LiveSORT®

The perfect enrichment for Ores, Minerals, Gemstones & Energy Raw Materials

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A COMPANY OF LOMGroup

The Source of Leading Ores & Mines

LiveSORT® is a registred brand of LOM Mining Ltd, specialized in dveloping Enrichment Facilities

LiveSORT is specialized in the use of optical sorting machines in preparing raw materials for energy feedstock, industrial minerals, ores and precious stones. Other areas of use include metal sorting and the separation of high-caloric bits of refuse derived fuels from household garbage and industrial wastes.

The combination of modern computer science with high-resolution line cameras and reliable machine components makes the sorting of mass volumes feasible.

Working closely together with the customer, **LiveSORT** develops in each case the most optimal sorting strategy. Apart from increasing the extraction level of valuable substances through optical sorting, increasing the efficiency of subsequent phases and the options of also substituting these through the use of optical sorting are also considered.

The use of our sorting machines provides the following advantages:

- Reduction of transportation and processing costs through optical shale separation
- Improvement in the level of effectiveness and efficiency of processing procedures
- Improved extraction of valuable substances and/or increased product purity
- Economic processing of bottom ash
- Workability of low ore units through cost-efficient design of raw material processing procedures
- Improved cash-flow and shorter amortization periods of raw material projects and recycling projects

Industrial minerals include a wide range of different raw materials. They are put to use in many ways ranging from the high purity fillers for dyes and paints, plastics and paper to the use as flowing and lubricating agents and as the basic materials for the ceramic, glass and chemical industries. Thus, the sorting specifications for the respective raw materials are also equally wide-ranged.

LiveSORT sorting units are being successfully used, amongst other things, in the manufacturing of high purity fillers and grains, in the sorting of raw salts as chemical raw materials and also in the sorting of quartz as basic material for manufacturing high purity silicon.

Examples

- Limestone
- Talc
- Rock salt
- Quartz
- Magnesite

One consequence of advancing mechanization in mining is that the proportion of useless rock excavated with the good is increasing considerably as compared with more selective but sometimes much more expensive extraction methods. The increasing costs of conveying, crushing and preparing the raw material are threatening to virtually wipe out the cost advantages to be obtained from highly mechanized mining methods. It makes good economic sense therefore to separate out optically the larger fractions of useless rock at any early stage, close to the workings and even underground, provided the optical characteristics of the wanted and unwanted components of the excavated rock permit their identification.

Industrial minerals II

LiveSORT has developed tailored procedures for sorting BASE METALS and also for sorting mineral bulk materials containing precious metals. These procedures exploit special metallographic and crystallographic optical features and with their help concentrates with a much higher content of high-value material can be achieved. In some cases this approach has for the first time made it possible to create a smeltable product. This has also meant that deposits previously regarded as not worth excavating will in future be economically exploitable as well.

Gold containing arsenopyrite

Improvements in economic efficiency

Nickel Ore

Depending on the origin of the deposits, particularly high levels of valuable metals (gold, platinum, chromium) are frequently found in the immediate contact zone of a mineral formation and the surrounding rock. When the raw ore is crushed there is a fraction whose particles are composed of both the valuable material and the surrounding rock. Sorting methods based on the difference in density between the wanted mineral and the surrounding rock cannot separate out a major proportion of these intergrowths which contain a high proportion of valuable mineral.

Installing an optical sorting facility downstream means that the particles containing valuable minerals can be recovered. This makes for an overall improvement in the yield of valuable materials. **LiveSORT** sorting equipment can therefore have a very positive influence on the economic efficiency of a raw materials project which generally depends very critically on the yield of valuable materials in the preparation process.

Platinum Ore

Platinum Ore

The use of **LiveSORT** machines has made possible a higher yield in the extraction of precious and semi-precious stones.

