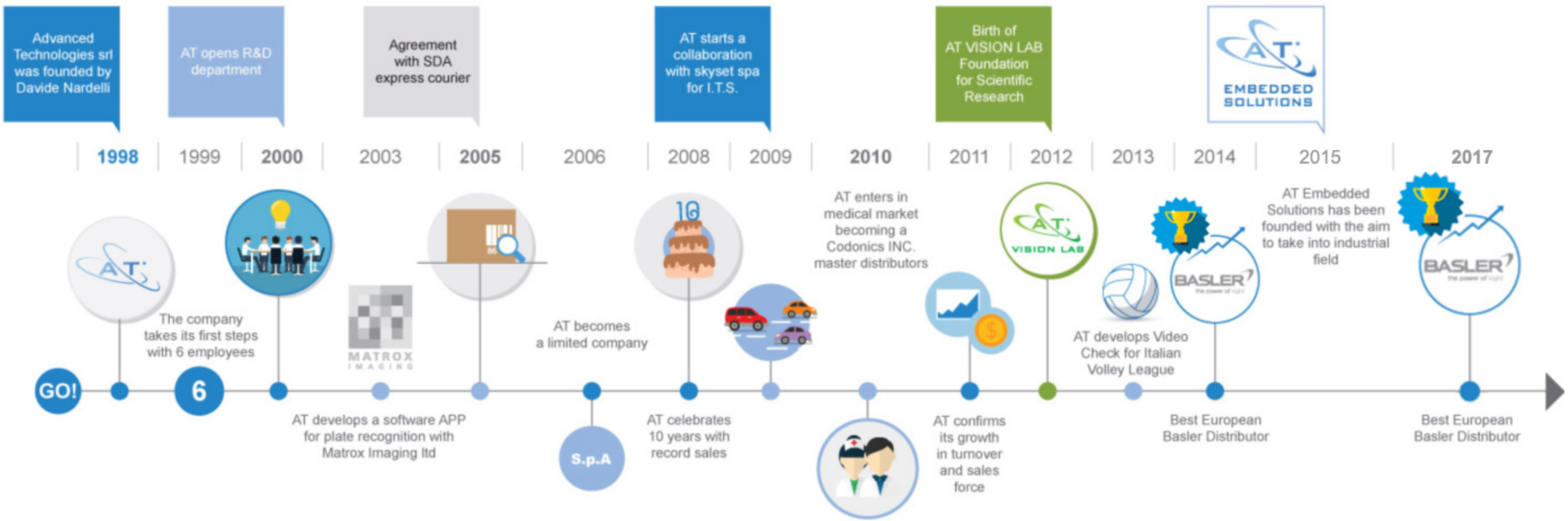
Davide Nardelli

ADVANCED TECHNOLOGIES

VISION EXPERTS

Advanced Technologies - Milestones



AT at a glance

Industrial Vision Systems

There are many definitions about the systems that use «Imaging» algorithms in the industrial field:

"Industrial Vision" - "Machine Vision" - "Smart Sensor" - etc.

But they all refer to the use of technologies and methodologies used to extract information from an image.

Industrial Vision Systems

The information extracted can be a simple signal ON / OFF (good or bad)

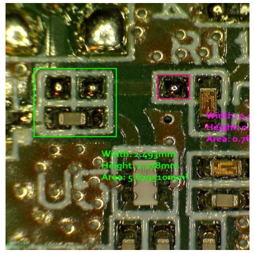
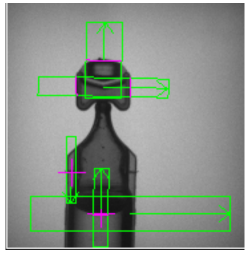
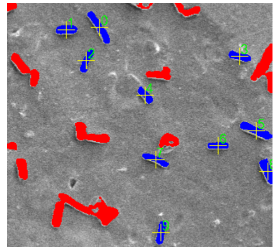
or

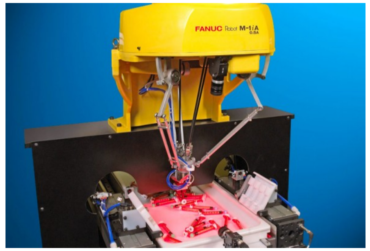
a complex list of data and instructions to extract detailed information to be used in classification and quality control.

Industrial Vision Systems

some examples…

- Check the presence/absence of a component on an electronic PCB
- Measurement of a mechanical part
- Counting of particles in suspension in a pharmaceutical liquid, Vial Inspections
- Print Inspection
- Check defects on a plastic and / or fabric film
- Pick & Place




Industrial Vision Systems

The target of a Vision System
is that the result must be
certain and repeatable

Industrial Vision Systems

The brain of a vision system is mainly based on

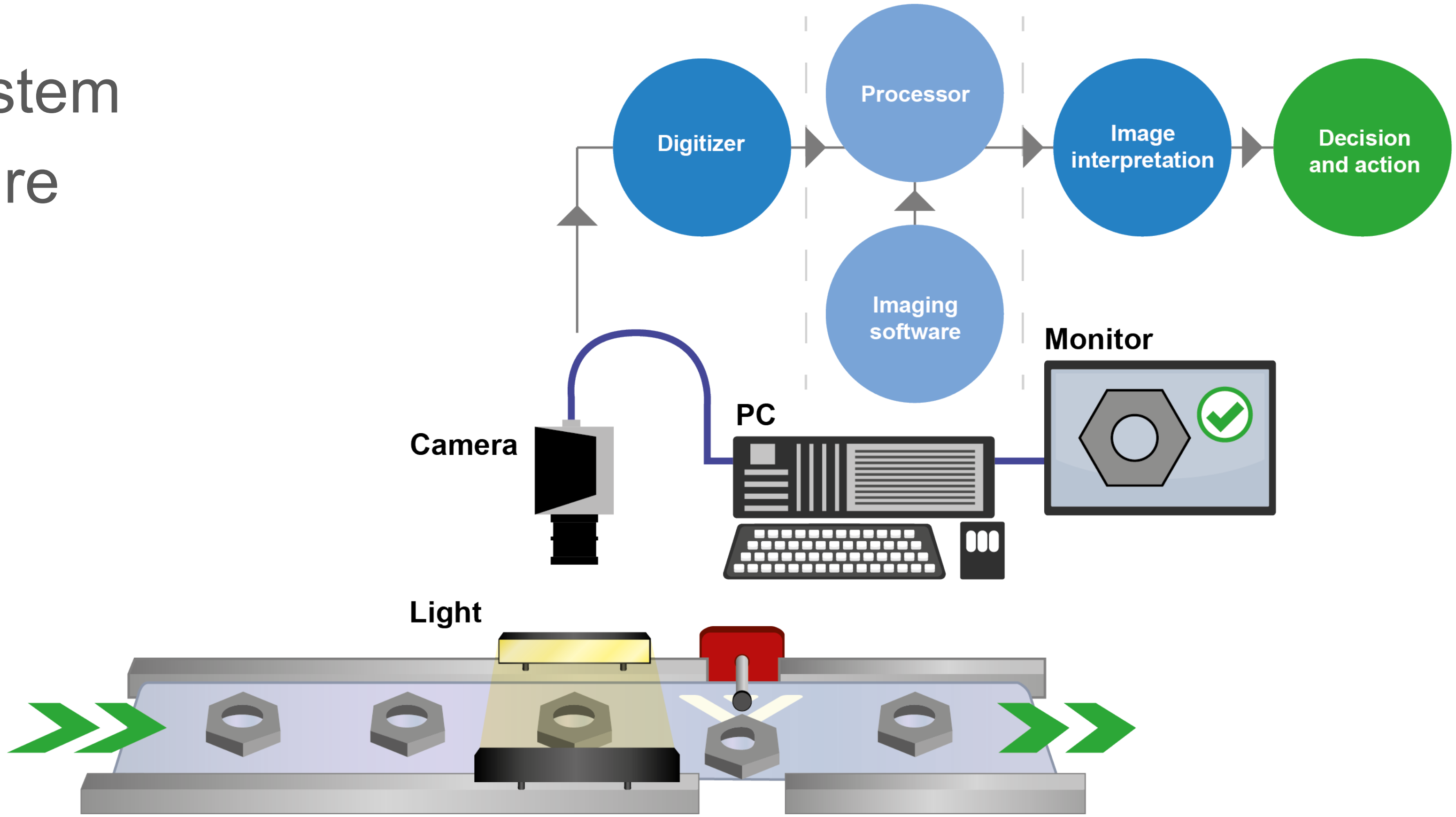
Image Processing algorithms

That applied individually or combined in more complex logics allow data extraction

