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Automation and Integration of Industries through Computer Vision Systems

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Abstract

Computer vision is the enterprise of automating and integrating a wide range of processes and representations used for vision perception. It includes many techniques that are useful by themselves, such as image processing (transforming, encoding, and transmitting images) and statistical pattern classification (statistical decision theory applied to general patterns, visual or otherwise). Moreover, it also includes techniques for geometric modeling and cognitive processing. The field of computer vision may be best understood by considering different types of applications. Many of these applications involve tasks that require either work in a hostile environment, a high rate of processing, access and use of large databases of information, or are tedious for people to perform. Computer vision systems are used in many and various types of environments – from manufacturing plants, to hospital surgical suits, and to the surface of Mars. For example, in manufacturing systems, computer vision is often used for quality control. In this application, the computer vision system scans manufactured items for defects and provides control signals to a robotic manipulator to remove defective parts automatically. Current examples of medical systems being developed include: systems to diagnose skin tumors automatically, systems to aid neurosurgeons during brain surgery, systems to perform clinical tests automatically, etc. The field of law enforcement and security is also an active area for computer vision system development with applications ranging from automatic identification of fingerprints to DNA analysis. The aim of this paper is to show some of the most important vision-related topics which can have a more or less direct impact on the machine vision and industrial automation research fields. The paper covers a general purpose computer or machine vision systems with its industrial applications.

Keywords: Computer Vision, Machine Vision, Industrial Vision System Applications, Image Processing.

1. Introduction

Machine vision provides innovative solutions in the direction of industrial automation [6]. The introduction of the automation has revolutionized the manufacturing in which complex operations have been broken down into simple step-by-step instruction that can be repeated by a machine. In such a mechanism, the need for the systematic assembly and inspection have been realized in different manufacturing processes. These tasks have been usually done by the human workers, but these types of deficiencies have made a machine vision system more attractive.. Our expectation from a visual system is to perform the following operations: the image acquisition and analysis, the recognition of certain features or objects within that image, and the exploitation and imposition of environmental constraints [1]. A plethora of industrial activities have benefited from the application of machine vision technology on manufacturing processes. These activities include, among others, delicate electronics component manufacturing [18], quality textile production [2], metal product finishing [22], glass manufacturing [17], machine parts [14], printing products [21] and granite quality inspection [19], integrated circuits manufacturing [15] and many others. Machine vision technology improves productivity and quality management and provides a competitive advantage to industries that employ this technology.

2. Overview on Machine Vision Systems

Traditionally, visual inspection and quality control are performed by human experts [16]. Although humans can do the job better than machines in many cases, they are slower than the machines and get tired quickly. Moreover, human experts are difficult to find or maintain in an industry, require training and their skills may take time to develop. There are also cases were inspection tends to be tedious or difficult, even for the best-trained experts. In certain applications, precise information must be quickly or repetitively extracted and used (e.g., target tracking and robot guidance). In some environments (e.g., underwater inspection, nuclear industry, chemical industry etc.) inspection may be difficult or dangerous. Computer vision may effectively replace human inspection in such demanding cases [15].

3. Machine Vision Components

The main components of a typical vision system have been described [1, 16,7,3]. Several tasks such as the image acquisition, processing, segmentation, and pattern recognition are conceivable. The role of image-acquisition sub-system in a vision system is to transform the optical image data into an array of numerical data, which may be manipulated by a computer. Fig. 1 shows a simple block diagram for such a machine vision system. It includes systems and sub-systems for different processes. The big rectangles show the sub-systems while the parts for gathering information are presented as small rectangles in Fig. 1. The preprocessing, segmentation, feature extraction and other tasks can be performed utilizing this digitized image. Classification and interpreta- tion of image can be done at this stage and considering the scene description, the actuation operation can be per- formed in order to interact with the scene. The actuation sub-system, therefore provides an interaction loop with the original scene in order to adjust or modify any given condition for a better image taking.

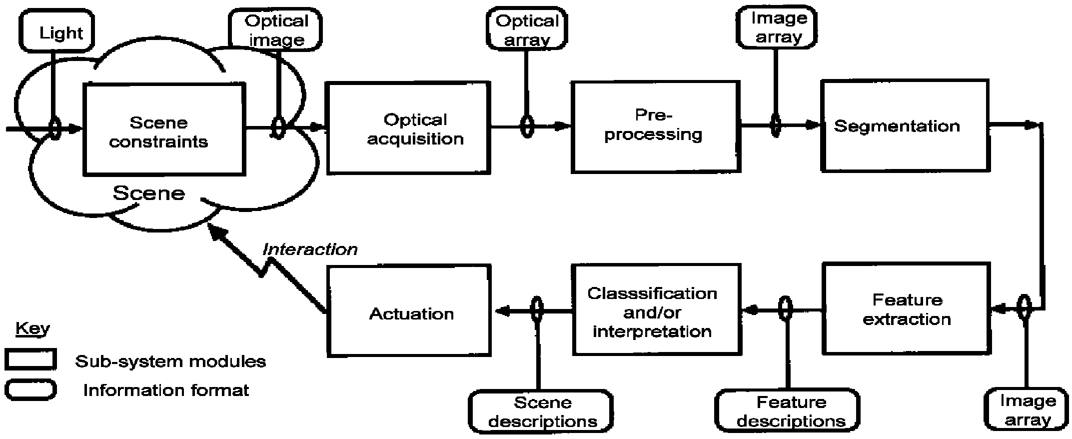

Fig. 1: A simple block diagram for a typical vision system operation [1].

