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A Review :

Quality inspection of food products by computer vision

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ABSTRACT

With increased expectations for food products of high quality and safety standards, the need for accurate, fast and objective quality determination of these characteristics in food products continues to grow. Computer vision provides one alternative for an automated, non-destructive and cost-effective technique to accomplish these requirements. This inspection approach based on image analysis and processing has found a variety of different applications in the food industry. Considerable research has highlighted its potential for the inspection and grading of fruits and vegetables. This paper presents the significant elements of a computer vision system and emphasizes the important aspects of the image processing technique.

Key words : Machine vision, Computer vision, Image processing, Image analysis

The increased awareness and sophistication of consumers have created the expectation for improved quality in consumer food products. This in turn has increased the need for enhanced quality monitoring. Quality itself is defined as the sum of all those attributes which can lead to the production of products acceptable to the consumer when they are combined. Quality has been the subject of a large number of studies (Shewfelt and Bruckner, 2000). The basis of quality assessment is often subjective with attributes such as appearance, smell, texture, and flavour, frequently examined by human inspectors. Consequently Francis (1980) found that human perception could be easily fooled. Together with the high labour costs, inconsistency and variability associated with human inspection accentuates the need for objective measurements systems. Recently automatic inspection systems, mainly based on camera—computer technology have been investigated for the sensory analysis of agricultural and food products. This system known as computer vision has proven to be successful for objective measurement of various agricultural (He *et al.*, 1998; Li and Wang, 1999) and food products (Sun, 2000; Wang and Sun, 2001).

Computer vision includes the capturing, processing and analysing images, facilitating the objective and nondestructive assessment of visual quality characteristics in food products (Timmermans, 1998). The potential of computer vision in the food industry has long been recognised (Tillett, 1990) and the food industry is now ranked among the top 10 industries using this technology (Gunasekaran, 1996). As a result, automated visual inspection is under going substantial growth in the food industry because of its cost effectiveness, consistency, superior speed and accuracy. Traditional visual quality inspection performed by human inspectors has the potential to be replaced by computer vision systems for many tasks. This paper presents the latest developments and recent advances of computer vision in the food industry.

Basics of computer vision:

Computer vision is the construction of explicit and meaningful descriptions of physical objects from images (Ballard and Brown, 1982). The term which is synonymous with machine vision embodies several processes. Images are acquired with a physical image sensor and dedicated computing hardware and software are used to analyze the images with the objective of performing a predefined visual task. Machine vision is also recognized as the integrated use of devices for non-contact optical sensing and computing and decision processes to receive and interpret an image of a real scene automatically. The technology aims to duplicate the effect of human vision by electronically perceiving and understanding an image (Sonka *et al.*, 1999). Table 1 illustrates the benefits and drawbacks associated with this technology.

A computer vision system generally consists of five basic components: illumination, a camera, an image capture board (frame grabber or digitiser), computer hardware and software as shown in Fig. 1.

As with the human eye, vision systems are affected by the level and quality of illumination. Sarkar (1991)

Table 1 : Advantages and disadvantages of machine vision

Advantages	Reference
Generation of precise descriptive data	Sapirstein (1995)
Quick and objective	Li *et al.* (1997)
Reducing tedious human involvement Consistent, efficient and cost effective	
Automating many labour intensive process	Gunasekaran (2001)
Easy and quick, consistent	Gerrard *et al.* (1996)
Non-destructive and undisturbing	Tao *et al.* (1995a)
Robust and competitively priced sensing technique	Gunasekaran and Ding (1993)
Permanent record, allowing further analysis later	Tarbell and Reid (1991)
Disadvantages	
Object identification being considerably more difficult in unstructured scenes	Shearer and Holmes (1990)
Artificial lighting needed for dim or dark conditions	Stone and Kranzler (1992)

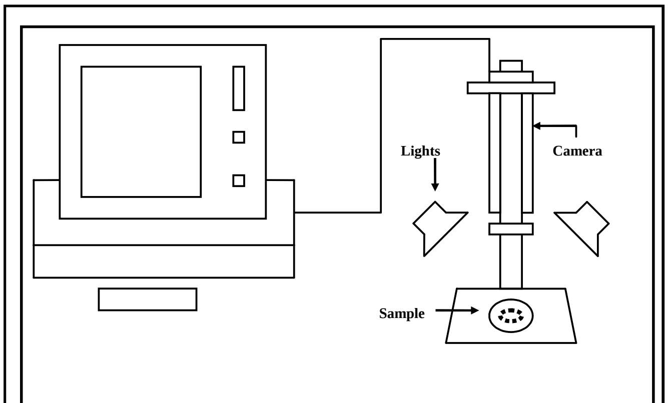

Fig. 1 : Components of a computer vision system

found that by adjustment of the lighting, the appearance of an object can be radically changed with the feature of interest clarified or blurred. Therefore, the performance of the illumination system can greatly influence the quality of image and plays an important role in the overall efficiency and accuracy of the system (Novini, 1995). In agreement Gunasekaran (1996) noted that a well-designed illumination system can help to improve the success of the image analysis by enhancing image contrast. Good lighting can reduce reflection, shadow and some noise giving decreased processing time. Various aspects of illumination including location, lamp type and colour quality, need to be considered when designing an illumination system for applications in the food industry (Bachelor, 1985).

