Machine Vision

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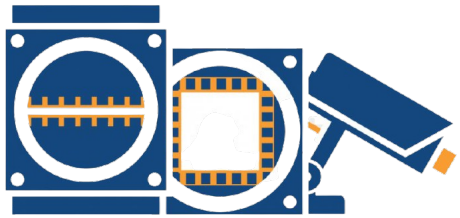


Machine Vision

- Machine vision (MV) is the technology and methods used to provide imaging-based automatic inspection and analysis for such applications as automatic inspection, process control, and robot guidance, usually in industry.
- Machine vision refers to many technologies, software and hardware products, integrated systems, actions, methods and expertise.

Machine Vision

- Machine vision as a systems engineering discipline can be considered distinct from computer vision, a form of computer science.
- It attempts to integrate existing technologies in new ways and apply them to solve real world problems.
- The term is the prevalent one for these functions in industrial automation environments but is also used for these functions in other environments such as security and vehicle guidance.

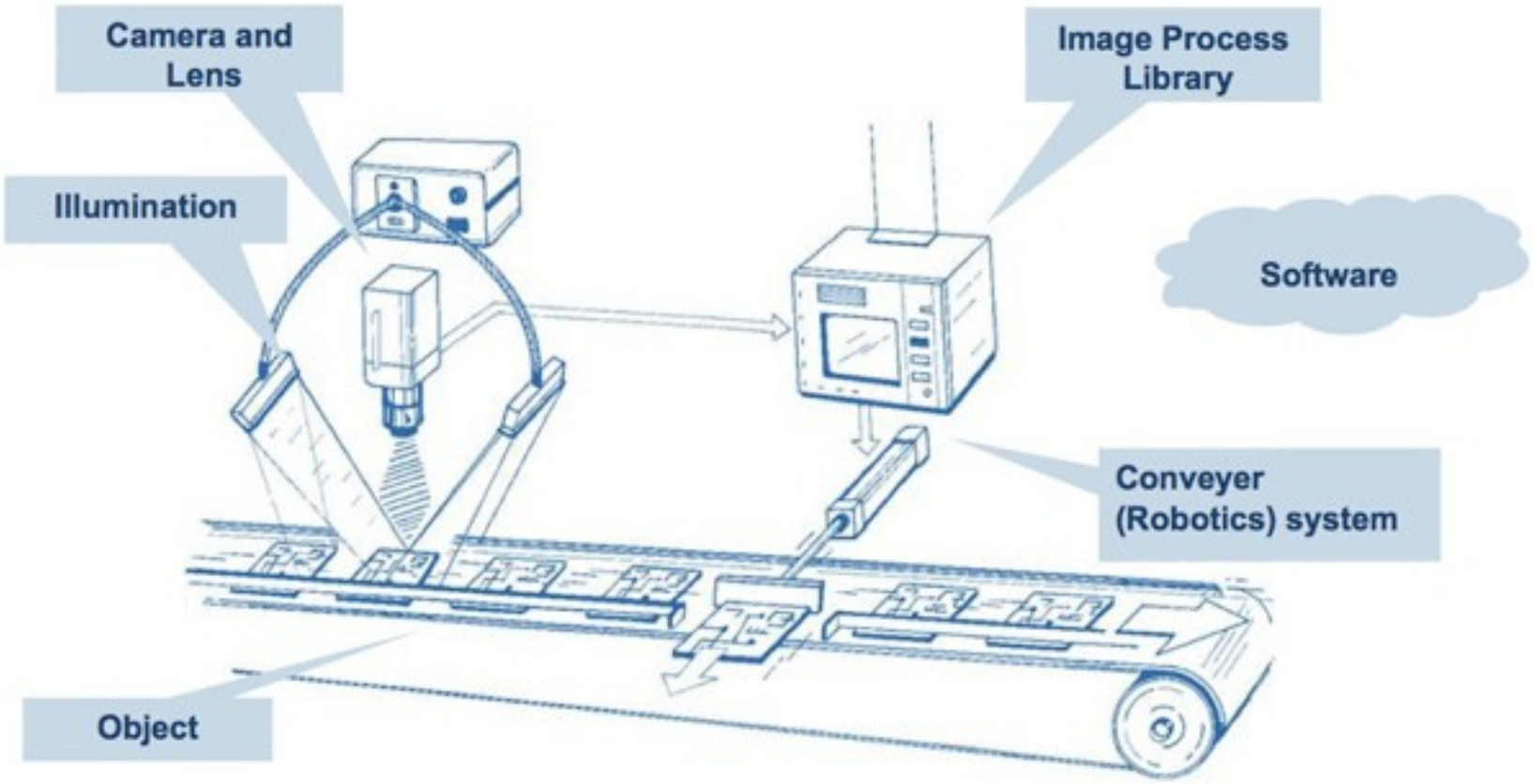
Machine Vision

- The overall machine vision process includes planning the details of the requirements and project, and then creating a solution.
- During run-time, the process starts with imaging, followed by automated analysis of the image and extraction of the required information.

