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ANIE AUTOMAZIONE

IL RUOLO DELLA VISIONE ARTIFICIALE NELL'AUTOMAZIONE INDUSTRIALE

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OPTO ENGINEERING

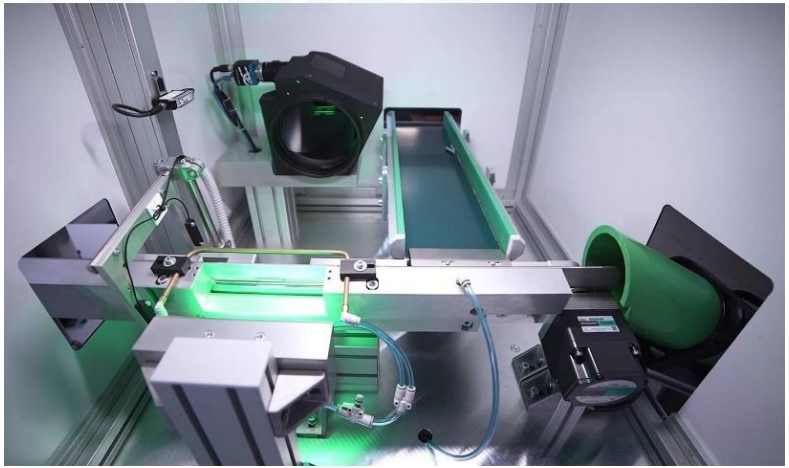
Machine Vision

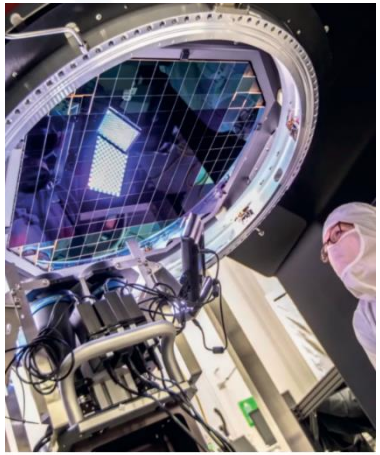
Machine Vision is the discipline that combines imaging technologies and methods to perform automatic inspection and analysis in several types of applications, such as verification, measurement, and process control.

Vision System

A **vision system** is made up of every component that is needed to acquire and analyze an image in order to perform the intended task, these components include optics, lighting, cameras and software.

When designing and building a vision system, it is important to find the right balance between performance and cost to achieve the best result for the desired application.





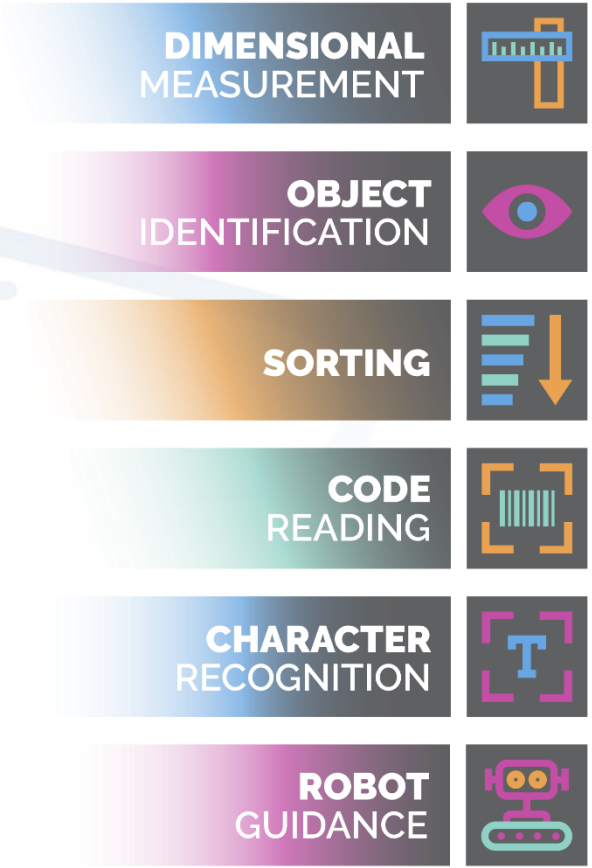
Credits: Farrin Abbott/SLAC National Accelerator Laboratory.

