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A Review on Applications of Machine Vision Systems in Industries

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Abstract

Objectives: This paper presents a review on the applications of machine vision technology in various industries such as food industry, textile industry, PCB industry and tile industry, thereby enhancing the conventional system. **Methods:** This technique used for inspection, sorting, handling and testing various components by machine vision is given with ample illustrations. Using this as a guide, generic machine vision approaches can be derived and applied to solve many problems. **Findings:** The machine vision techniques applied in the above mentioned fields are studied. It has been proven from research that automating processes in several industries has led to better results than manual processing. As a scientific discipline, machine vision is concerned with the concept behind artificial systems that incorporates image processing. Machine vision systems are based on extracting the images of the objects which are to be inspected/tested and processing them to retrieve the required data. This review paper provides an insight on how to combine two or more machine vision techniques to successfully incorporate them in more generic applications that may have the potential to perform with greater agility and accuracy.

Keywords: Image Processing, Inspection, Machine Vision

1. Introduction

Machine Vision (MV) is the technology used to provide image-based analysis for applications such as automatic inspection[1], process control and robot guidance[2,3] in industry. Vision Sensors/Machine Vision Systems analyse images to perform appearance inspections, character inspections, positioning, and defect inspections. The machine vision systems can be used in a wide range of applications because of their flexibility and versatile features. The use of vision systems in inspection and motion control applications imposes several real-time constraints on image processing. However, constantly increasing performances and decreasing costs of machine vision software and hardware make vision measuring systems more advantageous than the conventional measuring systems. These vision systems can be used to precisely measure variables such as distance, angle, position, orientation, colour, etc. The main advantage of a machine vision based system is its non-contact inspection principle, which is important in the cases where it is difficult to implement contact measurements. Also Machine Vision technology helps to achieve better productivity and aids in the overall quality management, thus posing a prominent competition to other industries which do not implement vision systems[4,5]. The scope of Vison based systems is not only limited to the fields described in this paper and it extends widely to much more industries such a welding industries, where Machine vision is used to identify and classify weld defects in welding environments, where human inspection is not efficient[6]. With the advancements in this field, Computer vision encompasses even to human gait recognition system[7]. In this paper, a broad awareness of the application

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of Machine Vision systems in different industrial scenarios is being discussed with relevant examples to get a better understanding of the subject matter.

2. Steps in Machine Vision

The various components of a machine vision system include a camera, a frame grabber (in case of an analog camera), light source, a processor and a controller as shown in Figure 1. The first and foremost step in machine vision is the acquisition of image. Capturing of image is done using a primary input device, a basic analogue/ digital camera. A frame grabber has to be used in case of an analogue image in order to convert it into a digital image. Acquisition has to be done with at most care as a proper image would eliminate most of the processing steps such as enhancement, noise reduction etc. Image processing refers to the way by which the captured image is converted into a particular format so as to proceed with the further testing or inspection. The various steps involved in image processing are shown in Figure 2.

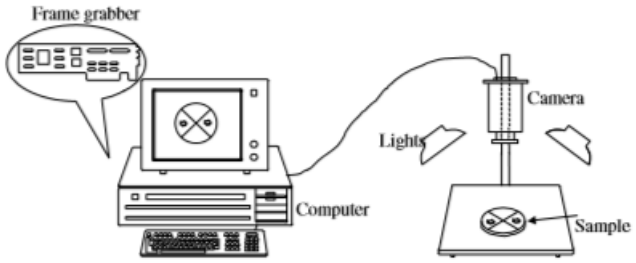

Figure 1. Various components of Machine Vision System.

3. Machine Vision in Food Industry

Machine Vision has been used in food industry for the past two decades to assure the quality of the products. Machine vision has been successfully implemented for applications ranging from simple inspection to complex robot guidance[8]. Vision based inspection systems reduce human interaction with the examined goods, categorize generally faster than human beings, and tend to be more reliable in their product classification. Food industries use vision based inspection systems for testing the quality of products such as meat, fruits and vegetables, bakery products etc.

