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Machine Vision System for Industrial Engineering and Its Applications

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Abstract

This paper describes how to develop a machine vision (MV) system. The goal of machine vision system is to reduce human error and inspection time. The applications of MV will increase as a result of the decrease in price in MV equipment. In general there are three primary areas to apply MV which are measurement, inspection and guidance. MV measurement systems measure the two dimensions or three dimensions by enhancing and processing the digital image of the objects under investigation. Inspection systems compare the objects with a pre stored images. Guidance systems instruct a machine to execute specific actions based on what it perceives. Today many production lines use automation to do repetitive tasks quickly and efficiently. Machine vision has been used statistical, mathematical , or trial and error methods to extract useful information from the captured images. Several mathematical and statistical methods has been used in MV such as Histogram Equalization, Probability and Statistics, Fourier Transforms, Differential Equations, Integration, Matrix and Algebra. The paper presents a concise overview of how to design a proper machine vision system and the tools that required to achieve this task. Also this paper shows some of the application of Machine vision system in Industrial Engineering

Keywords: Machine vision system, Camera Lens, Image processing techniques, Image sensor.

1. Introduction

Machine vision(MV) includes the techniques and methods used to extract useful data from 2D or 3D images on an automated basis, This data can be used for many applications such as robot guidance in industry, products automatic inspection, counting, sorting and picking, for security monitoring and vehicle guidance, etc. [1].

Machine vision and automated inspection have many applications in industrial measurement and quality control in the industrial engineering sectors. This fast development benefits from increasingly powerful computers and reasonably drop in cameras price [2].

Machine vision systems use industrial cameras fixed with digital sensors and advanced optics to capture images. Machine vision cameras digitalize this information and transfer it to an image

processing system which analyses the data and extract the required data and then makes a decision. Figure (1) shows the main components of a MVs.

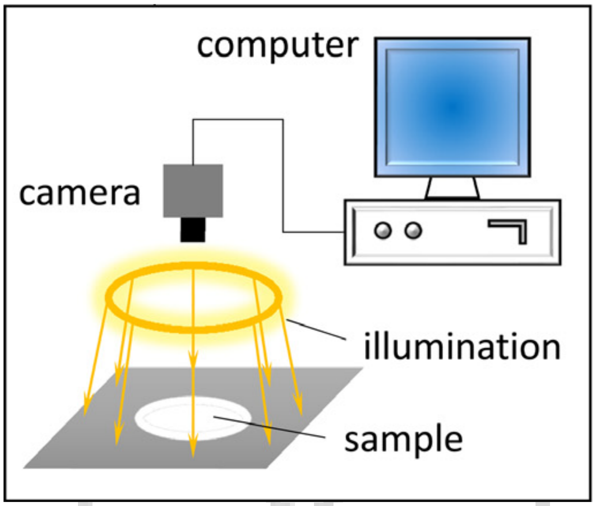

Fig. 1. Essential elements of a machine vision system [3]

2. Selection of Component of machine vision system

2.1 Machine vision Lens

A camera lens has an important task in computer vision: it projects three-dimensional scene objects onto a two-dimensional image plane where a digital imager is placed [4]. There is a direct relationship between the imager (sensor) used in the camera and the most suitable lens. The good lens should illuminate the entire imager in order to have high quality image of the object, if the optical resolution of the lens is high then we can produce image with more details. Choosing the right lens can improve measurement accuracy, speed, and reliability of the system. More commonly used lenses are:

2.1.1. Standard resolution lenses

Standard resolution lenses have Modulation Transfer Function (MTF) between 70-90 lp/mm (line pairs per millimeter) low distortion and vignetting) with fixed focal lengths range from 4.5 mm to 100 mm. they are used for image sensor with resolution less than one megapixel.

2.1.2. High resolution lenses

High resolution lenses generally have fixed focal lengths range between 4 mm and 75 mm, and normally their Modulation Transfer Function more than 120 lp/mm with distortion less than 0.1 %. They are used for applications that required precise measurement.

2.1.3. Telecentric lenses

The main applications of the telecentric lenses are in measurement in order to avoid image scaling can cause errors. And they are specifically used to measure 3D objects where image scaling can lead to incorrect information.

Telecentric lenses are large in size, heavy in weight, and more expensive comparing to normal lenses. the advantages of using telecentric lens consists of a long depth of field, a constant magnification over the whole depth of field, high accuracy and tiny distortion [5] as they collimate (make rays of light accurately parallel) the light that enters the lens.

The telecentric lens is suitable for most image based measurement imaging applications, they are particularly suited to measuring 3D objects. Since telecentric lens has the capability to reduce image distortion, perspective and poor image resolution as a result meaningful date can be gained.

2.2. Light

With the development of the technology, more and more application based on machine vision was used in actual production. The choosing of light source and lighting technique are a crucial stage in designing of machine vision system, which has effects on the quality of imaging and the processing techniques used for munopliating the images [6].

In machine vision, illumination is a key issue to determine the complexity of the inspection algorithms. Suitable illumination will produce clear and sharp images with the highest contrast between the object under investigation and the background [7]. A good lighting technique can reduce image processing methods and as reduce the cost of the system to a certain extent [8].

Proper machine vision illumination should increase the contrast between the interested object and the back ground, high contrast images improve the process of finding information from the object under inspection, resulting in increasing the system performance. Images with low contrast and poor illumination will decrease the system efficiency and increase processing time.
The following lighting sources are now commonly used in machine vision:

2.2.1. Fluorescent light

Fluorescent light are commonly used as a lighting source in machine vision applications [9] for illuminating large areas, fluorescent illumination existing in several sizes, and their cost is reasonable.