A good knowledge of mathematics is important for developing Machine Vision Application

Industrial Vision Systems

Vision System Architecture



Vision System Architecture

All these technologies can be found already combined
for example in the Smart Sensors and Smart Cameras
or
appropriately selected and assembled to
meet specific requirements
«Vision Components»

Smart Sensor

Designed to perform single functions, e.g.: Barcode reading, OCR

Vision Components

Light

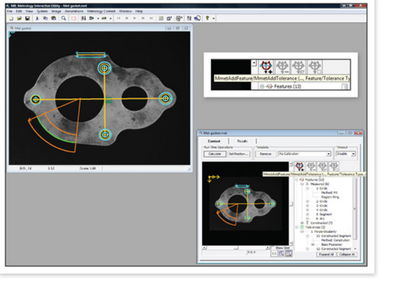
Lens

Camera

Frame Grabber

Computer

Image Processing software



Design a vision system - 2D

Step 1: Choosing the right camera

Sensor resolution and speed are imposed by the type of analysis and by the production cycle time

- 1. The accuracy of the analysis must be defined: e.g., measurement of an object with a precision of 0.1 mm
- 2. You must define the "field of View" where there is the object : e.g., 100x50 mm
- 3. The theoretical minimum resolution is calculated: 1000x500 pixels
- 4. The effective resolution is normally calculated as twice the minimum theoretical resolution: 2000x1000 pixels = 2MPixel
- 5. The cycle time depends on the capacity of the production line: e.g. 200 pcs/sec = 200 frames per second (fps)
- 6. Select the camera that meets the above requirements

Design a vision system - 2D

Step 1: Choosing the right camera

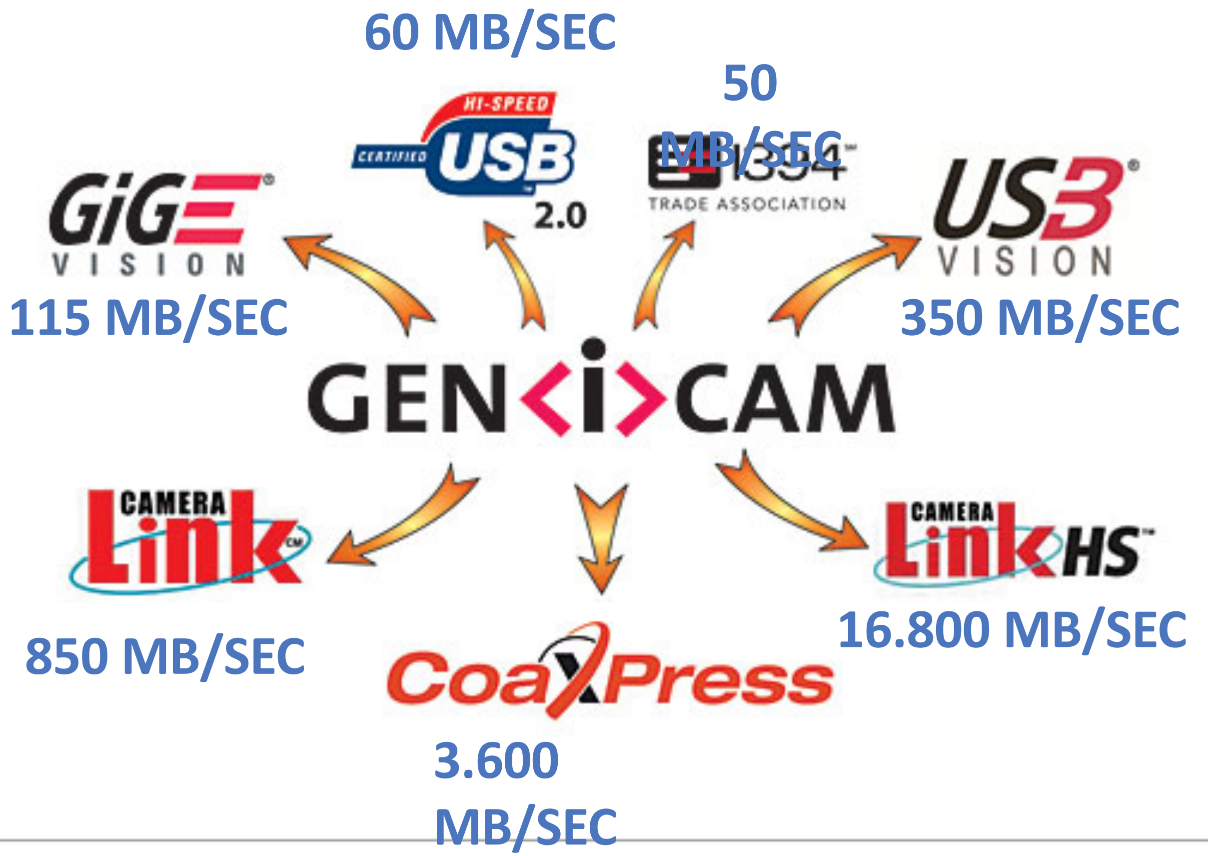
Resolution: 2000x1000 pixel equal to 2MP
Speed: 200 fps
Total Throughput: 400 MB/sec

In this case the speed in fps imposes the acquisition standard:
GigE, USB3, CameraLink, CoaxExpress

Model	Resolution HxV	Resolution	Sensor	fps	Mono/color	Interface
acA2000-50gm	2048 px x 1088 px	2 MP	CMV2000	50 fps	Mono	GigE
acA2000-165um	2048 px x 1088 px	2 MP	CMV2000	165 fps	Mono	USB 3.0
acA2000-340km	2048 px x 1088 px	2 MP	CMV2000	340 fps	Mono	Camera Link

Industrial Vision - Standard Interfaces

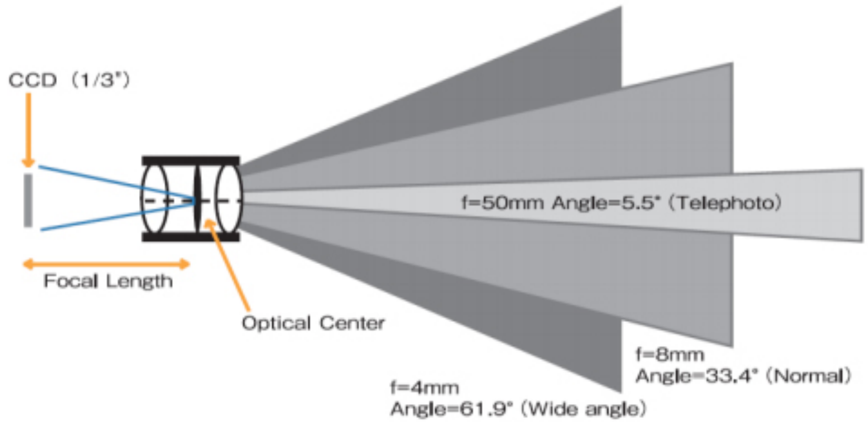
Bandwidth

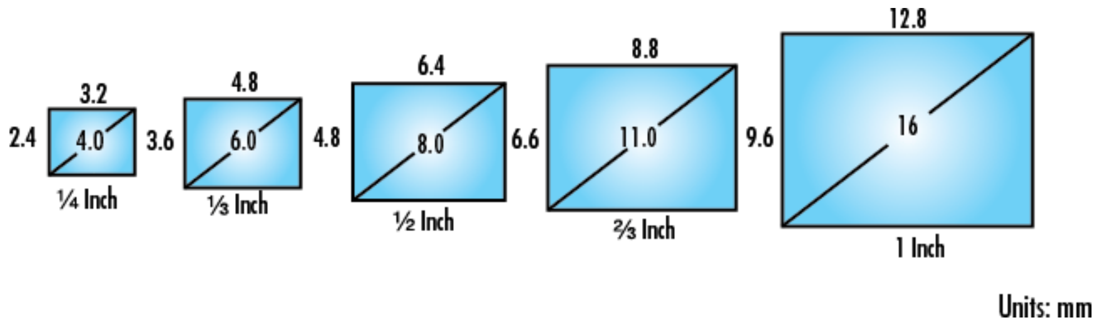


Design a vision system - 2D

Step 2: Choosing the right lens

To choose the right lens it is important to know the sensore size and the working distance





