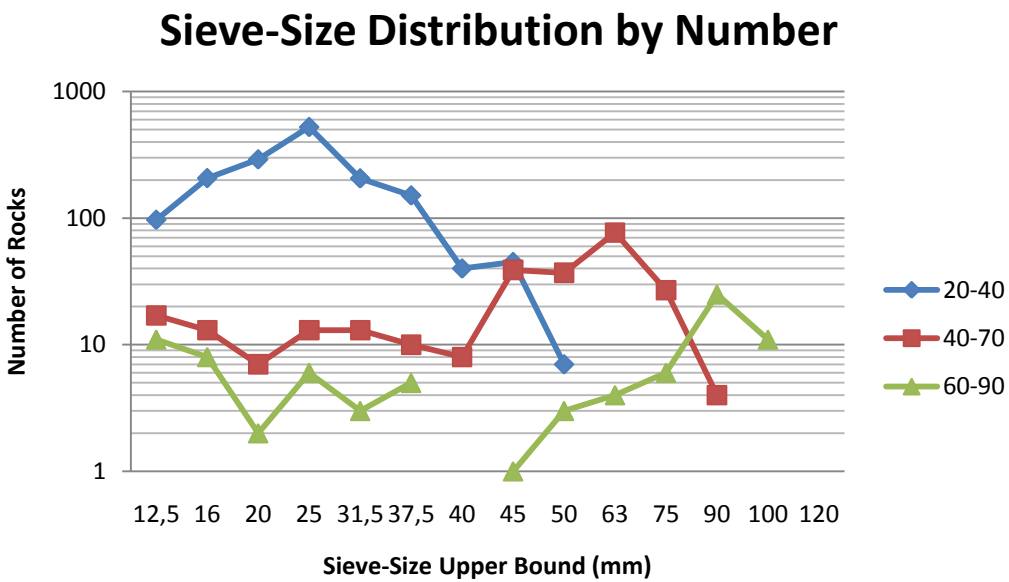
Estimating the Sieve-Size Distribution

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





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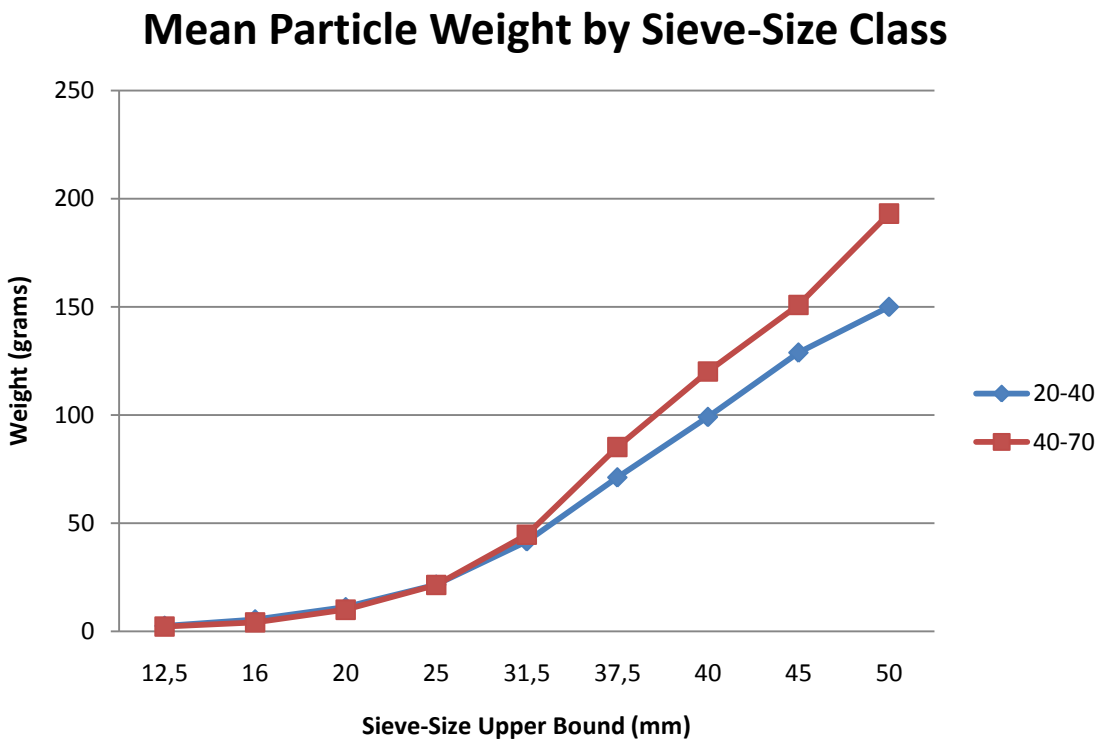
Estimating the Sieve-Size Distribution