Applications

Vision systems can do many different things, including:

- dimensional measurement
- object identification and sorting
- code reading
- character recognition
- robot guidance

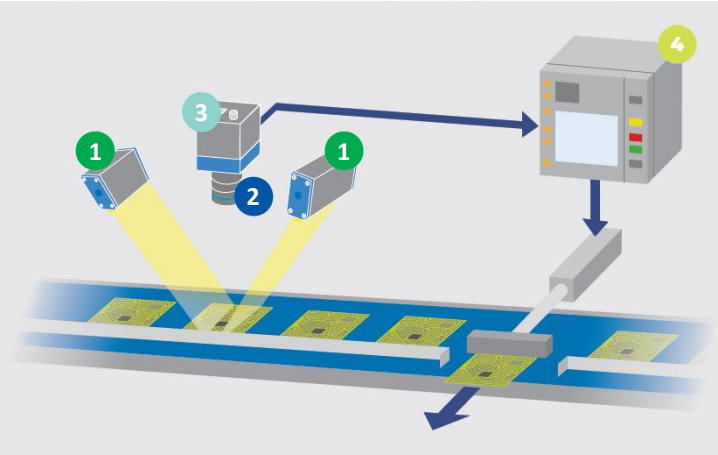
These systems can easily interact with other machinery through different communication standards and are an integral part of an automated system.



How a vision system works

A **vision system** is made up of every component that is needed to acquire and analyze an image

1. **Lighting**: it properly illuminates the object
2. **Optics**: it recreates an image of the object
3. **Cameras**: it captures, digitalizes and transmits the image
4. **Software**: it analyses the digital image and extracts the information needed



Analogies with human vision

A machine vision system can be considered in analogy with the **human visual system**.

Function	Machine vision	Human vision
it properly illuminates the object	Lighting	Environmental light
it recreates an image of the object	Optics	Eye
it captures and transmits the image	Camera	Retina and optic nerve
it analyses the image and extracts the information needed	Software	Brain

Machine vision and human vision

The human species perceives reality through the senses, such as sight, hearing, balance, smell, taste or touch.

Similarly, it is possible to equip machines with sensors capable of gathering information about the surroundings through the detection of stimuli related to temperature, sound, acceleration, and others.

Machine vision allows machines to see. This is its importance in industrial automation.

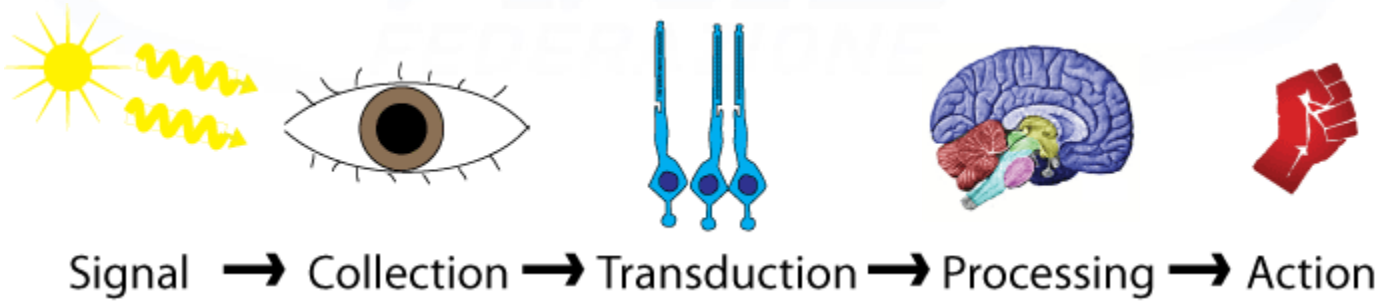
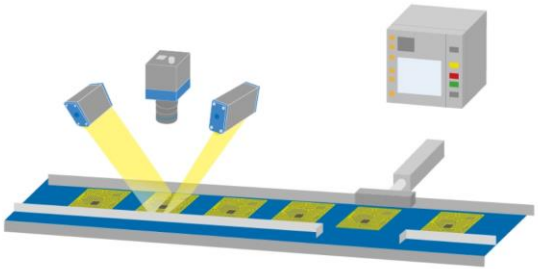


Image credits to: en.wikipedia.org/wiki/Sense

Machine vision in automation

To perform a task such as measuring a dimension, revealing a defect, or reading a code, **a machine needs to acquire and analyze images** and search for the relevant information.