Since 2005 nine **LiveSORT** systems of the Gemstar type have been in successful operation in South African mining operations, primarily for sorting smaller diamonds with particle sizes in the 0.5 to 10 mm range. Both qualitatively and quantitatively, the **LiveSORT** procedure is here often superior to classic x-ray sorting. It can also be employed in re-sorting relatively old spoil heap material which often still contains a considerable amount of precious stones which could not be extracted with the preparation technology of the time.

Depending on the mineralogical characteristics of a particular deposit and the preparation methods used, one possibility for obtaining the best possible yield of diamonds is to combine x-ray methods with **LiveSORT** technology.

Further improvements in productivity and reductions in costs can moreover be achieved by carrying out optical pre-sorting of the raw excavated material close to the place of extraction. In this case the sorting primarily concentrates on separating the useless wallrock from the host rock holding the precious stones.

Diamond sorter LiveSORT-Gemstar

Diamond mine

Kimberlite

Diamonds

A relatively new application for **LiveSORT** sorting equipment is the optical sorting of brown coal. The challenge here is to remove from organic brown coal intended for power stations those (lighter colored) portions of low caloric value which contain more mineral substance. Individual objects here may be as large as the palm of the hand.

TECHNOLOGI
Material conditioning and image capturing

Automated optical sorting is in effect a developed version of the miners picking techniques.

This process is aimed at separating the objects of the bulk solid flow according to color and/or geometrical parameters and at high flow speed achieving a low error rate along with good repeatability of reproducing the sorting decisions.

Normally, material conditioning is required before performing the actual sorting activity. During material conditioning, the bulk solids that are to be sorted are first separated according to their grain fractions and passed, if required, through a washing sieve in order to remove the dirt (clay, fine dust) that covers the actual color of the objects and also to make full use of a higher color contrast of the moistened objects.

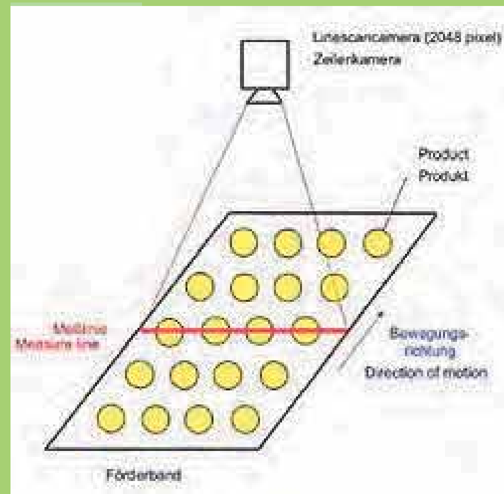
The individual objects of a bulk solid flow are captured by a color line camera in a detection plane. The particles of the bulk solid flow can be fed via a fast-moving flat conveyor belt (belt sorters) or a vibrating conveyor belt (gravity sorter).

In the detection plane, the camera system scans the objects at high frequency perpendicular to the direction of their movement. This results in two-dimensional image sequences that are then forwarded to a computer in a digital format suitable for image processing.

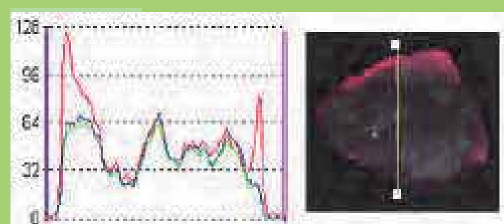
The color line camera has 2040 pixels on the CCD chip. It is possible to achieve a resolution of approx. 0.6 mm² (pixel area) for a normal working width of 1200 mm of the sorter – depending on the feeding speed of the objects.

The camera is equipped with sensors that capture the color of the objects (or rather that of the pixels) using the respective proportion of **r**ed, **g**reen and **b**lue whereby each color channel can assume the values between 0 and 255. According to the rules of additive color mixing, it is thus possible to display more than 16 million different colors in the RGB color space (see adjacent illustration).

