Common Applications of Optical Matrix Sensors for Dimensional Control

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Abstract – *Optical sensors are used in a large range of industrial applications for generating information about various objects without physical contact. The sensors detect the modifying of optical radiation by the object, due to size, shape, reflection or color. With optical sensors the object detection could be realized in the range 5 mm … 250 m. The need of covering a larger detection field leads to appearance of matrix sensors which permit the areas monitoring, dimensions measurement or object recognizing. Besides these ones, there are developed too matrix sensors for detection of object presence in a defined field. The paper has the aim to realize a review of matrix sensors practically used for dimensional control.*

Keywords – *optical sensors, matrix sensors, dimensional control, industrial application.*

1. INTRODUCTION

The use of mono-dimensional optical matrix sensors type "barrier" for dimensional control leads to cheap, fast and accurate enough solutions for applications calling for detection, measurement and object recognizing.

The most important utilizations are related to measurement of objects geometrical dimensions, verifying of holes presence and positioning, control of belts position, recognition of object surfaces, detection of objects position and shapes, monitoring of boxes and storage spaces.

2. OPTICAL MATRIX SENSORS TYPE BARRIER

The main characteristics of optical matrix sensors type barrier are: operating distance, resolution, height of measurement field, response time, thermal operating range and protection class according IEC regulations.

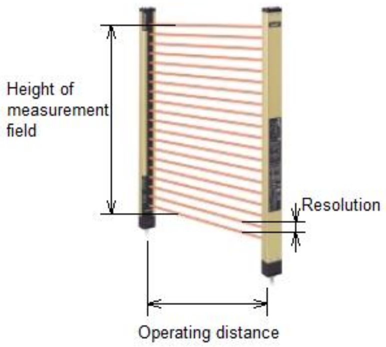

Fig. 1. Dimensional characteristics of optical matrix sensors type "barrier" [22].

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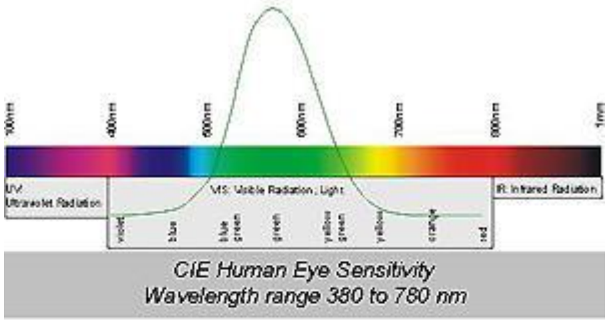

Fig. 2. Human eye sensibility [17].

The major part of optical sensors, regardless the detection type, use optical radiation in visible spectrum, within the range 380 … 780 nm. The reason consists in an easier mounting of the sensor and the possibility to be distinguished by a human operator, due to the human eye sensibility.

For the optical matrix sensors type barrier destined to objects measurement, the manufacturers use the near-infrared (NIR) optical spectrum within the range

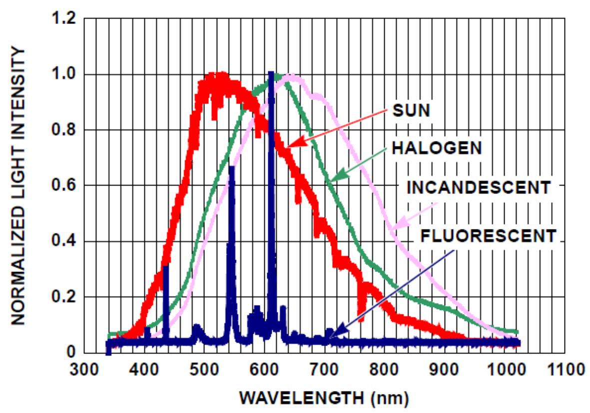

Fig. 3. Normalized spectrum of usual light sources [21].

800 … 1 400 nm. In the infrared range, the light intensity of usual sources decrease according increasing of wavelength, allowing the attenuation of perturbations generated by these sources.

A great part of optical matrix sensors manufacturers, like Balluff, Di-soric, Leuze and Sensopart, use optical radiation with the wavelength of 880 nm. Baumerelectric use the wavelength of 950 nm, and Allen-Bradley use 940 nm. Manufacturers Sick, Rrumba and Pepperl+Fuchs specify in the technical documentations only the use of infrared optical radiation.

