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Machine Vision: Concept and Components

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***Abstract*— Vision system is one of the most approached system in the field of industrial automation that plays an important role in replacing the manual inspection procedure done by human inspector. Today, machine vision is the preference in industries for automatic inspection and industrial robot guidance and many more as it have number of benefits directly and indirectly. For developing a vision system, full understanding of the system and its components are important. There are number of components in machine vision system which are matured and some of them are still emerging. The main objective of this paper is to have the basic understanding of the machine vision system and the related components which will help to understand the basic concept of the vision system.**

***Index Terms*— Machine vision, digitization, monochromatic imaging, frame grabbers, image processing.**

I. INTRODUCTION

The Machine Vision Association of the Society of Manufacturing Engineers and the Automated Vision Association/Robotics Industry Association defines machine vision as *"the use of devices for optical, non-contact sensing to automatically receive and interpret an image of a real scene in order to obtain information and/or control machines or processes".*

Before proceeding to the concept of machine vision, we must know about the computer vision. Computer vision refers to capturing of the images followed by automation of image analysis function across a wide range of theoretical and practical applications [1]. Machine vision refers to the use of computer vision in an industrial or practical applications. We can also consider machine vision as a system where it is necessary to execute a certain function and output is based on the processing and analysis i.e. done by the vision system [1]. This paper includes the introduction to machine vision, methods, components, and basic machine vision system. One of the nature's best e.g. of vision system is human eye because at front end human eye is sensing the radiations and making an image of the scene and at the backend human brain is working perfectly to store or to perform operation on the sensed image. But in the machine vision or computer vision the system uses software to identify pre-programmed features.

As if we consider the human vision system, the very first thing is, the eye that is one of the most important organs of human body. Humans have a remarkable skilled vision system providing us the ability to see, recognize and to distinguish the objects in three dimensional world. Also we can estimate the distance and it can simply be termed as visual perception [2]. Human sense is very amazing for the vision system and if we talk about the vision system in industry i.e. machine vision, humans are continuously approaching to develop this sense to machine, but it still lacks behind. Somehow for some industrial and non-industrial applications, machine vision has a significant role.

Machine vision is not a part of design and a concept of graphics, simply we can say it as the technique of artificial vision. The goal of machine vision system is to create a model of the real world from images or videos i.e. the sequences of images [2]. Images are 2D projection of 3D world, so the information in an image is not available directly, therefore, the information is retrieved from the images by applying some operations. Machine vision system can also be considered as the expert system as the decisions need to be made at every stage according to the goal. Without the concept of knowledge, machine vision system can work in limited environment. Thus for making the system flexible, the knowledge stored in the database is directly used by the system. The system efficiency depends on the quality of knowledge used by the system [3].

II. WORKING OF MACHINE VISION

We simply can define machine vision as the ability of a machine to see. In general way, we can say that, machine vision system does require some hardware and software, some of them are camera, programs, operations etc. We can say that with the help of camera, processes and operations, computer can see, recognize and make right decisions accordingly. Thus, the entire system deals with the images or sequences of images with the objectives of manipulating the images, analyzing them for improving the image quality by performing operations on color, contrast, brightness etc. to restore images by reducing the noise with the help of some filters. Vision technique can be applied whenever the images are available or whenever the images are generated and whenever they are required for analyzing [2]. These can be used in medical field, defence services, metrology, industries etc. Most of the vision technology works with the help of some methods such as automating and integrating the number of processes for the purpose of performing the tasks such as acquisition of the image, preprocessing or post processing the image, segmentation of the image, feature extraction from the image etc. for having the desired output.

III. METHODS

There are number of methods which can be applied in machine vision system. But very first thing is to know that for what purpose machine vision has to set up. Each and every field do have different functions and reasons to set up a machine vision system. Thus, simply machine vision method

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is the process of defining and creating machine vision solution [4] [5]. The very first step of machine vision operation is the acquisition of an image, normally by using cameras. But further number of factors does matter in camera e.g. a type of lens used in camera and the very important factor is the illumination i.e. the lighting that does matter according to the requirement. Further, some operations has to apply on the images and they can be considered as Image processing which can be digital or analogue. Techniques are used to extract the information and further in some cases the expert system is required for the purpose of decision making.

Imaging: - In most of the machine vision system there are two types of imaging are used which are monochromatic and multispectral. Monochromatic imaging consists only one band. Usually, such images are displayed as gray scale images. Thus, monochromatic colors are the colors of single hue, they are derived from a single base hue and can be extended with the help of shades, tones and tints. Tints are achieved by adding white color to the particular color, shades are achieved by adding a darken color and tones are achieved by adding the combination of black and white i.e. grey color to the particular color. Monochromatic color schemes are derived from a single base line and hue is actually a property to determine a certain color e.g. for violet the hue is blue and for rust the hue is orange etc.

