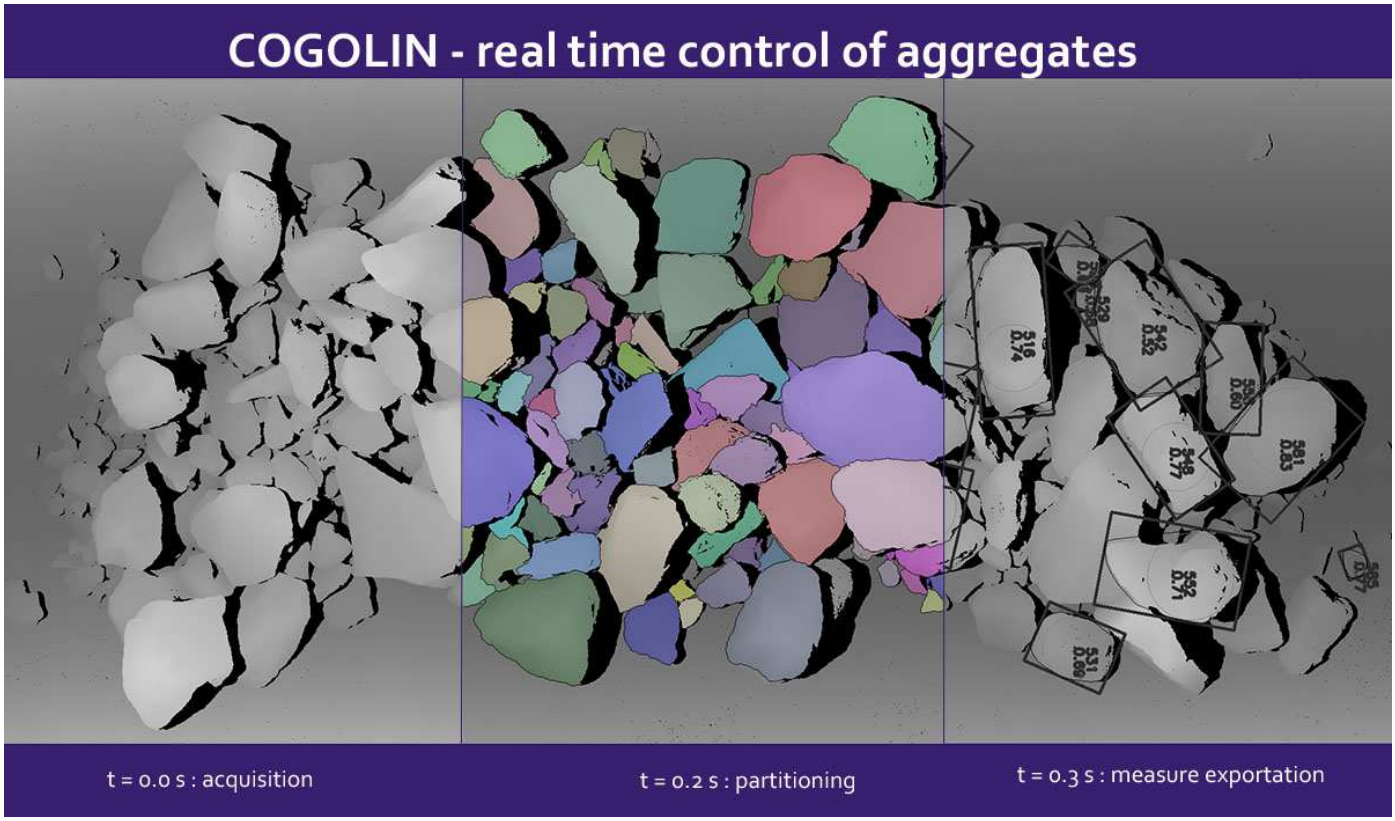



## Presentation

COGOLIN is the French acronym of Optical Control of Aggregates and Online Optimization of INstallations. The project, with 600k€ in funding provided by the Public Service of Wallonia DGO6, takes place in the context of the Marshal 2.Green plan.

## Objectives

In the era of advanced technology, mineral industry still uses old and sometimes obsolete methods. A concrete example is the manual sampling and sieving. Unfortunately, these techniques are time and cost consuming and can't provide real-time reports to optimize their supply chain management.

COGOLIN's purposes have been defined in the context of sustainable development by creating an innovating machine vision for the mineral industry. This machine aims at analysing and measuring aggregates on conveyors belts, in real-time. The real-time feedback can later be used to improve the quality control of the product, optimize the production facilities and reduce the overall energy consumption. The latest point is a way to make a positive environmental impact knowing that mineral crushing represent no less than 0.5% of the world's energy consumption.