Optical matrix sensors have analogue outputs in the range of 0…10 V and/or 4…20 mA, and digital outputs type PNP or NPN, which could work in the modes normally-open, normally-closed or push-pull. The digital outputs are protected at short-circuit, reverse supplying and overload, and could generate a current within 50 … 200 mA. The matrix sensors are interfaced by the use of serial buses like RS232, RS 485, CAN, ModBus or ProfiBus.

3. SCANNING METHODS FOR OPTICAL MATRIX SENSORS

Optical matrix sensors of "barrier" type uses two principles for optical beams assessment: parallel (used by the major part of matrix sensors) and interlaced.

The parallel method is used for optical matrix sensors destined to object measurements, by manufacturers like Pepperl+Fuchs, Sensopart, Balluff, Di-soric, Rrumba, Baumerelectric, Stiscanners, Cedes, Reer, Allen-Bradley, Leuze, Sick and Banner.

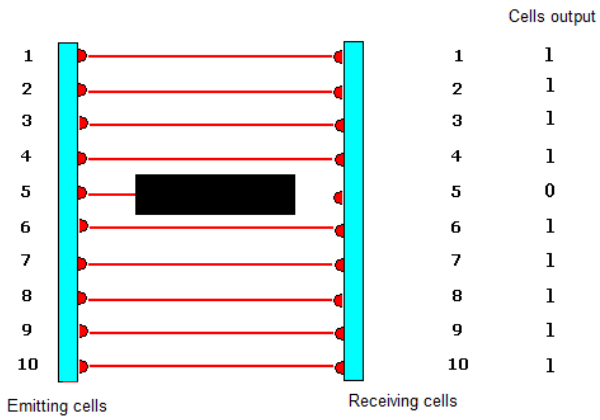

Fig. 4. Optical matrix sensor with parallel assessment of optical beams.

The dimension of the object present in the measurement field is determinate by the number of interrupted beams and the distance between these ones.

The interlaced method for assessment of optical beams is used till now only by Banner and Baumerelectric.

An example of interlaced scanning for the optical barrier matrix sensor A-GAGE MINI-ARRAY is presented and produced by Banner [1]. The method alternate the parallel scanning and diagonal scanning. The diagonal scanning starts from the second emitter channel to the first receiver channel, and continue till the last emitter channel is activated. The method of alternating parallel-to-diagonal scanning leads to the increasing of optical resolution in the central part of measurement range.

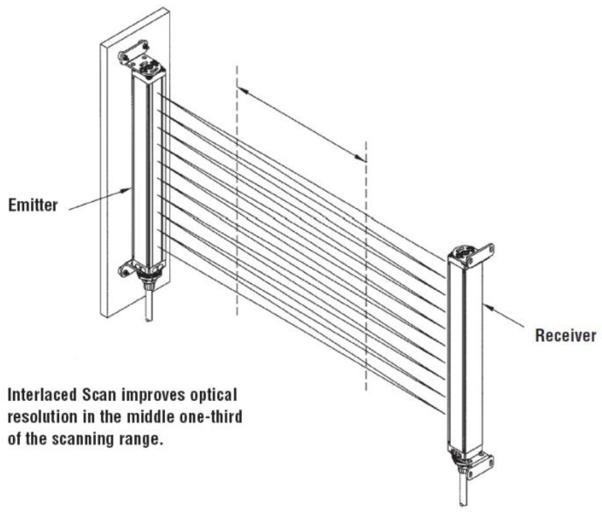

Fig. 5. Example of interlaced scanning [1].

Baumerelectric uses the interlaced scanning for SpiderScan matrix sensors, this scanning being called double scanning [32]. A diagonal beam is introduced between parallel beams and split at half the interval between cells, leading to an increasing of resolution to 1.25 mm for a distance between cells of 2.5 mm.

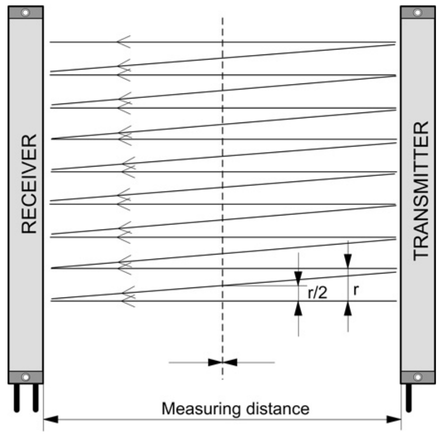

Fig. 6. Interlaced scanning for SpiderScan sensors [32].

Optical matrix sensors type barrier work in a synchronous mode, for triggering the simultaneous processes in emitter and receiver matrix.