IV. COMPONENTS

Machine vision system has number of components that are very basic requirements for the system. Some of the major components are:

Imaging Device
Lightning
Frame grabbers
Processor
Programs
Technology

1 Imaging Device: - Imaging device is the camera which is used to capture the image. There are some considerations while selecting the camera. The very first is the resolution, it depends on the requirement. Simply, the resolution of an image can be defined as the total number of pixels i.e. rows and columns on the image sensor in the camera [6]. Image capturing is not only the requirement of the machine vision, but the basic concept is to gather the information from the image, for that, the quality of image does matter. So image processing is done to enhance the image. Therefore, higher image resolution can provide more detail to the vision system which can help to resolve on the part and even higher the vision systems measurements [6]. Higher image resolution provides more image information but it may be heavy to transmit the image and hence takes time for processing thus limiting the speeds of the system. Also, higher image resolution requires a very high quality and expensive lens [6]. The second consideration while selecting the camera is whether to use monochromatic or multispectral imaging. The type of imaging actually depends on the application for what vision system is used. If any sort of application does require any discrimination with color then we do need color imaging camera, for such types we do have some basic choices e.g. single chip color cameras [6]. The single chip color camera means the single image sensor chip which has an image sensor exactly like a monochrome camera, only the difference is that each pixel has a color filter over each which only response to the red or green or blue light depending on the RGB color space model. In case if the application does not require any sort of manipulation or identification of color then we are not require to choose a multispectral camera, our work may be done with the help of monochrome camera only [6].

The third consideration while selecting the camera is the concept of interface i.e. interface to the processer e.g. CSI-3 based on UniPort-M. Also with the rise of technology in cameras, the camera and the processer are both integrated together, and thus no further consideration of camera to processer is required in smart cameras [6].

Lens: After selecting the camera, now its need to select the lens which helps to provide the correct magnification and must be compatible with image resolution. In normal conditions smaller lens are available and for high resolution imaging larger lenses with different lens mount are used. For the purpose of selecting the magnification, the very first requirement is to know the size of image sensor(S) which can be known from the data sheet of the camera and the required field of view (FOV) size. The magnification can be determined by the ratio of the sensor size(S) and FOV [6].

I.e. M=S/FOV

Focal length of the lens can be calculated by knowing the sensor size (SS), working distance (WD) and field of view as [8]

F= (SS/WD) FOV

2 Lightning: Light is one of the major factor in vision system. Image capturing does depends on the source of light under which the images has been captured. If the lighting condition is not compatible, it may be difficulties for the researcher or observer to observe the data from an image. Commonly there are two basic approaches for lighting i.e. backlighting and front lighting [6]. There can be other considerations too for lightning such as side lights. In the case of back lighting the position of the source of light is at the opposite side of the camera. It help to provide the high contrast to the image. In case of front lighting the position of the source of light is on the same side of the camera. It is very sensitive to the height, reflection, texture or slope of the surface [6].

Simply the light source is required to capture the image because at presence of light we can gather the information. The source of light can be direct or indirect.

Direct energies are the sort of energy which people can consume by their activities e.g. amount of electricity used to run electronic gadgets. The consumption of such energy can be easily calculated. Indirect energy are not actually consumed by human by their own. E.g. sunlight, wind etc. Such sort of energy may vary with time and location as they are nature dependent.

3 Frame grabbers: Frame grabbers are electronic devices that captures digital frames from an analogue images. These are specialized AD converters which converts analogue signals into digital information. It is one of the major component of vision system, in which the images are captured in the form of digital signal and then perform operations on them. E.g. display the images, store them and even transmit them [7]. Simply frame grabbers is a device that digitize the analogue signal.

4 Processer: Processor is used to process or to manipulate the images. But the very basic question here is that what processer is to use. Some basic choices are**:** Very first choice is personal computer processer of pc, it works according to the environment. Such systems are compatible with software and programs and are able to handle the number of cameras [6]. PC has a major impact on the use of machine vision application. Pc's work is to handle the basic input output requirements, displaying the output data transfer rates. Second choice is embedded processer, such processors are embedded with the cameras termed as smart cameras [6]. Well in the machine vision system smart cameras are commonly used.

5 Program: For the purpose of interfacing with the camera we need a program. With the help of program we can process the image and further programs are responsible for interfacing the results to further automation components [7]. **Software:** Graphical User interface and libraries provides the interaction between user and machine. It provides a comprehensive way to control machine parameters. With the help of GUI and the development process machine vision is a user friendly tool [8].

6 Technology: The use of high speed data ports like the universal serial bus will speed up the data transfer rate and also the use of radio communication will reduce the use of wires which will lead to increase the capability of machine vision system [7].

V. BASIC MACHINE VISION SYSTEM

The working of machine vision is based on the application to solve a problem. The technique of vision system provides a fast and efficient way for solving the problem.

