

Optimising the Machine Vision Unit used in an Automated Component Handling System

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ABSTRACT

In most manufacturing areas there is concern with quality assurance and developing cost-effective automated inspection systems that can provide feedback necessary for closed-loop manufacturing.

A Machine Vision system can perform quick, repetitive inspection on large numbers of products and operate 24 hours a day. It can identify materials and components, locate and orient parts and verify proper assembly. The measurement, alignment or verification results can be logged on a database for later reference, e.g. when there is a customer complaint or fabrication fault.

Certain parameters will restrict the capability of a Machine Vision System in some or other way. The goal is to establish all parameters that will influence the capabilities of the Machine Vision system and to minimize the restrictions they cause.

1. Introduction

As mentioned by Rosandich [1, p.13] inspection is the oldest category of Machine Vision tasks and represents the widest variety of installed systems. The first crude Machine Vision system appeared in the 1950s! Engineering and science communities, as well as mass-production factories and industries, needs quick and efficient quality checking. As technology grows more accessible, vision inspection and measurement systems are becoming more common in the engineering and science communities.

2. The parameters of Machine Vision

The parameters of a Machine Vision system might differ from one application to the next, but the basic parameters will be the same. As mentioned by Rosandich [1, [26] the design of the limitations of an automated vision inspection is a difficult task – knowledge in many technical areas is required.

Illumination, cameras, computer interfacing, programming and image processing are among them.

2.1 The inspected product

The systems engineer must know what product is going to be inspected. Factors like the products' orientation must also be known, as well as the spacing between products. If the entire product doesn't need inspection then the systems engineer must know which parts of the product must be inspected. Some consistent reference point is also needed for the image processing software.

The product's geometry and surface must also be known. Shiny or curved products will need a different illumination technique than matt or flat products. The size of the product also plays a role. If the product's size exceeds the field of view of the camera, two cameras will probably be needed to acquire images synchronously.

In this project, childrens' building blocks are inspected. The surfaces of the blocks are shiny and have protrusions which might cause shadows. Only one camera is needed because of the small size of the blocks.



Figure 1: The rectangular building block

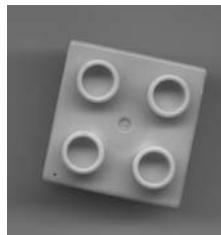


Figure 2: The square building block

2.2 The camera

As soon as the product's properties are available to the systems engineer, a choice of camera can be made. The choices include whether the camera should be analogue or digital, CMOS or CCD, area scan or line scan. As described by Govier [2], vertical resolution is not limited in digital cameras, offering higher resolution.

The output signal is digital, therefore little signal loss occurs during signal processing. However, digital cameras are typically larger than analogue cameras and analogue cameras are sometimes favoured above digital because it is older, known technology.

Area scan cameras are a better choice for applications that require an immediate snapshot of an image, whereas line scan cameras will be better suited for applications that have limited memory and very large images must be acquired. According to Litwiller [3], both CCD and CMOS image sensors are pixilated metal oxide semiconductors. They accumulate signal charge in each pixel proportional to the local illumination intensity. When exposure is complete, a CCD transfers each pixel's charge packet sequentially to a common output structure, which converts the charge to a voltage, buffers it and sends it off-chip. In a CMOS imager, the charge-to-voltage conversion takes place in each pixel.

In this project a digital, area scan camera with a CMOS lens was used, shown in Figure 3.



Figure 3: The Basler A601f camera

2.3 Illumination

Illumination is a very important aspect and it can be very time consuming, but worth the effort, to find the optimum illumination conditions and equipment. It is a very big mistake to think that poor illumination can be corrected for in an algorithm. Ambient lighting is unlikely going to provide consistent lighting

levels. There are a lot of types of illumination and illumination is application specific.

According to [9], successful Machine Vision requires a clean and constant imaging environment created by suitable illumination. Without this, development energy will be wasted on the environment rather than using the energy wisely on the application itself! The light types that can be used for illumination include xenon, halogen and fluorescent. In this project, DC halogen bulbs are used (DC because AC causes an interference).

There are a lot of illumination techniques and it is not uncommon to use combinations of techniques to achieve desirable results. Front, back or light field and dark field illumination can be used and combined with polarisers or diffusers, or can be used directionally or coaxially. Sometimes it is necessary to house the camera and/or lights in an enclosure to eliminate the influence of surrounding light, as in this project's case. For this project, diffused illumination provided the best results. As shown in Figure 4 and Figure 5, the DC lights are projected towards the enclosure's roof and only diffused, reflected light reaches the products under inspection.



Figure 4: The camera and DC lights setup



Figure 5: The camera together with the DC lights

2.4 Capturing hardware

There are a number of capture boards (image acquisition boards), Smartcams and Compact Vision Systems (CVS) available. Capture boards must be installed on a computer which will be standing in the inspection environment. A Smartcam is a camera with integrated capturing hardware. The CVS is a stand-alone, rugged unit and is being used in this project. It is a National Instruments product and software that is compatible with it includes Vision Builder for Automated Inspection, LabVIEW and OCR software. The CVS has three FireWire ports, a serial I/O port, a 44pin digital I/O port, RJ-45 port, an isolated digital direct connection as well as two digital TTL output direct connections. Figure 6 depicts the CVS and connections.



