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Conveyor belt camera based on ADVACAM WidePIX F detector

The X-Mine project is an about 12 M€ research project funded by the European commission Horizon 2020 programme. The project supports better resource characterisation and estimation as well as more efficient ore extraction in existing mine operations, making the mining of smaller and complex deposits economically feasible and increasing potential European mineral resources (specifically in the context of critical raw materials) without generating adverse environmental impact.
The project is implementing large-scale demonstrators of novel sensing technologies improving the efficiency and sustainability of mining operations based on X-Ray Fluorescence (XRF), X-Ray Transmission (XRT) and 3D vision technologies, and their integration with drill core scanning, mineral sorting equipment, ore deposit modelling and mine planning software systems.

One of the demonstrators of the project is a container-based mineral sorting prototype, which separates ore and waste particles on a conveyor belt using pneumatic nozzles. The classification to ore or waste is based on X-ray transmission and 3D camera sensor technologies. For this purpose, a new generation of high-resolution energy-sensitive multichannel pixel detector equipped with fast readout interface for continuous X-Ray inspection of moving objects was developed for conveyor belt application within the X-Mine project. This detector consists of six modules as is illustrated in Figure 1. Each module has independent USB3 fast readout interface for communication with computer and five Medipix3 chips equipped by 1 mm CdTe sensor. The total number of thirty chips is assembled without any gaps in between. It covers 42 cm of the conveyor belt width.

The camera is based on Medipix3 technology developed within Medipix collaboration lead by European organization for nuclear research CERN. Medipix3 chip is equipped with matrix of 256 by 256 pixels with pixel pitch 55 µm. Each pixel has two integrated 12-bit digital counters and two energy discrimination thresholds. Both counters can be joined to a single 24-bit counter providing enhanced dynamic range. The camera can be constructed with Si or CdTe edgeless sensor tiles. The edgeless sensor technology allows placing all tiles tightly together from all sides. Thus the whole imaging area of the camera is fully sensitive to the radiation - there are no gaps between the tiles in the image. The size and length of such imager can be increased by modular assembly.

An essential feature for conveyor belt scanning application is the ability to work in Time-Delayed-Integration (TDI) mode. The detector is operated in special mode synchronized with continuously moving scene. The current content of the pixel matrix is digitally shifted along image columns synchronously with moving objects of the scene. Then the detector continues in sensing adding new content to the pixels. This process repeats row-by-row. When the imaged object passes through all the rows the content of the last row is send out of the chip and processed by electronics. This way a continuous stream of image data is produced. The exposure time is equal to time till object traverses all detector rows. The scene can move at maximal theoretical speed of 6.3 m/s. TDI mode is used together with multi-energy X-ray imaging.

Figure 1. The first prototype of Conveyor belt camera developed by ADVACAM was installed at COMEX facility in Poland.

The key parameters of the Conveyor belt camera are listed in the following table.

Sensor Material	CdTe
Sensor Thickness	1 mm
Sensitive Area	14 x 420 mm
Number of Pixels	256 x 7680
Pixel Pitch	55 µm
Readout Speed	450 frames/s
Belt Scanning Speed	6.3 m/s
Thresholds per pixel	1 or 2 thresholds
Threshold Step Resolution	0.1 keV for SHGM mode
Energy Resolution	1.2 - 3.6 keV based on gain mode
Minimum Detectable Energy	5 keV
Pixel Mode of Operation	Counting in Single Pixel Mode (SPM) or Charge Summing Mode (CSM)
Counter Depth	12 or 24 bits (configurable)
Connectivity	USB3
Data Transfer Speed	Up to 3 Gb/s per module, 18 Gb/s for full camera

The first prototype of the Conveyor belt camera has been used at COMEX facility in Poland. Example of acquired data is on Figure 2. The second camera will be installed into X-Mine pilots soon.

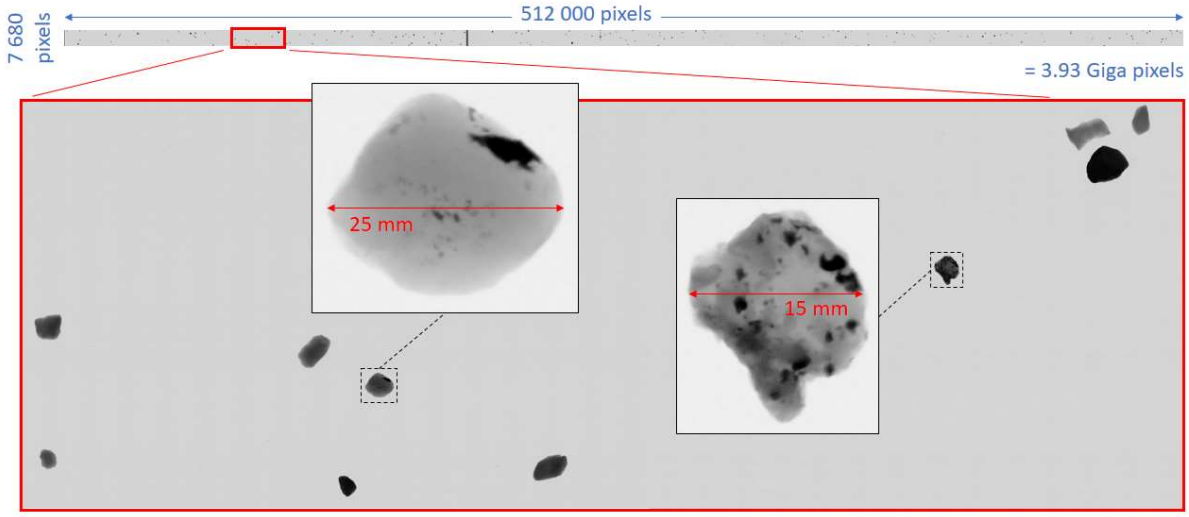

Figure 2. Example of data acquired at COMEX facility. Approximately twelve square meters of the conveyor belt carrying rock samples has been scanned in ten seconds. It corresponds to the belt speed 2.8 m/s.

For more information about Advacam products, please contact:

CEO Juha Kalliopuska (juha.kalliopuska@advacam.com)
Tomas Hofbauer (tomas.hofbauer@advacam.com)

For more information about project in general, please contact:

Project leader: Janne Paaso (janne.paaso@vtt.fi)
3D-modelling: Geologist Ronald Arvidsson (ronald.arvidsson@sgu.se)
Scanning: Mikael Bergqvist (mikael.bergqvist@orexplore.se)
Sorting: Jazek Kolacz (jacek.kolacz@comex-group.com)
Information: Stefan Sädbom (stefan.sadbom@bergskraft.se)

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