Overview on Industrial Vision Systems

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***Abstract*— This paper gives the overview of Machine Vision Technology. Industrial vision has become a key technology with ever increasing demands regarding product quality and documentation. In automated manufacturing, industrial, Vision systems have been essential. Machine vision has been used in many industries such as: electronics, medical devices, consumer goods, semiconductor and packaging. Machine vision systems can be used for inspecting and identifying parts, accurately measuring dimensions, or guiding robots or other machines during pick-and-place and other assembly operations. Vision systems' use have encouraged in general manufacturing automation because of the continuous improvements in cost, performance, algorithmic robustness and ease of use.**

Keywords*— *Image processing; Machine vision; Industry, Analysis.

I. INTRODUCTION

Human experts are performed the quality control and visual inspections [1]. In many cases, humans can do the job better than machines, but they are slower and get tired quickly. Human experts require training and they need time to develop their skills.

Also, precise information must be quickly or repetitively extracted and used in certain applications such as robot guidance.

Inspection may be difficult or dangerous in some environments such as nuclear industry, chemical industry etc.)So Computer vision may effectively replace human experts.

A large number of industrial activities have benefited from the application of machine vision technology on manufacturing processes.

Today, machine vision applications crop up in many industries, including semiconductor, electronics, pharmaceuticals, packaging, medical devices, automotive, quality textile production consumer goods and many others [2], [3], [4], [4], [6].

The productivity and quality management have been improved by Machine vision technology. This technology provides a competitive advantage to industries that employ it.

Vision systems' use have encouraged in general manufacturing automation because of the continuous improvements in cost, performance, algorithmic robustness and ease of use.

II. IMAGE PROCESSING SYSTEMS STRUCTURE [7]

Past years, inspection tasks for image processing systems can be categorized. The tasks for image processing systems in industrial manufacturing subdivide into the following categories:

- Positioning
- Mark identification
- Shape and dimensions check, gauging
- Completeness check
- Color processing
- Image and object comparison
- Surface inspection
- 3D image processing

Image processing system can be roughly divided according to the hardware into three parts: sensors, computer, and communication interfaces, as depicted in Fig 1This method is characterized as follows:

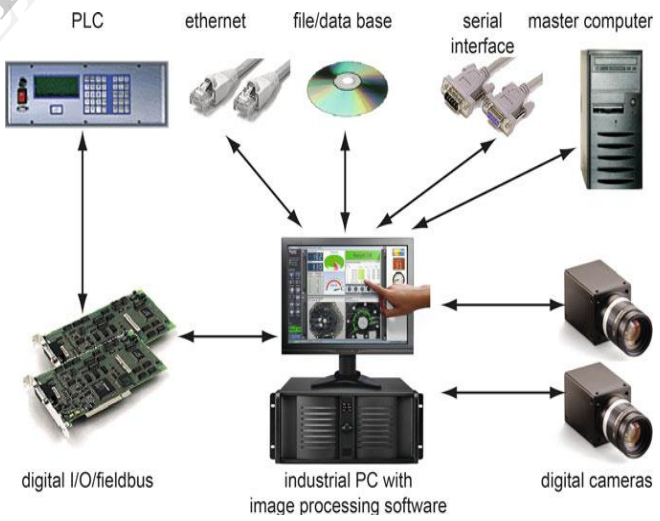


Fig. 1. Industrial vision system

1 Sensors:

The image-producing sensors can be cameras, laser, scanners and ultrasonic sensors. Typically cameras are the sensors of a system for visual quality control. Using digital media such as FireWire, Gigabit-Ethernet or USB, The connection between sensors (i.e. cameras) and computer is achieved. Over the past years in industrial applications, these PC mass market technologies have established themselves and the mass profits are used to drive the development in the industrial high tech sector.

2 Computers:

Very different types of computers may be used depending on the application .Typically in the case of extremely data-intensive, parallel computers are used. In order to handle the data rates in the extremely data-intensive inspections of continuous manufacturing processes like steel, paper or textile production, Parallel computers are often used because these devices provide sufficient memory bandwidth and computation speed. Usually, PCs and standard components are used in the bulk of industrial inspection tasks. These days, from manufacturing control to quality inspection, PC systems play an important role in all areas of industry.

3 Communication:

In order to work in step with the manufacturing process, the control of the image processing system for industrial quality must be possible from the outside, so the results must be transmitted to an external control. This way are used in automated production and quality control systems. The image processing system must be capable of communicating with other devices.