For today matrix, there are used two triggering modes, electrical and optical. The electrical triggering is realized by electric signals transmitted through a conductive wire between matrixes, and the optical triggering by a dedicated emitter-receiver coupler.

The producers of optical matrix sensors using electrical triggering are Pepperl+Fuchs, Sensopart, Balluff, Di-soric, Rrumba, Baumerelectric, Stiscanners, Cedes, Reer, Allen-Bradley, Leuze, Sick and Banner. The only manufacturer that offer too the possibility of optical triggering between emitter-receiver is Reer.

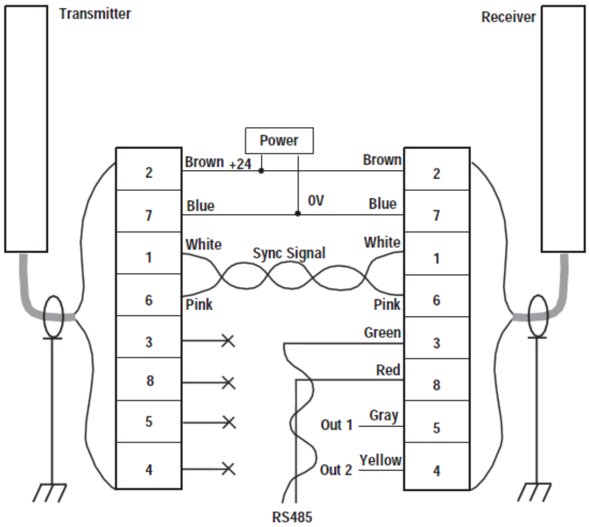

Fig. 7. Electrical triggering between emitter-receiver matrixes [34].

4. MEASUREMENT OF OBJECTS GEOMETRICAL DIMENSIONS

Measurement of height is used for sorting the objects related to this parameter.

An example is the measurement of carton boxes with mono-dimensional matrix of optical sensors, applied by Allen-Bradley at a conveyer belt [8]. The user could establish various heights, each acting on a digital output connected to logical control unit that will realize the sorting according the height.

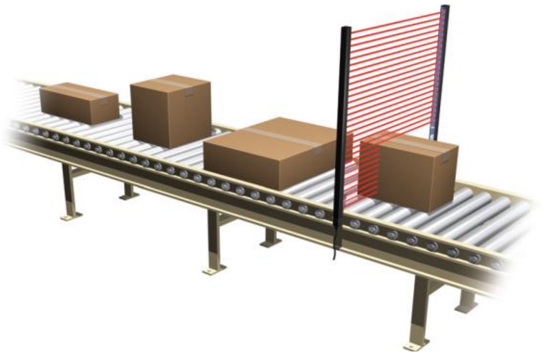

Fig. 8. Measurement of objects height [8].

The same method could be used for measuring object width and position simply by changing orthogonally the orientation of light beams.

A complex application maximizing the capability of optical matrix sensors to offer multiple dimensional data about objects is multi-dimensional measurement.

A stand for tires sorting depending on their size and shape deformation was realized by Banner with mono-dimensional sensors [11]. Due to the resolution higher enough of the optical matrix sensors could be determinate the inner and outer diameter of tires. The data are transmitted to the logical control unit, and if the dimensions are outside the preset types, this will be directed to a scrap chamber.

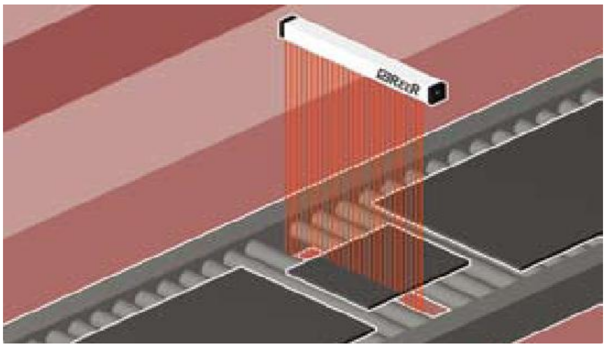

Fig. 9. Measurement of object width and position [25].

