The Automation Renovation: Planning your first vision system

A renovation always looks easy on paper. Just pry off that wood paneling and prime the existing drywall. It won't take long at all. But after that 1970s rec-room wood paneling comes off and you find the drywall crumbling away, you've hit an unexpected snag. Even if you're the DIY type, you still have to go to Home Depot, buy new drywall, fit it into your car, take it home, and install it. Your project gets put on hold, and you've lost time because of an unexpected set-back.

Building a vision system is a lot like renovating your house, especially if you are upgrading an existing manufacturing system to include vision. There are dozens of details to consider and a lot of hard work. Even the best-planned project can hit a snag. If you're not an architect or a contractor, you could be building for a very long time.

Experts in the machine vision field say that vision is often an afterthought in manufacturing systems. Adding vision is often thought of as an "upgrade", so like a home renovation, you will have to work within the limitations of your current space.

Any upgrades to your house should have some kind of project plan with blueprints, specifications, and dimensions. You might need a permit or specialized tools. You should also have Plan B tucked away in case of unforeseen events. When you plan a vision system, you'll determine requirements, research equipment, and look into industry regulations.

This article will help you understand the needs of your vision system so you can develop a successful project. One way to determine your requirements is to develop the project in three stages.

The Sketchbook
This is the stage where you brainstorm a list of tasks for the vision system to accomplish. In the sketchbook stage you will answer some basic questions.

The Little Picture
This is the stage where you will determine the equipment you need to work on your prototype in the lab or at the test bench. You'll use a camera to take sample images.

The Big Picture
This is the stage where you'll look at how the vision system fits into the production process and choose your equipment. After you build a working prototype you'll want to move it to the factory floor to see how it fits.

The Sketchbook: Start doodling

Brainstorm. Scribble. Doodle. Whichever word you use, this is your time to establish the parameters and the role of your new vision system. The basic question is: what do you want vision to do? Do you need it to guide? For example, do you need to pass coordinates to a stage, robot, or gantry? Will the system inspect objects? For example, do you need to count pills in a blister pack or measure the dimensions of machined parts? Or, do you need to read text characters or 1D and 2D barcodes? Many applications will perform several functions, so list everything you want the vision system to do.

You will need to determine the vision system's expected performance in terms of its accuracy, precision, repeatability. In metrological terms, accuracy is defined as the degree to which a given measurement conforms to the standard value for that measurement. Indeed, governments oversee weights and measures to ensure instruments give accurate results. Precision defines the degree of certainty with which a measurement can be stated. Repeatability is the range of variation in repeated measurements. If an object is measured ten times by different people and they get the same result, we can assume that the measurement process is highly repeatable.

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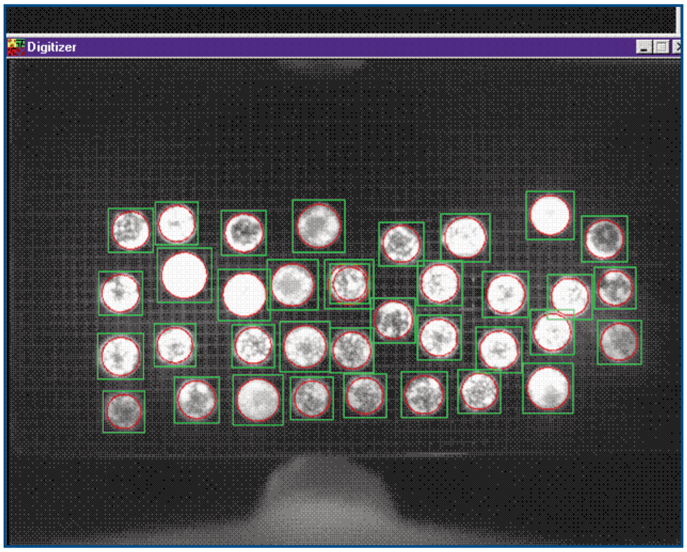
But in a vision system, it's the image of the object that gets measured. The imaging software will use the pixels (mapped to the real-world coordinate system through calibration) to calculate the measurements of the object. An important rule of metrology (the science of measurement) is that the instrument should be ten times better than what you want to measure. If the object has a tolerance of ± 0.5mm, then the image's pixels must be in the order of 50 microns). Essentially, the relationship between the camera and working plane will influence the optics. And most – if not all – image processing packages offer sub-pixel accuracy, so you'll be sure to get the required precision from your images... if you have the right lens.



