How To Plan Your PC-Based Machine Vision System

When determining the need for and the implementation of a machine vision system, there are many important factors to consider. Machine vision systems (also referred to as "automated visual inspection systems") typically contain a wide array of components that can directly affect the system's performance. To take full advantage of these powerful systems, and painlessly integrate them into your manufacturing line, it is best to take some time to learn the basics about what makes up a vision system, how it is implemented, and the importance of proper planning.

Uses of Machine Vision
Machine vision can be used in a wide variety of manufacturing operations where accuracy and reliability are important for repetitive inspection tasks. Some common tasks include: verifying date codes on food packaging, inspecting automotive parts for proper assembly, performing robotic guidance for pick and place operations, verifying the colors of pills used for pharmaceuticals, reading bar codes on parts, and verifying the presence of logos on products.

The Basic Components of a PC-Based Machine Vision System
Because the uses of machine vision are so diverse, specific components can vary from system to system. However, components usually fall into the following general categories (Figure 1).

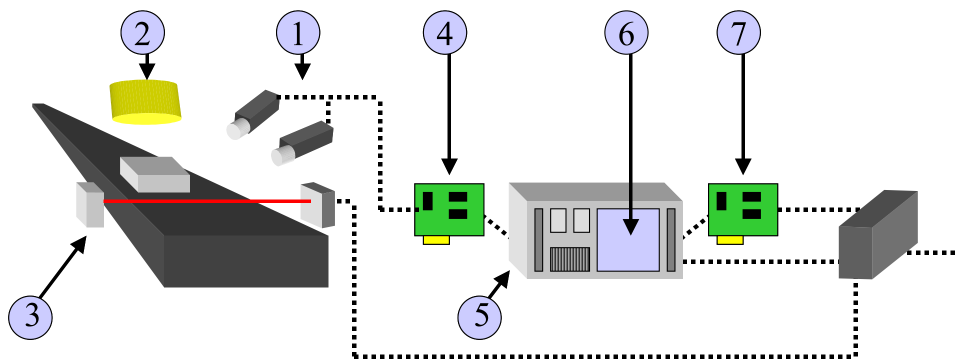

FIG. 1 – Main components of a typical Machine Vision system

1. Cameras and Optics - This category usually consists of one or more cameras and lensing (optics), which take a picture of the part being inspected. Depending on the application, the cameras can be standard monochrome RS-170/CCIR, composite color (Y/C), RGB color, non-standard monochrome (variable-scan), progressive-scan, or line-scan.

2. Lighting - Lighting is needed to illuminate the part so that the best possible image can be acquired by the camera. Lighting assemblies come in various shapes and sizes and are available in a variety of intensities. The most common forms of lighting are high-frequency fluorescent, LED (Light Emitting Diode), incandescent, and quartz-halogen fiber-optic types.

3. Part Sensor - Often in the form of a light barrier or sensor, this device sends a trigger signal when it senses that a part is in close proximity. The sensor tells the machine vision system when a part is in the correct position for an image to be acquired.

4. Frame Grabber – Also referred to as a video capture card, this component is usually in the form of a plug-in board that is installed in the PC. A frame grabber's job is to interface the camera (or cameras) to the host computer. It does this by taking the image data provided by the camera (in either analog or digital form) and converting it into information for use by the host PC. It also can provide signals to control camera parameters such as triggering, exposure/integration time, shutter speed, etc. Frame grabbers come in various configurations to support different camera types as well as different computer bus platforms (PCI, Compact PCI, PC104, ISA, etc.)

5. PC Platform - The computer is a key element of a machine vision system. For inspection type applications, usually a Pentium III or equivalent is used. In general, the faster the PC, the less time the vision system will need to process each image. Due to the vibration, dust, and heat often found in manufacturing environments, an industrial-grade or ruggedized PC is often required.

6. Inspection Software – Machine vision software is used for creating and executing programs, processing incoming image data, and making PASS/FAIL decisions. Machine Vision software can come in many different forms ("C" Libraries, ActiveX controls, Point & Click programming environments, etc.) and can be single function (e.g., designed only for one purpose like LCD inspection, Ball Grid Array (BGA) inspection, alignment tasks, etc.), or multi-function (e.g., designed with a suite of capabilities including gauging, bar code reading, robot guidance, presence verification, etc.).

