Machine Vision Application Analysis and Implementation – Part 1

SYSTEMATIC PLANNING

This is the first of a series of articles designed to provide the framework for a successful machine vision system installation. The process described is targeted at companies that are planning the adoption of a machine vision system for the first time or that have a unique application that no one has previously attempted to implement.

Significantly, today one can find many application-specific machine vision systems for somewhat generic applications in many manufacturing industries. Purchasing these "off-the-shelf" solutions poses little risk to any first time buyer. In some cases, one can find application-specific software developed by suppliers of general-purpose machine vision systems, imaging board/frame grabber suppliers, software suppliers or merchant system integrators. While these are not turnkey packages, the vision experience is itself less risky. Examples of these packages include: alignment, OCR/OCV, LCD/LED inspection, BGA inspection, etc.

Even less risky are the turnkey machine vision systems that are industry specific; e.g. bareboard or assembled board inspection for the electronic industry, overlay registration/critical dimension inspection for the semiconductor industry, various industry specific web scanners, systems targeted at food sorting, etc. Virtually every manufacturing industry has these systems, many of which can be identified through the resources of the Automated Imaging Association.

Where these "solutions" are not the answer and a machine vision application has been identified, success requires proceeding systematically and not treating the purchase as if one is purchasing a commodity item. It is not sufficient to send good and bad parts to various vendors and ask them if they can tell the difference.

Table 1 - Application Analysis and Implementation

Systematic planning
Know your company
Develop a team
Develop a project profile
Develop a specification
Get information on machine vision
Determine project responsibility
Write a project plan
Issue request for proposal
Conduct vendor conference
Evaluate proposals
Conduct vendor site visits
Issue purchase order
Monitor project progress
Conduct systematic buy-off

The above table depicts the process that should be used as one proceeds with the deployment of a machine vision system that is uniquely defined for a company. In this article we are going to cover the topics “Systematic Planning,” “Know Your Company,” “Developing a Team” and “Develop a Project Profile.” In future articles we will cover the balance of the topics in the table.

It is observed that today's machine vision technology is often sold on the basis of its "configurability" and, consequently, in theory, its ability to be reapplied as plant conditions change. In fact, most often the performance envelope or configuration of specific systems limit the applications they can address, and those with more capacity require nontrivial application engineering content to address different requirements. So, for example, techniques well suited to gaging sheet metal assemblies can be reconfigured with moderate engineering content for differently shaped assemblies. They cannot, however, be engineered to address surface inspection applications.

Furthermore, there is the issue of technology obsolescence. Virtually al machine vision implementations today are based on “Wintel.” As microprocessors continue to improve and Windows migrates from one version to the next, products based on earlier generations become obsolete.

What this suggests, as noted above, is that the treatment of the purchase of machine vision systems as if one is purchasing a commodity item can be a serious mistake. Attention must be paid to evaluating an application for both near- and long-term requirements and to develop a comprehensive specification thoroughly reflecting the requirements. Vendors with appropriate technology and experience must be identified, solicited, and properly evaluated as suppliers. Since the technology is advancing rapidly and similarly the applications it can address are increasing rapidly, a conscious effort must be made to stay "on top of it." Vendors selected must have demonstrated an ability to keep up with advances.

Complicating the decision about machine vision is the fact that it is unlikely that one supplier will have the capacity to satisfy all applications identified in a facility. Recognizing that in the long term products from different vendors will be operating side by side, a consideration in the vendor selection process is how many different vendors' products can a facility with limited technical resources support, especially since machine vision is only one of many advanced manufacturing technologies now being introduced.

One approach to addressing these concerns was taken very early on by General Motors in their evaluation of machine vision requirements. Internal plant surveys designed to evaluate the need for machine vision were conducted. These requirements were distilled into generic requirements, such as precision measurement, sheet metal gaging, two- and three-dimensional robot guidance, character reading, and so on. Machine vision companies were then evaluated. It was established that there were roughly 30 types of machine vision techniques. The applications were then assessed to determine which machine vision techniques could satisfy them. Companies offering a range of suitable capabilities were thus identified.

