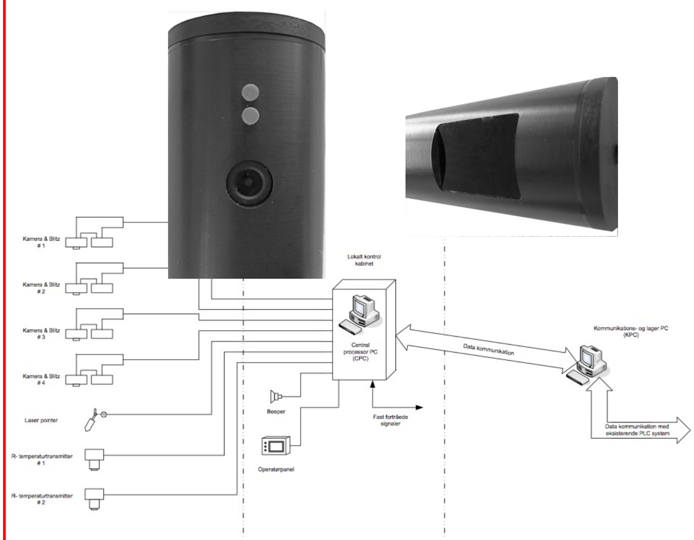
An Introduction to Machine Vision

In this general introduction to machine vision we will look at some of the technology involved in a typical Machine Vision system.

Traditionally machine vision has been used for narrowly defined tasks such as object counting, label checking or reading serial numbers. However the importance of Machine Solutions system is increasing, because the improvements in computing power, optics, computer programming, connectivity and light sources has expanded the possible industrial applications where Machine vision systems can be used.

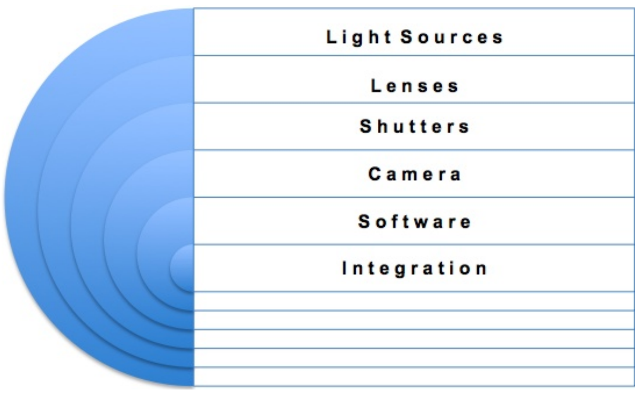
The predictions are that machine vision systems will play an increasingly important role as means for industry manufacturing companies to increase productivity and quality.



Technology and Improvements

A typical machine vision system consist of these component:

All areas have has benefitted from the general fast paced evolution in electronic devices for the past 50 years, Moore's Law is an often cited description of this evolutionary pace.



Light Sources

A well-calibrated light setting is key for a proper working Machine Vision system. Shadows, bright light and unwanted contrast can damage image recognition seriously. The capture of an image requires light in some form and the usage of artificial light is typically key when obtaining high-resolution images. There are different light sources available, but due to the improvement in light-emitting diode (LED) technology and durability, LED's has become the standard light system in the industry. Adding to the popularity is the availability of LED’s with increased intensity and in varying wavelengths. For example near infrared (NIR) LED’s technology has also meant that object can be inspected for structures and cracks. By using LED'S to increase the light intensity and increasing the camera shutter speed, images can be captured without motion blur.

Higher image accuracy at higher speeds off course increases the industry applications where machine vision can be adopted tremendously. Another reason for the popularity of LED illumination is that they are very stable over time and have a long life.

Whilst LED's can provide stable area illumination for very long periods and can also provide reasonably high light intensity at short distances there becomes a point when LED's cannot provide sufficient light.

Where objects are travelling at high speed and exposure times of a few tens of microseconds are required and distances are greater than a few centimetres, Xenon flash becomes a superior option. Xenon flash is able to provide 10 to 100 times the intensity of LED in pulses of a few tens of microseconds. This allows high-speed motion blur free images and large distances. Other applications for Xenon flash include applications where the imaging system should only respond to the illumination source and not ambient lighting. Xenon flash is so intense compared to ambient lighting that to all intent there is no ambient illumination. Our Xenon flash systems can operate at frame rates of up to 25fps in burst mode with flash life times in excess of 60 million. This new generation Xenon flash opens up many more applications for machine vision.

Lenses

A crucial factor for the image quality in every Machine Vision system is the lens, which the light has to pass through. A camera lens focuses an image onto an imaging chip. However, optical properties such as focal length are not the only important factor. Lenses with the same optical characteristics have different sized defects on the lens. If the defects are larger than a pixel on the imaging chip, the chip could be a lower resolution and get the same quality of results. Lenses with smaller defects tend to be more expensive, and imaging chips with fewer pixels tend to be cheaper. Therefore the correct balance of cost vs. performance is required for each individual application. A lens system can cost as little as $5 USD and as much as $1500 USD for the same image area. However the difference in performance of a $5 dollar micro lens and a $1500 dollar telecentric lens is vast and may make the difference between success and failure. In many applications the lens system may cost significantly more than the camera.

Shutters

The purpose of a shutter is to stop the imaging chip from being exposed to any more light. A mechanical shutter blocks the light by moving a barrier across the front of the imaging system. These are reliable for around 20,000 operations, which is very low for most machine vision applications. The alternative is to use an electronic shutter which is built into the imaging chip, these are reliable for billions of electronic shutters are widely used today.