## Partner

We work in close partnership with the GeMMe's department of ULg which is the promoter of the project. This strong partnership offers the opportunity to combine all the expertise and skills of both complementary departments. GeMMe (MICA group) has a long time experience in image processing of particles, especially in the shape and size analysis, while the department of Applied Sciences & Computing of the HEPL (CECOTEPE) has a high competence in application design, image processing and programming skills.

## Research

The research is divided in 3 main sections targeting closely the competences of the 2 departments:

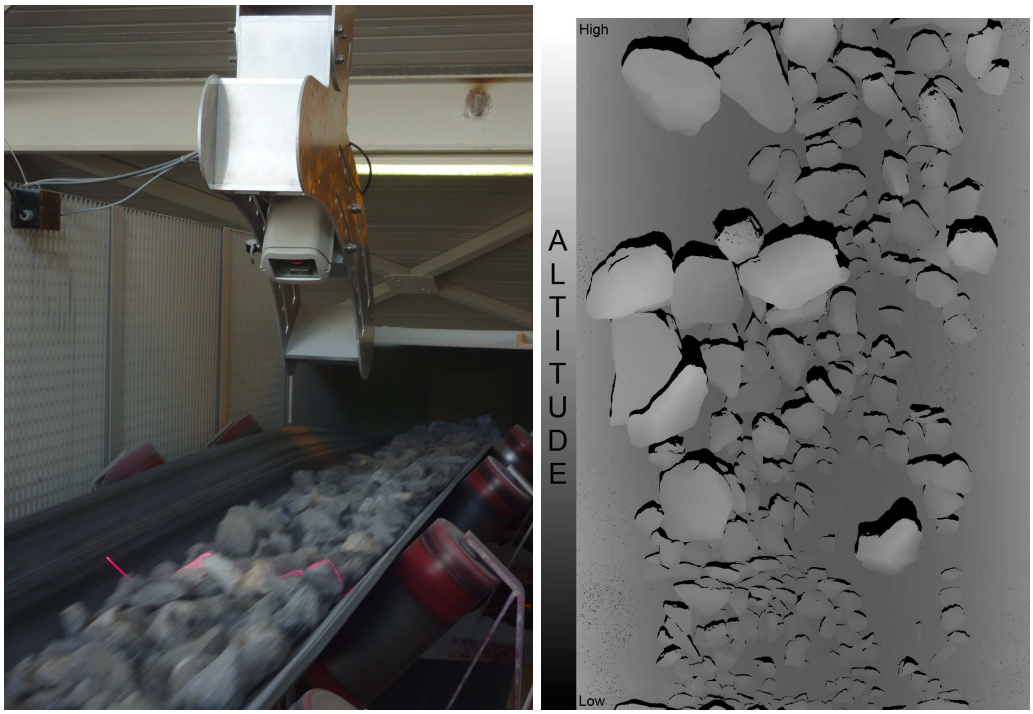
- Image acquisition

- Image analysis and optimization
- Validation and Results

## Image acquisition

Unlike most of work in the domain, COGOLIN's innovation revolves around the use of a 3D scanner. Its principle is the laser triangulation. This well-known technology allows us to acquire surface 3D images at high speed and thus keeping up with the industrial conveyer belt velocity. Furthermore, it's worth noting that even at high speed (i.e. 1.2m/sec), we manage to get an accurate spatial resolution of 0.5mm/pixel.

The IP67 COGOLIN prototype and 3D surface image.




One of the aspects of the research is to totally master the acquisition system. In this perspective, we optimized the machine vision system (camera's parameters, lens, laser, etc.) in order to obtain the best 3D image in term of quality and spatial resolution. Another interesting part of the research is the calibration of the acquired images. Calibrated images are images without all the modifications due to lens distortion and perspective. These corrections allow us to directly measure real features in the image.

