QUALITY INSPECTION OF PASSENGER CAR WHEELS

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ABSTRACT

The objective of this paper is to introduce the visual system for self-acting inspection of welding seams of passenger car wheels. This system was devised for company Hayes Lemmerz Autokola a.s (HLA), that produces car wheels for some car factories (Škoda, Ford, Opel,…). During the automated production process a plenty of defects that have to be inspected arise on the seam's surface. It is used a triangulation method. The destription of the working priciple of this system is mentioned.

1 INTRODUCTION

The welding seam connects the wheel's bowl and rim. During welding arise a lot of defects, for example: pinholes, bubbles, protrusions. The created seam can have wrong length or width or it can be wrongly located or discontented too. All these defects have to be automatically detected and system has to weed out faulty wheels from production line.

Because it was real application for particular client it was necessary to respect his requirements on the system and technical parameters of existing line. First of all, the supervisory system mustn't influence functionality, reliability and velocity (just 7 s for one wheel) of production. Furthermore the operator must be able to set the system for different types of the wheels (radius 13 ÷ 17 inches, different location of the seam). Required accuracy is 0.2 mm in all directions. Due to these desiderative attributes ware speculated optical methods of measuring, which are very fast and reliable. The big advantage of these methods is non-contact measuring too. It was selected an active 2-D triangulation method.

2 MEASURING METHOD

The optical methods of measuring using charge coupled devices (CCD) cameras and digital image processing found widespread applications in industry. Fast and non-contact optical form measurements have importance, for example, in robot vision, inspection on tolerances and completeness, surface inspection, navigation, surveillance of secured areas and 3-D object recognition. For all these domains are significant to obtain three-dimensional notion (information about shape, surface 3-D coordinates) about investigated object.

Unfortunately in standard projective imaging (for example, by means of CCD cameras), one dimension (usually depth information) from 3-D scenes is lost. A human observer does not lose 3-D interpretation, because he or she uses a priori knowledge. The human visual system is capable of exploiting , for example, “shape from shading” and “structure from motion” and is supported by two powerful sensors (eyes) capable stereovision and autofocus adaptation. Therefore were searched techniques, which can be able to substitute human eyes. Nowadays are used these techniques for computer vision of 3-D objects:

- Triangulation
- Interferometry
- Time-of-Flight Measurement

The most widely used technique is triangulation. We distinguish the following variants, which look greatly different, but use same principle: focus techniques, active triangulation with structured illumination, passive triangulation techniques on the basis of digital photogrammetry and stereoscopy, theodolite measuring systems and shape from shading techniques.

Active triangulation

As shows Fig. 1, the light source, the detector and the illuminated part of measurement object form triangulation triangle. On the side of the sender, the angle α to the triangulation base is fixed whereas the angle β on the side of the detector (CCD camera or position-sensitive photodetector) changes. From this angle, the depth can be determined.

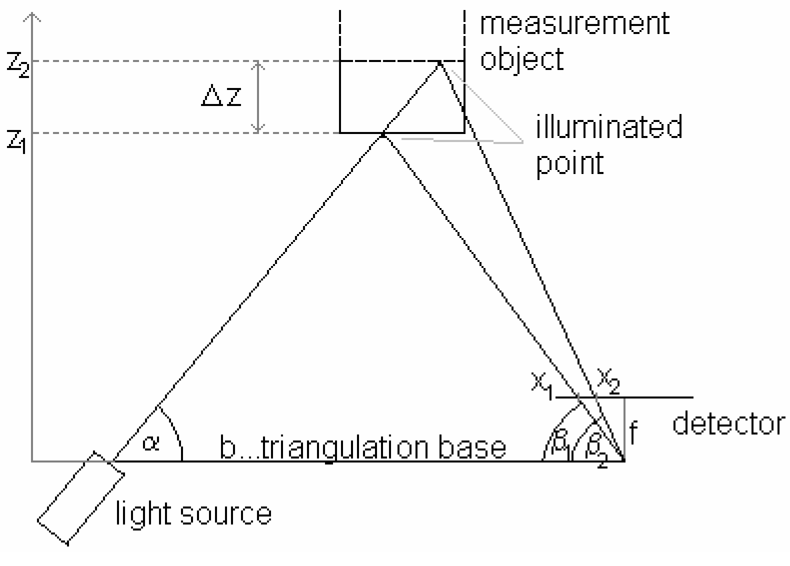

Fig. 1: *The triangulation triangle*

$$tg\beta_1 = \frac{f}{x_1}, \qquad z_1 = b \cdot \frac{tg\beta_1 \cdot tg\alpha}{tg\beta_1 + tg\alpha} \qquad (1), (2)$$

According to the light source we distinguish these variants: 1-D triangulation – light point; 2-D triangulation – light stripe; 3-D triangulation – light volume.

