DANUBE ADRIA ASSOCIATION FOR AUTOMATION & MANUFACTURING

DAAAM INTERNATIONAL VIENNA

PDF OFF-PRINTS

Author(s):

HORAK, K[arel]; RICHTER, M[iloslav] & KALOVA, I[lona]

This Publication has to be referred as:

Horak, K.; Richter, M. & Kalova, I. (2009). Automated Flaws Detection on Bottles in Food Industry (2009). 0133-0135, *Annals of DAAAM for 2009 & Proceedings of the 20th International DAAAM Symposium*, ISBN 978-3-901509-70-4, ISSN 1726-9679, pp 067, Editor B[ranko] Katalinic, Published by DAAAM International, Vienna, Austria 2009

Annals of DAAAM for 2009 & Proceedings of the 20th International DAAAM Symposium, Volume 20, No. 1, ISSN 1726-9679
ISBN 978-3-901509-70-4, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2009
Make Harmony Between Technology and Nature, and Your Mind will Fly Free as a Bird
DAAAM World Symposium

AUTOMATED FLAWS DETECTION ON BOTTLES IN FOOD INDUSTRY

HORAK, K[arel]; RICHTER, M[iloslav] & KALOVA, I[lona]

Abstract: *This paper describes visual system for non-contact inspection of glass bottles. The main aim is to detect flaws for rejection of faulty bottles from industrial flow line automatically. Flaws detection and localization is done by means of complex camera system with special image processing algorithms. Defects as a dirt, crack, mildew, remainders of labels etc. form inhomogeneous regions on uniform glass material. These distinctive non-homogeneities are detected in all images of the bottom, neck and side of the each bottle. In addition to mentioned basic image processing methods there is also included pattern recognition sub-system, which is able to distinguish between synthetic patterns (e.g. manufacturer logo) and genuine flaws (e.g. mildew in the bottle).*
Key words: *flaw, detection, recognition, pattern*

1. INTRODUCTION

Visual inspection systems in food industry are generally efficient solutions for considerable increasing of production quality. Described system for automated food bottles inspection is working for several years in number of countries and has to detect flaws on bottles in the production line. On these glass bottles often occur many types of various defects as dirt, failure crack, mildew, dropped in items, glass fraction and many others flaws which had to be detected and classified.

Inspection procedure is done on images of the bottom, neck and side of the bottle. At the beginning of the evaluation process, basic image processing methods are only used to detect and to describe inhomogeneous regions (include both defects and synthetic patterns). In the next step recent published novel method (Horak & Kalova, 2008) based on moment invariants (Hu, 1962) discriminates between regions belong to genuine defects and regions belong to synthetic patterns (generally manufacturer logo, labels on glass etc.). In the end a simple if-then classifier makes a final decision about the bottle quality.

The whole system is composed of industrial personal computer, control cards, frame grabbers, industrial CCD cameras, special illuminators and optical sensors (Fig. 1). The only one CCD camera is dedicated for bottle neck inspection as well as for bottle bottom inspection. On the contrary four cameras (or six in case of higher accuracy) are needed to guarantee complete inspection of entire surface of the bottle side (all-around the bottle). It comes to this that evaluation of each bottle includes acquiring and subsequently processing of six images in real-time (or eight in case of higher accuracy), that means very high computational demands.

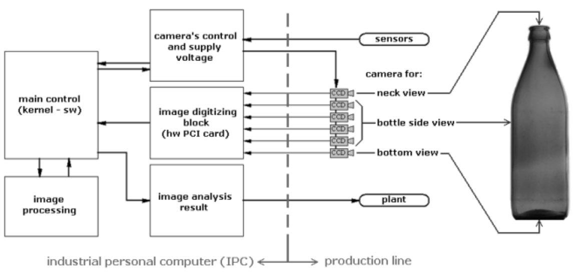

Fig. 1. Schematic diagram of visual inspection system

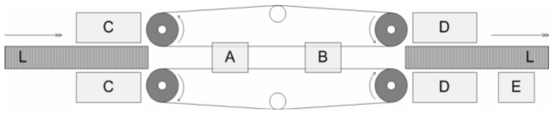

Fig. 2. Inspections emplacement on the production line

Visual inspection system (Fig. 2) is integrated into the production line by mechanical interruption of conveyor belt (letter L on the figure) and insertion of the visual system machine instead. On the input and output of the machine are located inspections of the bottle side (letters C and D respectively). Both bottle side inspections C and D are consist of camera block and illuminator block on the opposite side of the conveyor belt. Bottle neck (A) and bottle bottom (B) inspections are located inside the machine, where bottles are clutched at their side and drifted by foamy belts. Finally, bottles marked as defective are moved to waste end (E).

