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AN EXPERIMENT ASSEMBLY FOR EVALUATING EQUIPMENT PERFORMANCE

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Technical Field

The present invention relates to an experiment assembly which enables to determine performance and efficiency of sensor-based sorters important for mineral enrichment.

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Background of the Invention

Mineral sorting is a highly important process in mining. Being the oldest sorting method, manual sorting is still being used in small-scale mines today. After 1950's, it has been started to develop sensor-based sorting systems which enable sorting based on characteristics of minerals such as electrical conductivity, radioactivity, fluorescence, brightness, colour, atomic weight, thermal conductivity and electromagnetic radiation reflectance. Sensor-based sorting systems are defined as automatic sorting, ore sorting, waste sorting and optical sorting as well. Sensor-based sorting systems are generally intended for analysing grains within an ore stack by means of a sensor and removing grains, which are selected in accordance with the parameters identified to the system, from the stack by mechanical or pneumatic systems. Sensor-based sorting systems use current detection and analysis methods. For example, all kinds of colour differences detected by human eye can also be detected by optical sensor quickly and efficiently. For this reason, sensor system have been used be used for industrial purposes from 80's to present. Developments in sensor technology particularly in chemical, medical and food industry have paved the way for future-oriented sensor technology. Upon development of software interfaces, micromechanical technologies, faster and more powerful computers and more precise sensors;

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sensor-based technologies have gained a strategic importance almost in all areas as well. Whereas in mine and raw material extraction and recovery, sensors systems came into use in many areas such as machine control, automation and quality control, ore enrichment.

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Collection of electromagnetic radiation by collimation at first, then dispersion thereof by means of a transmission element and detection of different wavelengths one by one are the working principle of most of hyperspectral imaging systems performing linear scanning of prior systems. The resulting light ray then focuses
10 on the sensor detector. Consequently, each pixel in a hyperspectral image comprises all reflections (reflectance or absorbance) of the electromagnetic radiation detected. These data are used in areas such as detection of objects on a conveyor belt, mapping by remote sensing, evidence analysis applications in forensic sciences, industrial quality control applications, waste management, etc.

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Similarly, Moroni et al. developed and tested “An Adjustable Filter-Based System” by using three sensors (visible light sensor, infrared and medium infrared) that can take image between only 400 nm-720nm, 650 nm-1,100 nm and 850 nm-1,800 nm and optical filters. Although the system is being used for
20 mapping by field scanning and PVC-PET identification with high precision, the number of images to create a detailed spectroscopy and the time required for processing the data do not fulfil quick and simple solutions necessary for current ore preparation.

25 Sensors, which are used in VIS and NIR systems other than hyperspectral imaging, do not have “built-in” and numerous filters. Besides, some of current sensors may have a “built-in” filter in a narrow band range specific to application and material. MEMS-FPI (C14272) Spectrum Sensor of Hamamatsu company which has a filter with a spectral permeability between 1350-1650 nm is an
30 example for this.

Although sensor-based sorters are compatible and common in certain minerals (quartz, boron, etc.), current methods remain incapable in terms of expansion of application area. Due to the fact that reflectances shade each other multiple mineral systems, mineral enrichment (selective sorting of minerals and turning
5 them into different products) is inefficient and it is not usually possible. Therefore, there is need for a superior and unique assembly which will enable to realize content determination by evaluating performances of sensor-based sorters, detecting whether it is necessary to make change in the sorter structure or not and determining wavelength for the most efficient sorting and which is also less costly
10 compared to current hyperspectral systems.

The Chinese patent document no. **CN103605955**, an application in the state of the art, discloses an image capturing apparatus based on single sensor and optical filtering. The image capturing apparatus based on single sensor and optical
15 filtering comprises a shell, an illuminator, an objective lens, a collimating lens, a class chessboard filtering sheet, a focusing lens, an image sensor, a connector and an image processor.

Summary of the Invention

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An objective of the present invention is to realize an experiment assembly which enables to evaluate sorting performance of sensor-based sorters being used in mining and recycling when suitable applications are in question.

25 Another objective of the present invention is to realize an experiment assembly which enables to determine sortability of grains composing any mineral, by sensor-based sorters.

Another objective of the present invention is to realize an experiment assembly
30 which enables to detect from which differences at which wavelengths does the mineral sorting result most efficiently.

Another objective of the present invention is to realize an experiment assembly which enables to realize content determination for mineral samples.

- 5 Another objective of the present invention is to realize an experiment assembly which enables to merge analysis methods with optical filtering in order to use sensor-based sorters while performing mineral sorting and to make decisions for change in structure of current sensor-based sorters.

10 Detailed Description of the Invention

“An Experiment Assembly for Evaluating Equipment Performance” realized to fulfil the objectives of the present invention is shown in the figures attached, in which:

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Figure 1 is a general view of the inventive experiment assembly.

Figure 2 is a view of the first skeletal structure of the experiment assembly and the elements connected thereto.