3 PRINCIPLE

By means of the diode laser with cylindrical lens is on the welding seam projected laser stripe. Illuminated line, that brings information about profile of the seam, is recorded by matrix CCD camera. In this way is acquired, without supplemental diagonal movement, the two-dimensional measuring method (coordinates in one plane – height and width of the seam). The third dimension (length of the seam) is obtained by axial rotation of the sensor unit (system of laser and camera) above the car wheel.

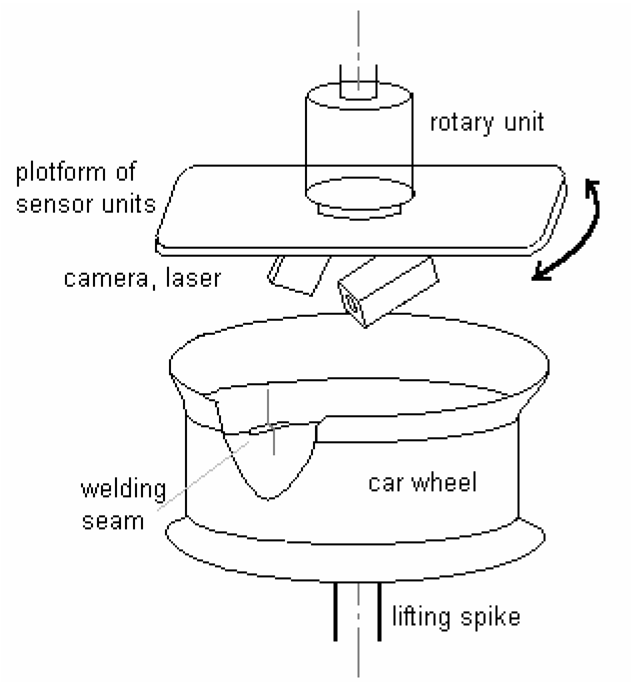

Fig. 2: *Principle*

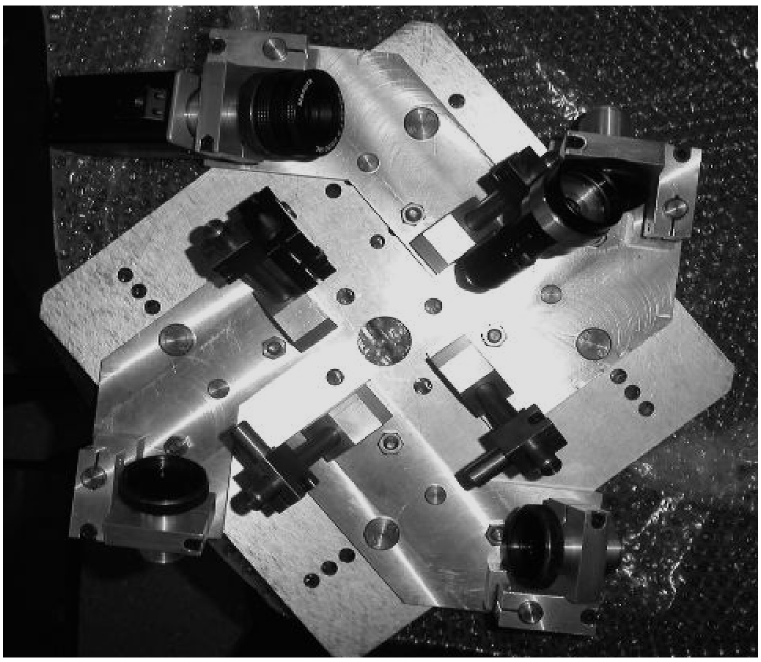

Fig. 3: *Platform of sensor units. On the photo is only one unit completely fitted with camera and laser*

The sensor unit was designed in order to acquire the best image without reflections, shadows and umbral places and to see just required area. Units are fixed on the platform (Fig. 3), which enables to set the system for different types of the wheels.

Time of measuring is reduced by using four sensor units, operating in parallel. During one cycle (one wheel), rotary unit (servomotor with IRC sensor) turns platform with sensor units through ninety degrees. So each unit measures one quarter of the wheel.

Memory space is spared by images superposition. Second single image is superimposed to the first image, but thirty rows lower (first row of the second image is added to the 31. row of the first picture). Next images are added in the similar way. Thus is obtained an image like on the Fig. 4. In picture like this, one profile takes memory only for thirty rows instead of whole image.