An example of this concept is the possibility to instantly reject a product deemed non-compliant to set standards.



Machine vision example

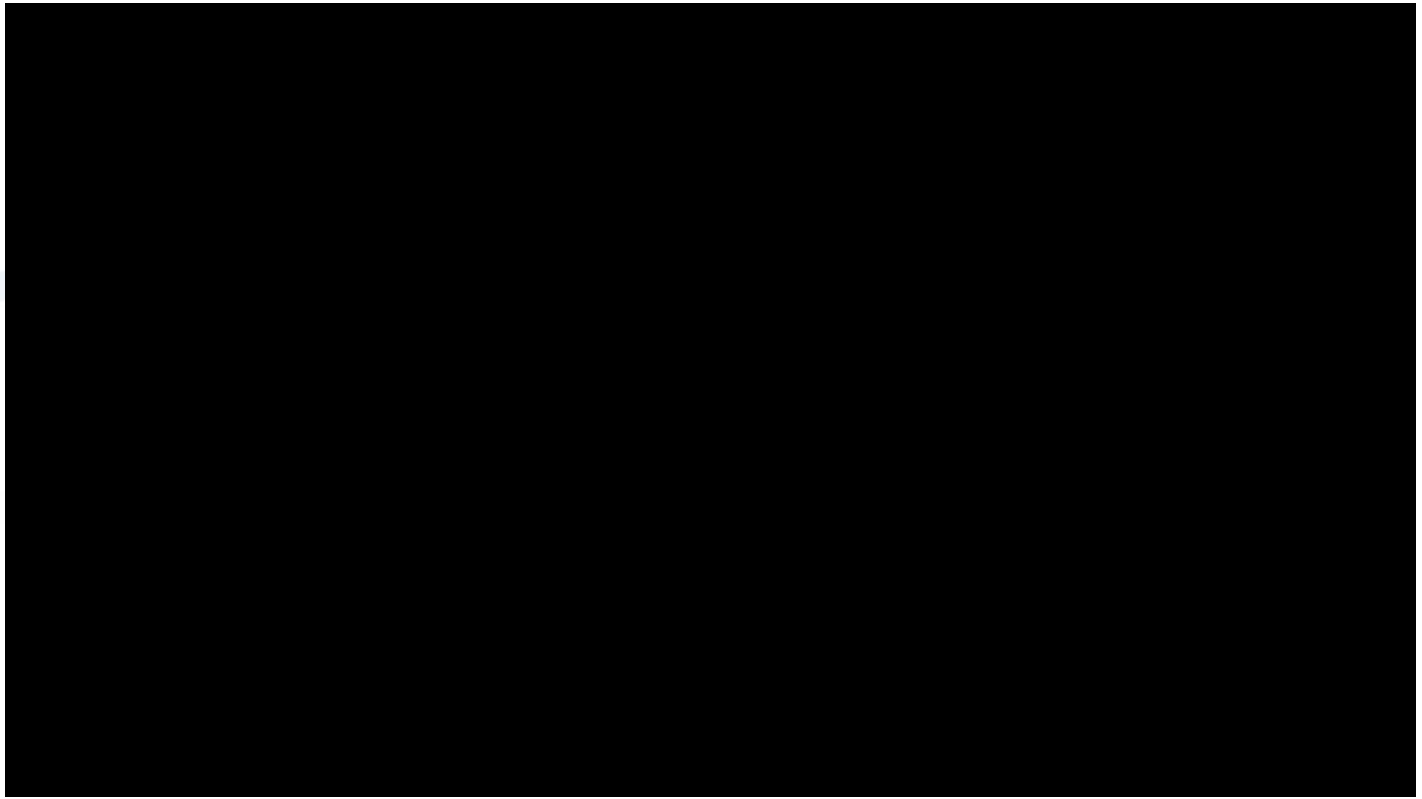
Vision tasks
- precise measurement of turned parts between 3 and 50 mm in diameter
- Inspection of surface defects
- Up to 30,000 part/hour

Vision system 1:
- **Camera** 12M pixels mono GigE
- **Optics** telecentric
- **Lighting** diffused backlight with collimating filter green

Vision system 2:
- **Camera** 12M pixels mono GigE
- **Optics** telecentric
- **Lighting** telecentric backlight green