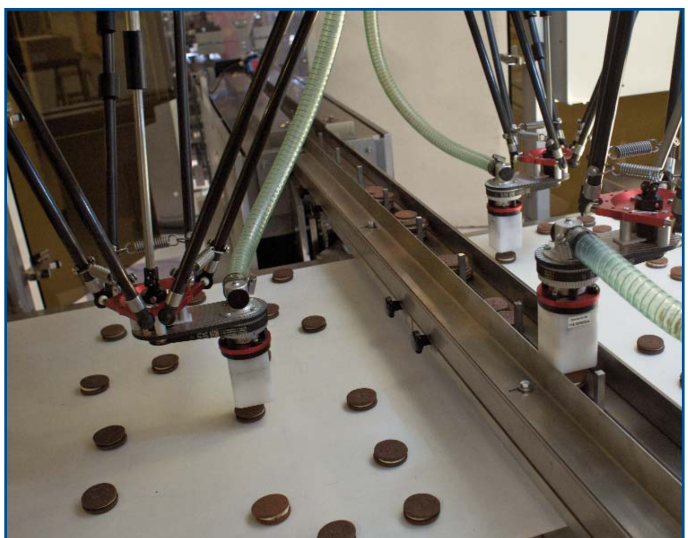
Your application's expected speed is another factor you need to consider in stage one. You need to know the rate your widgets will pass the camera's field of view. With the timings, you'll figure out how much time is available for processing, and your camera vendor (and later, software vendor) will be able to understand your needs.

Next to consider is the camera and lighting. Where will they go? You will have to determine the physical constraints and environment of the system. You need to make sure that the camera will fit in the space that you have, and the lighting as well. Your factory environment is important here too. The environmental variables are temperature, humidity, dust, vibrations, and electro-magnetic noise from DC motors. If the camera's wire/cable is placed near a DC motor or its housing, the motor's electro-magnetic noise could corrupt not only the transmission but your image data.

If the system is to be PC-based, determine the proximity of the camera to the computer. The cable length will determine your choices for the camera interface. This is true even for a smart camera, because the cables have to connect to something. You'll also want to take cable flexing into account if the cable is part of a moving assembly.

How will you operate the vision system? Will it be deeply embedded or will it have a user interface? If the latter, determine the requirements for the human-machine interface (HMI). Some industries have very strict controls and require product tracking at every step in the manufacturing process. The pharmaceutical industry, for example, requires access permissions and change logs for regulatory compliance.

Your last step in the Sketchbook phase is straight-forward math. You need to come up with a budget. Estimate both up-front and recurring costs, and don't forget maintenance costs such as cleaning, lighting replacements, and regulatory compliance updates.



Vision-guided robots is quite common. In this cookie sorting application, the robots place different shaped cookies into a blister tray for packaging. The imaging software (top left), based on the Matrox Imaging Library, will help determine the correct shape of the cookie, index it so as not to overfill the tray, and (above) send coordinate information to the robot. Images courtesy of Bosch Packaging Technology.

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The Little Picture: Set up the lab

When you know your application's requirements, you will shop around for the components. Once you have your smart camera or camera, frame grabber, PC, and illumination device you get to have some fun. Time for the photo shoot!

In order to develop your application's software, you need to have a clear idea of what the software will "see" in the images. So take pictures. Lots of them. You need a representative set of images that show the range of situations (i.e., defects) that could occur. This set of images will show you how the scene or object can change over time. Take pictures of good and as many atypical images as possible; remember, it's the defects you want the vision system to find. If, for example, you're inspecting machined parts, be sure to acquire images of burrs, parts that are bent, or parts with too-small openings.

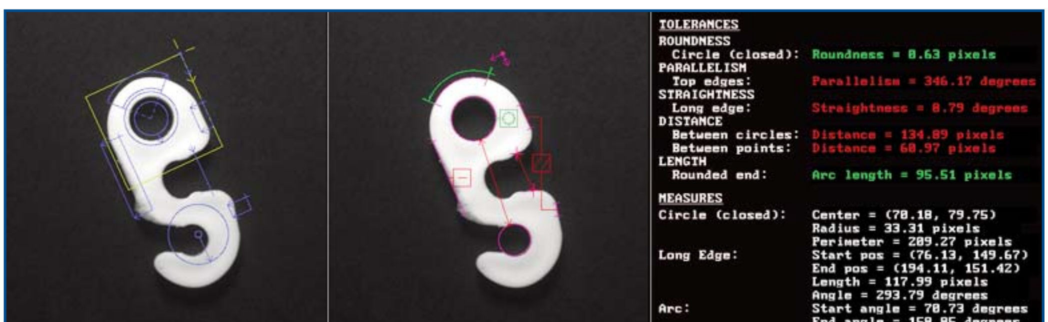
Look at the images carefully. Take note of shadows (dark regions), reflections (bright spots), or uneven lighting. The human visual system is fine-tuned to spot irregularities in images, but a computer isn't. For example, if the software is looking for edges, an object's shadow might be misinterpreted as an edge. A reflection could be counted as a blob. A picture is only as good as its lighting, and depending on what appears in your images, you may need to tune or reconsider the illumination setup.