20 **Figure 3** is a view of the second skeletal structure of the experiment assembly and the elements connected thereto.

Figure 4 is a view of the inventive optical filter element.

Figure 5 is a view of the inventive data processing algorithm.

25 The components illustrated in the figures are individually numbered, where the numbers refer to the following:

- 30
1. Experiment assembly
 2. Sample table
 3. First skeletal structure
 4. Belt
 5. Servo motor

- 6. Reducer
- 7. Control unit
- 8. Controller
- 9. Controller connection unit
- 5 10. Sensor
- 11. Optical filter element
- 12. Lens
- 13. Light source
- 14. Second skeletal structure
- 10 15. Computer and software unit
- 16. Data transfer unit

The inventive experiment assembly (1) comprises:

- 15 - a sample table (2) which is the place where the mineral samples requested to be sorted are placed and which can move;
- a first skeletal structure (3) which provides support for the sample table (2);
- a belt (4) which provides the motion of the sample table (2) by means of the rotary motion performed by it;
- 20 - a servo motor (5) which enables the sample table (2) to move lineally at a constant speed;
- a reducer (6) which runs the rotary motion as requested;
- a control unit (7) which provides control of the servo motor (5);
- a controller (8) which contains buttons to issue commands to the sample table (2);
- 25 - a controller connection unit (9) which provides connection of the control unit (7) to the controller (8);
- a sensor (10) which takes the sample image in the sample table (2) at high resolution;
- 30 - an optical filter element (11) which provides detection of mineral contents for image analysis;

- a lens (12) which is connected to the end of the optical filter element (11) and used for imaging the sample;
- a light source (13) which generates electromagnetic radiation that will enable the sensor (10) to take image;
- 5 - a second skeletal structure (14) which provides support for the sensor (10), the optical filter element (11), the lens (12) and the light source (13);
- a computer and software unit (15) which will process the data received by the sensor (10);
- 10 - a data transfer unit (16) which transfers the data received relative to the sample, to the computer and software unit (15).

In a preferred embodiment of the invention, the near infrared (NIR) or visible light (VIS) reflectance value of the sample table (2) is too low.

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In a preferred embodiment of the invention, the sample table (2) is made of aluminium.

In a preferred embodiment of the invention, the sample table (2) is located on the
20 first skeletal structure (3).

In a preferred embodiment of the invention, the first skeletal structure (3) has a table-shaped structure having a plate in a position parallel to the ground and legs in a position perpendicular to the place that is connected to the edges of the plate.

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In a preferred embodiment of the invention, the belt (4) is placed between the plates of the first skeletal structure (3).

In a preferred embodiment of the invention, the belt (4) allows the sample table
30 (2) to move right-left or forwards-backwards with linear velocity, by performing rotary motion (the direction of movement is shown in the Figure 2 by arrow).

In a preferred embodiment of the invention, the servo motor (5) is positioned such that it will be connected to the end of the belt near the first skeletal structure (3).

- 5 In a preferred embodiment of the invention, the servo motor (5) enables to provide speed, acceleration and motion to the sample table (2).

In a preferred embodiment of the invention, the reducer (6) supports the servo motor (5) to generate a stable and constant torque.

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In a preferred embodiment of the invention, the reducer (6) is connected to the servo motor (5).

- 15 In a preferred embodiment of the invention, the control unit (7) enables to program and also to control speed and acceleration of the sample table (2) by means of the servo motor (5) and the belt (4).

- 20 In a preferred embodiment of the invention, the control unit (7) programs the speed of the sample table (2) such that it will be equal to the image taking speed of the sensor (10).

- 25 In a preferred embodiment of the invention, the control unit (7) programs the acceleration of the sample table (2) such that it will be zero as soon as it comes into the angle of view of the sensor (10).

- In a preferred embodiment of the invention, the control unit (7) is placed on the side of the first skeletal structure (3) such that it will be seen easily.

- 30 In a preferred embodiment of the invention, the controller (8) has buttons for issuing command in order that the sample table (2) is started, stopped and reset.

In a preferred embodiment of the invention, the sensor (10) enables to take high-resolution images of the mineral samples placed onto the sample table (2).

In a preferred embodiment of the invention, the sensor (10) takes high-resolution
5 continuous images in 1024×1 pixel size and in the form of strip.

In a preferred embodiment of the invention, the sensor (10) reads the reflectance value of the radiation sent onto the mineral samples from the light source (13).

10 In a preferred embodiment of the invention, the sensor (10) is made ready for taking image by creating a certain distance between it and the top of the mineral samples on the sample table (2) and making definition settings before starting the image taking work.

15 In a preferred embodiment of the invention, the sensor (10) can be a near infrared sensor (running between 700-3000 nm) or a visible light sensor (running between 400-1000 nm).

In a preferred embodiment of the invention, the sensor (10) uses BASLER® (line
20 scanning, up to a pixel hour speed of 60MHz in a single 8 bit output mode-CCD) and GOODRICH® (line scanning, indium gallium arsenide (InGaAs) respectively, a pixel hour speed of 50MHz is a 14 bit output mode) cameras for visible and near infrared imaging, respectively.