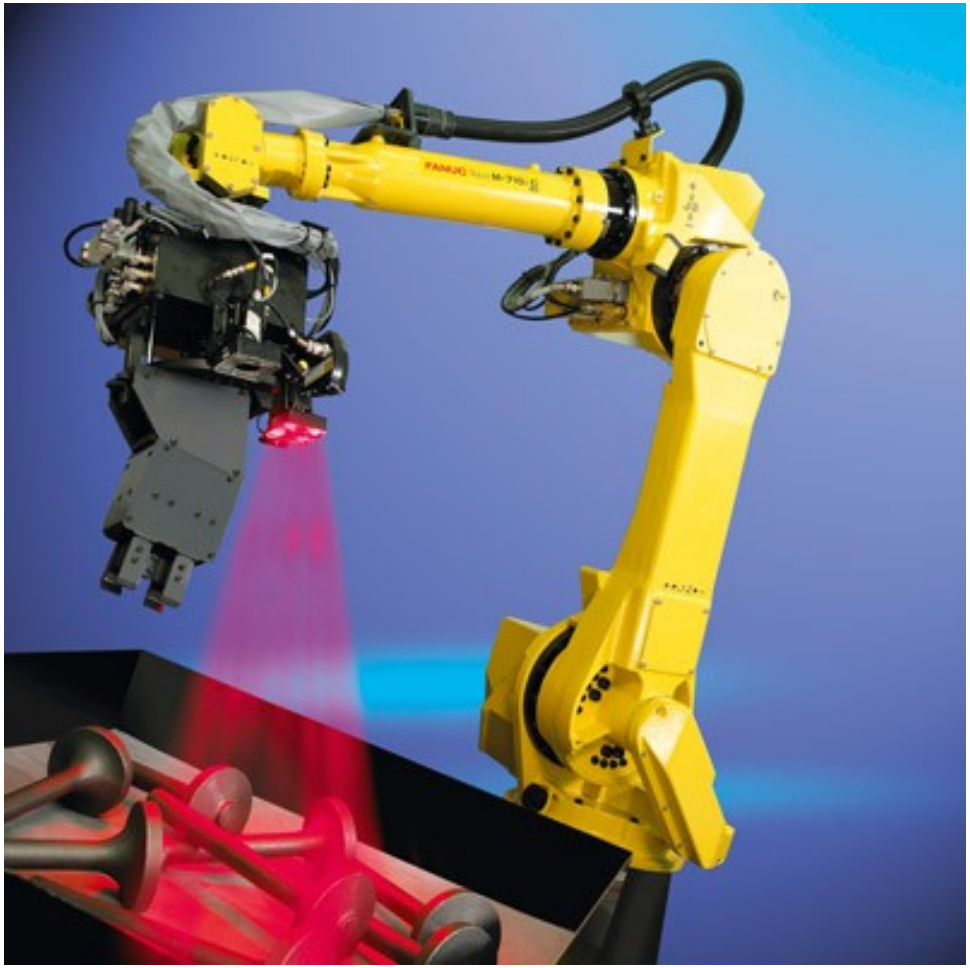
Machine Vision

- Machine vision is usually linked with a computer's ability to see.
- The term, computer vision, is used to designate the technology in which a computer digitizes an image, processes the data, and takes some type of action.
- A machine vision system uses a sensor in the robot for viewing and recognizing an object with the help of a computer.
- Machine vision is used in a variety of industrial processes, such as material inspection, object recognition, pattern recognition, electronic component analysis, along with the recognition of signatures, optical characters, and currency.

Machine Vision: How it works?



Robotic Vision



Robotic Vision

- A robot’s vision system is sorted into three main categories based on the color of the objects.
- These are (1) binary image, which consists of black and white images; (2) gray images; (3) images based on the colors of red, green or blue.
- An electronic image is established using pixels classified into these three categories.
- If an image does not fall into any of these categories, then the category that is closest to the image is selected.

Imaging based automatic inspection and sorting

- The primary uses for machine vision are imaging-based automatic inspection and sorting and robot guidance.
- The overall process includes planning the details of the requirements and project, and then creating a solution.

Methods and sequence of operation

- The first step in the automatic inspection sequence of operation is acquisition of an image, typically using cameras, lenses, and lighting that has been designed to provide the differentiation required by subsequent processing.