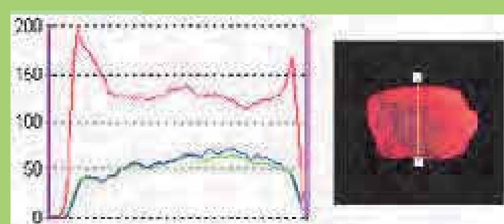
Apart from the color, the camera system also captures other geometric features such as area and form of the objects.



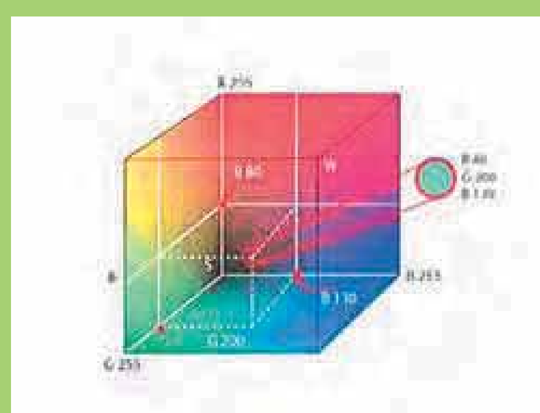
Illumination by white and red light



Poor material



Good material



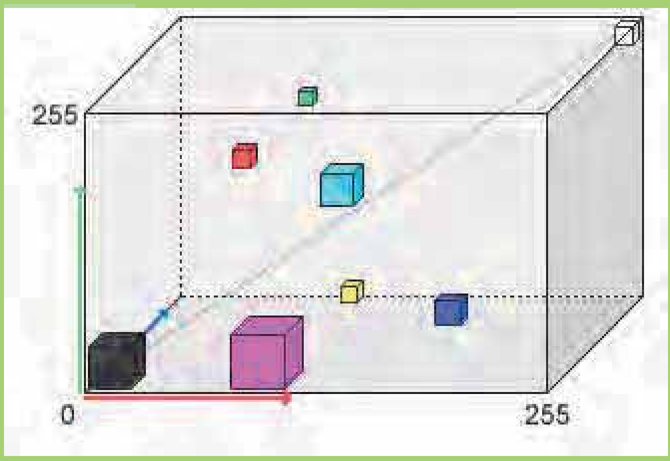
RGB color space

Color classification and Bayes classifier

Classification mean summarizing objects on the basis of pre-defined parameters (here: color) to form classes with same parameter instances. How does the optical sorting system know to which color category the captured color of a pixel is to be assigned?

Sorting units of the type **LiveSORT** are self-learning. When using the system function “Learning”, objects are registered as a color category by the user after searching for identical color parameters and then passing them through the sorting unit. A maximum of 8 different color categories can thus be specified and learnt. Transferring this to the RGB color space means the learning of color classes and the marking of demarcated spaces within the color space.

Color classes



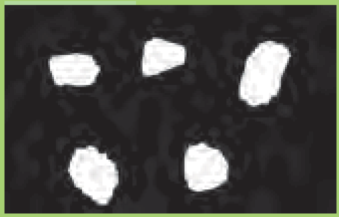
RGB color space with 7 learned color classes (good, poor, 1-5) and background (black).

During color classification within the scope of image processing, the detected colors of the pixels are assigned to the learnt color categories. The decision as to which of the learnt color categories are assigned to a pixel is done by the system with the help of the Bayes classifier. The latter selects the classification based on mathematical-statistical basis according to the principle of the lowest probability of error.

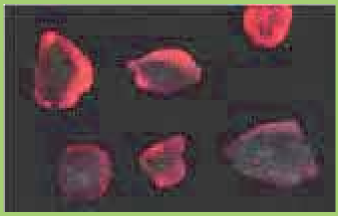
After the color classification, the objects of a bulk solid flow that are first captured in color are displayed internally in the system as so-called attribute objects that consist of sub-areas that are assigned to color categories (see figure).