Design a vision system - 2D

Step 2: Choosing the right lens

The following formula allows us to calculate the focal length f of the lens

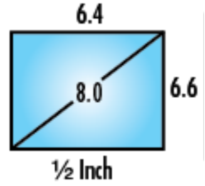
$$f = h\,\frac{D}{H}$$

h = the horizontal dimension of the sensor (e.g., sensor ½" = 6.4 mm)

D = working distance (let us assume 188 mm)

H = horizontal dimension of the working area (e.g., 100 mm)

$$f = 6{,}4\,\frac{188}{100} = 12\ \mathrm{mm}$$



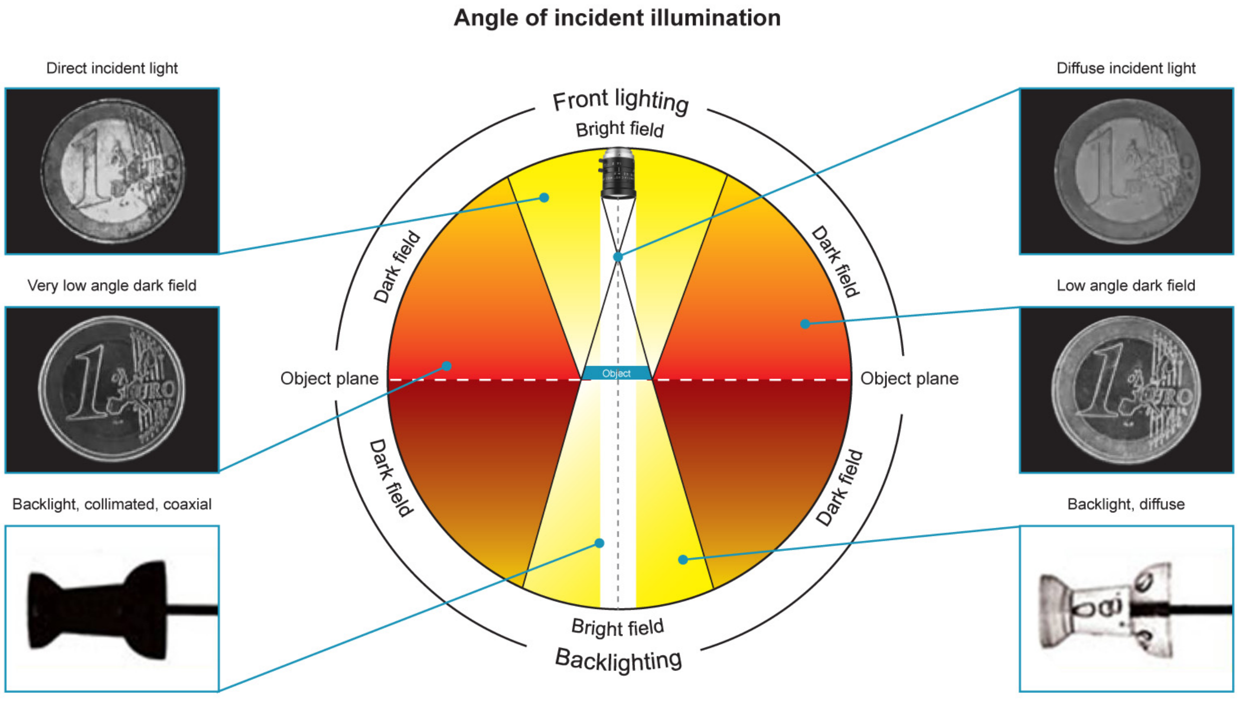
Design a vision system - 2D

Step 3: Choosing the right lighting

There are multiple lighting techniques that allow you to effectively highlight some details of the objects to inspect