- MV software packages and programs developed in them then employ various digital image processing techniques to extract the required information, and often make decisions (such as pass/fail) based on the extracted information.

Equipment

- The components of an automatic inspection system usually include lighting, a camera or other imager, a processor, software, and output devices.

Imaging

- The imaging device (e.g. camera) can either be separate from the main image processing unit or combined with it in which case the combination is generally called a smart camera or smart sensor.
- Inclusion of the full processing function into the same enclosure as the camera is often referred to as embedded processing.

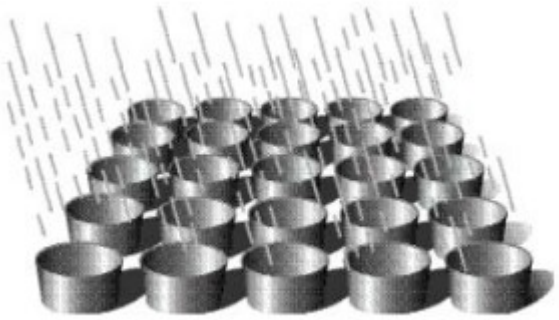
Imaging

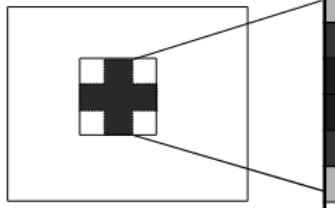
- When separated, the connection may be made to specialized intermediate hardware, a custom processing appliance, or a frame grabber within a computer using either an analog or standardized digital interface (Camera Link, CoaXPress).
- MV implementations also use digital cameras capable of direct connections (without a framegrabber) to a computer via FireWire, USB or Gigabit Ethernet interfaces.

Imaging

- While conventional (2D visible light) imaging is most commonly used in MV, alternatives include multispectral imaging, hyperspectral imaging, imaging various infrared bands, line scan imaging, 3D imaging of surfaces and X-ray imaging.
- Key differentiations within MV 2D visible light imaging are monochromatic vs. color, frame rate, resolution, and whether or not the imaging process is simultaneous over the entire image, making it suitable for moving processes.