3.1 Fruits and Vegetables

The external appearance of the fruits and vegetables is what makes the customers get attracted towards them. These include the size, shape, colour and the presence of other deformities on the fruit/vegetable surface. In[9] implemented the technique of Fourier based separation for grading potatoes based on their shape. It was found that the machine vision system matched with the human assessment for about 89%. Machine vision was implemented in defect segmentation on Golden Delicious apples[10]. Also these differences in their appearances help to sort the various fruits and vegetables. An integral automation of Industrial Fruits and Vegetable sorting was done by colour processing and size estimation using C means algorithm[11]. Computer vision has also been used for the automated inspection and grading of mushrooms[12]. Discolouration and occurrence of blemishes over the

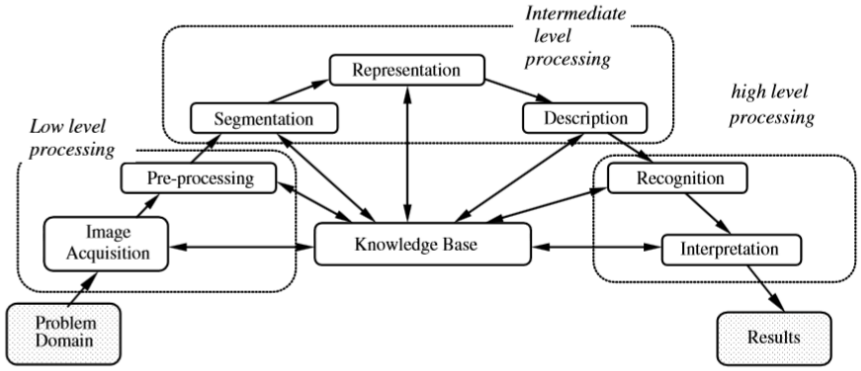

Figure 2. Steps involved in Machine Vision.

caps of the mushroom reduces its market value and is detrimental to health.

3.2 Bakery

Machine vision is being incorporated in bakeries to automate inspection and sorting of bakery products in real-time. Automated Tuning of a Vision-based Inspection System for Industrial Food Manufacturing[13]. The system was developed to minimize the errors that were prevalent when manual tuning was performed to classify the bakery products. Feature selection and cross validation are used for categorization. To assess the quality of different kinds of bread, devised a technique where the height and slope of the bread were considered[14]. In analysed the internal structure of bread to identify minor deviations and take corrective measures. In[15] proposed a technique to inspect the quality of cookies by capturing their images and processing them in terms of size, shape, baked dough colour, etc.[16].

3.3 Others

Machine vision is used to inspect food products like eggs, meat, grains, etc. Detecting Preserved Eggshell Crack using Machine Vision was developed[17]. Median Filtering and Morphological closing operations are used to detect the cracks. Another application of machine vision is the processing of grape leaves. In[18] Robert's operator is used to extract the desirable characteristics of the grape leaves. Sausage Appearance Defect Inspection system based on Machine Vision was implemented by[19]. Defects are identified using contour extraction and binarization. Quality Evaluation of Hydrothermal Treated Quicker Cooking Scented Rice was developed[20]. The fissures in the grain structure are calculated using techniques like Gaussian Low pass filtering and morphological image opening.