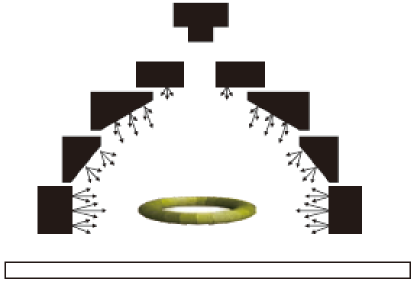
Design a vision system - 2D

Step 3: Choosing the right lighting

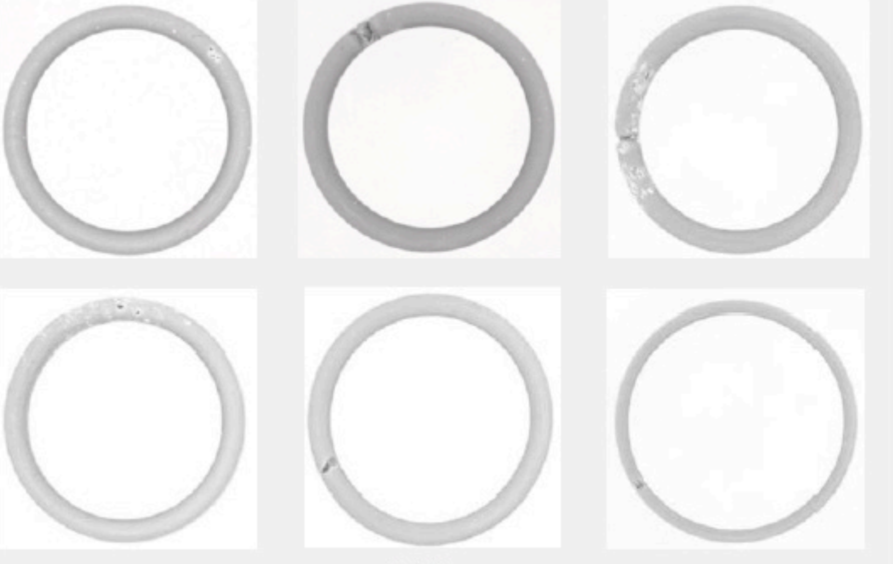


Design a vision system - 2D

Step 3: Choosing the right lighting

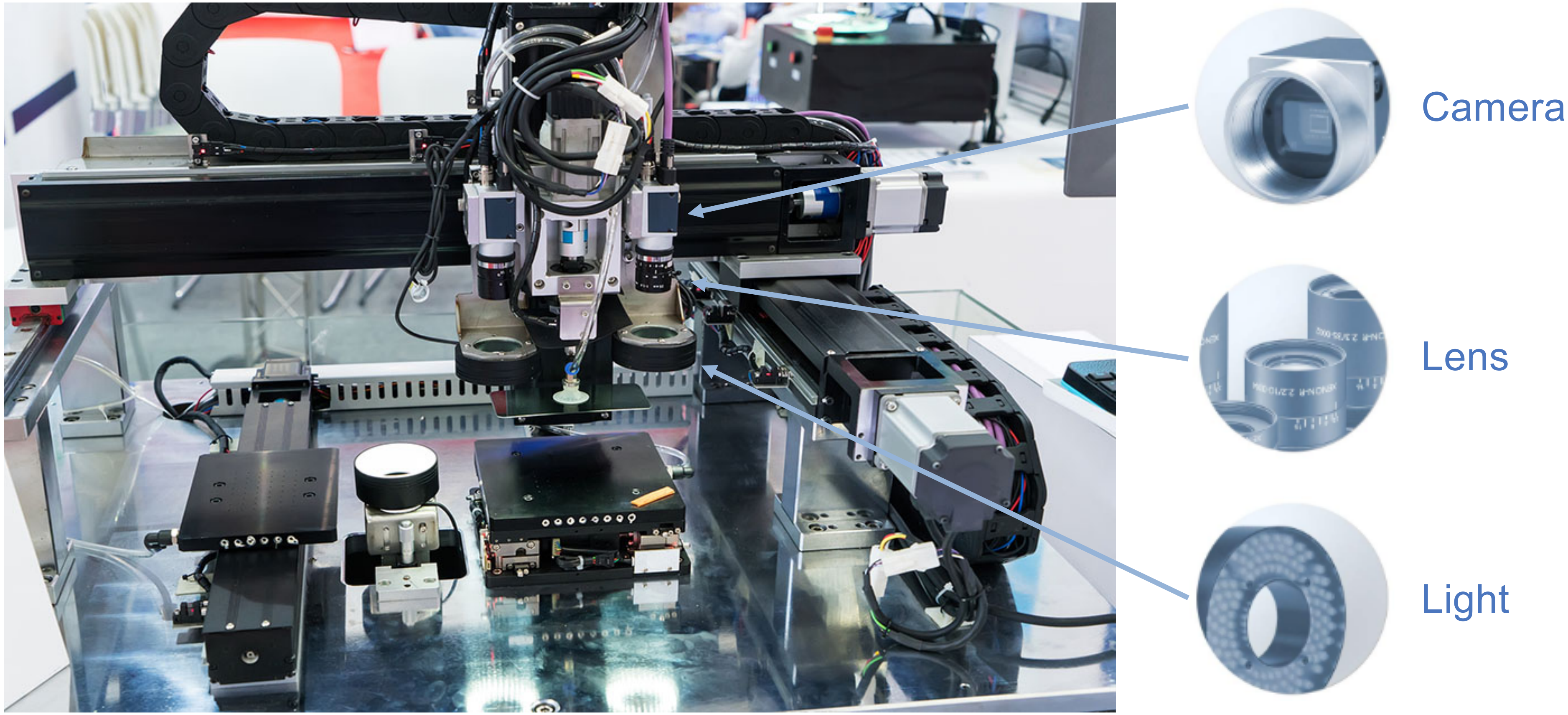


Object images



Result Image

Industrial Vision Systems



Design a Vision System - 2D

Step 4: Definition of Image Processing Algorithms

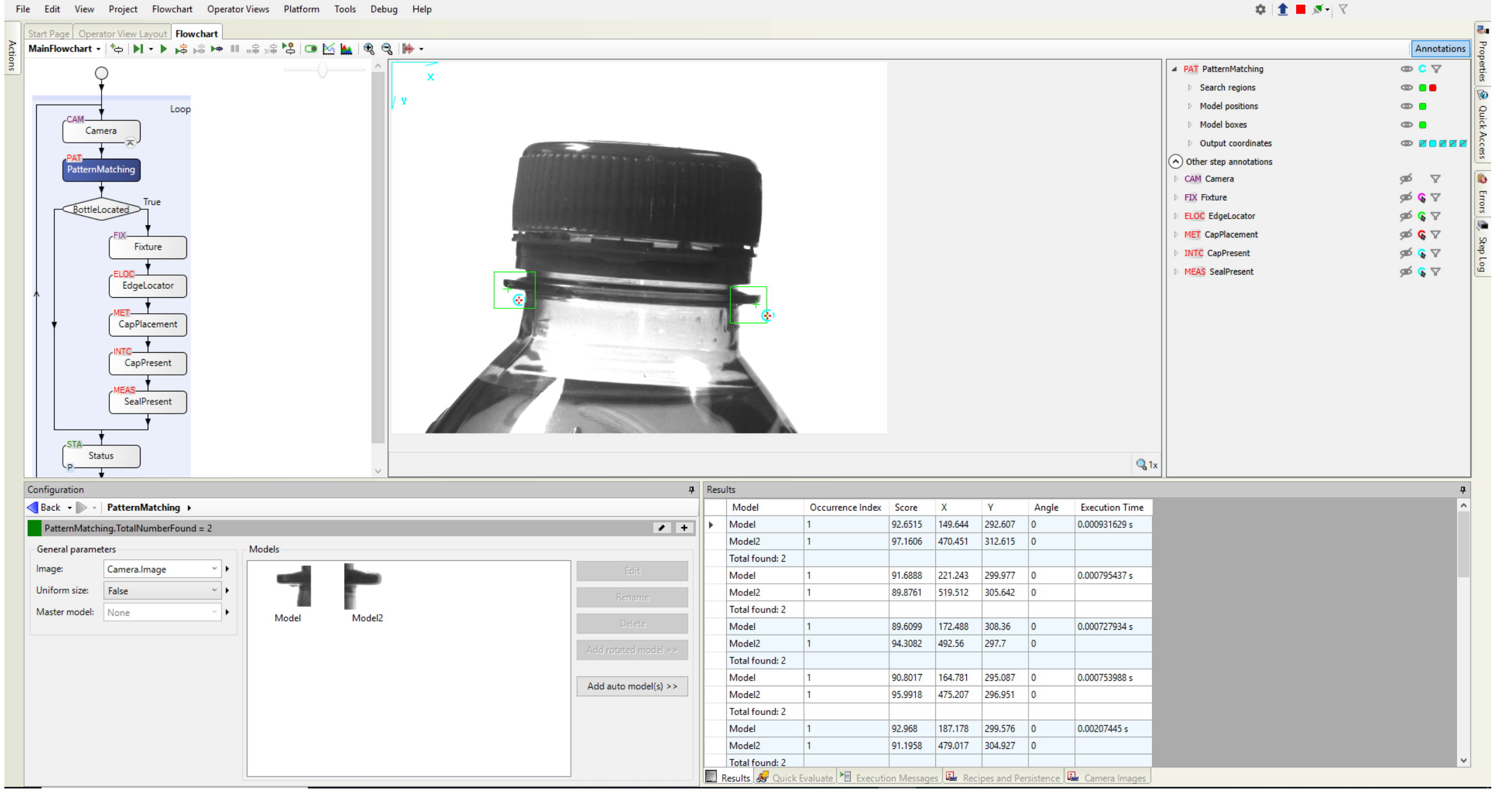
Today, there are many «Imaging Libraries» which provide all the primitives of «Image processing» and tools which easily configure complex algorithms for extrapolation of various informations

To respect the time cycle of the system it is important to make a benchmark of the algorithms, this also allows us to define the necessary computing power

Design a Vision System - 2D - Imaging Libraries

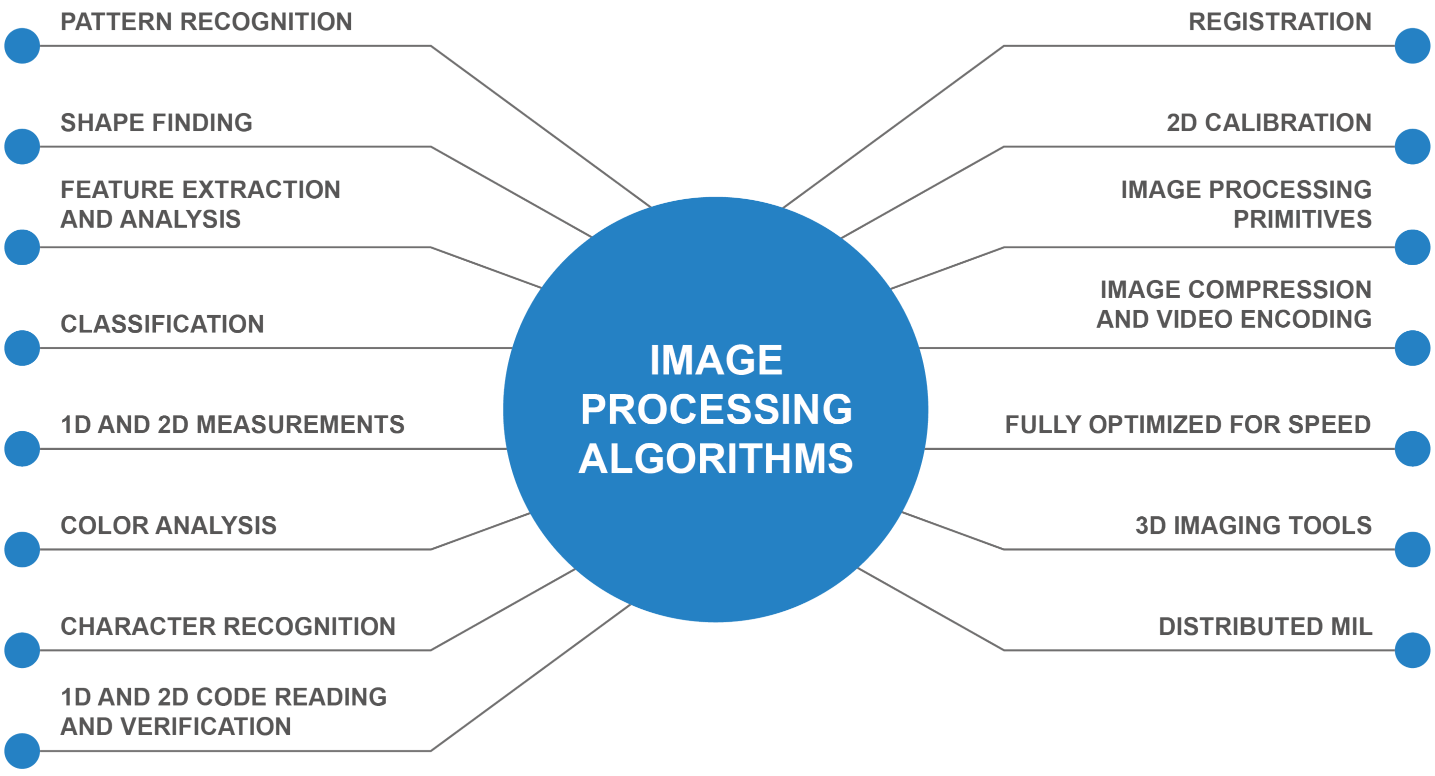
```
/**************************************************************************/
/*
 * File name: MDigGrab.cpp
 *
 * Synopsis:  This program demonstrates how to grab from a camera in
 *            continuous and monoshot mode.
 */
#include <mil.h>

int MosMain(void)
{
   MIL_ID MilApplication,  /* Application identifier.  */
          MilSystem,       /* System identifier.       */
          MilDisplay,      /* Display identifier.      */
          MilDigitizer,    /* Digitizer identifier.    */
          MilImage;        /* Image buffer identifier. */

   /* Allocate defaults. */
   MappAllocDefault(M_DEFAULT, &MilApplication, &MilSystem,
                               &MilDisplay, &MilDigitizer, &MilImage);

   /* Grab continuously. */
   MdigGrabContinuous(MilDigitizer, MilImage);

   /* When a key is pressed, halt. */
   MosPrintf(MIL_TEXT("\nDIGITIZER ACQUISITION:\n"));
   MosPrintf(MIL_TEXT("----------------------\n\n"));
   MosPrintf(MIL_TEXT("Continuous image grab in progress.\n"));
```