There are many different sensors, which can be used to generate an image, such as ultrasound, X-ray and near infrared spectroscopy. Images can be also obtained using displacement devices and documents scanners.

Typically the image sensors used in machine vision are usually based on solid state charged coupled device (CCD) camera technology with some applications using thermionic tube devices. CCD cameras are either of the array type or line scan type. Array or area type cameras consist of a matrix of is obtained based on output proportional to the minute photosensitive elements (photosites) from which the complete image of the object amount of incident light. Alternatively line scan cameras use a single line of photosites which are repeatedly scanned up to 2000 times per minute to provide an accurate image of the object as it moves under the sensor (Wallin and Haycock, 1998).

The process of converting pictorial images into numerical form is called digitization. In this process, an image is divided into a two dimensional grid of small regions containing picture elements defined as pixels by using a vision processor board called a digitizer or frame grabber. There are numerous types of analogue to digital converters (ADC) but for real time analyses, a special type is required and this is known as a flash ADC. Such flash devices require only nanoseconds to produce a result with 50–200 mega samples processed per second (Davies, 1997).

Image processing and analysis:

Image processing and image analysis are recognized as being the core of computer vision (Krutz *et al.*, 2000). Image processing involves a series of image operations that enhance the quality of an image in order to remove defects such as geometric distortion, improper focus, repetitive noise, non-uniform lighting and camera motion. Image analysis is the process of distinguishing the objects (regions of interest) from the background and producing quantitative information, which is used in the subsequent control systems for decision making. Image processing/analysis involves a series of steps, which can be broadly divided into three levels: low level processing, intermediate level processing and high level processing (Gunasekaran and Ding, 1994; Sun, 2000), as indicated in Fig. 2 (Sun, 2000).

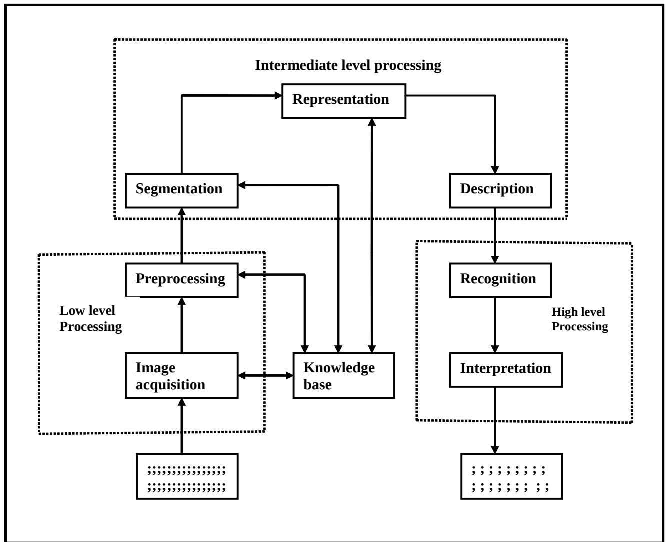

Fig. 2 : Different levels in the image processing process

Low level processing includes image acquisition and pre-processing. Image acquisition is the transfer of the electronic signal from the sensing device into a numeric form. Image pre-processing refers to the initial processing of the raw image data for correction of geometric distortions, removal of noise, grey level correction and correction for blurring (Shirai, 1987).

Pre-processing aims to improve image quality by suppressing undesired distortions or by the enhancement of important features of interest. Intermediate level processing involves image segmentation and image representation and description. Image segmentation is one of the most important steps in the entire image processing technique, as subsequent extracted data are highly dependent on the accuracy of this operation. Segmentation can be achieved by three different techniques: thresholding, edge-based segmentation and region-based segmentation (Sonka *et al.*, 1999; Sun, 2000).

The segmented image may then be represented as a boundary or a region. Boundary representation is suitable for analysis of size and shape features while region representation is used in the evaluation of image texture and defects. Image description (measurement) deals with the extraction of quantitative information from the previously segmented image regions.

High level processing involves recognition and interpretation, typically using statistical classifiers or multilayer neural networks of the region of interest. These steps provide the information necessary for the process/ machine control for quality sorting and grading. The interaction with a knowledge database at all stages of the entire process is essential for more precise decision making and is seen as an integral part of the image processing process. The operation and effectiveness of intelligent decision making is based on the provision of a complete knowledge base, which in machine vision is incorporated into the computer.