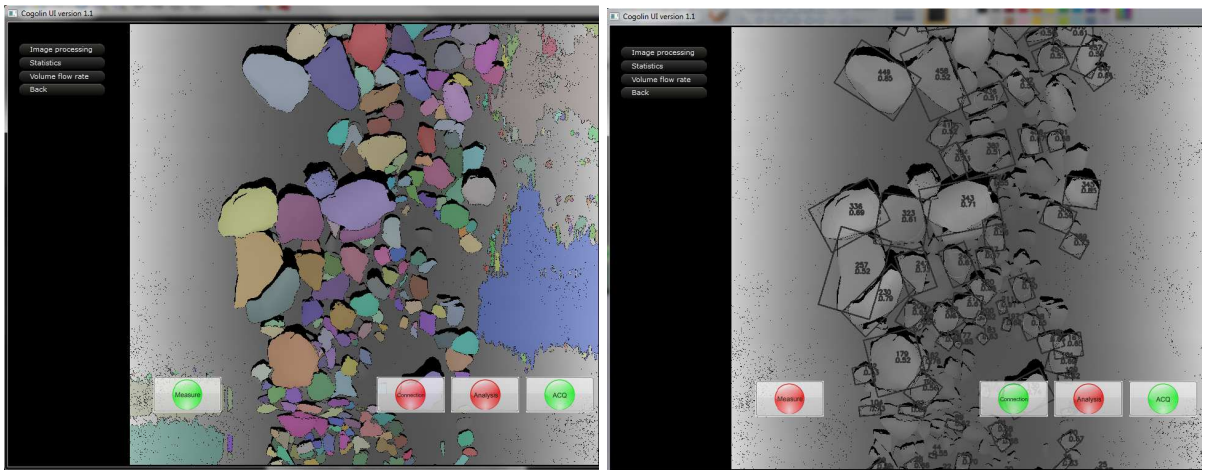
## Image analysis and optimization

An another challenge of the project is the image processing part. The huge amount of incoming data rate forces us to design effective application architecture and optimized algorithms. Moreover, the image segmentation, which is the partitioning of each stone, is a widely known and difficult problem in image processing. The designed application exploits both CPU and GPU capabilities of personal computers to provide real-time segmentation and analysis. Below, the list of accomplished work:

- Image processing - Segmentation
- Memory management
- Prepared data
- Pipeline architecture - enable multithreading
- GPU processing - enable massive parallel processing on GPU card
- CPU SSE2 instruction - enable the processing of a small vector of operands in parallel

With my personal laptop (i5 M480@2.67Ghz, 4Go RAM and a CG NVS-3100m), the optimized application analyses a 1536x3072 image in about 1 second. This includes the image segmentation, particles and features extractions and charts generations. Note that all the gathered data are accessible through a database.

Watershed image and extracted particles

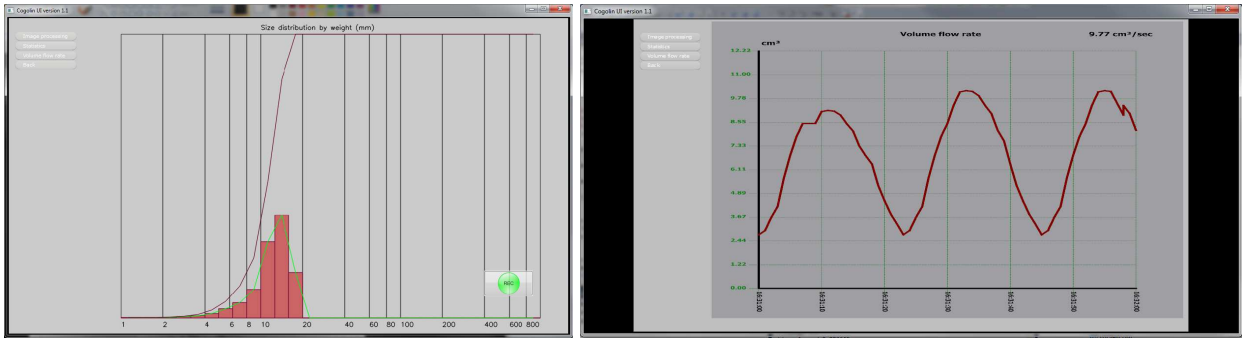



## Validation and Results

The final step of the research is the validation. In this section, we compare the measurement of the aggregates from the segmentated image to the one obtained by sieving. While this step is still in progress, some conclusions can already be highlighted. Firstly, when facing up to aggregates in bulk, small stone are covered by the bigger ones. It implies segregation impacting strongly the granulometry so that small granulometry classes measured by 3D are greatly underestimated compared to the real distribution. The fact seems to be that we can only give granulometry trend in this situation. On the other hand, when the aggregate are enough split, the granulometry curves obtained yield similar results to the ones obtained using manual sampling. That is not surprising when using real 3D data measures.

Over these last 2 years R&D, a new industrial interest started with the volume flow rate data obtained by 3D vision. This method can be seen as an alternative to the mechanical weighing. The mains disadvantages of mechanical weighing is that it must to be calibrated several times per year and included in the industrial chain. Other disadvantage is that it's too sensitive to the belt stretching and needs a regular maintenance. Managing the volume flow rate by a non-intrusive machine vision seems to be a low cost and attractive solution for the industries.

Graphics of the real-time size distribution by weight and the volume flow rate rate




## Links

GeMMe
GeMMe - COGOLIN
Video - Presentation of COGOLIN FR version
Video - Presentation of COGOLIN EN version

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