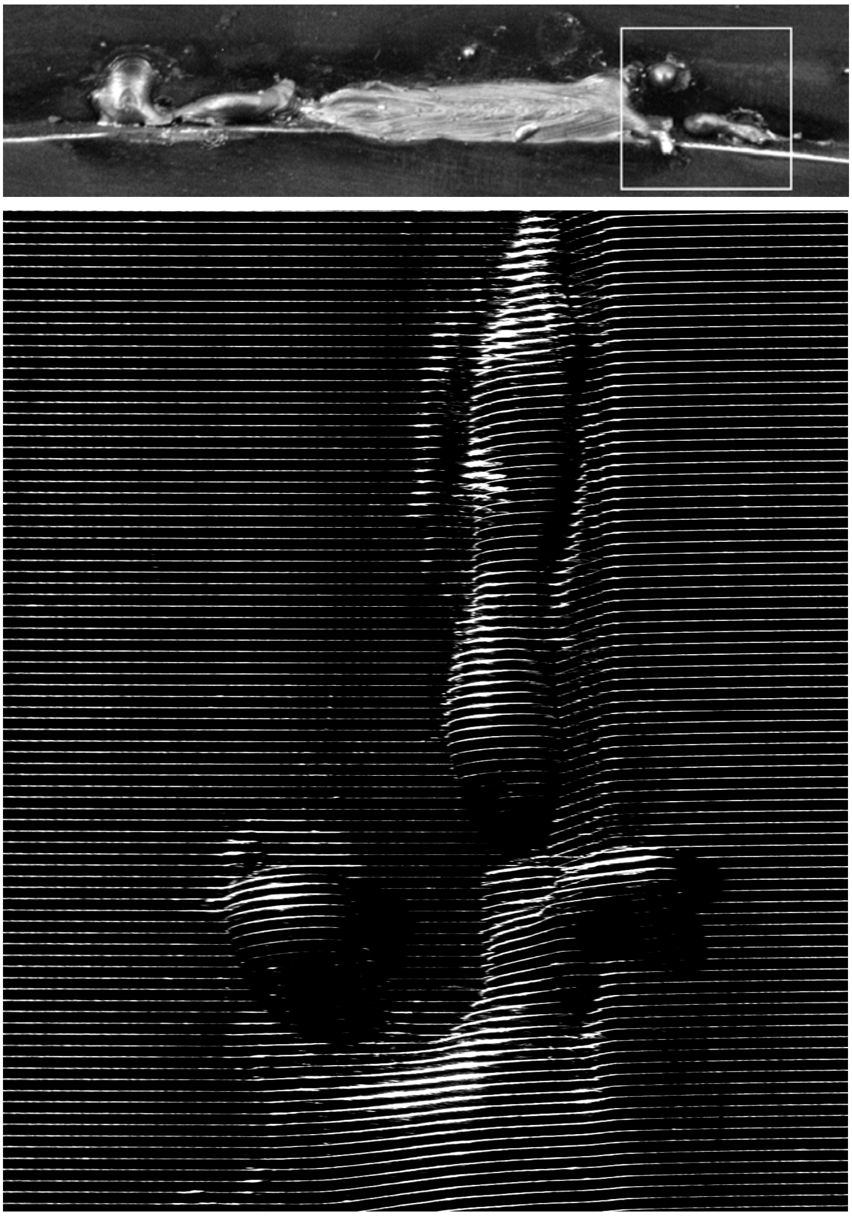

Fig. 4: *Upper picture shows a photo of the faulty seam, lower picture shows a part of the image from camera*

From the image are restored the surface cylindrical spatial coordinates *r*, *z* of the seam - image coordinates are multiplied by transformational matrix, which is obtained from the calibration and which represents attributes of the used camera. Coordinate φ is obtained from angular position of sensor units.

$$\begin{bmatrix} R \\ Z \\ W \end{bmatrix} = \begin{bmatrix} k_0 & k_1 & k_2 \\ k_3 & k_4 & k_5 \\ k_6 & k_7 & k_8 \end{bmatrix} \cdot \begin{bmatrix} u \\ v \\ 1 \end{bmatrix} \tag{3}$$

$$r = \frac{R}{W}, \qquad z = \frac{Z}{W}, \qquad (4), (5)$$

R, Z, W	auxiliary homogeneous coordinates
$k_0, k_1, \ldots, k_8$	elements of the transformation matrix
u, v	image coordinates [pixel]
r, z	cylindrical coordinates [mm]

Spatial coordinates are evaluated by defect-detecting algorithm. At the end of the working cycle all required details on the welding seam are available and a good/bad signal is transmitted to the main control unit. Wheels with significant defect are weeded out from the production line.

4 CONCLUSION

Result of this project is the visual system for defects detection on the surface of the welding seam. It incorporated – problem definition, selection of the measuring method together with design of mathematical apparat for reconstruction of the sems, design of sensor unit including camera and illumination selection and modification, design of mechanical construction of the whole system, application program including communication with existing machines on the production line, design of the way of calibration, imlementation and finally tests and tuning.

In present time the visual system described above is in operation in production hall of company Hayes Lemmerz Autokola. It passed a trial run and it achieves good results. It is considered using of this system on another production lines.

REFERENCES

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