Design a Vision System - 2D - Imaging Libraries



Design a Vision System - 2D

Step 4: Definition of Image Processing Algorithms



Design a Vision System - 2D

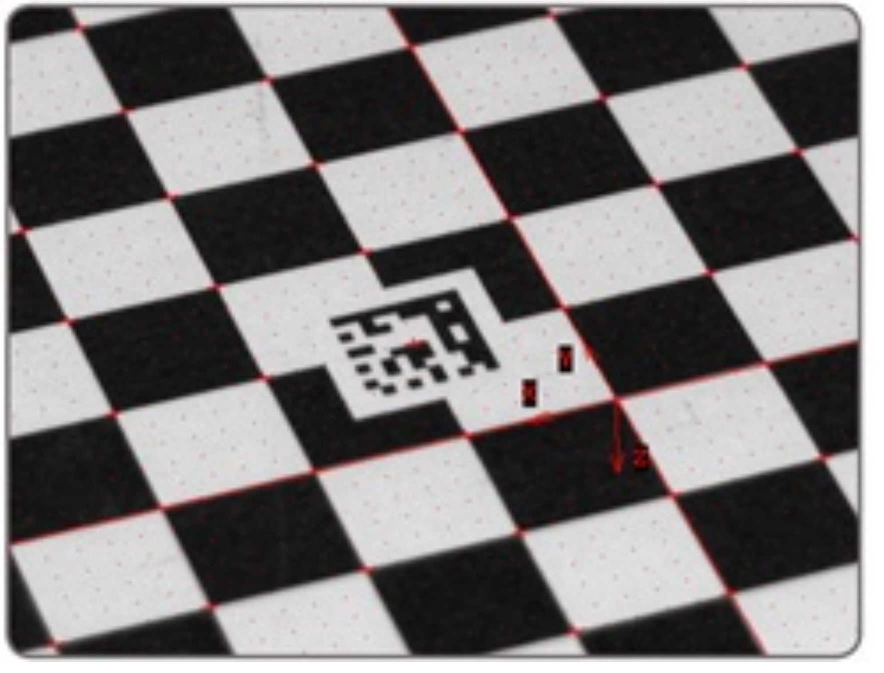
Definition of Image Processing Algorithms

- **2D calibration**

Calibration is a routine requirement for imaging, a 2D calibration tool to convert results (i.e., positions and measurements) from pixel to real-world units and vice-versa.

The tool can compensate results, and even an image itself, for camera lens and perspective distortions.

Calibration is achieved using an image of a grid or chessboard target, or just a list of known points.



Design a Vision System - 2D

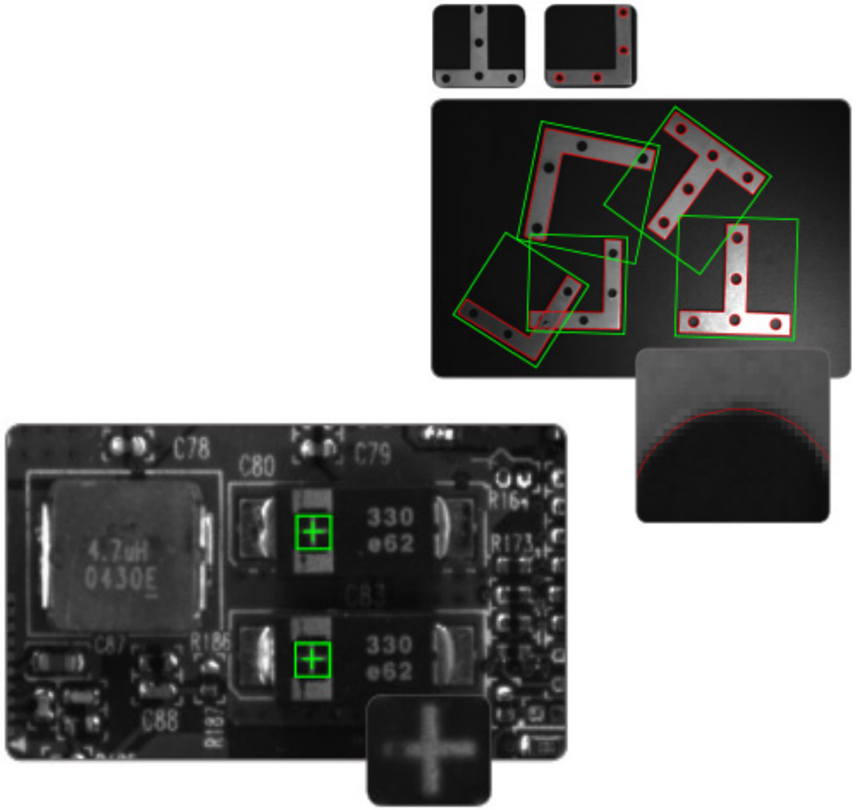
Definition of Image Processing Algorithms

- **Pattern recognition**

Two tools for performing pattern recognition: Pattern Matching and Geometric Model Finder (GMF).

The Pattern Matching tool is based on normalized grayscale correlation (NGC), a classical technique that finds a pattern by looking for a similar spatial distribution of intensity.

The GMF tool uses geometric features (e.g., contours) to find an object. The tool quickly and reliably finds multiple models—including multiple occurrences—that are translated, rotated, and/or scaled with sub-pixel accuracy. GMF locates an object that is partially missing and continues to perform when a scene is subject to uneven changes in illumination, thus relaxing lighting requirements.



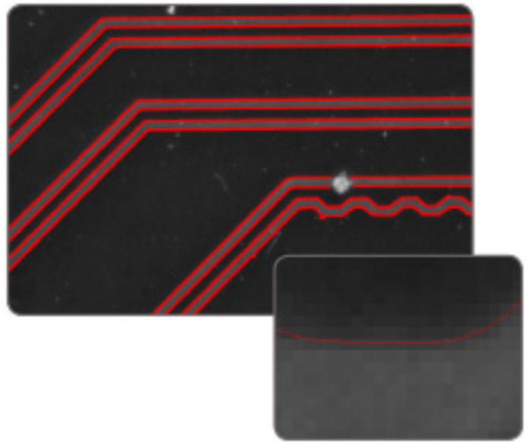
Design a Vision System - 2D

Definition of Image Processing Algorithms

- **Feature extraction and analysis**

Tools for image analysis: Blob Analysis and Edge Finder. These tools are used to identify and measure basic features for determining object presence and location, and to further examine objects.

The Blob Analysis tool works on segmented binary images, where objects are previously separated from the background and one another.



The Edge Finder tool is well suited for scenes with changing, uneven illumination. The tool using a gradient-based approach quickly identifies contours, as well as crests or ridges, in monochrome or color images and can measure over 50 characteristics with sub-pixel accuracy. Measurements can be used to sort and select edges.