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

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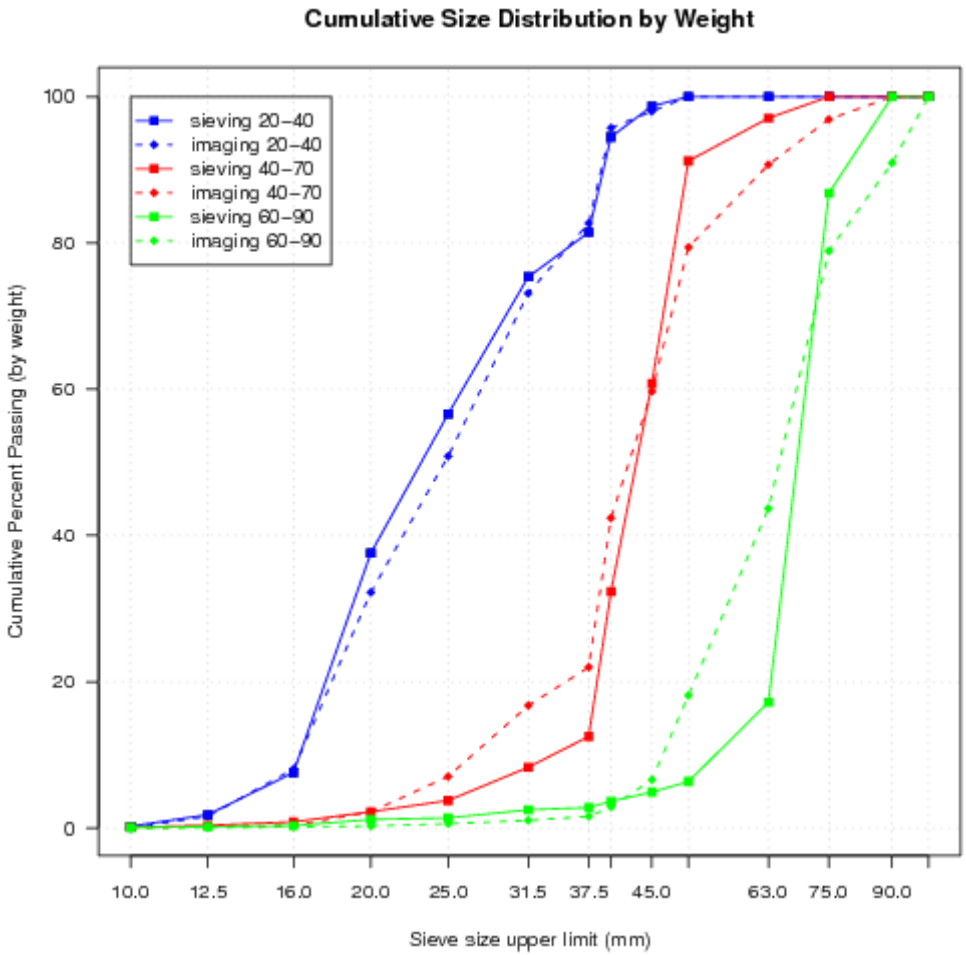
Estimating the Sieve-Size Distribution by Weight

Nordkalk – limestone quarry

- Segmentation
- Detection of non-overlapped particles
- Sizing uClassification sing 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