25 In a preferred embodiment of the invention, images of a great number of different filters can be taken by the sensor (10).

In a preferred embodiment of the invention, the optical filter element (11) and the lens (12) are located on the end of the sensor (10) respectively.

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In a preferred embodiment of the invention, optical filters are placed into the optical filter element (11).

5 In a preferred embodiment of the invention, the optical filter element (11) examines the mineral grains –that are received from the ore representatively– one by one by means of all optical filters placed into it, by using a suitable light source.

10 In a preferred embodiment of the invention, a visible light (VIS) filter transmitting light at narrow band (FWHM 40 ± 8 nm) is placed into the optical filter element (11).

15 In another embodiment of the invention, a near infrared light (NIR) filter transmitting light at narrow band (FWHM 10 ± 2 nm and 10 ± 2 nm) is placed into the optical filter element (11).

In a preferred embodiment of the invention, a visible light filter transmitting light at long band is placed into the optical filter element (11).

20 In a preferred embodiment of the invention, a near infrared light filter transmitting light at long band is placed into the optical filter element (11).

25 In a preferred embodiment of the invention, the filters placed into the optical filter element (11) are featured such that they will pass only 400, 450, 500, 550, 600, 650, 700, 750, 800 and 850 nm wavelengths with ± 20 nm precision for visible range.

30 In a preferred embodiment of the invention, the filters placed into the optical filter element (11) are featured such that they will pass only 900, 1000, 1100, 1200, 1300, 1400, 1500, 1550 and 1600 nm wavelengths with ± 10 nm precision for NIR (near infrared) range.

In a preferred embodiment of the invention, it is possible to work in the range of wide wavelengths by the filters placed into the optical filter element (11).

- 5 In a preferred embodiment of the invention, filters enabling transition of radiations of electromagnetic radiation at only certain wavelengths are used inside the optical filter element (11).

10 In a preferred embodiment of the invention, the optical filter element (11) is connected to the experiment assembly (1) from the places where the sensor connection (112) located under the sensor (10) and the lens connection (113) located above the lens (12) exist and the filter (111) is placed in the middle of it (shown in the Figure 4).

- 15 In a preferred embodiment of the invention, the light source (13) is made according to the sensor (10) selection.

20 In a preferred embodiment of the invention, for example the light source (13) can be NIR lamps, halogen lamps, fluorescent lamps, rarely tungsten filaments or a combination thereof.

In a preferred embodiment of the invention, the light source (13) can generate light up to 1650 nm wavelength.

- 25 In a preferred embodiment of the invention, the second skeletal structure (14) has a table-shaped structure having a plate in a position parallel to the ground and legs in a position perpendicular to the place that is connected to the edges of the plate.

30 In a preferred embodiment of the invention, the second skeletal structure (14) is positioned such that it will be located on the first skeletal structure (3).

In a preferred embodiment of the invention, the second skeletal structure (14) creates a structure where to the sensor (10), the optical filter element (11), the lens (12) and the light source (13) will hold on.

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In a preferred embodiment of the invention, the computer and software unit (15) enables to co-evaluate the reflectance value of the image of each mineral grain received by each filter and the data obtained after grinding and performing the chemical analysis of these sample grains.

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In a preferred embodiment of the invention, the computer and software unit (15) provides an evaluation intended for sorting performance of sensor-based sorters that are used for recycling the mineral samples as a result of the analysis done.

15 In a preferred embodiment of the invention, the computer and software unit (15) provides an evaluation intended for determining the sortability of grains composing any mineral, by means of sensor-based sorters as a result of the analysis done.

20 In a preferred embodiment of the invention, the computer and software unit (15) provides an evaluation intended for detecting from which differences at which wavelengths does the mineral sorting result most efficiently as a result of the analysis done.

25 In a preferred embodiment of the invention, the computer and software unit (15) provides a content information for mineral samples according to the result of the analysis done.

30 In a preferred embodiment of the invention, the computer and software unit (15) provides an evaluation intended for using sensor-based sorters or making change

in the structure of current sensor-based sorters while performing mineral sorting as a result of the analysis done.

5 In a preferred embodiment of the invention, the computer and software unit (15) creates the image of the mineral grain on the sample table (2) by adding the images taken, one under the other instantly.