Vision system 3:
- **Camera** 5M pixels mono GigE
- **Optics** fixed focal 35 mm
- **Lighting** ringlight

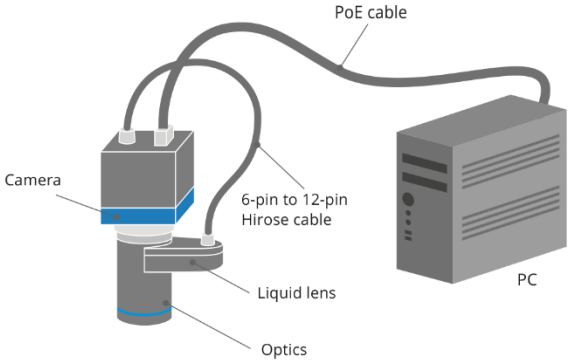
Software: in common with parallelization



Machine vision applications

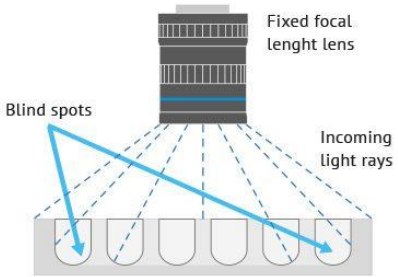
Code and data reading:

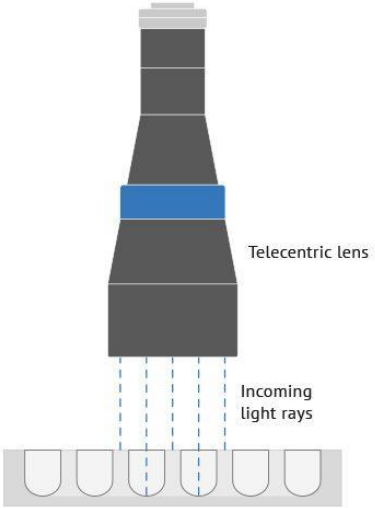
- Optical Character Recognition
- Barcode
- QR code
- Datamatrix