1. Frame (global) shutter

In applications where the speed of the object could blur the picture one would use a frame (global) shutter. This is because the global shutter captures all of the information all at once. When the entire frame is exposed and after the programmed “shutter time” has elapsed, the image sensor stops gathering light and changes the exposure into an electronic image. Because the shutter speed can be programmed and due to the shutter methodology itself, no image skew, partial exposure or wobbles will occur on the image.

2. Rolling Shutter

If object speed or lighting conditions do not play a factor during the image capture a rolling shutter can be used. The rolling shutter captures each individual movie frame by scanning the frame line by line from top to bottom. This means that different segments of the frame are exposed at different times than other segments. In case the object would move during the exposure the image would be distorted (skew, wobble). Furthermore usage of artificial light sources such as xenon flash's, would generate a partial exposure, due to how the rolling shutter "rolls" through the frame, thus exposing segments of the frame at the prevailing light conditions. These are some of the limitations, which users of rolling shutters should consider.

Camera

Cameras used in todays machine vision applications are mostly digital cameras. In recent decades the number of pixels, also referred commonly as resolution, in an image has increased tremendously, which has meant that images today are a very close representation of the original. The speed of data rate transfers has also increased to support more than 250 MB/s from the camera to the image processor. Technologies like USB 2.0, CameraLink and GigaBit Ethernet are offering speeds in excess of 1GB/s. Communications aside there are three fundamental types of cameras;

1. Line scan cameras

The image acquisition is made line by line like on a fax machine, which is good for capturing images at high speed and with high resolution. If the object is not moving a line scan camera cannot be used. A computer will collect and process the one dimensional picture into a two dimensional image. The downside is that you have to use frame grabbers and the cost is higher than with area scan cameras.

2. Area scan cameras

Most Machine Vision applications use area scan cameras due to their lower costs advantages compared with line scan cameras. Combined with a frame (global) shutter the area scan cameras are well suited for applications where the complete object is requested pictured at once.

3. Global Shutter cameras

Global shutter cameras combine the best of both line scan and area technologies. Global shutter provides simultaneous exposure of the entire image area as with line scan whilst providing full area images for easy analysis. Global shutter cameras are therefore ideal for machine vision applications such as product quality control analysis.

For example, the VisionEYE technology is based on global shutter imaging with LED and/or Xenon flash illumination. The cameras take full control of the illumination system, optimising the lighting for a specific image requirement. This is all done on a frame by frame basis allowing a rapid sequence of frames, illuminated and exposed for the specific requirement of the software analysis. This can be achieved with several cameras operating synchronously allowing several views of the target to be taken at the same instant in time. Equally the cameras can be synchronised to provide a rapid sequence of images with a defined time interval between the images.

Selecting between a line scan, area scan or global shutter camera is dependant on factors for the given application including: object size, speed, image resolution, lighting and cost.

The interface between the camera and the lens should support either a C or CS mount, and for low cost, low resolution application M12 micro lens. The camera should also be able to control peripheral equipment such as zoom and focus on the lens system.

Software

The software typically performs three important tasks

1. Intelligently operates the camera and illumination system
2. Analyses captured images and execute intelligent knowledge and rule based decisions
3. Interacts with the factory systems and operates, for example a robotic arm

To keep maintenance cost down the software should control the number of images taken and ensure the usage of flash is kept at the exact quantity and intensity, which is sufficient to solve a defined task.

One of the most important parts in a Machine Vision system is to apply computer logic to the captured images and identify the exact features that are important. Hereafter the software will perform different analysis and comparisons and ultimately give instructions to a external devices, for instance a robotic arm to perform certain actions to the object.

The software can either be embedded in a 'smart camera' or be located on a separate computer, which is the best solution if the application requires a lot of image processing.

Integration

All though ‘smart cameras’ try to provide a ‘fit for all’ solution, a typical complex Machine Vision solution requires comprehensive research of the application. A typical solution is a combination of many subsystems, which have to integrated into one system. A system can for example consist of cameras, illumination technology, software, PLC integration, robotics integration, I/O platforms and enterprise applications. Bringing this together requires good-quality engineering and integration skills. Many projects fail because the lack of adequate time and resources spend on analysing the application requirements and for developing a suitable solution for the application in question.
The integration should have 3 stages;

1. Feasibility study
2. Proof of Concept
3. Commissioning

The feasibility study should reveal if the application is technically, economically, operationally feasible to deploy.

The Proof of concept is typically a partial deployment of the Machine Vision application, with the aim to test and verify the solution. The proof of concept will show if the designed application is workable and feasible, before moving to commission of the solution.

It important to exercise tight control of this phase and prior to the testing define the success criteria. The proof of concept data will compared with this as the proof of concept provides feedback for technical, budgeting and other forms of discussions.

Commissioning will assure that machine vision solution is delivered according to the application specifications and been through fully tested, installed and correctly operated by the end-user. As the Machine Vision solution becomes a key component in the production line, proper maintenance and properly trained operators are crucial for the continuous operation of the application.

Machine Vision and the technologies it encompasses are useful in many industrial applications and HN Miljøudvikling provides innovative turnkey factory floor solutions based on the advanced VisionEYE technology and sold under the HNM-MV product family name.

The VisionEYE technology uses a global shutter camera and near infrared (NIR) Xenon flash, a light immune technology to provide ultra sharp images with no motion blur for many different industries' applications. The VisionEYE software package integrates multi-platform hardware and software, data acquisition, image analysis, report generation and data export in one package.

We provide our customers with optimized hardware and software designed solutions in order to achieve the highest possible technical, environmental, economic and competitive advantages.

Our expirienced technical and support team provides advice and support in all phases of design, commissioning and post sales support of the solution.