2. IMAGE ACQUISITION

Images of the neck, bottom and side of the bottles are mutually obtained in a different way (Fig. 3). For the bottleneck inspection is used reflective method, when camera and flash illuminator (here formed from LED ring) are on the same side of the bottle. Conversely bottle bottom and bottle side inspections employ transmission method, when camera and light source are on the opposite sides of the bottle. Nevertheless image acquisition of the bottle bottom and bottle side are also mutually different, because they use continuous and flashlight illuminators respectively.

Situation about image acquisition is more complicated in case of the bottle-side inspection, because here is need to obtain at least four images all-around the bottle. In order to realize this, two images are obtained on the input of the machine, after that bottle is 90 degree turned in foamy belts and then the remaining two images are obtained on the output of the machine (Fig. 4). Angle of turn of bottles inside the machine is exactly given by different velocities of the foamy belts.

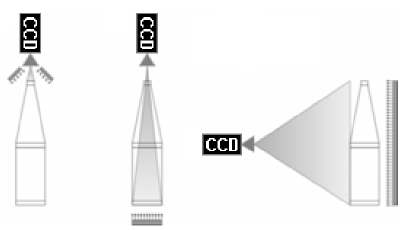

Fig. 3. Image acquisition methods

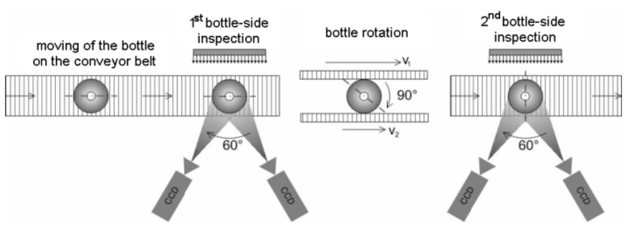

Fig. 4. Image acquisition in case of the bottle-side inspection

Fig. 5. Images without and with exposure compensation

Moreover, for the sake of different colours of glass bottles an analogue exposure control method (Horak et al., 2007) is used to achieve uniform images of all bottles (Fig 5). Simply, exposure time is longer for dark bottles than for light-coloured bottles and vice versa. On the left picture are two bottles (brown and white glass) acquired by camera without exposure control and on the right picture are the same two bottles acquired by camera with analogue exposure control.

3. IMAGE PROCESSING

3.1 Inhomogeneous regions detection

First step in all the inspections is exact localization of the neck, bottom or side of the bottle in the images. This is done by means of modular gradient methods and amplitude projections. Very important step is determination of inhomogeneous regions in images with the aid of basic image processing methods as noise filtration, edge detection, threshold computation, cluster analysis and others (Russ, 1994). On images of the bottleneck are only detected interruptions in tangential direction and consequently is executed cluster analysis (Fig. 6). Simple classifier rejects such bottles, which contain more clusters with certain dimensions than specified in parameters of the visual system.

On images of the bottom and side of the bottles are detected inhomogeneous regions in the sense of image gradient (Fig 7). Next step is pattern recognition module, because regions detected by mentioned manner may contain both genuine defects and synthetic patterns. In case some region corresponds to factual defect, bottle is marked as faulty and later removed from production line.

3.2 Pattern recognition

Before all detected inhomogeneous regions are processed by the classifier, it is necessary to exclude all the synthetic patterns from a list of suspicion regions. Every inhomogeneous region detected on the current image is primarily considered as the suspicion region. Synthetic patterns as manufacturer's logos or intended labels on the glass look like factual defects and create the same inhomogeneous region as defects (Fig. 8). They have to be recognized from true defects before classification.