Design a Vision System

Step 5: Choice of acquisition / processing hardware

Smart Camera

Advantages

- Sensor, CPU and I/O integrated in a single device
- FanLess
- IP66/IP67

Disadvantages

- Limited number of sensors
- Average / low CPU performances
- Expensive solution in multi-camera applications
- Dimension

Design a Vision System

Step 5: Choice of acquisition / processing hardware

Non-expandable embedded PC

Advantages

- CPU e I/O integrated in a single device
- Certificates
- Supports 2 cameras
- FanLess

Disadvantages

- Average / low CPU performances

Design a Vision System

Step 5: Choice of acquisition / processing hardware

Expandable PC embedded

Advantages

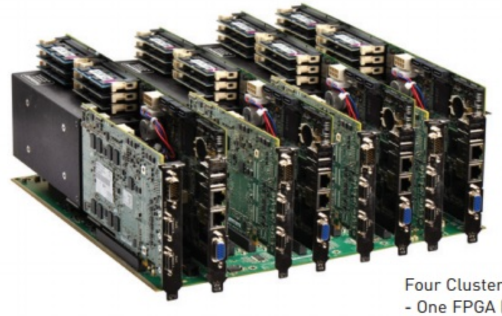
- CPU and I / O integrated in a single device
- Complainat USB3 VISION GiGE VISION
- Supports 6/8 cameras
- FanLess
- Expandable with FrameGrabber or GPU

Disadvantages

- Average CPU performances

Design a Vision System

Step 5: Choice of acquisition / processing hardware
PC Server

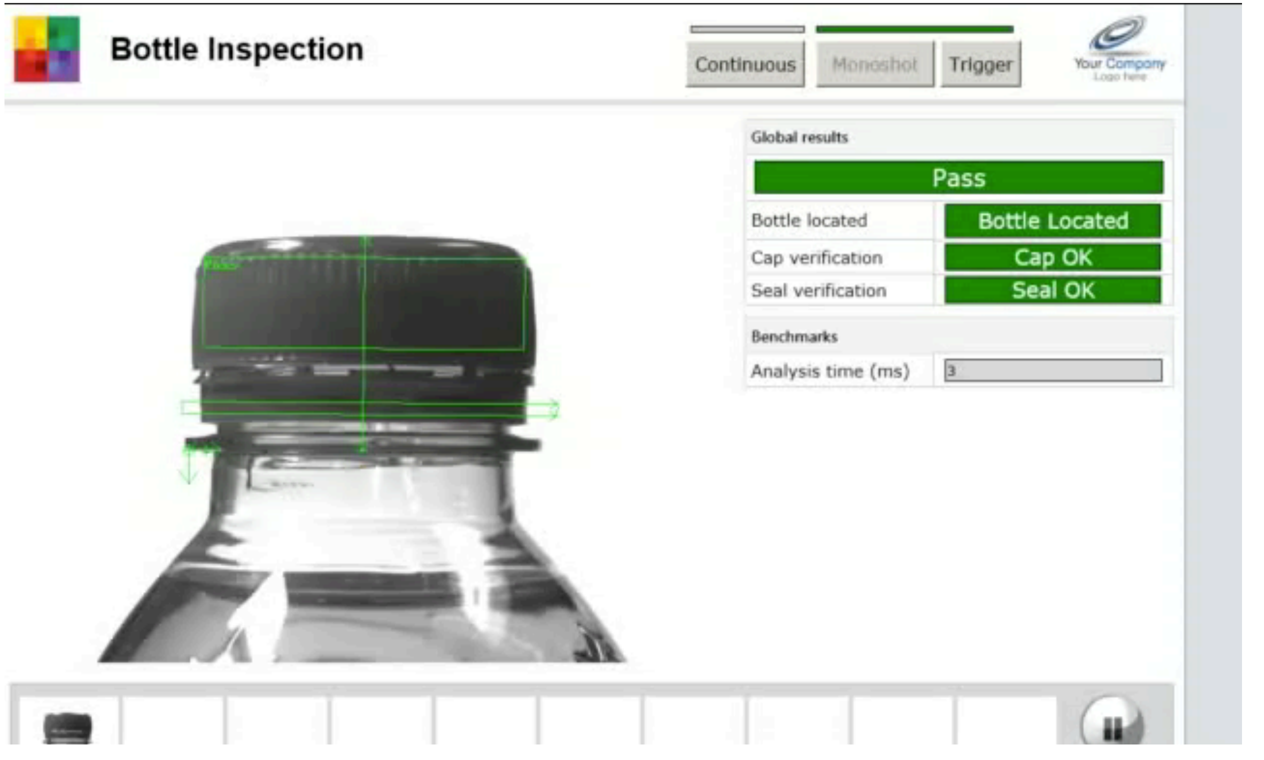


Four Clusters with:
- One FPGA (Matrox Radient eCL)
- Two CPUs (Matrox SHB-5520)

Advantages
- CPU with high computing power
- Expandable with n FrameGrabber and / or GPU
- Long life

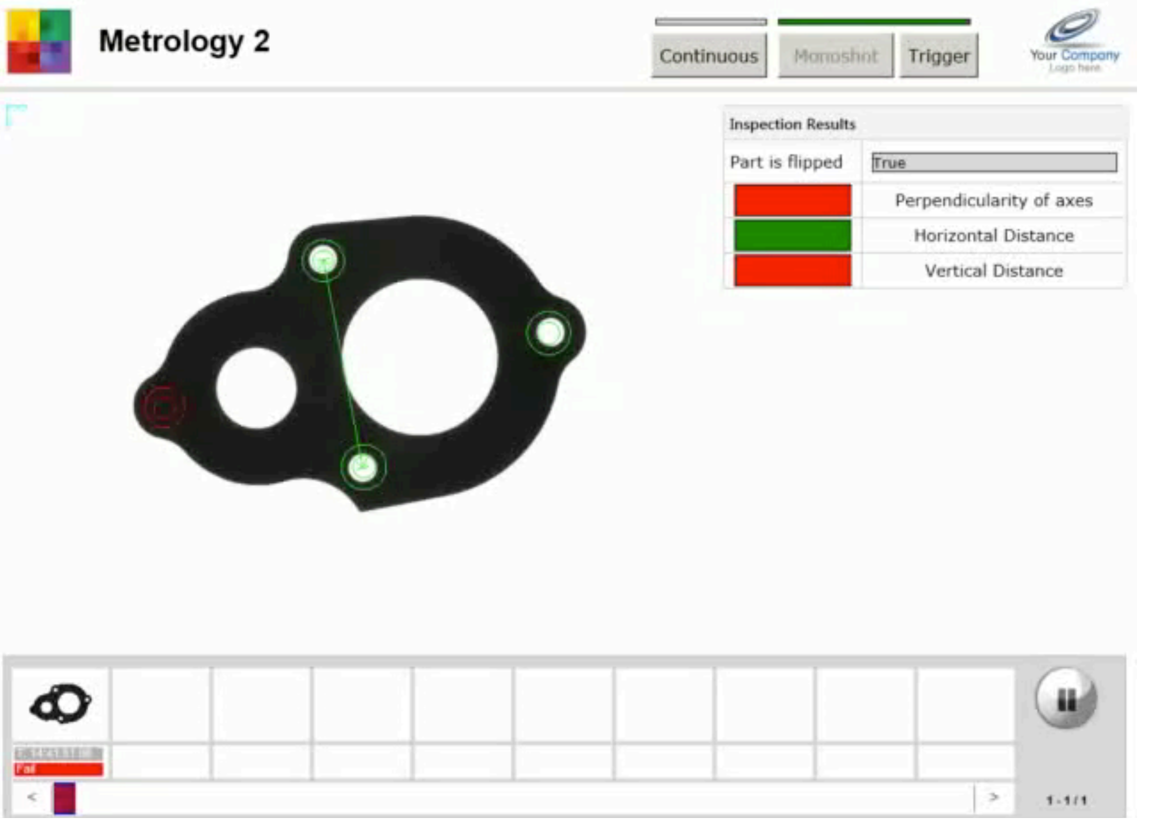
Disadvantages
- High cost
- Large footprint