In order to control and evaluate the final results of the image processing system: The digital interfaces or Fieldbus are used to connect the system to PLC (programmable logic controls), which are directly responsible for the synchronization of inspection system and production process. - Network or serial communication are used to connect the master computer to the system, which is responsible for global control and logging of quality data

4 Intelligent cameras:

Because of the development, there was a trend to use of intelligent cameras, which follow the hardware setup outlined above. These cameras include a computer inside them with the small size and low cost of purchase, these cameras appear attractive as a first step into the world of image processing in particular for small and medium-sized companies. Due to the small size of these cameras, the computation performance and especially the memory capacity are limited. An additional PC requires as a terminal, because the inspection applications cannot be carried out directly on the camera.

Signal Flow in Process Environment

Image processing system is connected to the outside world via at least two interfaces: Output interface and Input interface. The signal flow of an image processing system can be represented by Fig 42 in order to derive a quality statement from an image scene.

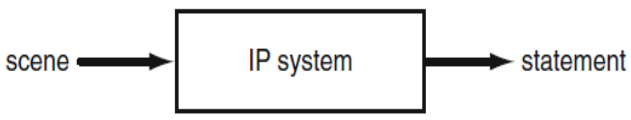


Fig. 2. Schematic signal flow of an image processing system

III. IMAGE ACQUISITION AND ILLUMINATION

To start image processing process, digital images must be acquired, the properties and quality of these images have the utmost importance in solving image processing tasks. Different sensors can be used to create these images. The visible light passing through a lens onto a camera sensor is the important case.

The quality of the digital image depends on this sensor chain—starting with the lens and the light-sensitive elements and leading to the transmission to the computer.

Image sensors can be categorized according to:

• The geometrical arrangement of the light-sensitive elements (pixels) in line or

Matrix sensors.

• The mode of operations and manufacturing technology in Charge Coupled

Device (CCD) and Complementary Metal Oxide Semiconductor (CMOS).

1 CCD cameras

A CCD (Charge-coupled Device) camera uses the CCD sensor technology. Theses sensors have many features, the most common camera sensors use this technology. The possibility of over exposure is the Disadvantage of these sensors

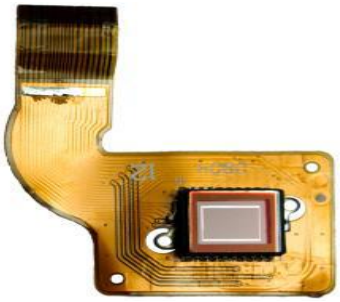
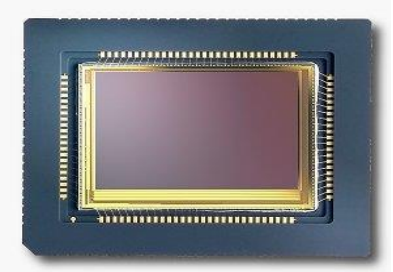


Fig. 3. shows a CCD sensor.

5 CMOS cameras

CMOS cameras are alternatives to CCD cameras. Theses sensors have many features such as: very high frame speed of these sensors, low manufacturing cost, low power consumption. But these sensors have poor image quality.



shows a CCD sensor

6 Color sensors:

For capturing color images, two types of color sensors have been used:

- Three-chip color cameras with a beam splitter that guides the light according to color onto one of three solid-state sensors.
- Single-chip color cameras with a color filter array through which only the light of a single color reaches each pixel of the single solid-state sensor.

IV. IMAGE DATA TRANSFER

Number of digital interfaces are used in industrial image processing:

- **Camera Link:** Camera Link is the first data interface developed for image processing. This interface use in high-speed applications because of its great bandwidth.
- **FireWire:** The serial data bus standardized as IEEE1394 is a high-performance and highly reliable data interface. This standardization allows for data rates of 800 Mbit/s (IEEE1394b). Bus can be used to Supply connected cameras with power.
- **USB:** The most important interface for linking personal computers with peripheral equipment is the Universal Serial Bus (USB). In industrial image processing, the new USB 3.0 standard can establish itself.

Table 1 Data rates of USB

Specification	Speed class	class Data rate
1.1	Low speed Full speed	1.5 Mbit/s 12 Mbit/s
2.0	High speed	480 Mbit/s
3.0	Super speed	5 Gbit/s

Gigabit Ethernet:

- Gigabit Ethernet uses for transferring image data as transfer medium. The digital interface Gigabit Ethernet is allowing cable lengths of up to 100 m.