4. Machine Vision in Textile Industry

Inspection of the texture and nature of the material used in textile industries using the conventional manual method tends to be infeasible owing to the intricate design of the textile fabrics. Quality inspection is one of the major problems for fabric manufacturers. To overcome this difficulty, machine vision technology is now used which makes inspection easier and faster, thus decreasing the overall processing time. Machine vision was used in detecting the fabric printing quality with the help of JSEG algorithm proposed in, which takes into account both colour information and spatial information[21]. Computer vision is also used in Cloth Handling Robots[22] to pick and place clothes by using 3D shape extraction technique. This algorithm detects the highest position of the piled clothes, rough corner point and decides the direction to be pulled along. Supporting the usage of machine vision to inspect the texture of the material, in paper on detection of yarn evenness using CCD sensors is a perfect example[23]. When using photoelectric sensors, the incident light affects the measurement of yarn evenness. But with the help of CCD sensors, the problem is eliminated and the signal to noise ratio is lowered, thus improving the overall quality of inspection. Machine vision system is also being employed to inspect faults in textile web materials using wavelets and ANFIS (Adaptive Neuro-Fuzzy Inference System)[24]. In this fabric fault detection methodology, proposed by in wavelet transforms with Multi Resolution Combined Statistical and Spatial Frequency (MRCSF) level 3 are used and then for feature extraction, Gray Level Co-occurrence Matrix (GLCM) technique is being implemented.

5. Machine Vision in PCB Inspection

PCB is one of the most important components in electronics industries. A Printed Circuit Board (PCB) mechanically supports and electrically connects electronic components. Machine vision is widely incorporated in PCB manufacturing industries. It is used for detecting the defects in PCBs, distinguishing and identifying specific PCBs. Detection of particular PCBs was proposed by[25]. They devised a dataset for vision based PCB analysis comprising images of 165 different PCBs that were sampled randomly. The segmentation was done by GrabCut method which is followed by recognition of specific PCBs. Another application of machine vision in PCB industry is depaneling of PCBs. Highly accurate milling curves are generated to depanel PCBs using Auto-Teaching[26]. In implemented a computer aided system for defect inspection in PCB manufacturing[27]. Defect detection was performed using Danielson algorithm based on Euclidean distance map and classification of

defects was carried out using BST algorithm. Another method for detecting defects in PCB is to process the images using double sigmoid algorithm which reduces noise and produces a sharp image of the PCB under examination as shown in Figure 3(a) and Figure 3(b)[28]. Segmentation of the images is performed using OTSU algorithm. A real-time machine vision system for solder paste inspection was incorporated[29]. Which involve a fast image matching method to align the PCBs, analyse the PCBs to obtain a pseudo-3D feature of the PCBs. An artificial neuron network was used to classify the solder pastes. Fast inspection of bare PCBs is implemented using parallel processing reference comparison method to overcome the time delay in using Design rule verification process for the same[30].

Figure 3. (a). Original image of PCB.

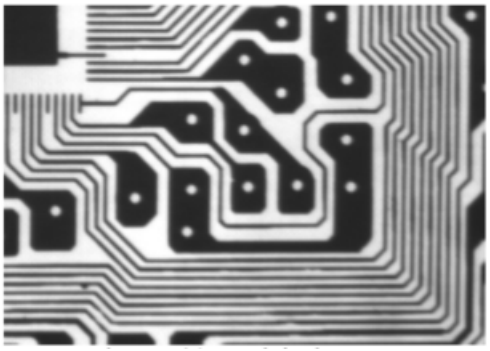

Figure 3. (b). Enhanced image of PCB.

6. Machine Vision in Tile Industry

Machine vision is these days implemented in tile and ceramic industries for inspection of the colour, defects, quality and finish of the products. Automatic colour grading for industrial inspection of plain and patterned ceramic tiles was proposed[31]. Here, by spatial variation of illumination over a tile is represented by a second order 2D polynomial whose coefficients are computed using least square error fitting, the tiles are graded and sorted. Failure Detection and Isolation in Ceramic Tile Edges Based on Contour Descriptor Analysis was implemented[32]. The irregularities in the ceramic tile edges are inspected by edge detection technique using histograms.

7. Conclusion

We have presented a survey on the applications of machine vision technology in the fields of food industry, textile industry, PCB industry and tile industry. Machine Vision automated system replaces the hardship of manual labour. Vision based systems acquire images, process them and perform contactless examination. Looking at the examples of various scenarios where machine vision has been employed, there are numerous possibilities for incorporating machine vision to produce better results than manual labour. Machine Vision systems are versatile and have immense future potential and scope for improvement in various fields.

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