… some application examples



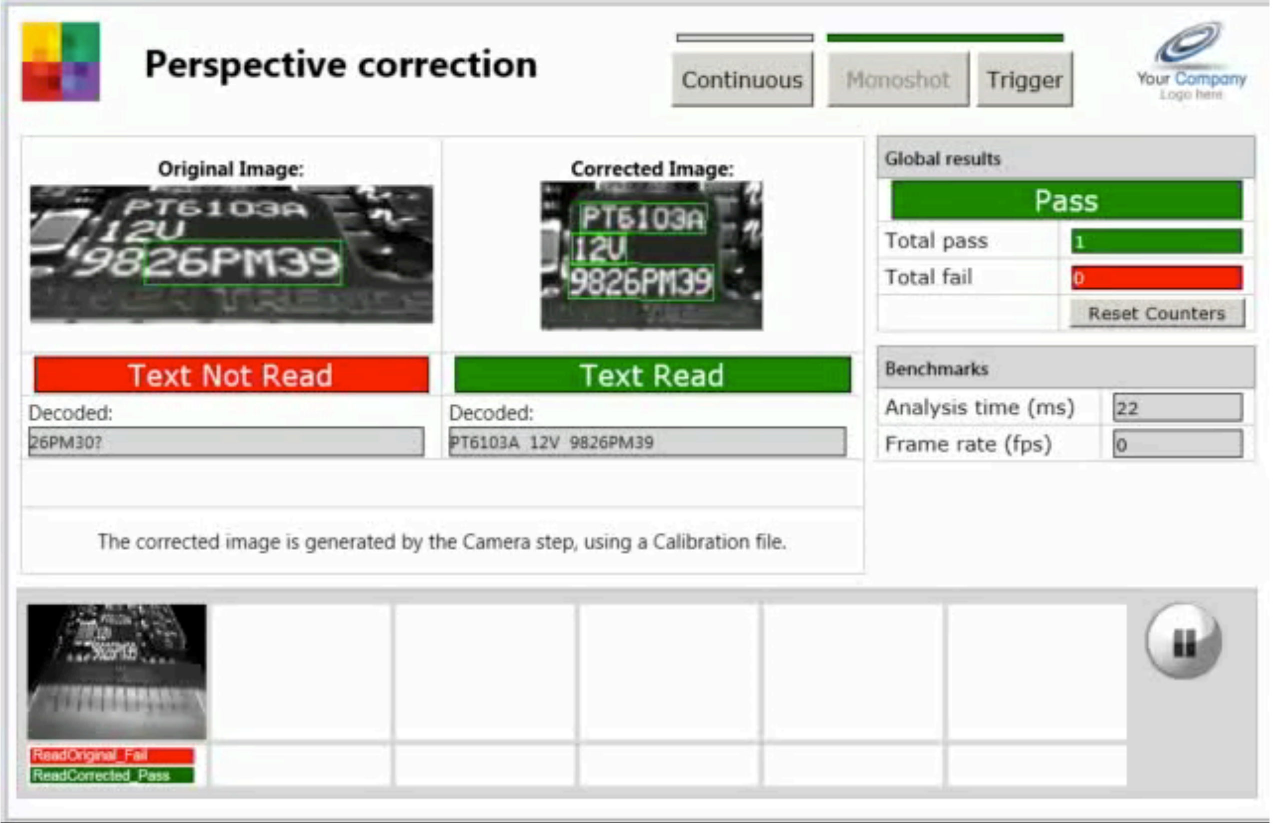
video

… some application examples



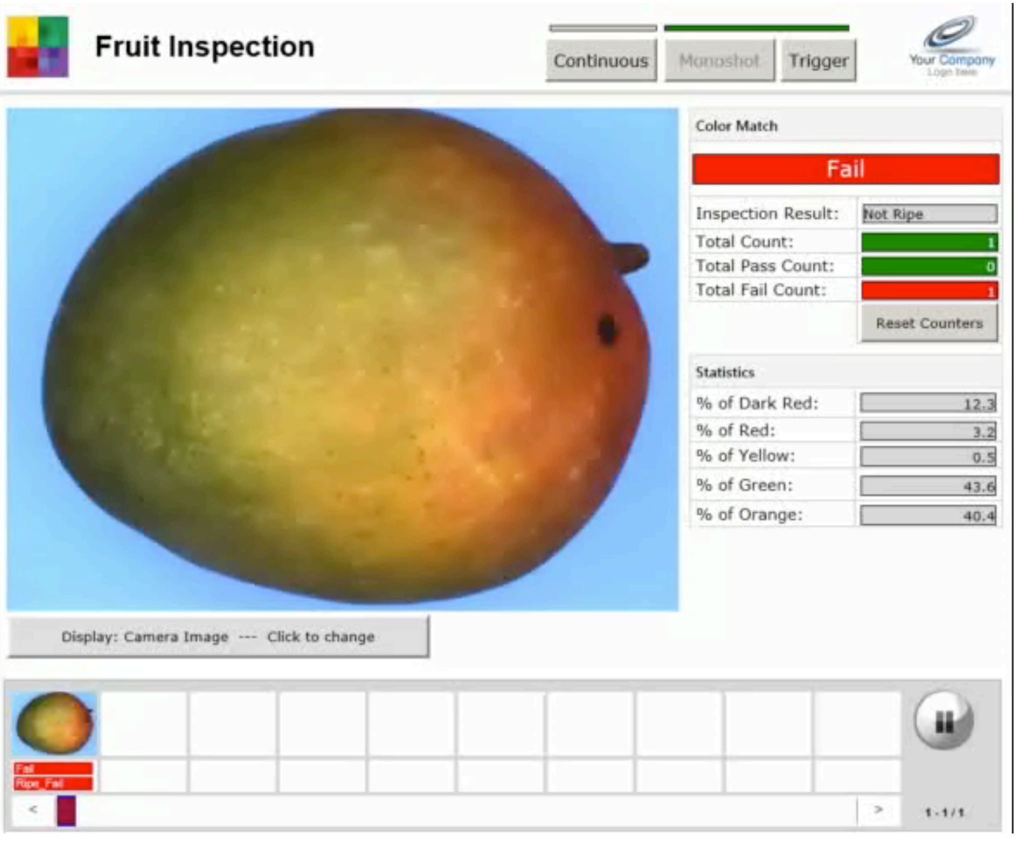
video

… some application examples



video

… some application examples



video

… some application examples imaging swir

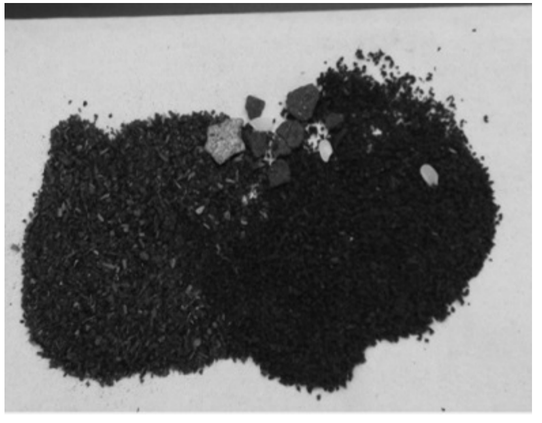
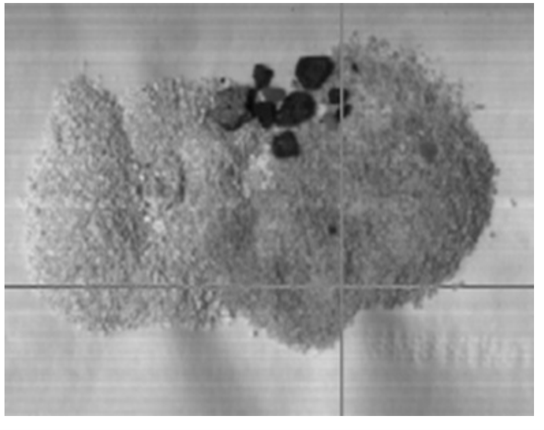
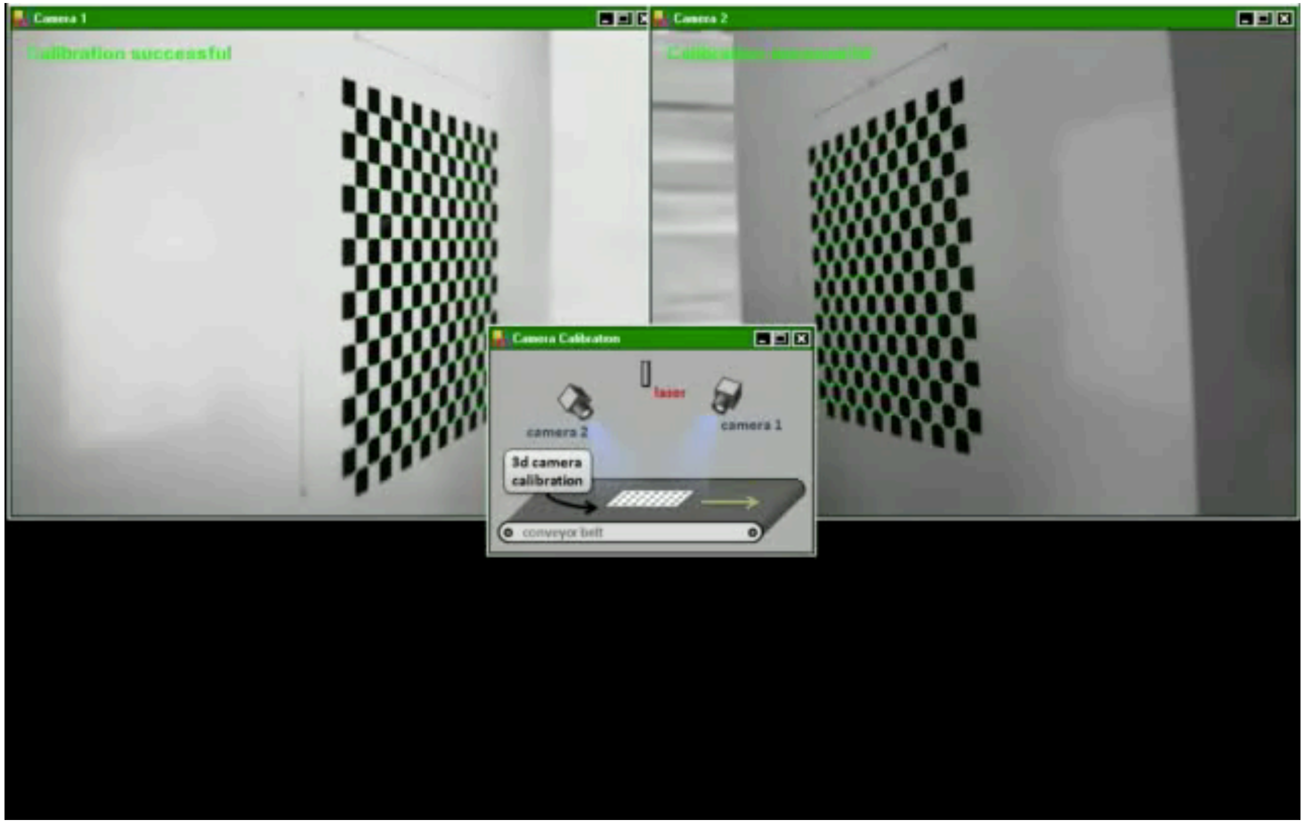


Image in the visible



Imaging SWIR

… some application examples



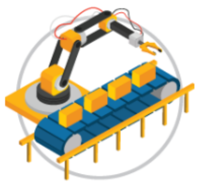
video

Target Markets


Automation


Automotive


Logistic