KNOW YOUR COMPANY

There are many factors that should be taken into consideration before proceeding with a machine vision installation. Fundamental factors include recognizing the short- and long-term manufacturing philosophy of the company. For example, is there already in place or under consideration the wherewithal to tie together the manufacturing process via a hierarchy of controllers and computers? Is there an overall advanced manufacturing technology plan? Should this be anticipated? This therefore dictates the use of a machine vision system with compatibility, the ability to be interfaced to and communicate with an arrangement of computers. Essentially, then, the machine vision system becomes a computer peripheral.

This is an important consideration when one must accommodate the inspection of products manufactured in small batches. If no means is available to down- load inspection programs, the system will have to be retrained at the beginning of each run. The result could be a significant setup time that would interfere with efficient batch production. Even if provision is made for local

program storage on a cassette or floppy disk, are there so many models to be concerned with that a second system will be required for "training" - the development of the "golden" files? Interfaceability back to a CAD database that dictates the inspection criteria on the basis of design rules or its own golden file will be far more efficient.

Table 2 - Know Your Company

Manufacturing philosophy
Productivity improvement versus capital expansion
In-house skills
Age of capital equipment
Innovations
Materials
Processes
Industry
Technology "leap"
Build or buy
Risk-taking organization
Design for inspection

Other considerations include the following: Is the contemplated installation intended for productivity improvement or to expand production capacity? In either case, is the machine vision system to be delivered a "stand-alone" system or is the installation to be "turnkey"? The former case implies that the ultimate responsibility for making the system work rests with the buyer. This in turn implies that the buyer must be prepared to train staff to become reasonably familiar with image-processing theory as well as system properties so he or she can optimize the performance of the system.

As a turnkey system, the machine vision supplier or a systems house assumes total responsibility for making it work. The end user never has to understand why it works, simply that it does work. In this case the supplier must become familiar with the buyer's manufacturing process. In other words, a successful turnkey installation requires the buyer develop a specification that correctly establishes the criteria characterizing a reject condition. The development of the specification may also provide focus to the type of machine vision technology that will be required for the installation. For example, if color variation must be tolerated and only shape monitored, a system that does not operate on shades of gray may be more appropriate. Similarly, a backlighted arrangement might be more appropriate so only silhouetted properties are captured and operated on.

Other "systemic" considerations might include the following: How old is the capital equipment and the manufacturing process itself? For example, does it make sense to augment the capabilities of the equipment if it has already been fully depreciated and may be replaced in a year or two because of technological changes in materials? Are there manufacturing technology breakthroughs that may be taking place that will result in wholesale replacement of capital equipment?

Keyboards represent a good example. For years the characters on the key caps were developed by injection molding techniques. Now the keyboard industry has largely adopted a transfer printing process that in one shot transfers all the legends onto the key caps. The inspection problem is completely different. Whereas before, key transposition was a major cause for rejection and legend quality only of secondary concern, with the printing technique, transposition

problems are all but eliminated, but legend quality is more difficult to control. On the other hand, will it be possible to get payback from the system by using it over in another application?

Another issue revolves around the "technology leap." This is a two-sided issue. On the one hand is the concern that the company does not have adequate resources to support the technology when it is introduced. This, of course, can be overcome by training or hiring personnel with appropriate skills. The flip side of the issue is that for a given application, the technology is not quite ready.

Other managerial philosophies must be examined. Is there a "build-or-buy" decision contemplated? That is, is there a possibility the company may seek outside vendors in the future rather than produce it internally? Is the emphasis of management being placed on making it right in the first place and, therefore, monitoring the production process to avoid rejects as opposed to culling rejects in final inspection?

Are there risk-takers in the organization willing to stick their necks out to change a situation or is it strictly a laissez-faire organizational philosophy that prevails? (We beat the Germans in World War II without robots in the battlefields so why do we need them now?) Is there a management concern for the employee that is the motivation for considering machine vision automation - one's health -avoiding hazardous or hot environments?

Another consideration involves product design changes or possibly even manufacturing changes that could make it more viable to inspect or perform optical operations automatically on the object. "Design for inspection" should be a philosophy wherever possible. For example, where color does not impact function, light-dark colors can enhance the contrast associated with the task. The addition of machine-vision-readable codes can be useful for identification purposes. The addition of fluorescent dyes may also be a means of providing contrast to an otherwise difficult scene.