In an example of the invention, the controller (8) connected to the control unit (7) has buttons for enabling the movable sample table (2) to take commands of
10 “start”, “stop” and “restart”. The acceleration of the sample table (2) moved by means of the servo motor (5) and the belt (4) is set such that it will be zero as soon as it comes into the angle of view of the sensor (10). Similarly, the constant speed of the sample table (2) is programmed such that it will be equal to the image taking speed of the sensor (10). Programming is realized by means of the control
15 unit (7) according to speed and acceleration. In order that the servo motor (5) can generate a stable and constant torque, it needs to be supported with the reducer (6). The optical filter element (11) and the lens (12) are located on the end of the sensor (10) respectively. Before the image taking work, the distance between the end point of the sensor (10), the optical filter element (11) and the lens (12) group
20 and the top point of the grain –the image of which will be taken on the sample table (2)– is calculated and the definition settings are made. A filter is placed into the optical filter element (11) and the sample table (2) wherein the mineral grains are placed moves in accordance with the parameters. At the point where the light sources (13) and the sensor (5) are located, the sample table (2) completes its
25 acceleration and reaches constant speed. The sensor (5) takes high-resolution continuous images in 1024×1 pixel size and in the form of strip and these images are sent to the computer and software unit (15) by means of the data transfer unit (16). The computer and software unit (15) creates the image of the mineral grain on the movable sample table (2) by adding the images taken, one under the other
30 instantly. The images taken by means of the sensor (10) are the reflectance value of the radiation sent onto the mineral grain from the light source (13). The amount

and the intensity of the electromagnetic radiation are correlated with the structure of the mineral grain. For example, there may be precious and nonprecious grains with high reflectance value in an image taken by the NIR sensor (5) as unfiltered. It is not possible to determine in which wavelength does the reflectance exist in this image taken in 700-3000 nm wavelength range. When the same image is taken by optical filters, the ones outside a certain wavelength are filtered and only the related wavelength is examined. Thereby, if the minerals providing unfiltered reflectance provide reflectance in different wavelengths, they can be sorted out from one another by using filters.

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The 'x' reflectance value in the algorithm shown in the Figure 5 indicates the chemical content value in 'y' percent. One of the equations of $y=ax+b$, $y=ax^2+bx+c$, $y=ax^3+bx^2+cx+d$ is selected in accordance with the x and y values obtained as a result of the analysis (1000) and it is aimed to determine the relation

15 between x and y according to the selected equation. If the equation compatible with the x and y values is in the form of $y=ax+b$ (1100), the x and y values to be used in the equation are determined as x_1 and y_1 (1110). Here, it is controlled whether the x_1 value is between 0 and 255 or not (1120). If the x_1 value is in this range, it is concluded that the x is greater than x_1 and y is greater than y_1 (1121). If
20 the x_1 value is not in this range, it is concluded that the x is less than x_1 and y is less than y_1 (1122). If the equation compatible with the x and y values is not $y=ax+b$, compatibility of the $y=ax^2+bx+c$ equation is analysed (1200). If this is the equation compatible with the data, the x and y values are determined as x_2 and y_2 (1210). Here, it is controlled whether the x_2 value is between 0 and 255 or not
25 (1220). If the x_2 value is in this range, it is concluded that the x is greater than x_2 and y is greater than y_2 (1221). If the x_2 value is not in this range, it is concluded that the x is less than x_2 and y is less than y_2 (1222). If the equation compatible with the x and y values is not $y=ax^2+bx+c$, compatibility of the $y=ax^3+bx^2+cx+d$ equation is analysed (1300). If this is the equation compatible with the data, the x
30 and y values are determined as x^3 and y^3 (1310). Here, it is controlled whether the x_3 value is between 0 and 255 or not (1320). If the x_3 value is in this range, it is

concluded that the x is greater than x_3 and y is greater than y_3 (1321). If the x_3 value is not in this range, it is concluded that the x is less than x_3 and y is less than y_3 (1322). If the equation compatible with the x and y values is not $y=ax^3+bx^2+cx+d$, it is decided that there is no required relation between x and y (1400) and it is necessary to scan other regression models (1500). In accordance with the relation established between x and y values, analysis is done by using statistical approaches and software solutions via the computer and software unit (15).

10 Filters and wavelengths used in experiment assembly are shown in the Table 1

Table 1. Filters and wavelengths used in experiment assembly

VIS filters (BP-bandpass)			NIR filters (BP-bandpass)		
Filter	Central Wavelength	FWHM*	Filter	Central Wavelength	FWHM*
FB400-40	400±8 nm	40±8 nm	FB850-40	850±2 nm	10±2 nm
FB450-40	450±8 nm	40±8 nm	FB900-40	900±2 nm	10±2 nm
FB500-40	500±8 nm	40±8 nm	FB1000-40	1000±2 nm	10±2 nm
FB550-40	550±8 nm	40±8 nm	FB1100-40	1100±2 nm	10±2 nm
FB600-40	600±8 nm	40±8 nm	FB1200-40	1200±2 nm	10±2 nm
FB650-40	650±8 nm	40±8 nm	FB1300-40	1300±2 nm	12±2.4 nm
FB700-40	700±8 nm	40±8 nm	FB1400-40	1400±2 nm	12±2.4 nm
FB750-40	750±8 nm	40±8 nm	FB1500-40	1500±2 nm	12±2.4 nm
FB800-40	800±8 nm	40±8 nm	FB1550-40	1550±2 nm	12±2.4 nm
FB850-40	850±8 nm	40±8 nm	FB1600-40	1600±2 nm	12±2.4 nm
VIS filters (LP-longpass)			NIR filters (LP-longpass)		
	LP500			LP1100	
	LP700			LP1300	
	LP900			LP1500	

*FWHM (Full Width at Half Maximum): Distance of wavelengths to the centre of

spectrum in conditions wherein permeability is 50%

Within these basic concepts; it is possible to develop various embodiments of the inventive experiment assembly (1); the invention cannot be limited to examples disclosed herein and it is essentially according to claims.