The fluorescent tubes contains a noble gas such as neon and argon with low pressure mercury vapor and they produce little heat, easy to diffuse and inexpensive [14] [15] so it is suitable for illuminating machine vision systems where continues illumination is required.

2.2.2. Halogen lights

Halogen lights are used for machine vision applications when the requires illumination should be very bright. They produce high heat and their intensity is reduced over time and have short life cycle. In order to increase their life cycle it is better to run it at 80 % of their maximum power.

2.2.3. LED light

light emitting diodes (LED) has a long life cycle, a smaller size and easier handling, low energy consumption, are available in a wide variety of shapes (eg ring, line,) and tend to be stable [16][17].

2.2.4. Lasers light

Lasers are highly collimated light sources with high intensity, so they can be placed in a distance from the object under inspection. The Laser light requires special safety as they present an eye hazard hazards (one mW laser directed into the eye will produce a small point of light many times brighter than would result from staring directly at the sun) [14] and it is very expensive.

2.3 Image sensor

The sensor received an image of an object which is focuses by the lens, then the sensor produces an electrical signal that representing the image. The output analog signal from the sensor then convert into a digital signal using a digitizer, and the digitized signal processed by a computer. The light intensity proportional to the amount of electrical output from the imager [10].

Solid state sensor are widely used devices in computer vision systems, as they are relatively cheap, reliable and rugged. The camera works as transducer and all image processing happens after the camera video signal is sampled and digitized to obtain a matrix of numbers in the frame buffer [11].

In solid state camera each pixel element in the sensor produces a separate electrical signal. The sensor can be arranged in either a linear or in a rectangular array. The signal that produced from the image sensor is a continuous electric signal which reflects the intensity of the light. The signal is then sent to an electronic device called a framgrabber, the framegrabber digitize the image into a 2D rectangular array and stored in a memory buffer [12], [13].

Solid state cameras are not subject to blooming and flare, virtually no geometric distortion, drift or lag and they are light, rugged and consume little power. Solid state sensors compromise CCD (charge coupled device), CMOS (complementary metal oxide semiconductor), CID (charge injected device) and CPD (charge priming device) [10].

2.4 Image Processing Software

The purpose of processing a digital image is used to extract information from the image and may take place in a PC-based system Processing is performed by software and consists of several steps. First, an image is attained from the imager, pre-processing may be used in order to high light the features under interest. Next, the software locates the features under interest, runs measurements, and compares these to the specification. Then a decision is made and the results are obtained. Many software are available for image processing such as OpenCV (Open Source Computer Vision Library), Matlab, openVINO..etc.

3. Application of M.V in Industrial

The following illustrates some of the applications of machine vision systems in manufacturing and industrial engineering.

3.1 Measurement

Measuring different objects, their area, volume, length and width is necessary to estimate the space they occupy. Measuring with tools such as a micrometer or a vernier caliper inevitably introduces errors due to individual differences between operators and measurement conditions. Other methods for measuring size are optical comparators and 3D measuring systems. They share the common problems of manual editing, which takes time and money.

Image processing allows you to obtain different sizes of captured images. Based on this data, it is easy to measure the dimensions of different sections of parts and products and evaluate whether they are within tolerance limits. Another benefit is that you can measure the angles or roundness of circles at the same time as the lengths of different sections and store them as numeric data. For example, the inside diameter of an engine cylinder bore can be measured using an image captured with a 2D camera or a 3D camera using computer vision.

3.2 Inspection

In modern industry there is tremendous competition in the manufacturing industry, so you need to maintain a good-quality inspection process to stay ahead of the competition. This can be accomplished with machine vision. This technology uses a non-contact inspection process. Compared to the existing technology, this technology has improved efficiency and accuracy, with less time investment [18].

Inspection vision system identifies faults, contamination, functional defects and other abnormalities in industrial products. Machine vision can also check the completeness of products, such as ensuring the compatibility of products with packaging in the food and pharmaceutical industries and to check safety seals, caps, and rings on bottles.

MV makes a significant contribution to the manufacturing industry by providing automatic inspection capacity under quality control procedures. MV uses smart cameras to perform inspection tasks and deliver approve or deny result to the control system [19].

3.3 Robotic Guidance

Vision guided robot systems (VGRs) are an important aspect of modern intelligent robotics. vision-guided robots are widely used in industries that can easily navigate any environment using the feedback received from a vision sensor. There are several modules to build a vision-guided system namely perception, localization, path planning, and control [20].

Robots require machine vision to navigate their workspace while avoiding obstacles, and to identify and locate parts, to improve their positioning accuracy [21]. For example, automated pick-and-place systems will assemble the components of any object very quickly by using vision-guided robotic systems.

3.4 Surface of surface defects

detection of surface defects is another use of computer vision that is a vital step in quality control. Manually identifying surface defects is a tedious task and operators can overlook them. Machine vision can provide surface inspection accuracy and efficiency in an easy-to-train model. In the manufacturing industries, surface defect inspection can identify faults in casting components, bearings, and many metal surfaces. For example [22] applied machine vision system to detect surface defects in Aluminum die casting , Navid et all, 2012 [15] used machine vision system to detect surface defect in vegetables.

In addition, image processing technology can be used in many areas, such as parts counting, detection of printing errors, wear measurement of machine tools

4. Conclusion

Machine vision is a scientific field that involves using technology to understand images and videos. The objective is to use automate vision system that replace human beings. This paper presented a survey on the major component of machine vision system and how to choose the proper one to achieve better results. Also it illustrated some of the common tasks that are being automated include Object detection ,2D and 3D measurements, automated inspection, Food and Packaging and objects counting. Machine vision systems are important area for mechanical and industrial engineering students as they reliable, accurate and efficient. The objective was to provide mechanical and industrial engineering students with theoretical and practical experience with automation technologies that will be necessary in the near future.

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