Experience has shown that by paying attention to the production process, a new and better understanding often results in modest redesigns to make the product easier. Similarly, points for process control with simpler sensors (e.g., proximity switches) are often identified that serve to prevent the reject conditions one is buying a machine vision to detect. A machine vision system then becomes an insurance policy.

All the preceding factors play a role in specifying a system. Similarly, understanding these factors beforehand can make the difference between a “white elephant" and a successful installation. The message should be clear - know the company before proceeding with the identification and feasibility assessment of a machine-vision installation.

DEVELOPING A TEAM

Given that a decision has been made to deploy machine vision, what procedure does one follow? The first thing to do is to identify all those who can provide input. People involvement is critical and "Jack-of-all-trades" is frequently associated with project failure. Both "bottom-up" enthusiasm and "top-down" directives are doomed to failure.

Involvement should include all those that will be affected by the installation: line supervisors, foremen, and operators. All those that have to ultimately take “ownership” of the system for it to be a successful project. Others that should be included are plant engineering, maintenance, quality control, manufacturing engineering, industrial engineering, and so on. While meeting as a "team" may not be necessary, one should plan to involve each as appropriate in the project. Involvement results in a sense of ownership associated with the change.

Communications and education can accomplish this. An orientation seminar attended by all those to be involved in a machine vision project can significantly reduce resistance to change stemming from an apprehension about the unknown. Such seminars will not only spark enthusiasm on the part of some participants but will also result in the less enthusiastic not standing in the way.

Table 3 - Machine Vision Team

Management
Manufacturing
Manufacturing engineers
Quality control engineers
Line supervision
Operators
Support engineering
Plant Engineering
Industrial Engineering

DEVELOP A PROJECT PROFILE

The team should be used to develop a "profile" for a machine vision project. This can be based on input about experiences with manufacturing technology of complexity and costs comparable to machine vision and one example for a first time installation is summarized in what follows:

Perceived Value. Corporate staff and plant operations should share in the perception that a successful machine vision installation will have a value. Similarly, at the installation facility quality control, manufacturing engineering and plant engineering should share in a similar perception of value.

Cost-Justifiable. The benefits of an installation should be tangible. A post installation audit should be possible or a set of measures developed to evaluate the application.

Table 4 - Project Profile <u>Example</u>

Perceived value
Cost-justifiable
Recurring concern
Straightforward
Corrective action possible
Technical feasibility
User-friendly potential
Dedicated line
Long line life
Operator champion
Management commitment

Recurring Concern. The application of the machine vision system should be associated with the detection of a condition that is experienced with some frequency (ideally, several times a shift). In other words, there should be an opportunity for "instant gratification" stemming from improved quality in goods shipped.

Straightforward. The installation of the machine vision system should not require extensive line rearrangements or line modifications associated with delivering the product to the vision station. Ideally, an idle station should exist in a line that holds the parts well organized and in a repeatable position. Indexed motion may be preferable and touching and overlapping parts should be avoided. Room should be available to install the system.

Corrective Action. It should be possible to do something about the condition being detected. Detection should not be an end unto itself.

Technical Feasibility. The first installation of machine vision systems should employ "off-the-shelf" technology that has been applied in similar (though not necessarily identical) applications.

User-Friendly Potential. The machine vision technology deployed should not be intimidating to the operator or to plant engineering who must maintain the equipment. Ideally, the technology will be virtually transparent, and a computer language should not have to be learned.

Dedicated Line. Ideally, the first installation, although of a system with potential for reconfigurability, should not be required to be reconfigurable. Essentially, a fixed automation scenario would be preferred.

Long Line Life. Installations of the machine vision system should be associated with a new model or one that has been introduced recently. This should guarantee the payback from the system. Ideally, the system should be incorporated with new tooling.

Operation Champion. The plant selected for the installation should have someone, preferably in manufacturing engineering, who wants to see it work and will ensure it does.

Management Commitment. Management must agree to the value of the application and be committed to doing something about it.

Future articles will cover the balance of the topics listed in Table 1.

Paper has been adapted from Chapter of the same title in book titled “Understanding and Applying Machine Vision,” published by Marcel-Dekker, January 2000.

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