5

CLAIMS

1. An experiment assembly (1) **characterized by**

- 5 - a sample table (2) which is the place where the mineral samples requested to be sorted are placed and which can move;
- a first skeletal structure (3) which provides support for the sample table (2);
- a belt (4) which provides the motion of the sample table (2) by means of the rotary motion performed by it;
- 10 - a servo motor (5) which enables the sample table (2) to move lineally at a constant speed;
- a reducer (6) which runs the rotary motion as requested;
- a control unit (7) which provides control of the servo motor (5);
- a controller (8) which contains buttons to issue commands to the sample table (2);
- 15 - a controller connection unit (9) which provides connection of the control unit (7) to the controller (8);
- a sensor (10) which takes the sample image in the sample table (2) at high resolution;
- 20 - an optical filter element (11) which provides detection of mineral contents for image analysis;
- a lens (12) which is connected to the end of the optical filter element (11) and used for imaging the sample;
- a light source (13) which generates electromagnetic radiation that will enable the sensor (10) to take image;
- 25 - a second skeletal structure (14) which provides support for the sensor (10), the optical filter element (11), the lens (12) and the light source (13);
- a computer and software unit (15) which will process the data received by the sensor (10);
- 30

- a data transfer unit (16) which transfers the data received relative to the sample, to the computer and software unit (15).
- 5
2. A system (1) according to Claim 1; **characterized by** the sample table (2) the near infrared (NIR) or visible light (VIS) reflectance value of which is too low.
- 10
3. A system (1) according to any of Claim 1 or 2; **characterized by** the sample table (2) which is made of aluminium.
- 15
4. A system (1) according to any of the preceding claims; **characterized by** the sample table (2) which is located on the first skeletal structure (3).
- 20
5. A system (1) according to any of the preceding claims; **characterized by** the first skeletal structure (3) which has a table-shaped structure having a plate in a position parallel to the ground and legs in a position perpendicular to the place that is connected to the edges of the plate.
- 25
6. A system (1) according to any of the preceding claims; **characterized by** the belt (4) which is placed between the plates of the first skeletal structure (3).
- 30
7. A system (1) according to any of the preceding claims; **characterized by** the belt (4) which allows the sample table (2) to move right-left or forwards-backwards with linear velocity, by performing rotary motion.
8. A system (1) according to any of the preceding claims; **characterized by** the servo motor (5) which is positioned such that it will be connected to the end of the belt near the first skeletal structure (3).

9. A system (1) according to any of the preceding claims; **characterized by** the servo motor (5) which enables to provide speed, acceleration and motion to the sample table (2).
- 5 10. A system (1) according to any of the preceding claims; **characterized by** the servo motor (5) which supports the servo motor (5) to generate a stable and constant torque.
- 10 11. A system (1) according to any of the preceding claims; **characterized by** the reducer (6) which is connected to the servo motor (5).
- 15 12. A system (1) according to any of the preceding claims; **characterized by** the control unit (7) which enables to program and also to control speed and acceleration of the sample table (2) by means of the servo motor (5) and the belt (4).
- 20 13. A system (1) according to any of the preceding claims; **characterized by** the control unit (7) which programs the speed of the sample table (2) such that it will be equal to the image taking speed of the sensor (10).
- 25 14. A system (1) according to any of the preceding claims; **characterized by** the control unit (7) which programs the acceleration of the sample table (2) such that it will be zero as soon as it comes into the angle of view of the sensor (10).
15. A system (1) according to any of the preceding claims; **characterized by** the control unit (7) which is placed on the side of the first skeletal structure (3) such that it will be seen easily.

16. A system (1) according to any of the preceding claims; **characterized by** the controller (8) which has buttons for issuing command in order that the sample table (2) is started, stopped and reset.
- 5 17. A system (1) according to any of the preceding claims; **characterized by** the sensor (10) which enables to take high-resolution images of the mineral samples placed onto the sample table (2).
- 10 18. A system (1) according to any of the preceding claims; **characterized by** the sensor (10) which takes high-resolution continuous images in 1024×1 pixel size and in the form of strip.
- 15 19. A system (1) according to any of the preceding claims; **characterized by** the sensor (10) which reads the reflectance value of the radiation sent onto the mineral samples from the light source (13).
- 20 20. A system (1) according to any of the preceding claims; **characterized by** the sensor (10) which is made ready for taking image by creating a certain distance between it and the top of the mineral samples on the sample table (2) and making definition settings before starting the image taking work.
- 25 21. A system (1) according to any of the preceding claims; **characterized by** the sensor (10) an instance of which is a near infrared sensor (running between 700-3000 nm) or a visible light sensor (running between 400-1000 nm).
- 30 22. A system (1) according to any of the preceding claims; **characterized by** the sensor (10) wherein BASLER® (line scanning, up to a pixel hour speed of 60MHz in a single 8 bit output mode-CCD) and GOODRICH® (line scanning, indium gallium arsenide (InGaAs) respectively, a pixel hour

speed of 50MHz is a 14 bit output mode) cameras are used for visible and near infrared imaging, respectively.