Image Acquisition





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59	54	60	59	41	46	42	46	46	42	48	46
100	120	120	115	51	41	43	49	110	116	118	105
255	255	255	118	62	44	42	57	115	255	255	255
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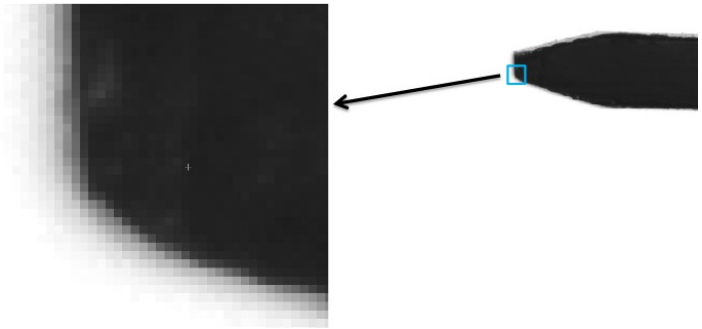


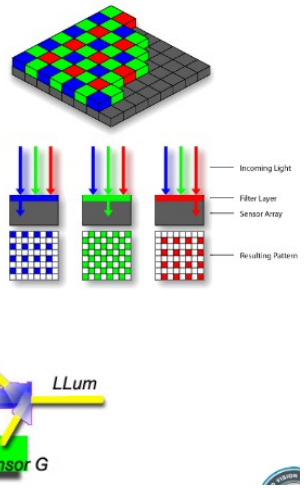


Image processing

- After an image is acquired, it is processed. Central processing functions are generally done by a CPU, a GPU, a FPGA or a combination of these.
- Deep learning training and inference impose higher processing performance requirements.
- Multiple stages of processing are generally used in a sequence that ends up as a desired result.
- A typical sequence might start with tools such as filters which modify the image, followed by extraction of objects, then extraction (e.g. measurements, reading of codes) of data from those objects, followed by communicating that data, or comparing it against target values to create and communicate "pass/fail" results.

Image processing methods

- Stitching/Registration: Combining of adjacent 2D or 3D images.
- Filtering (e.g. morphological filtering)
- Thresholding: Thresholding starts with setting or determining a gray value that will be useful for the following steps.
  - The value is then used to separate portions of the image, and sometimes to transform each portion of the image to simply black and white based on whether it is below or above that grayscale value.

Image processing methods

- Pixel counting: counts the number of light or dark pixels.
- Segmentation: Partitioning a digital image into multiple segments to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze.
- Edge detection: finding object edges.
- Color Analysis: Identify parts, products and items using color, assess quality from color, and isolate features using color

Image processing methods

- Blob detection and extraction: inspecting an image for discrete blobs of connected pixels (e.g. a black hole in a grey object) as image landmarks.
- Neural net / deep learning / machine learning processing: weighted and self-training multi-variable decision making Circa 2019 there is a large expansion of this, using deep learning and machine learning to significantly expand machine vision capabilities.

Image processing methods

- Pattern recognition including template matching. Finding, matching, and/or counting specific patterns.
  - This may include location of an object that may be rotated, partially hidden by another object, or varying in size.
- Barcode, Data Matrix and "2D barcode" reading
- Optical character recognition: automated reading of text such as serial numbers.
- Gauging/Metrology: measurement of object dimensions (e.g. in pixels, inches or millimeters)