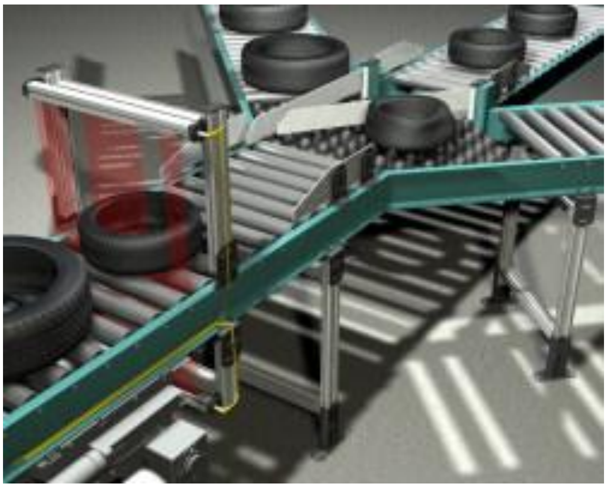

Fig. 10. Bi-dimensional measurement of tires dimensions [11].

An application of tri-dimensional measurement is the sorting of carton boxes according their volume, realized by the same company [11]. The carton boxes moves on a conveyer belt passing through three pairs of mono-dimensional optical sensors. The total number of beams blocked for each matrix shows in turns one dimension and the logical control unit will sort and guide the boxes to corresponding directions.

Fig. 11. Tri-dimensional measurement of carton boxes [11].

5. VERIFYING OF HOLES PRESENCE AND POSITION

These types of measurements are found in recognizing of certain hole patterns in various materials, selection of objects depending on hole presence or dimensions in their structure. Such kind of applications appear in wood processing, automotive and pharmaceutical industries.

A typical example is the repetitive inspection of a holes pattern from a punched tape for detecting the missing holes, realized by Banner [11]. The mono-dimensional matrix sensor was programmed to recognize the patterns by combining two decision modes acting on two digital outputs.

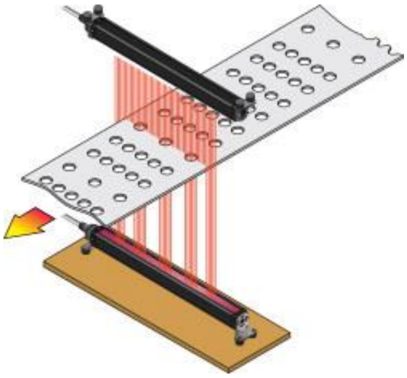

Fig. 12. Recognizing the hole pattern of a tape [11].

Another application is realized by Stiscanners for detecting the holes in a wood plate with the aid of matrix sensor [26].

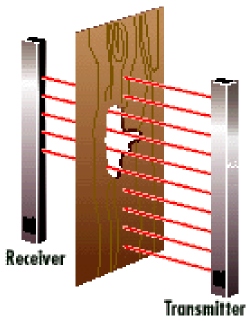

Fig. 13. Holes detection in a wood plate [26].

6. VERIFYING OF BELTS POSITION

An application of optical matrix sensors is proposed by Banner [11], for maintaining the central position of a textile tissue.

The mono-dimensional emitting matrix with high resolution is posted above the material, and the receiver is posted below, for minimizing the attenuation effect of transmitted light beam produced by the unclean lens. The pair of optical matrix sensors transmits the material position to a correction mechanism.

In the case of metal bands from mechanical manufactories, the metal form a loop needed by the feeding process of machine-tools. The speed differences should be compensated and the reserve

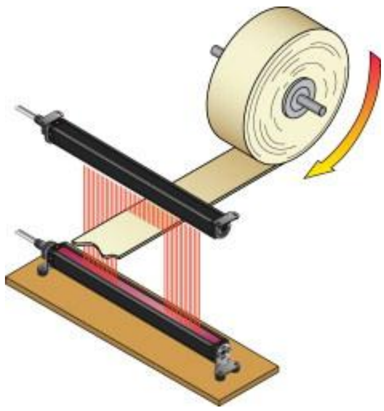

Fig. 14. Centering of spread belts [11.

from the metal loop could be used for reducing the feeding time intervals. For maintaining a constant loop, a continuous monitoring is needed.

The first solution is presented by Sick, by the use of mono-dimensional matrix [29]. The blocking of optical beams by the metal loop permits to determine the dimension that will be used for adjusting the speed of metal band.

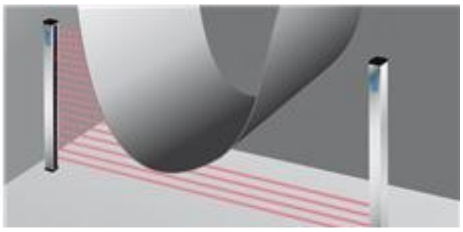

Fig. 15. Loop control with optical matrix sensors [29].

As general application of loops control, Stiscanners presents an automate control with mono-dimensional optical matrix sensors [26]. The loop dimension is determinate same way as the previous example, and the dimensional information is transmitted to the logical control unit through the serial bus RS-485.