- 5 **23.** A system (1) according to any of the preceding claims; **characterized by**
the sensor (10) which can take image by means of a great number of
different filters.
- 10 **24.** A system (1) according to any of the preceding claims; **characterized by**
the sensor (10) wherein the optical filter element (11) and the lens (12) are
located on the end of it respectively.
- 25.** A system (1) according to any of the preceding claims; **characterized by**
the optical filter element (11) wherein optical filters are placed.
- 15 **26.** A system (1) according to any of the preceding claims; **characterized by**
the optical filter element (11) which examines the mineral grains –that are
received from the ore representatively– one by one by means of all optical
filters placed into it, by using a suitable light source.
- 20 **27.** A system (1) according to any of the preceding claims; **characterized by**
the optical filter element (11) wherein a visible light (VIS) filter
transmitting light at narrow band (FWHM 40 ± 8 nm) is placed.
- 25 **28.** A system (1) according to any of Claim 1 to 25; **characterized by** the
optical filter element (11) wherein a near infrared light (NIR) filter
transmitting light at narrow band (FWHM 10 ± 2 nm and 10 ± 2 nm) is
placed into the optical filter element (11).
- 30 **29.** A system (1) according to any of Claim 1 to 25; **characterized by** the
optical filter element (11) wherein a visible light filter transmitting light at
long band is placed.

30. A system (1) according to any of Claim 1 to 25; **characterized by** the optical filter element (11) wherein a near infrared light filter transmitting light at long band is placed.

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31. A system (1) according to any of the preceding claims; **characterized by** the optical filter element (11) wherein the filters placed into it are featured such that they will pass only 400, 450, 500, 550, 600, 650, 700, 750, 800 and 850 nm wavelengths with ± 20 nm precision for visible range.

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32. A system (1) according to any of the preceding claims; **characterized by** the optical filter element (11) wherein the filters placed into it are featured such that they will pass only 900, 1000, 1100, 1200, 1300, 1400, 1500, 1550 and 1600 nm wavelengths with ± 10 nm precision for NIR (near infrared) range.

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33. A system (1) according to any of the preceding claims; **characterized by** the optical filter element (11) can work in the range of wide wavelengths by the filters placed into it.

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34. A system (1) according to any of the preceding claims; **characterized by** the optical filter element (11) wherein filters enabling transition of radiations of electromagnetic radiation at only certain wavelengths are used inside the optical filter element (11).

25

35. A system (1) according to any of the preceding claims; **characterized by** the optical filter element (11) wherein the optical filter element (11) is connected to the structure from the places where the sensor connection (112) located under the sensor (10) and the lens connection (113) located above the lens (12) exist, and the filter (111) is placed in the middle of it.

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36. A system (1) according to any of the preceding claims; **characterized by** the light source (13) which is decided according to the sensor (10) selection.
- 5 37. A system (1) according to any of the preceding claims; **characterized by** the light source (13) an instance of which can be NIR lamps, halogen lamps, fluorescent lamps, rarely tungsten filaments or a combination thereof.
- 10 38. A system (1) according to any of the preceding claims; **characterized by** the light source (13) which can generate light up to 1650 nm wavelength.
- 15 39. A system (1) according to any of the preceding claims; **characterized by** the second skeletal structure (14) which has a table-shaped structure having a plate in a position parallel to the ground and legs in a position perpendicular to the place that is connected to the edges of the plate.
- 20 40. A system (1) according to any of the preceding claims; **characterized by** the second skeletal structure (14) which is positioned such that it will be located on the first skeletal structure (3).
- 25 41. A system (1) according to any of the preceding claims; **characterized by** the second skeletal structure (14) which creates a structure where to the sensor (10), the optical filter element (11), the lens (12) and the light source (13) will hold on.
- 30 42. A system (1) according to any of the preceding claims; **characterized by** the computer and software unit (15) which enables to co-evaluate the reflectance value of the image of each mineral grain received by each filter and the data obtained after grinding and performing the chemical analysis of these sample grains.

5 **43.** A system (1) according to any of the preceding claims; **characterized by**
the computer and software unit (15) which provides an evaluation intended
for sorting performance of sensor-based sorters that are used for recycling
the mineral samples as a result of the analysis done.

10 **44.** A system (1) according to any of the preceding claims; **characterized by**
the computer and software unit (15) which provides an evaluation intended
for determining the sortability of grains composing any mineral, by means
of sensor-based sorters as a result of the analysis done.