What goes into your toolbox?

With a complete set of images you will be able to analyze them. You will be able to put your requirements into concrete terms that will help determine the kind of machine vision tools (algorithms) you'll need.

Imaging algorithms used in machine vision applications generally fall into three categories. The first group of tools are used for locating. Locating tools go by names such as pattern recognition, pattern matching, pattern search algorithms, and blob analysis. They are good examples of the superiority of the human brain – we can easily see the object in an image, but a computer needs a little help. A locating algorithm determines the coordinates of an object so that other analysis functions have a reference point. Locating algorithms also help speed up the processing for other measuring and reading functions by closing in on an area of interest.

The next group of algorithms are used for measuring. These tools go by names such as measurement, metrology, edge-and-stripe, and blob analysis (some tools have multiple uses). Measurement tools are quite capable of measuring geometric features and will allow you to set tolerances to help sort the conforming parts from the defective ones. These tools are indispensible for many applications, especially for machined parts. If you are measuring objects and want results in world units, calibration tools will also find their way into your toolbox. Most machine vision applications make use of a calibrated coordinate system.



The Matrox Imaging Library Metrology module analyzes the image of a machined hook. Based on its features, the metrology results determine that the part falls outside the accepted tolerances. Image courtesy of Matrox Imaging

The third group of algorithms are used for reading. Alpha-numeric characters come to mind with the word 'read'. Machine vision reads characters for two purposes. The first is for OCV, or optical character verification, which determines the presence (or absence) of specific printed text, such as an expiration date. The second is OCR, or optical character recognition, which actually 'reads' the characters and returns them as results. In machine vision, reading can also refer to 1D and 2D codes, or more specifically, both bar and matrix codes.

Machine vision specialists recommend using off-the-shelf tools instead of creating algorithms from scratch. The Matrox Imaging Library (MIL) is just one of several image processing packages out there, and the well-known ones are built with field-proven technology. Consider that developing and maintaining algorithms is extremely time-consuming and expensive. A vendor might have a large team of highly-skilled and experienced developers working on image processing algorithms. If you choose to 'buy' instead of 'build', you will spend your time developing your application and not creating algorithms. Remember too that a particular vision "problem" typically has more than one solution, and an image processing package will give you many options. Frankly, the algorithm (or more likely algorithms) used in the solution must be designed to catch the anomalies.

The big picture: moving to the factory floor

The Big Picture stage is when you begin building the machine. You've done all the prep work and assembled your materials. It's time for serious building. Don't take out the power tools just yet, though. A vision system is more than Lego® bricks that you can break apart to make space for a new piece.

Now you must consider the vision system's role in the manufacturing system, or possibly the entire enterprise. Think about what you will do with the imaging results and how the vision system must interact with other equipment. What must happen to a part that fails inspection? Will you it blast it with an air jet? Instruct a robot gripper to pick the object off the line? These are mechanical issues that will shape the physical design of the system. On the back-end, what will you do with the results gathered from the vision system? Will they be used to make real-time decisions, for example, to activate an ejector? Do you need to keep statistics in order to identify trends? Do you need to archive the images for regulatory compliance? When you're at the point of answering these questions, you're well on the way to building your prototype; the system validation must be done in-process and not just in the lab.

It might even be necessary to take a few steps backward and revisit your camera set-up. The camera, optic, lighting and algorithm selection process is iterative; you might find the chosen algorithm doesn't work properly in your set-up. For example, 2D code reading will work best if the minimum element size is 3 pixels tall and wide so the camera set-up needs to resolve to this level.

Is there a Stage 4?

Performing automated inspection with machine vision techniques is widely accepted across myriad industries. It has great potential to reduce long-term costs and improve the quality control of your product. That's key here, because vision is not meant to, and will not, fix your product. Instead, its purpose is to ensure the product's quality. Over time, it might even help define flaws in the manufacturing process.

At the same time, implementing vision is not a decision to be taken lightly, and the DIY approach requires expertise and time. Are you prepared for the work that's involved? If not, consult a systems integrator who specializes in machine vision. These integrators will be able to guide you through the process. They have the experience and foresight to prevent bad choices. Machine vision's complexity can be overwhelming, and working with an expert will ensure a successful deployment.

To learn about Matrox Imaging machine vision products or to locate an Authorized Integrator visit www.matroximaging.com.

References:
DeVries, Warren R. Analysis of material removal process. New York: Springer-Verlag ,1992.

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