Camera- and attribute image

Good material

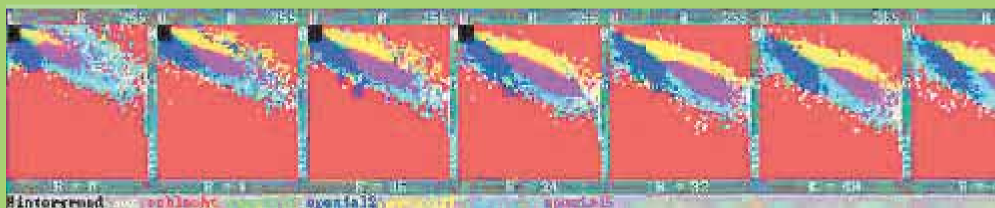


Attribute image of good material



Poor material

SORTING DECISION/



Color classes

Sorting decision and object separation

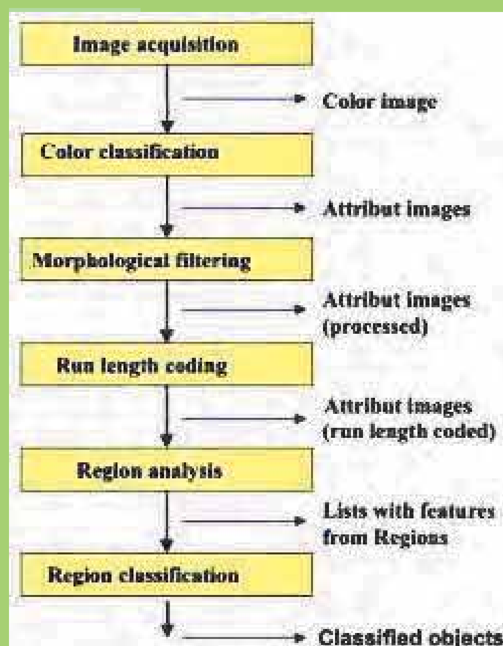
How does the **LiveSORT** sorting system decide which object is to be separated from the bulk solid flow using a thrust of compressed air?

The sorting decision (object good/ object bad) is made by the system as a result of processing a chain of decisions that is to be programmed by the user. In the process, decision conditions are linked to each other using logical operations and are processed by the system in the sequence of their linking.

The decision conditions are formulated according to the shared area of the learnt color category with respect to the object to be sorted. There are 9 maximum linking options for the parameter "color" between the 8 maximum color categories learnt by the system.

The result of the color classification can then be linked to the detected geometric parameters of the concerned object using logical operators. Thus it is now clear for each object whether it should be left in the bulk solid flow or if it is to be taken out.

The **LiveSORT** system makes its sorting decision within a very short period of time. Depending on the plant type, there is a time gap of approx. 30 ms between the detection of an object by the camera system and its entry into the area of the nozzle strip of the sorting unit. The sorting decision is generated during this period and the fast-working solenoid valves of the separation unit are accessed via a bus system.



LiveSORT can provide its customers with systems optimally tailored to their particular sorting task. These systems may differ in the technical designs of different components - and the illumination and rejection hardware in particular should be mentioned here - but are all essentially based on the two basic types of belt sorter and gravity sorter. The basic difference in the two systems is in the way they are fed with the objects to be detected and in the design of the conveyor belt systems.

In the case of gravity sorters the material is transported through a vibration conveyor and then over a slide with the help of the principle of gravity. With belt sorters, on the other hand, acceleration is provided by the horizontal movement of the conveyor belt. In both cases, images are captured right at the moment when the material crosses over into the flying phase. The principle of optical recognition, followed by image processing and classification of the materials, is in both cases identical.

Which system will ultimately be used, and in which version, depends on the particular application, the grain-size fraction and the desired throughput quantities. The decision as to which machine type will be recommended to our customers will also be securely backed up by the results of previous lab tests and trial sorting runs on the semi-technical scale in pilot installation at Schenefeld / Itzehoe.