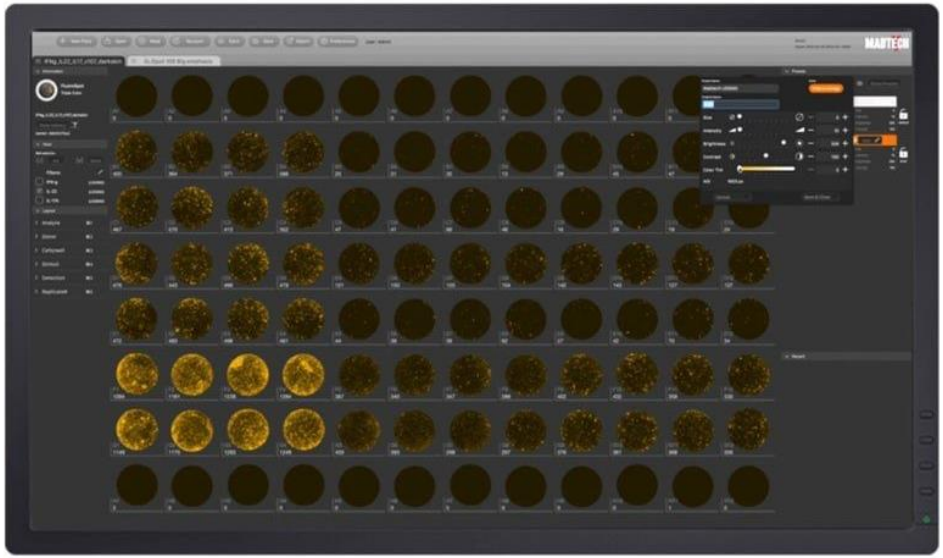


Machine vision applications

Object recognition, classification and sorting

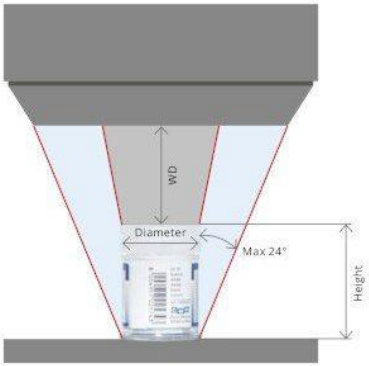


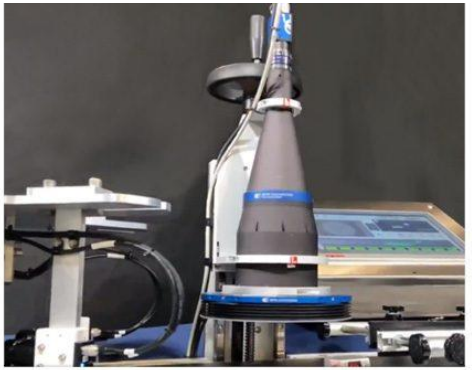


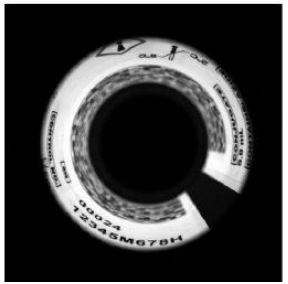


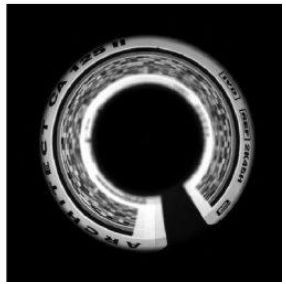
Machine vision applications

Object inspection and defect detection



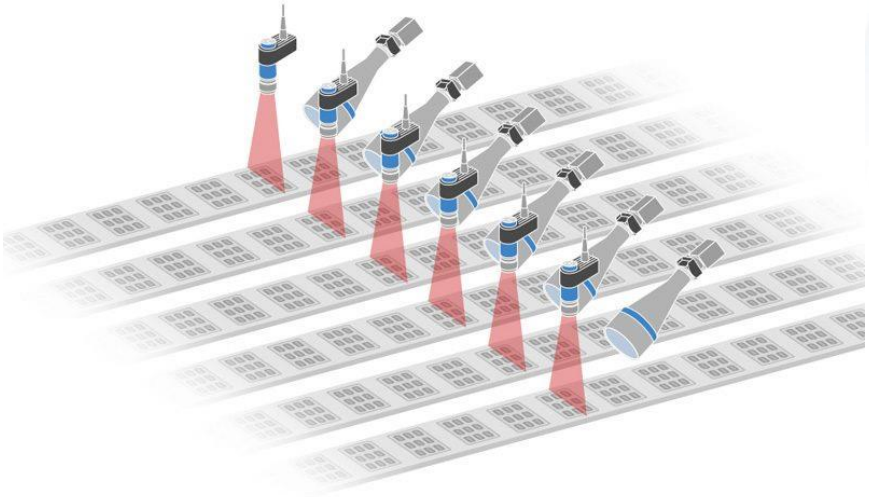


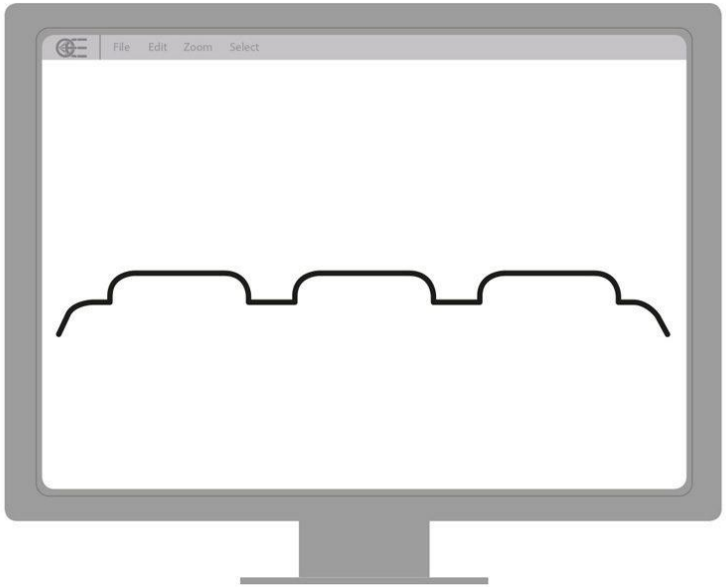




Machine vision applications

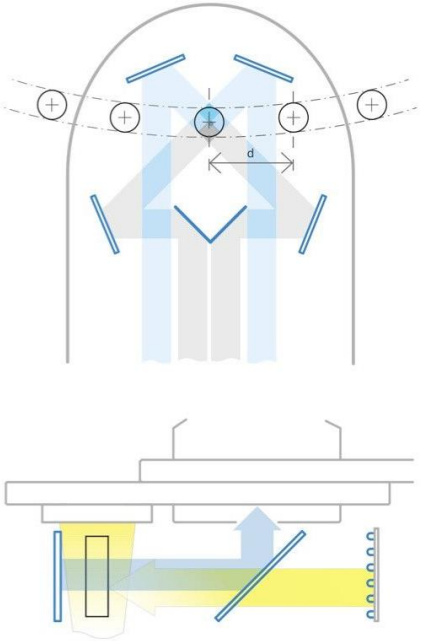
3D imaging for measurment or shape recognition