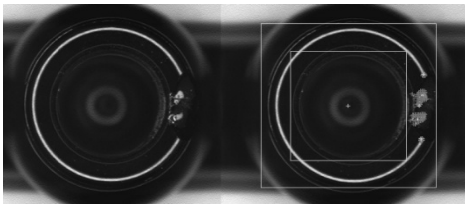

Fig. 6. Image evaluation of damaged bottleneck

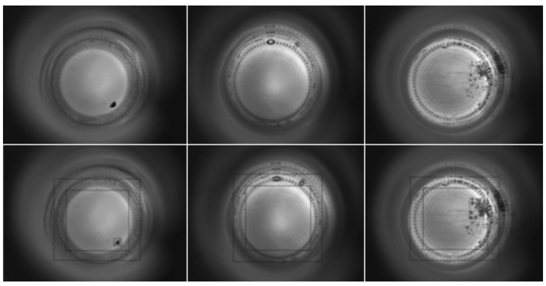

Fig. 7. Image evaluation of dirty on bottom of the bottle

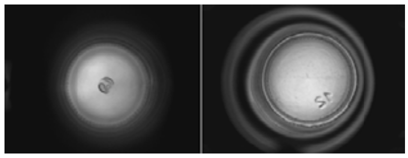

Fig. 8. Examples of manufacturer's synthetic patterns

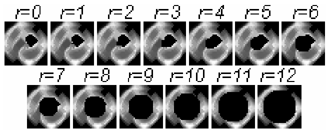

Fig. 9. Circle degradation in 13 degrees

In order to distinguish between image regions corresponding to an arbitrary defect and image regions corresponding to some predefined synthetic patterns, all detected inhomogeneous regions are processing by so-called circle degradation (Fig. 9). After it, moment invariants Ψ_1 and Ψ_2 (Flusser & Suk, 2003) are calculated from complex moments c_{pq} for each degraded region. Series of Ψ_1 and Ψ_2 values of only one region form functions Ψ_1^n and Ψ_2^n of moment invariants Ψ_1 and Ψ_2 respectively (superscript ^{n} denotes degradation degree).

On the basis of similarity of functions Ψ_1^n and Ψ_2^n corresponding to unrecognized inhomogeneous region and the functions Ψ_1^{Pn} and Ψ_2^{Pn} corresponding to an arbitrary predefined synthetic pattern can be decided about the region membership. Mentioned functions of invariants Ψ_1^n and Ψ_2^n are calculated for incrementing discrimination ability of the pattern recognition system, because only simple invariants Ψ_1 and Ψ_2 might be easily of the same values for two completely different regions. Conversely circular degradation has different influence on different regions and vice versa.

4. CONCLUSION

Paper briefly introduces inspection system intended for flaw detection on glass bottles in food industry. Machine containing visual inspection system is successfully implemented in many industrial plants for example in Kirov (Russia), Liepaja (Latvia), Jurajska (Poland) and several in Czech Republic (Hlinsko, Samson and others).

5. ACKNOWLEDGEMENT

This work has been supported by the Czech Ministry of Education under the projects 1M0567 and MSM0021630529.

6. REFERENCES

Flusser, J. & Suk, T. (2003). Construction of Complete and Independent System of Rotation Moment Invariants, *Proceedings of 10th International Conference on Computer Analysis of Images and Patterns*, Petkov, N. & M.A.Westenberg, pp. 41-48, Groningen, August 2003, Springer-Verlag, Heidelberg

Horak, K. & Kalova, I. (2008). Pattern Recognition by Use of Functions of Invariants. *Annals of DAAAM for 2008*, Katalinic, B., pp. 605-606, DAAAM International, ISSN 1726-9679, Vienna

Horak, K.; Kalova, I. & Richter, M. (2007). Řízení expozice kamerových systemů. *Proceedings of ARTEP 2007*, TU Kosice, pp. 271-275, The Technical University of Kosice, ISBN 978-80-8073-758-0, Kosice

Hu, M.K. (1962). Visual pattern recognition by moment invariants. *IEEE Transactions on Information Theory*, Vol. 8. February 1962, pp. 179-187, ISSN 0018-9448.

Russ, J.C. (1994). *The Image Processing Handbook.* CRC Press Inc., ISBN 0-8493-2516-1, Boca Raton Florida