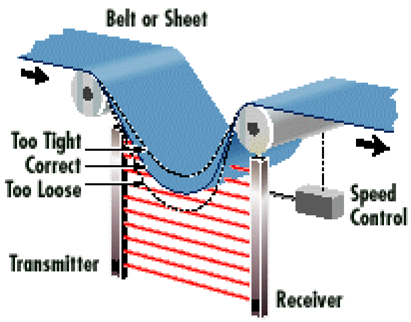

Fig. 16. Automate control with optical matrix sensors [26].

7. IDENTIFYING OF OBJECT SURFACES

These types of applications are used for identifying the shape of surfaces that need further processing, like repair, painting, and so on.

Banner realizes an application for automatic painting of pieces in automotive industry, based on two pairs of mono-dimensional optical sensors [11]. The matrix sensors furnish information about shapes and profiles of pieces that will be painted.

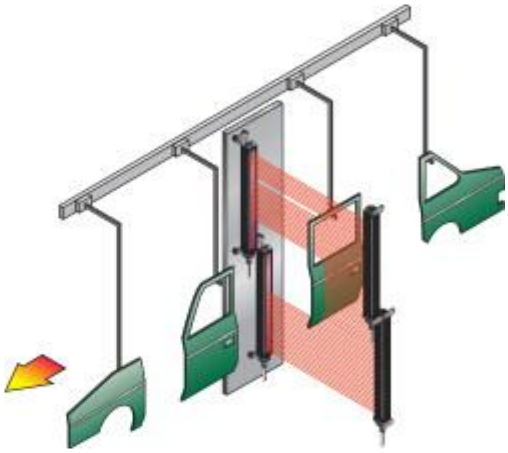

Fig. 17. Control of automatic painting [11].

Allen-Bradley proposes the same type of application, but this time for automatic painting of a wall.

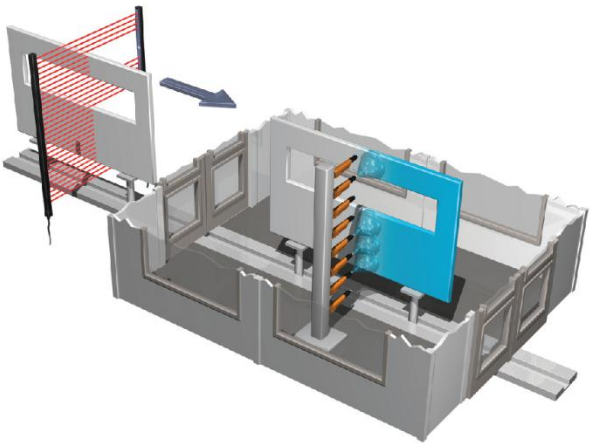

Fig. 18. Automatic painting of a wall [30].

The common aim of these applications is to recognize the object shape for painting only the object and not the holes. This procedure will permit to optimize the painting process, respecting the reducing of time and the paint quantity.

8. DETECTION OF SMALL OBJECTS

Often in industrial applications is necessary to detect small dimensions objects, even smaller than the optical matrix resolution. For solving this problem it is used the principle of interlaced assessment of optical beams. Thus, the objects could be detected by diagonally assessment of emitted beams.

Allen-Bradley presents an application for detecting envelopes with optical matrix sensors [8]. By diagonal detection of optical beams could be detected very thin objects, like a paper sheet or an envelope positioned perpendicular to the matrix sensors.

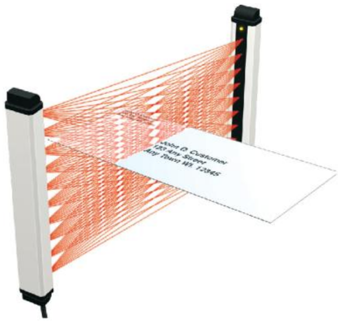

Fig. 19. Envelope detection with matrix sensors [8].

9. CONCLUSIONS

The optical matrix sensors for dimensional control could be characterized by the following common properties:

- Uses the parallel or interlaced assessment of optical beams for measuring the object dimensions;
- Emitter and receiver matrix operate in synchronous mode;
- Generates analogue and digital output signals, and are connected through serial buses for interfacing;
- Have measurement resolution in the range 2.5 … 50 mm, height of the measurement field between 100 … 3 200 mm, and operating distances in the range 150 mm … 20 m;
- All the optical matrix sensors are mono-dimensional sensors.

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