Figure 6: The CVS and its connections

2.5 Image processing software

Almost any programming software package can be used to process the images, provided it is done by an experienced programmer. The Measurement and Automation Catalog [4, pp. 593 - 595], states that National Instruments Vision Builder for Automated Inspection (VBAI) is configurable machine vision software for configuring, benchmarking, and deploying applications. NI Vision Builder for Automated Inspection does not require programming yet is scalable to LabVIEW graphical programming environments. VBAI uses a graphical interface and is suited for common calculations and less complex inspections. LabVIEW is more scientific oriented and will be more suitable for complex inspections.

This project required that skills in the fields of illumination, cameras, computer interfacing, programming and image processing had to be acquired and each field took a nice chunk of development time. Because of this, VBAI was chosen to configure inspections with since it appeared to require less study time. It delivered acceptable inspection capabilities and results for the specific application.

Shown in Figure 7 is a screen from VBAI, showing the inspection of a rectangular building block. The steps of the inspection are as follows:

- Detect Edge – to detect if there is a product present
- Detect 4 Straight Edges – to ensure either a rectangular or square block is being inspected

- Match Templates – Done twice to locate lower left and lower right corners of block
- Measure Distance – To determine whether the distance between lower left and lower right corner is that of a square or a rectangle

Decision – AND and OR functions to pass the inspection either as a Square, Rectangle or Reject according to the above steps' results.

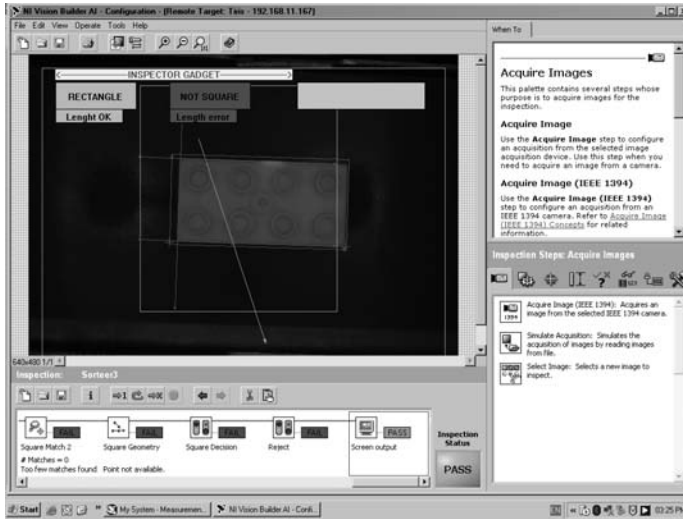


Figure 7: A screenshot from VBAI

3. Triggered acquisition

Triggered acquisition will allow for the inspection system only to acquire an image when there is a product present. Or, another approach would be to continuously let the camera take acquisitions and let the triggering sensor's pulse trigger a flash light to illuminate the inspection area when a product is present. In this project, a photoelectric through beam sensor is used to provide a pulse to the camera when there is a product present. Hence image acquisition occurs only when a product is present.

Figure 8 illustrates the triggered acquisition that is being used in this project. The output of the trigger connects to the isolated digital direct input (TRIG0) of the CVS. A pulse received here will trigger both the digital direct TTL outputs. Since one of these outputs is connected to the camera, an acquisition will take place whenever the sensor's beam is broken.

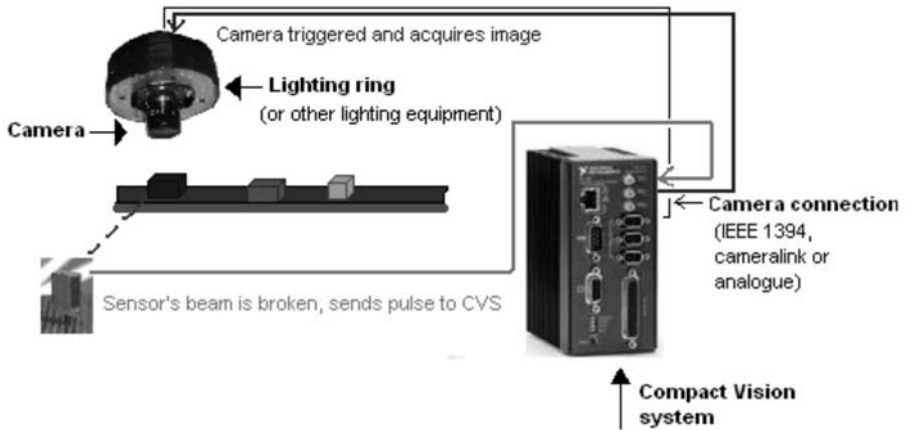


Figure 8: Depiction of triggered acquisition

4. Conclusion

Illumination is the most important and probably the most difficult parameter to establish for a Machine Vision system. There is no formula to determine what illumination technique and light type will be perfect for a specific application. It is strongly recommended that the order in which the parameters for Machine Vision are established are done in the order as were discussed (sections 2.1 to 2.5):

- The product under inspection
- The camera
- Illumination
- Capturing hardware
- Image processing software

It is *possible* to do it otherwise, but more *difficult*, *time consuming*, possibly more *expensive* and sometimes *confusing!* This project's parameters were not established in the order as mentioned above. This was due to the fact that the CVS, camera and software were purchased without prior knowledge of what products are going to be inspected. It caused several hiccups and headaches to do it this way.

5. References

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