LIVESORT advises its customers on the optimal use of sensor-supported optical sorting processes. Efficient sensor-supported sorting depends on the material-specific properties of the bulk material and on an optimum interplay between all of the components of an optical sorting system (material feed and conditioning, object detection and image processing, rejection of particles).

In addition to providing technical advice about sorting we can, as a service, also offer our customers more comprehensive feas bility studies and economic analyses to help them secure their investments. Alongside the requisite laboratory equipment for identifying grain-size distributions and mineral content, **LIVESORT** also has in its pilot facility at Schenefeld a series of different sorting systems which allow sorting tests to be carried out with relatively large throughput quantities on the semi-technical scale and also upscalably from this.

With the aid of a sliding table unit, representative samples of materials for sorting can be scanned in and the results sent to image processing. This makes it poss ble for **LIVESORT**, before carrying out a more complex test sorting run, to develop on the computer under reproduc ble conditions the best sorting strategy for a particular problem and to demonstrate to its customer the detection results obtained with different possible strategies.

With the aid of laboratory tests and test sorting runs **LIVESORT**, as part of its system design work, will investigate aspects which include:

- Appropriate material fractionation and conditioning
- Possibilities of optimum separation into single objects as the basis of faultless sorting decisions
- Selection of the optimum sorting strategy with regard to the highest possible product purity coupled with the lowest possible losses of good material in the flow of rejected material
- Selection of a suitable nozzle bank configuration to ensure all object sizes within a given particle size distribution are blown out and also to prevent incorrect entrainment due to the shape of the free jet compressed air pulse.

Sliding table installation

In the **LIVESORT** pilot facility test sorting runs can be carried out under close-to-production conditions with throughputs of up to 20 t/h. Customers can have the systems and sorting methods they have ordered tested in the technical laboratory as part of "Factory Acceptance Tests" even before the first acceptance stage.

Sorting installations in the technical laboratory

Belt sorters

With belt sorters, the material is transported into the detection plane of the camera system via a conveyor belt moving at a defined speed. Here the camera system covers the width of the conveyor belt with the number of pixels available on the CCD chip. With, for example, 2048 pixels and a working width of 1200 mm and a belt speed of 3.0 m/s we obtain a pixel area of approx. 0.6 mm² which the camera system detects.

If objects smaller than 4 mm are to be sorted - as is frequently required with precious stones - pixel areas of even 0.6 mm² are already too large to be a basis for optimum sorting decisions. In such cases the working width and belt speed are adjusted accordingly. This makes it possible for objects with dimensions in the range of just 0.5 mm to be detected via multiple (very small) pixel areas in a number which the sorting decision requires.

Depending on the size of the objects to be sorted **LIVESORT** currently offers the following belt sorters:

Sorter type	Working width	Grain size range*	Throughput*
Micro - GemStar	300 mm	0.5 - 2.0 mm	approx. 2 t/h
GemStar	600 mm	2.0 - 8.0 mm	up to 4 t/h
Belt Compact	600 mm	5.0 - 25 mm	up to 10 t/h
Beltsorter	1200 mm	8.0 - 60 mm	up to 60 t/h

Throughput will depend on the number of objects to be rejected in the bulk material flow and also on the sorting quality aimed at. In addition, the actual grain-size distribution of the material to be sorted will affect the throughput achievable under the given sorting quality criteria. The best sorting results are generally obtained with grain-size distr butions in which the smallest and largest grains have a maximum ratio of 1 to 4.

Belt sorters

Diamondsorter

Gravity sorters

On a gravity sorter, the material is transported by a v bration conveyor using out-of-balance or magnetic drives. V bration conveyors create a dense, single-layer flow of bulk material which is carried at a speed of 0.5 m/s and then at the end of the belt is thrown over a slide plate (whose angle can be adjusted) into the detection area of the camera system.