Conclusion:

This review presents the recent developments and applications of image analysis in the food industry, the basic concepts and technologies associated with computer vision. Image processing is recognized as being the core of computer vision with the development of more efficient algorithms assisting in the greater implementation of this technique. The automated, objective, rapid and hygienic inspection of diverse raw and processed foods can be achieved by the use of computer vision systems.

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REFERENCES

Bachelor, B.G. (1985). *Lighting and viewing techniques in automated visual inspection.* IFSPublica tion Ltd., Bedford, UK.

Ballard, D.A. and Brown, C.M. (1982). Computer vision. Prentice-Hall, Englewood Cli.s, NJ, USA.

Davies, E.R. (1997). *Machine vision*: *Theory, algorithms, practicalities*. Academic Press, London

Francis, F.J. (1980). Colour quality evaluation of horticultural crops. *Hort. Sci.*, **15** (1) : 14–15.

Gerrard, D.E., Gao, X. and Tan, J. (1996). Beef marbling and colour score determination by image processing. *J. Food Sci.*, **61**(1) : 145–148.

Gunasekaran, S. (1996). Computer vision technology for food quality assurance. *Trends in Food Sci. & Tech.*, **7**(8) : 245–256.

Gunasekaran, S. (2001). Non-destructive food evaluation techniques to analyse properties and quality. Food Sci. & Tech., **105**, Marcel Decker, New York.

Gunasekaran, S. and Ding, K. (1993). Using computer vision for food quality evaluation. *Food Technology*, **6** : 151–154.

He, D.J., Yang, Q., Xue, S.P. and Geng, N. (1998). Computer vision for colour sorting of fresh fruits. *Trans. Chinese Soc. agric. Engg.*, **14** (3) : 202–205.

Krutz, G.W., Gibson, H.G., Cassens, D.L. and Zhang, M. (2000). Colour vision in forest and wood engineering. *Landwards*, **55** : 2–9.

Li, J., Tan, J. and Martz, F. A. (1997). Predicting beef tenderness from image texture features. In 1997 ASAE Annual International Meeting, Paper No. 973124. St. Joseph, Michigan, USA: ASAE.

Li, Q. Z. and Wang, M. H. (1999). Development and prospect of real time fruit grading technique based on computer vision. *Trans. Chinese Soc. agric. Machinery*, **30**(6) : 1–7.

Novini, A. (1995). The latest in vision technology in today_s food and beverage container manufacturing industry. In : Food Processing Automation IV Proceedings of the 1995 Conference. St. Joseph, Michigan, USA: ASAE.products. In Food Processing Automation IV Proceedings of the FPAC Conference. St. Joseph, Michigan, USA: ASAE.

Sapirstein, H. D. (1995). Quality control in commercial baking: machine vision inspection of crumb grain in bread and cake

Sarkar, N.R. (1991). Machine vision for quality control in the food industry. In I. Fung, & E. Matthews (Eds.), *Instrumental methods for quality assurance in foods* (pp. 167–187). Marcel Decker, New York.

Shearer, S. A. and Holmes, R.G. (1990). Plant identi.cation using colour co-occurrence matrices. *Trans. ASAE*, **33**(6) : 2037–2044.

Shewfelt, R.L. and Bruckner, B. (2000). Fruit and vegetable quality: an integrated view. Technomic Publishing, Lancaster, Pennsylvania

Shirai, Y. (1987). *Three dimensional computer vision*. Springer-Verlag, Berlin.

Sonka, M., Hlavac, V. and Boyle, R. (1999). *Image processing, analysis, and machine vision*. USA: PWS Publishing, California.

Stone, M.L. and Kranzler, G.A. (1992). Image based ground velocity measurement. *Trans. ASAE*, **35**(5) : 1729–1734.

Sun, D.W. (2000). Inspecting pizza topping percentage and distribution by a computer vision method. *J. Food Engg.*, **44** : 245–249.

Tao, Y., Heinemann, P.H., Varghese, Z., Morrow, C.T. and Sommer, H.J. (1995). Machine vision for colour inspection of potatoes and apples. *Trans. ASAE*, **38**(5) : 1555–1561.

Tarbell, K. A. and Reid, J.F. (1991). A computer vision system for characterising corn growth and development. *Trans. ASAE*, **34** (5) : 2245–2249.

Tillett, R.D. (1990). Image analysis for agricultural processes Division Note DN 1585. Silsoe Research Institute.

Timmermans, A.J.M. (1998). Computer vision system for online sorting of pot plants based on learning techniques. *Acta Hort.*, **421** : 91–98.

Wallin, P. and Haycock, P. (1998). Foreign body prevention, detection and control. Blackie Academic & Professional, London.

Wang, H.H. and Sun, D.W. (2001). Evaluation of the functional properties of cheddar cheese using a computer vision method. *J. Food Engg.*, **49**(1) : 47–51.

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