7. Digital I/O and Network connection – Once the system has completed its inspection of a part, it must be able to communicate with the "outside world" to control the manufacturing process, communicate PASS/FAIL information to a database, or both. Usually, a digital I/O interface board and/or network card make up the interfacing through which the machine vision system communicates with the outside systems and databases.

Configuring a PC-based Machine Vision System

Careful planning and attention to detail will help ensure that your inspection system meets your application needs. The following is a checklist of issues you should consider.

Know your goals – This is perhaps the most important step in the process – deciding what you want to accomplish during the inspection task. Inspection operations fall into several categories:

- *Performing measurements or gauging*
- *Reading characters or encoded (barcode) information*
- *Detecting the presence of an object or marking*
- *Recognizing and identifying specific features – pattern matching*
- *Comparing objects or matching an object to a template*
- *Guiding a machine or robot*

The inspection process can contain just one operation or many depending on the inspection requirements and goals. To first determine the goal, you should identify what tests are needed to adequately inspect the part, as well as what type of defects you expect to occur. To help identify which are most important, it is best to create a weighted list of "must have" and "could have" tests. Once the main inspection criteria are satisfied, and keeping in mind that additional tests add additional inspection time (see below), more tests can be added later as the inspection process is refined.

Know your speed requirements - How much time will the system have to inspect each component or part? This will determine not only the minimum clock speed of the PC, but may also affect the speed of the line. Many machine vision software packages incorporate a clock/timer so that each step of the inspection operation can be closely monitored. From this data, the program and/or the motion process of the part can be modified to fit within the required timing window. Often, PC-based machine vision systems can inspect 20 to 25 components per second, depending on the number of measurements or operations required and the speed of the PC used.

Choose your hardware components wisely - A machine vision system is only as strong as its individual components. Any shortcuts made during the selection process – especially those involved in the optics and imaging path – can greatly reduce the effectiveness of a system. The following are a few basics you should keep in mind when choosing components involved in the image path.

- ***Cameras*** – Camera selection is directly tied to the application requirements, and usually involve three main criteria: a) monochrome or color acquisition b) part/object motion, and c) image resolution. Monochrome cameras are used for a majority of inspection applications since monochrome images provide 90% of the available visual data, and are less expensive than their color counterparts. Color cameras are used when inspection applications require color-specific image data to be analyzed. Whether the part being inspected is stationary or in motion will dictate if a standard interlaced camera can be used or if a progressive-scan camera is required to ensure a sharp image. In addition, the camera's resolution should be high enough to ensure that it can capture the proper amount of information needed for the inspection task. Finally, cameras should be high quality and rugged enough to withstand vibration, dirt and heat present in an industrial environment.

- ***Optics and Lighting*** - These crucial considerations are often the most overlooked. When poor optics or lighting are used, even the best machine vision system will not perform as well as a less capable system with good optics and adequate lighting. The typical goal for optics is to use lensing which produces the best and largest usable image, thus providing the best image resolution. The goal for lighting is to illuminate the key features being measured or inspected. Often the type of light used will be dictated by those features, e.g.: color, texture, size, shape, reflectivity, etc.

- ***Frame Grabbers*** - Although the frame grabber is only one part of a complete machine vision system, it plays a very important role. The frame grabber used is directly tied to the camera that it must interface to, e.g., monochrome, color, analog, digital, etc. With analog frame grabbers, the goal is to acquire the image data from the camera and convert it to digital data with *as little alteration to the image data as possible*. Using the wrong frame grabber can result in errors being introduced into this image data. Industrial frame grabbers are typically used for inspection tasks, where multimedia-types are avoided due to how they alter the image data with automatic gain controls, edge-sharpening, and color enhancement circuits. Although looking more appealing to the eye, the altered images, when processed by the system's software, result in errors that directly affect the accuracy of the inspection process. With digital frame grabbers, the goal is to ensure that the digital image data from the camera is formatted properly prior to passing it onto the PC for processing.