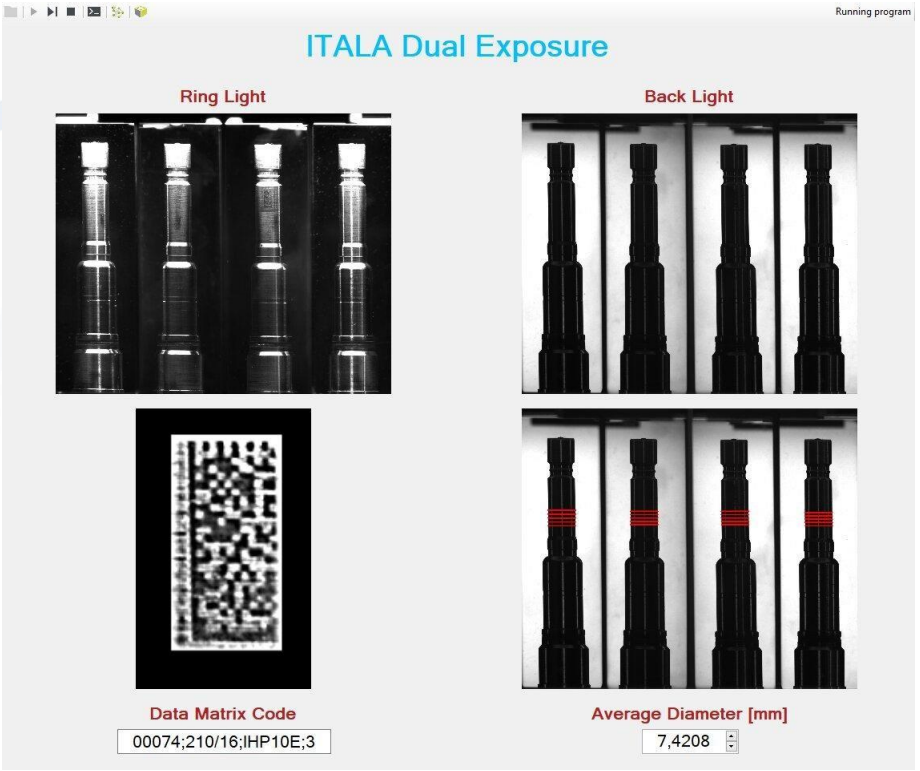




Machine vision applications

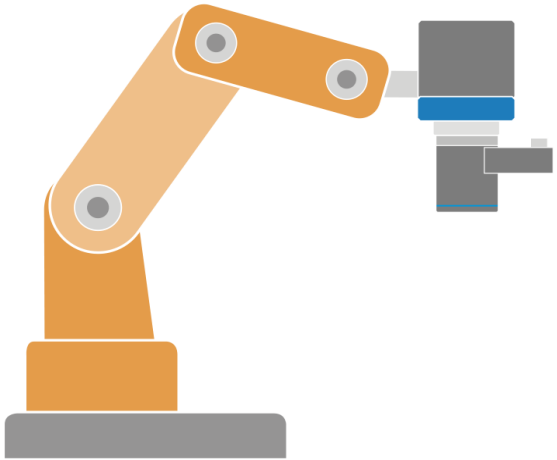
Dimension measurement





Machine vision applications

Robot guidance

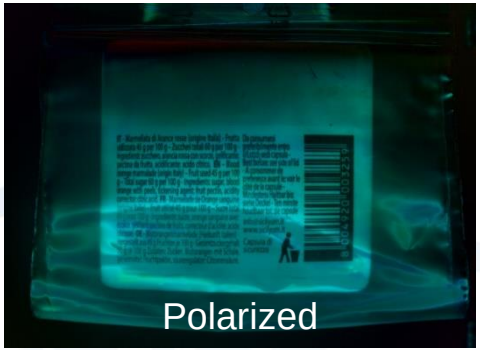


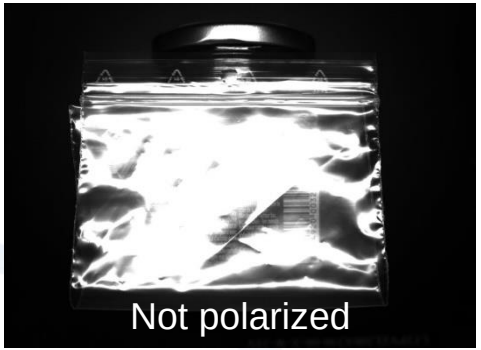
Machine vision challenges