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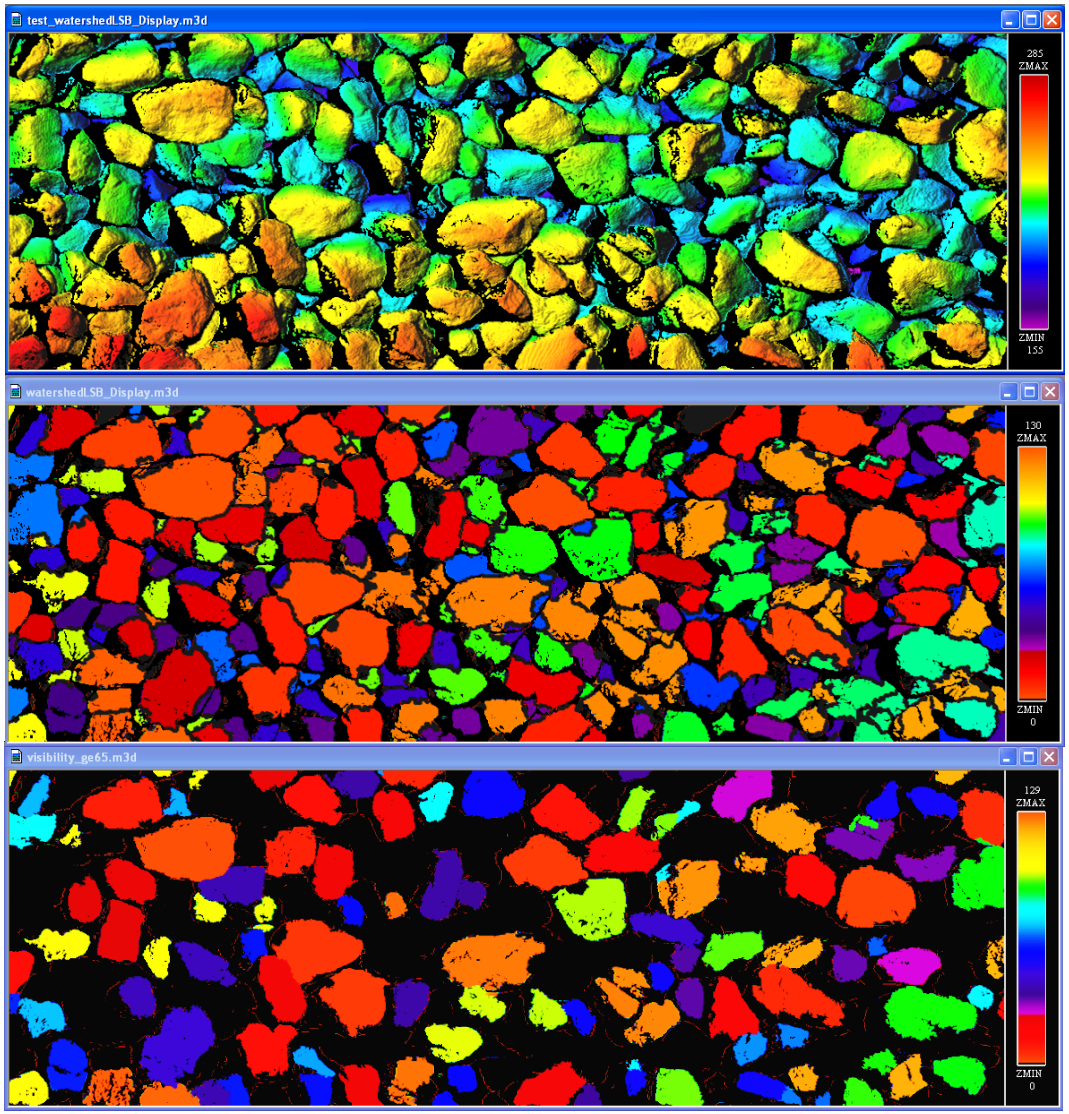
The next step

- 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

Automated Segmentation

1
2
3

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



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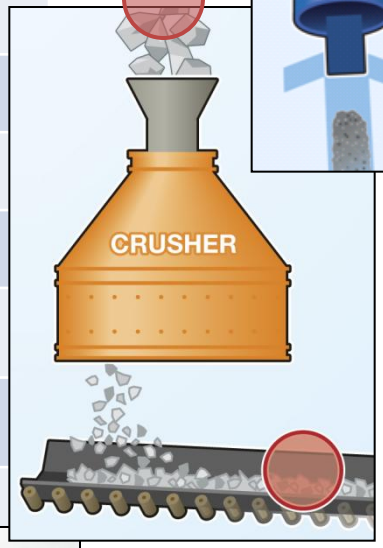
A Broad Range of Applications

Aggregates and Mining Industries

Application Area	Material	Location	Status
Pelletization automation	**Green pellets**	**Conveyor**	**Commercial-ready**
Ship loading	**Rocks**	**Conveyor**	**Prototype installed**
Blasting (underground)	**Rocks**	**LHD Buckets**	**Demonstrated**
Crusher control	Rocks	Conveyor	Key aspects solved
Feeders to Mills	Rocks	Conveyor	Key aspects solved
Heap leaching permeability mineral liberation	Rocks & agglomerate	Conveyor / Bucket	Key aspects solved
Blasting (above ground)	Rocks	Excavator Bucket	Open research
Blasting (above ground)	Rocks	Trucks	Open research

Commercial Ready



Research

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.

The Pile = Non-overlapped rocks + Overlapped rocks + Areas of fines

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