Tame the variables - The human eye and brain can identify objects in a wide variety of conditions. But a machine vision system is not as versatile; it can only do what it has been programmed to do. Knowing what the system can and cannot see will help you avoid false failures (i.e., wrongly identifying good parts as bad) or other inspection errors. Common variables to consider include large changes in part color or finish, surrounding lighting, focus, large changes in part orientation or position, and background color.

Proper camera mounting, secure lighting positions, constant and repeatable part/component positioning, and blocking of external or surrounding lighting can eliminate many common set-up and false-failure problems.

Choose the right software – The machine vision software forms the intelligence and is the centerpiece of the inspection system. The software selected will determine the length of time required to generate and debug inspection programs, what inspection operations can be performed, how well those operations can be performed, as well as many other important factors.

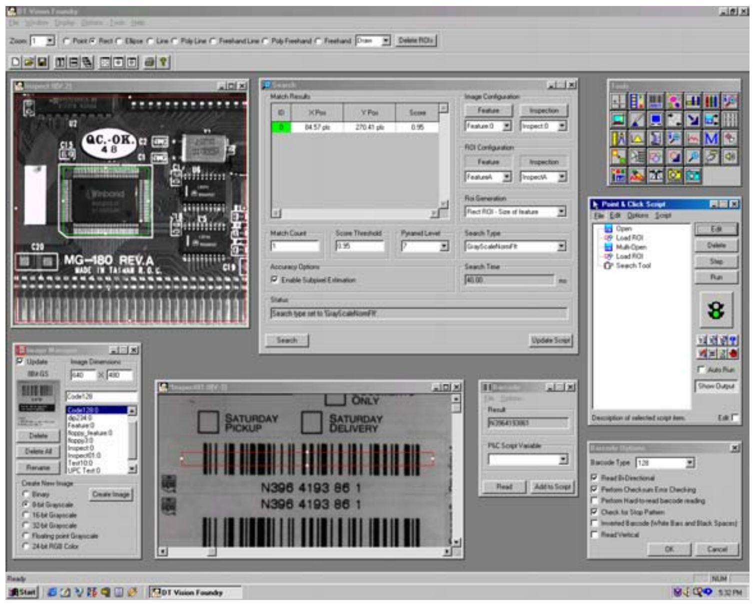

Figure 2 – DT Vision Foundry is a versatile, multi-function, graphical machine vision software package.

Machine vision software packages that provide a graphical user interface (often called "Point & Click") are usually easier to program than their code (Visual C, or Visual C++) counterparts, but can sometimes be limited when specialized features or functions are required. Code-based packages, although more difficult to program and requiring code expertise, can be more flexible when developing complex application-specific inspection algorithms. Some machine vision software packages offer both graphical and code-level development environments, providing the best of both worlds and giving the additional flexibility of selecting the environment needed to match the application requirements as well as the programming expertise level available.

Communicate and track the data - The overall objective for a machine vision system is to perform a quality role by separating the good parts from the bad ones. To do this, the system needs to communicate to the manufacturing line that a part is bad so that some action can be taken. Usually this communication is conveyed via the digital I/O board, which is connected to the manufacturing line's PLC (Programmable Logic Controller). The bad part is then separated from the good parts. In addition, the machine vision system may be connected to a network to allow data to be transferred to a database for data logging purposes. Data can then be analyzed by quality control personnel to determine why the fault occurred.

Careful planning at this stage will ensure smooth integration of the machine vision system into the line. Common questions that must be addressed are:

- What PLC will be used, and how is it interfaced?
- What types of signals will be required?
- What kind of network is currently used or required?
- What kind of file formats will be transferred on the network?

Typically, communication to a database is done via an RS-232 line connected to the manufacturer's network to track failure information.

Plan for the future – When selecting components for a machine vision system, consider future production requirements and changes. This can directly impact which features will be needed in the machine vision software/hardware, as well as how easily the system can be altered to meet changing requirements and different tasks. Planning ahead will not only save time, but will also help to reduce the overall cost of the system if it can be used for other inspection tasks in the future.

Summary

A machine vision system is only as good as its weakest component and only as accurate as the information it receives. Spending the time and effort to carefully select and set up the right components will result in a trouble-free and resilient visual inspection system.