4. Industrial Applications

In order to describe the applications of machine vision systems; four categories of the visual inspection, process control, parts identification, and robotic guidance and control mechanisms are considered. In this field, the most significant task of the machine is for the automated visual inspections (AVIs). The main concern of using machine is to recognize that the part is well made according to the specified qualifications. AVI and parts identification do not contribute a significant role in the flexibility in manufac- turing, however have considerable role in the automation task. On the other hand, vision systems in the process control and robotic guidance can play important role in achieving more flexibility in manufacturing [9,10]. Interesting surveys specializing in a single application field include among others for automatic PCB inspection [16], for wood quality inspection[4], and for automatic fruit harvesting[13]. Other important general reviews that cover all the fields of visual inspection have been published in [20], whereas model-based approaches to visual inspection are considered in [19] and [5] and more recently in [17, 8] and [9].

5. Automated Visual Inspection

The automated vision system can be used for the purpose of measurements, gauging, integrity checking, and quality control. In the area of measurements and gauging, the gauging of small gaps, measurements of the object dimension, alignment of the components, and the analysis of crack formation are common applications. Integrity checking in automotive plants, food industry and other production lines is performed by using such a vision system. The medical and pharmacological products can be inspected by the machine vision systems. A list of possible applications of AVI for measurements and gauging and quality controls are given in Table 2.[11]

Table 2: Possible operations for automated vision inspection.

Integrity checking and quality control	
Gauging of spark plug gap	Automotive plants
Measurement of belt width	Food industry (classify fruits, grades moving products)

6. Process Control

Utilizing a vision system could help a better analysis, control, tracking, and the issuing documents in different applications. Applying vision system also can help the analysis of the nozzle-plates, and monitoring production process. It also provides on-line inspection and imaging options for the biomedical, pharmaceutical, metal finishing, lumber production, and also in the automotive production assembly lines. Successful operations of the vision system for the process control and tracking tasks are shown in Table 3.[11]

Table 3: Example applications of vision systems for process control.

Process control	
Speeds food processing and high- speed sorting	Applying vision to nozzle-plate analysis
Fiber analysis in the wood panel industry	Event-capture system monitor paper-making process for breaks and defects

Control of flatness in float-glass manufacturing	On-line inspection ensures needle quality
Checks display pixels	Imaging options from biomedical, pharmaceutical to metal finishing and lumber production

7. Parts Identification

Parts identification and classification are one of the most important applications of a vision system. Sorting of the automotive castings, parts, and identifying and unloading of parts from pallets are important applications. Sorting and grading of the food and other products are another example of such identification applications. Some typical applicational examples for the identification and classifica- tions are listed in Table 4.[11]

Table 4: Typical applications of vision systems for part identification.

Parts identification	
Sorting of automotive castings	Sorting of automotive castings
Automobile well-to hob assembly	Identification of car bodies by outline
Automotive tyre-to-wheel assembly	Automatic decoration of chocolates
Precision application of car body seam-sealant	Sorting of fish by species, size determination and inspection

8. Robotic Guidance and Control

The automation process is based on the different robots, which require guiding systems. Alignment and adjustment processes also require smart guidance systems. In general, in the automotive plants guidance of the robotic action is performed by using the vision system as smart sensors for position determination in the welding or other processes. Table 5 gives a list of the possible applications of the vision system for the robot guidance and control.[11]

Table 5: Typical applications of vision systems in robotic guidance and control.

Automotive windscreen alignment and placement	High precession part-mating in aerospace applications
Seam location and following for welding car chassis members	Pattern-correct sewing in textile manufacture
Acquisition of cylindrical objects from the bin (bin picking)	Smart vehicles (imaging a target- rich environment)

Vision guided nuclear fuel sub- assembly dismantling	----

9. Conclusion

A general-purpose machine vision system with its industrial applications was described. The state of the art in machine vision inspection research and technology is presented. In the design and operation of a vision system, the image formation and visual process, computational methods and algorithms, depth information, image representation, and modeling and matching must be considered. On the other hand, the systematic consideration is important in the efficiency and the performance of the selected machine. The integration possibility, robustness, ease of operation, and adding intelligence into the system in order to make it a smart system are features of the advanced machine vision systems. The universal capability, PC requirement (self contained), off-the-shelf hardware, connectivity and I/O control options are the key factors in this respect. For any production line and manufacture plant, there should be a good reasoning for utilizing such a machine vision system. Improvement in safety and reliability of the products, improvement in the quality, and the introduction and possibility of a technology for new productions are key points in the support of the machine vision system. The economic and logistic considerations are also crucial factors, which justifies the utilization of a machine vision system.

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