V. CLASSIFICATION OF INDUSTRIAL VISION APPLICATIONS [8]

Most applications of modern industrial vision system are related to at least one of the following four types of inspection:

1. Inspection of dimensional quality,
2. Inspection of surface quality,
3. Inspection of correct assembling (structural quality) and
4. Inspection of accurate or correct operation (operational quality).

Table 2 Potential features of inspected products

Dimensional	Dimensions, shape, positioning, orientation, alignment, roundness, corners	
Structural	Assembly	Holes, slots, rivets, screws, clamps
	Foreign objects	Dust, bur, swarm
Surface	Pits, scratches, cracks, wear, finish, roughness, texture, seams-folds-laps, continuity	
Operational	Incompatibility of operation to standards and specifications	

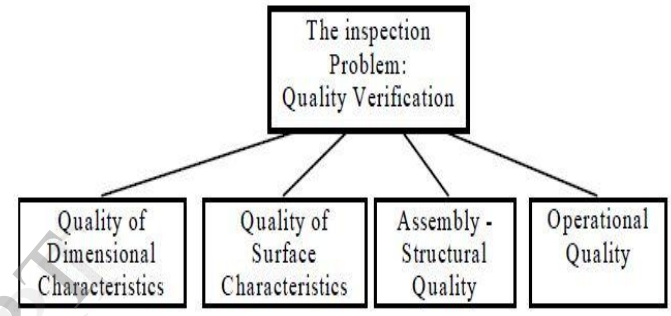


Fig. 4. Major categories of industrial vision applications.

1 DIMENSIONAL QUALITY

Industrial vision systems are checking whether the dimensions of an object are within specified tolerances or the objects have the correct shape, these tasks can be used in two or three dimensions.

2 SURFACE QUALITY

These tasks include: inspecting objects for scratches, cracks, wear, or checking surfaces for proper finish, roughness and texture.

Fault detection and quality verification are achieved in textile, wood and metal industries employing vision systems.

3 STRUCTURAL QUALITY

Typical tasks of this class of quality inspection are Checking for missing components (e.g., screws, rivets, etc.) on assembled parts or checking for the presence of foreign or extra objects (e.g., leaves, little sticks) .

4 OPERATIONAL QUALITY

According to the manufacturing standards, Inspection of operational quality is related to the verification of correct or accurate operation of the inspected products

VI. EXAMPLES OF INDUSTRIAL MACHINE VISION APPLICATION

1 Vehicle detection and tracking for safety purposes [9]

Intelligent Transportation System (ITS) has been used in many countries around the world, this system increases the the vehicle safety and traffic efficient, Intelligent Vehicle (IV) is an important part of ITS which provide safety insurance and autonomous navigation.

2 Textile industry

Machine vision has been used in textile industry. By detecting the impurities, the inspection of the cotton quality is done. An image acquisition board working within the PC and the lighting system are required to identify the impurities the color video camera. Because illumination or color of the light sources affects the apparent cotton color, the cotton is illuminated in the day light amps under controlled environment. The video input will convert into RGB by the image acquisition system. At the end, depending on color discrimination between cotton and impurities, the computer identifies the impurities in cotton using isodiscrimination [10].

3 Automotive

The automotive industry can be considered as a quality critical industry. Vision technology is applied directly on the assembly line. Also, the car component sub-suppliers specializing in quality production, such as brake systems, gearboxes... Etc.

4 Surface quality inspection

It is possible to continuously monitor the production process on-line at critical locations to verify that surface texture quality conforms to defined manufacturing norms and specifications via machine vision inspection

Industrial cameras for complete vision systems dedicated in-line production inspection of surfaces on continuous flat form products like textile, paper, sheet metal, plastics, films and wood [11].

VII. CONCLUSION

Industrial image processing can be used in a wide variety of application fields and industries, the suggested method can be effective method of automated quality assurance. Even where there are high demands on precision as well as high production speeds.

Image processing is a growing research field where many revolutionary ideas and efficient algorithms have been developed over the past few decades.

The hardware and software trends highlighted above will continue and even intensify in the future. Faster hardware, more intelligent tools and better application software development and deployment environments all will enable a broader and deeper proliferation of image processing in manufacturing.

ACKNOWLEDGMENT

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