The objects, since they are now in free fall, accelerate up to a speed of 3 m/s before entering the camera system detection plane and these results in the objects separating out into singles in the way called for by optimum detection. As is the case with belt sorters, the size of detectable pixels derives from the working width of the sorter and the speed at which the objects are transported through the camera plane. A working width of 1200 mm and a belt speed of 3.0 m/s will thus yield detectable pixel areas of 0.6 mm².

As with belt sorters, objects to be rejected are blown out of the bulk material flow by a compressed air pulse. Following the sorting decision made by the system for an object in the bulk material flow - and providing the object in question is to be ejected - the requisite number of valves in the nozzle bank are actuated for the correct time and locations.

Gravity sorters are used preferably for grain sizes larger than 40 mm. Depending on the design of the sorter nozzle bank, objects with a grain size up to 300 mm can be ejected by a compressed air pulse.

The standard working width of the **LiveSORT** gravity sorters is 1200 mm. Where so required in individual cases, **LiveSORT** can also supply machines with working widths up to 1800 mm.

Fraunhofer IITB

The Fraunhofer Institute for Information Technology and Data Processing (IITB) in Karlsruhe is one of the 55 institutes of the Fraunhofer Society – the largest institutional organization in Germany for applied research with a turnover of approximately 1 billion Euros per year. Of the 170 employees of IITB, more than 30 scientists are working in the field of imaging evaluation. This area of work in IITB has a tradition of more than 30 years. The application focus is currently on the interactive evaluation of aerial views (reconnaissance), automatic interpretation of natural scenes and automatic visual inspection for industrial applications. The last one is the area of work of the business unit "visual inspection systems".

The business unit "Visual inspection systems"develops and delivers image evaluation systems for especially demanding tasks in industrial visual inspection. Only line cameras are used as image-emitting sensors – these are mostly high resolution, high color line cameras with data rates of max. 60 MB/s. For inline evaluation of these data rates, IITB has developed its own system platform on the basis of industrial PCs under Windows 2000. The most important features of this platform are two special cards that can be inserted for entering and pre-processing images and a real-time programming system for Input/output and for image analysis.
On the basis of this platform, systems have been developed for three areas of application including the automatic inspections of blisters in the pharmaceutical industry, the automatic inspection of surfaces and the automatic sorting of bulk solids.

Since 1998, IITB has delivered a total of approx. 180 image evaluation systems. They are in use across the globe. Deliveries are sometimes done directly by IITB to the end-users – but a major part of these are delivered through system integrators such as **LiveSORT**.

References

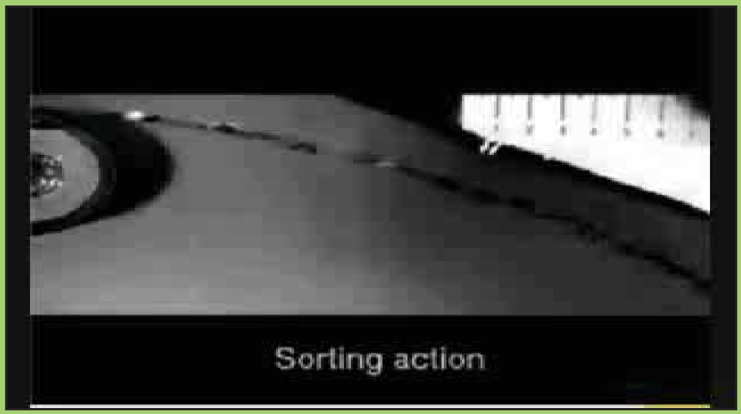
Sorting plants of type **LiveSORT** have been delivered since 1993 to, e.g.:

De Beers	South africa	Diamonds
Nordkalk	Finland	Limestone
DAM	France	Quartz
Omya Group	Europe	Limestone
Wacker Chemie	Germany	Silicon classification (Semiconductor)

Films

(click on film to play)

Belt sorting



Sorting process by optical reconnaissance

Brown Coal sorting