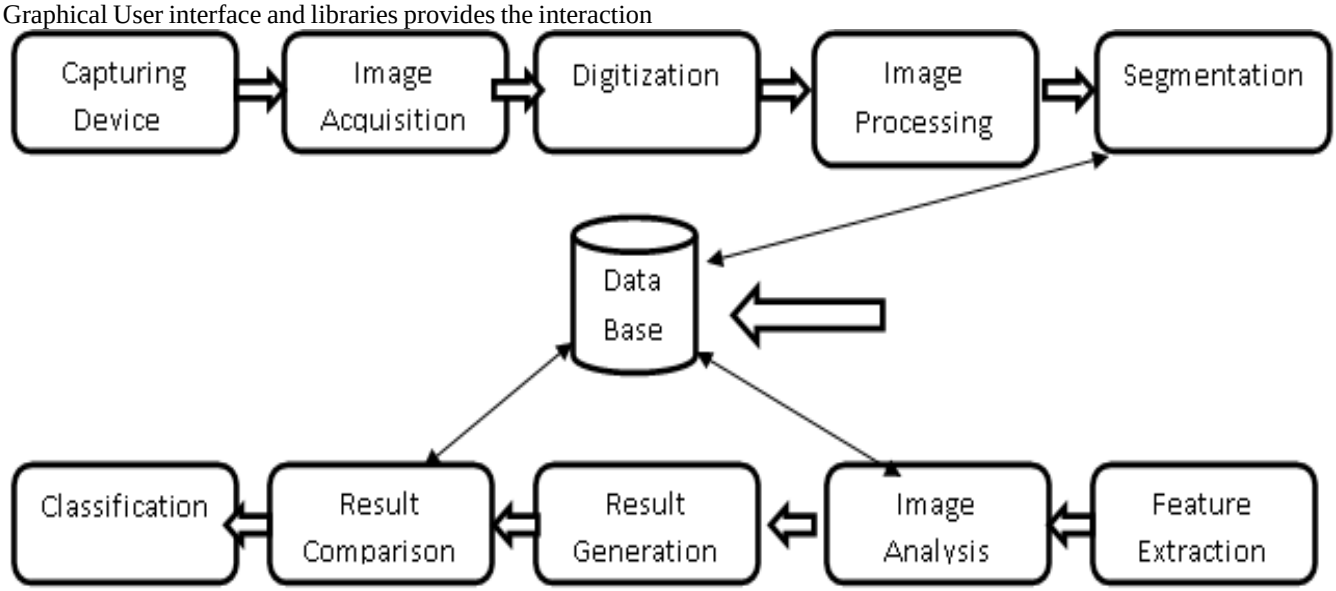

Fig 1: Basic Machine Vision System

1 Capturing device: It is the sort of device which is used to capture the image. Some factors are there which must be considered while capturing the images e.g. type and size of camera, its specification which must include the type of lens, its magnification, focal length etc.

2 Image Acquisition: It is the process of capturing the images from the capturing device e.g. digital cameras. While capturing the images some challenges are there which affects e.g. intensity of light, bands for gray of color images, resolution etc.

3 Digitization: A frame grabber is a device that captures the digital still frames from an analogue signal. As camera is taking images, the image data is digitized by frame grabber. It is one of the major components of a vision system which helps to capture the digital signal, display and transmit over the information in digital form.

4 Image Processing: It is a technique to enhance the input image to provide a clearer data. Digital image processing is done using the computer. Now a days it is also refers to digital image processing but analogue image processing is also possible. For the purpose of manipulating the image the very basic term used is image processing.

There are two types of processing:

A) Preprocessing: Before actually processing the images some sort of correctness is done over the images e.g. for correcting the brightness value, geometric correction which deals with the inaccuracy between location coordinates and actual coordinates etc.

B) Post processing: For the purpose of enhancing the image e.g. enhancing the brightness and remove the film artifacts, post processing is done over the images. Such filtering technique and classification is known as processing.

5 Segmentation: Process of dividing an image into multiple parts is known as the segmentation. The basic goal of segmentation process is to modify the image representation into something that is more meaningful and provides more information present in the image and makes it easier to analyses the image.

6 Image Analysis: After capturing and processing the images, analysis process is done over the images for gathering the information.

7 Feature Extraction: It is the process of extracting the features with the help of algorithms e.g. SURF (Speeded Up Robust Features,) SIFT (Scale Invariant Feature Transformation) etc. which helps to detect and extract the features on the basis of key points.

8 Result Generation: After extracting the features, the result is formed which is required to compare or match further for having an accurate result.
9 Result Comparison: As the result is generated it is compared to the predefined parameters which are already present in the database.
10 Decision Making: On the basis of comparison, the decision is made. On the basis of quality standards, maximum flexibility in the product and the product variability is classified and according to them decision is made based on soft computing.
11 Classification: After the decision is made the classification of the product is done that is either the result is providing the appropriate solution or not.

V. CONCLUSION

Vision system is the process of capturing the images, analysis of images and thus perform some operation to identify the features. Machine vision is common in wide variety of applications, makes this technology extremely flexible and innovative. It is still an emerging technology which makes it user friendly. Concatenation of advancement in technology in many field individually gives rise to machine vision technology. As the system is becoming fast, intelligent and more flexible, it is obvious to say that it is a mature tool for automation and also an indispensable tool in many manufacturing industries.

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