15 **45.** A system (1) according to any of the preceding claims; **characterized by**
the computer and software unit (15) which provides an evaluation intended
for detecting from which differences at which wavelengths does the
mineral sorting result most efficiently as a result of the analysis done.

20 **46.** A system (1) according to any of the preceding claims; **characterized by**
the computer and software unit (15) which provides a content information
for mineral samples according to the result of the analysis done.

25 **47.** A system (1) according to any of the preceding claims; **characterized by**
the computer and software unit (15) which provides an evaluation intended
for using sensor-based sorters or making change in the structure of current
sensor-based sorters while performing mineral sorting as a result of the
analysis done.

30 **48.** A system (1) according to any of the preceding claims; **characterized by**
the computer and software unit (15) which creates the image of the mineral
grain on the sample table (2) by adding the images taken, one under the
other instantly.

Figure 1

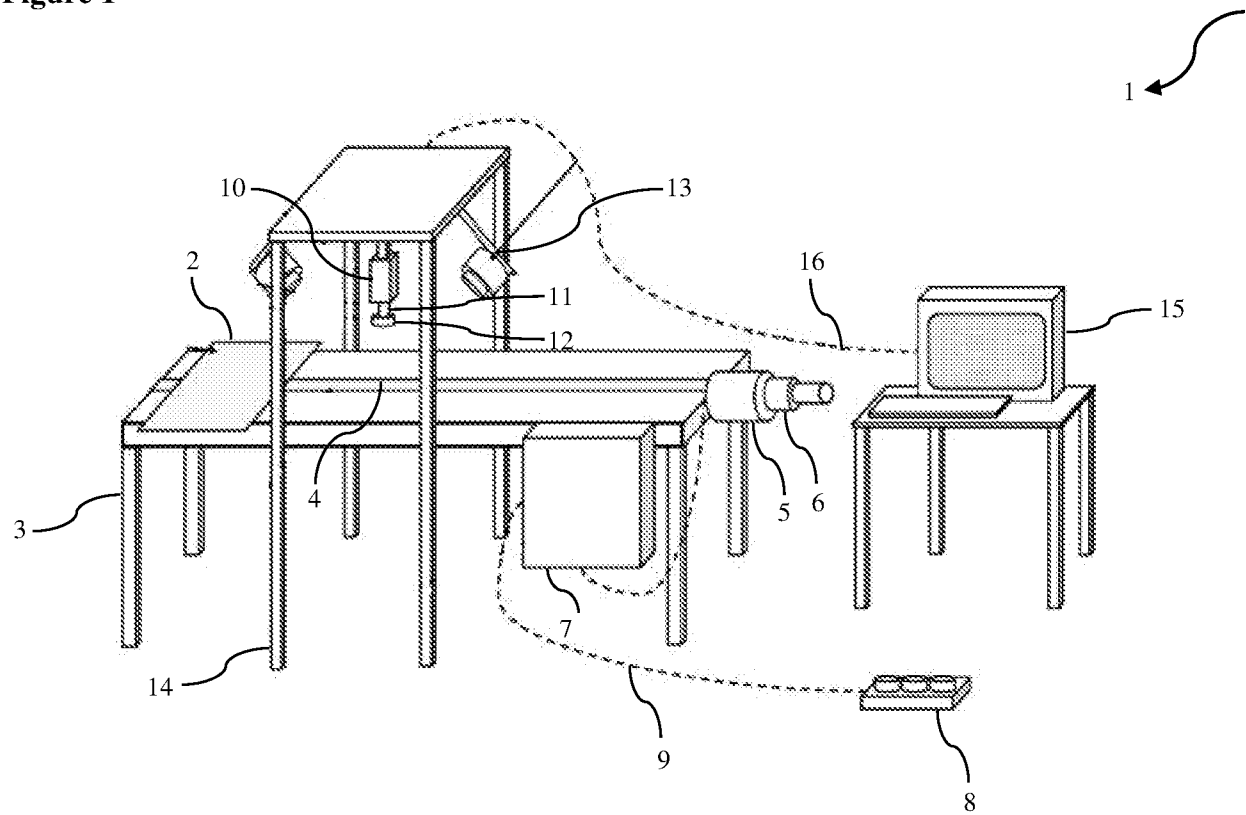


Figure 2

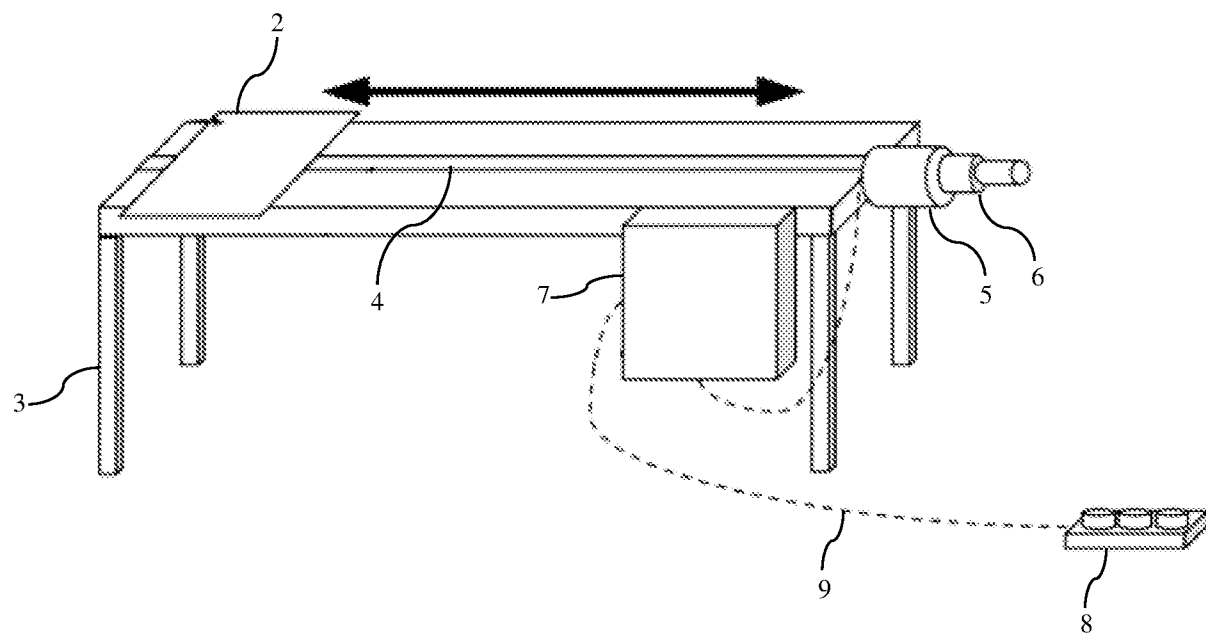


Figure 3

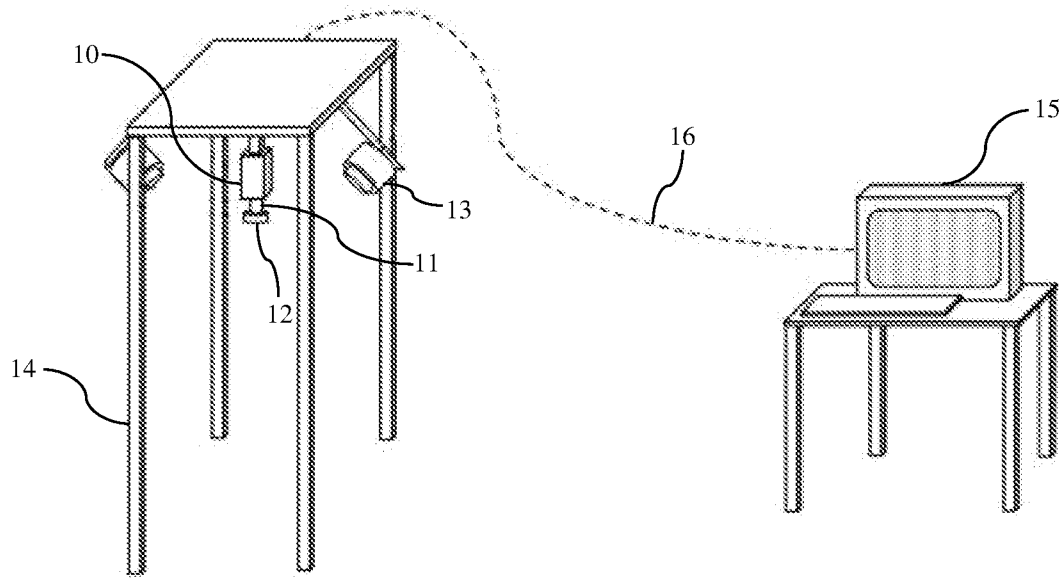


Figure 4

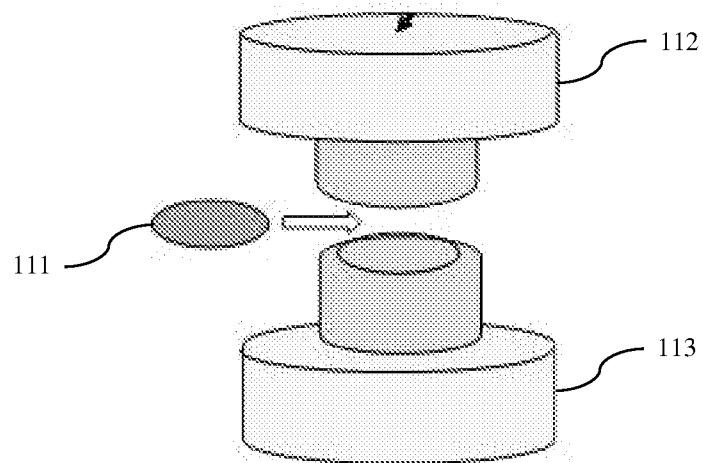


Figure 5