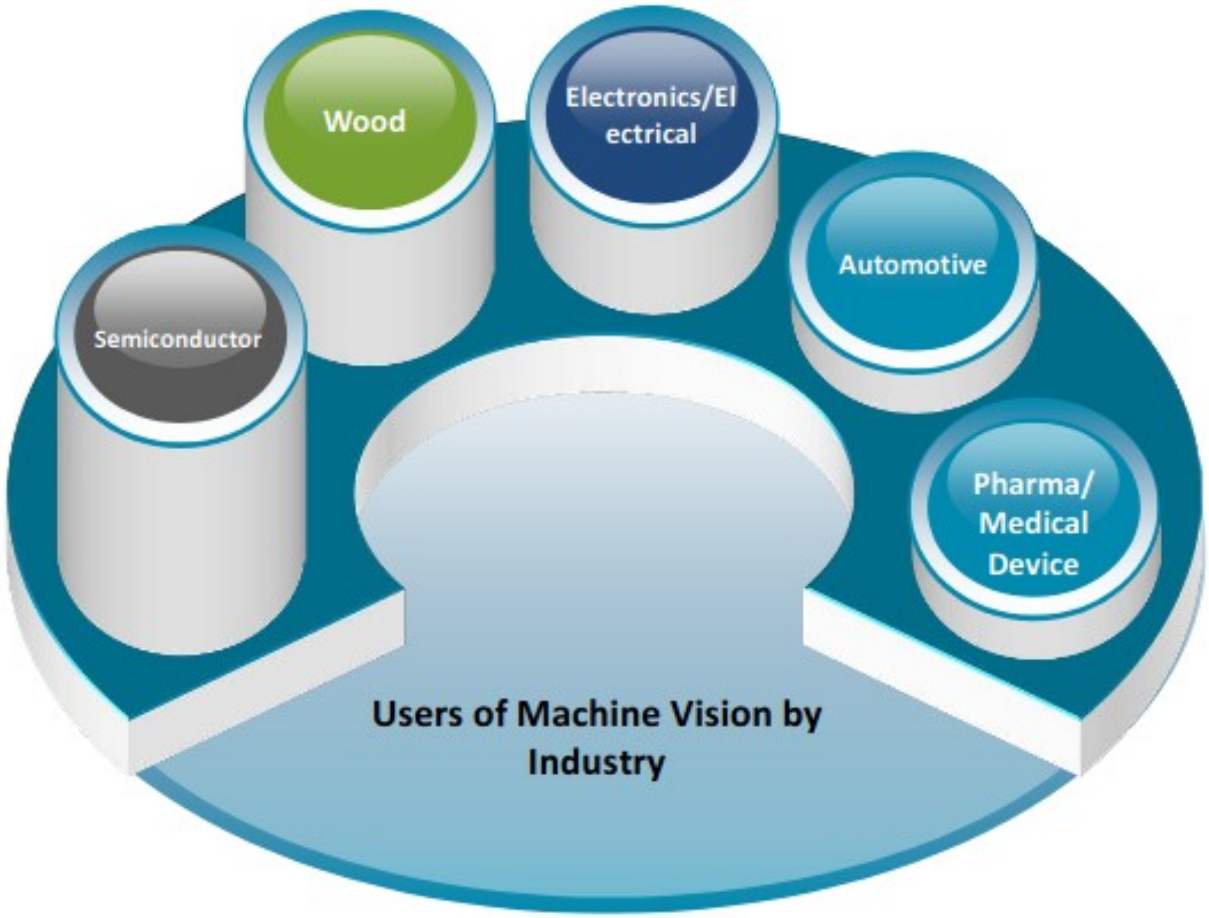
Outputs

- A common output from automatic inspection systems is pass/fail decisions.
- These decisions may in turn trigger mechanisms that reject failed items or sound an alarm.
- Other common outputs include object position and orientation information for robot guidance systems.

Outputs

- Additionally, output types include numerical measurement data, data read from codes and characters, counts and classification of objects, displays of the process or results, stored images, alarms from automated space monitoring MV systems, and process control signals.
- This also includes user interfaces, interfaces for the integration of multi-component systems and automated data interchange.

Industrial Applications



Industrial Applications

- Agriculture, Automotive, Biometrics/Security, Container,
- Cosmetic, Electronics/Electrical, Entertainment, Fabricated
- Metal, Fastener, Food/Beverage, Glass, Lab Automation,
- Lumber/Wood, Medical Devices, Medical Imaging,
- Military/Aerospace, Miscellaneous Mfg., Nanotechnology, Paper,
- Pharmaceutical, Plastics, Primary Metal, Printing, Rubber,
- Scientific Imaging, Semiconductor, Telecommunications,
- Textile/Apparel, Tobacco, Transportation

Industrial Uses of Machine Vision

- Machine vision application categories
  - Defect detection
  - Gauging
  - Guidance and part tracking
  - Identification
  - OCR/OCV
  - Packaging inspection
  - Pattern Recognition
  - Product Inspection
  - Surface Inspection
  - Web Inspection

Thank you

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