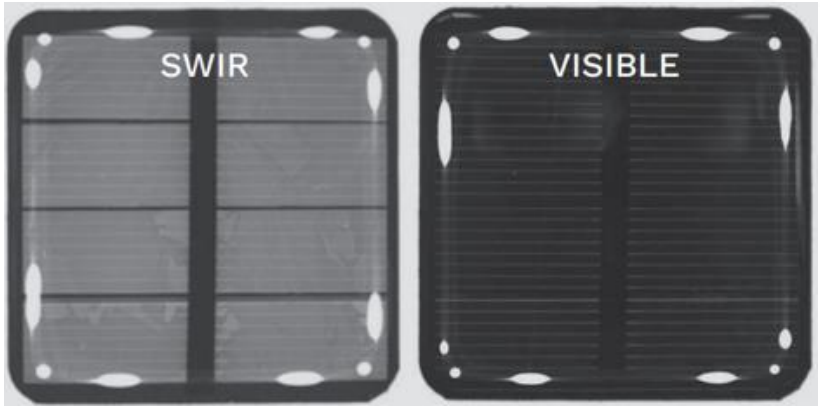
LIGHTING

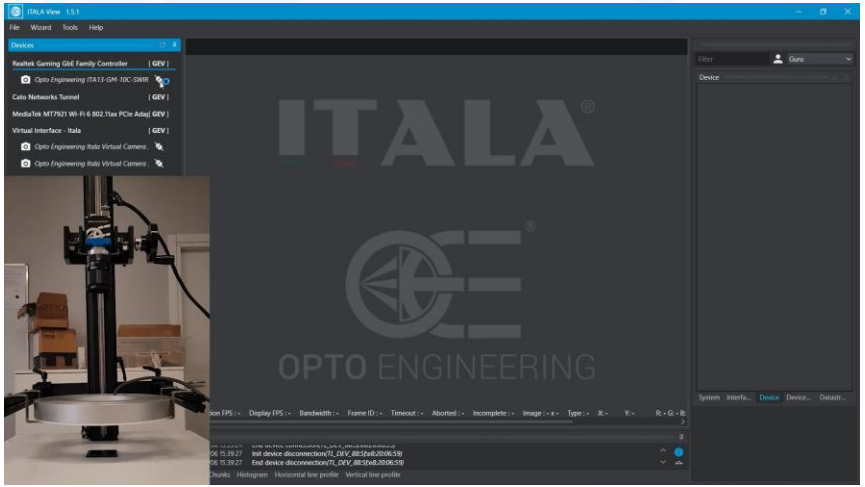
Unveiling the invisible:

- Light polarizaiont
- Infrared imaging







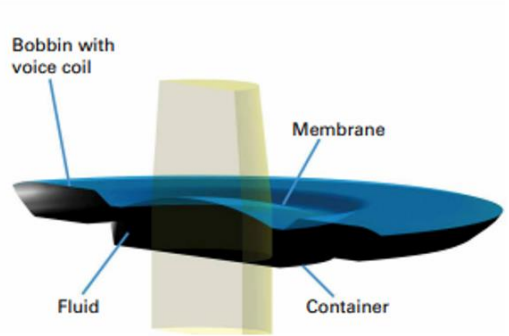


Machine vision challenges

OPTICS

Pushing the limits of physics:

- Extended Depth Of Field and Resolution
- Introduce degrees of freedom and flexibility with adaptive systems (i.e.: liquid lenses)



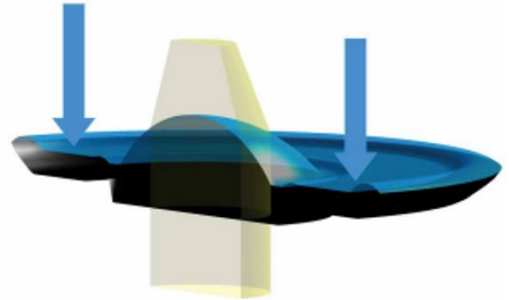


Image credits to: Tunable lenses — Optotune

Machine vision challenges

CAMERAS

Pushing the limits of micro electronics and digital communications:

- Image sensors sensitivity ranges
- Pixel miniaturization
- Sensor speed
- Digital interface speed (10GigE, CoaXPress, Optical fibers)
- Camera's onboard image processing

API C#
Programming with C# dedicated API

API Python
Programming with Python dedicated API

Linux
API available for Linux operating system

API C
Programming with C dedicated API

API C++
Programming with C++ dedicated API

Windows
API available for Windows operating system

Burst
Burst mode allows the user to take several images in quick succession

Sequencer
Real-time switch between different camera settings among different captured frames

Auto white balance
Automatically or manually equalize the color channels to get balanced images

Color correction matrix
Balance the color response to get better color fidelity

Dual exposure
Dual exposure mode allows the user to acquire two images in rapid succession

Fast trigger mode
Reduced jitter time between electrical trigger input and frame acquisition

Precision Time Protocol
PTP is used to synchronize system clocks through the network to have precise timings

Scheduled action command
Send and schedule actions at a precise time, such as camera triggering

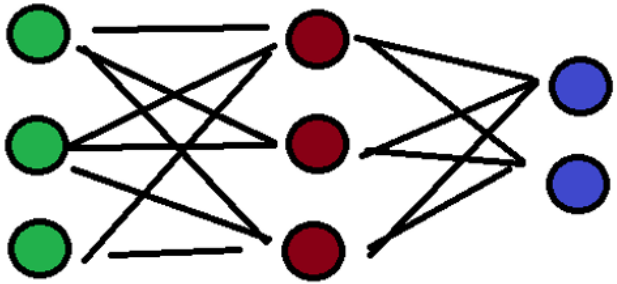
Image compression
Compress the output image to overcome the connection bandwidth limits

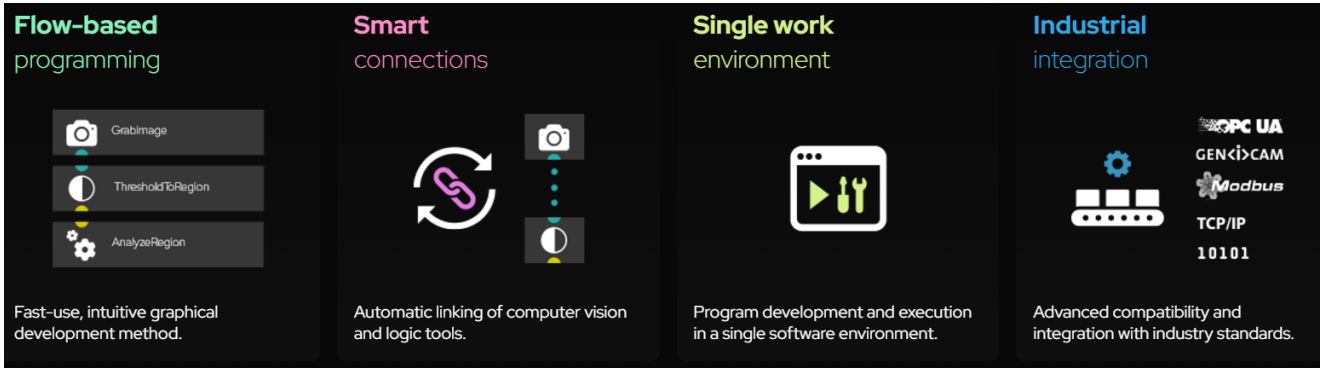
Machine vision challenges

SOFTWARE

Human-centric features:

- Learning capabilities by AI neural networks and Deep Learning
- Software ease-of-use and automatisms capabilities





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