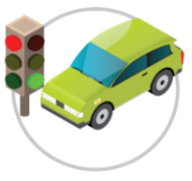

Packaging


Food & Beverage


Security


Medical


Sport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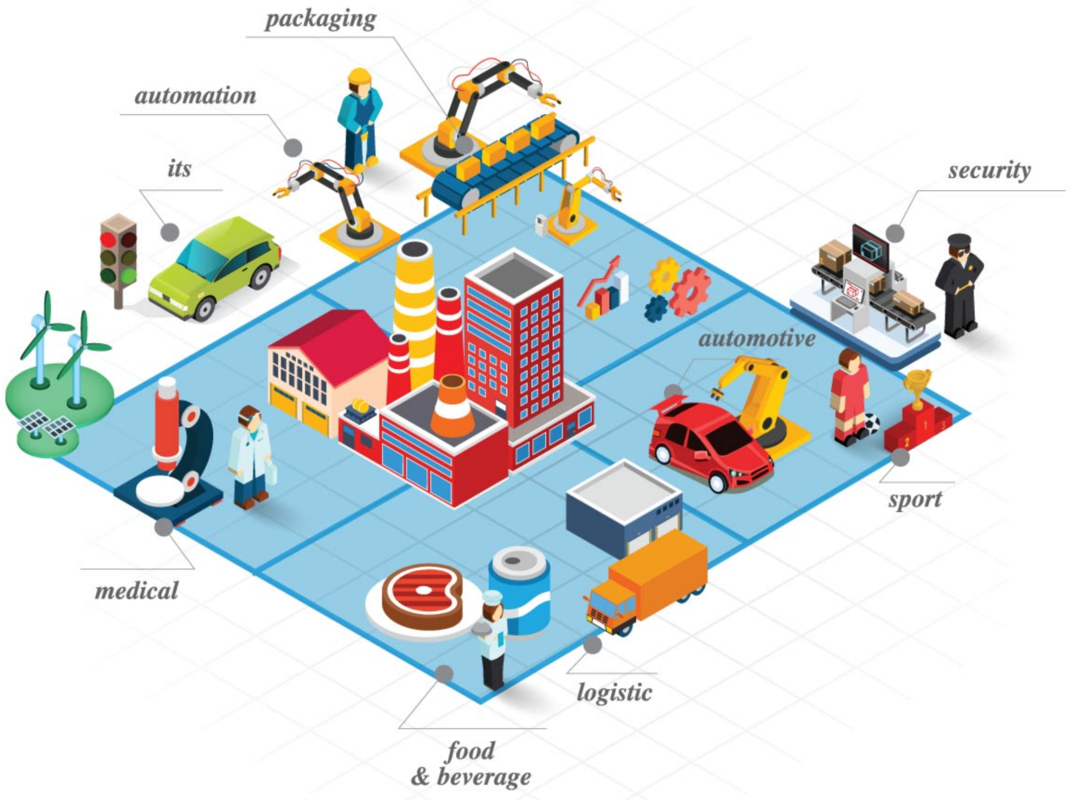


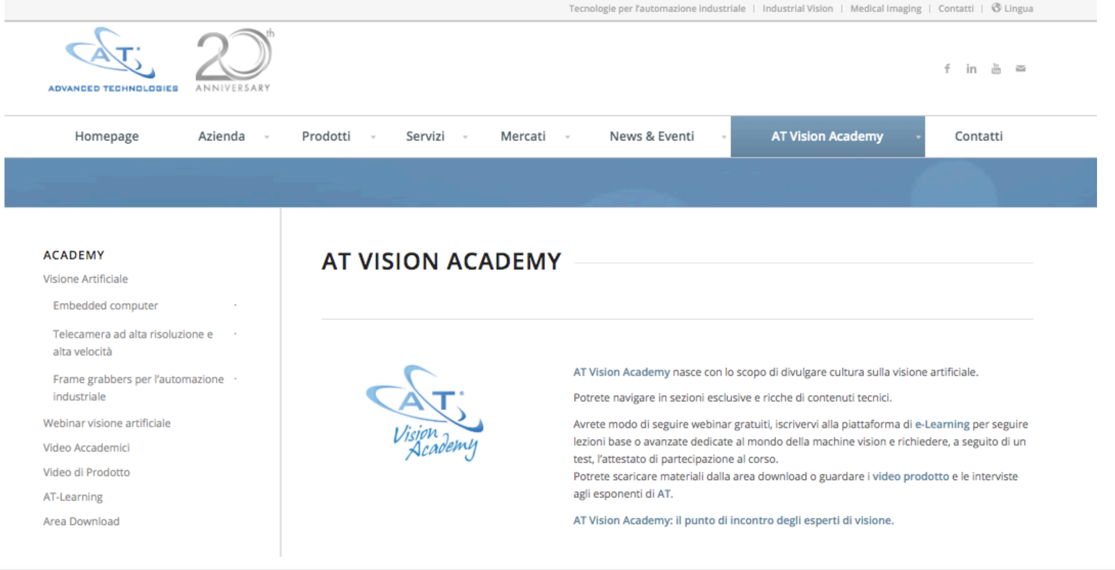
Making culture of the Artificial Vision

- The AT medium-term target is to become a reference point in the Artificial Vision market, spreading culture and skills inherent to the technology and techniques used in Machine Vision.

- We firmly believe that creating value and skills is the right way to bring our world closer to future Machine Vision engineers.

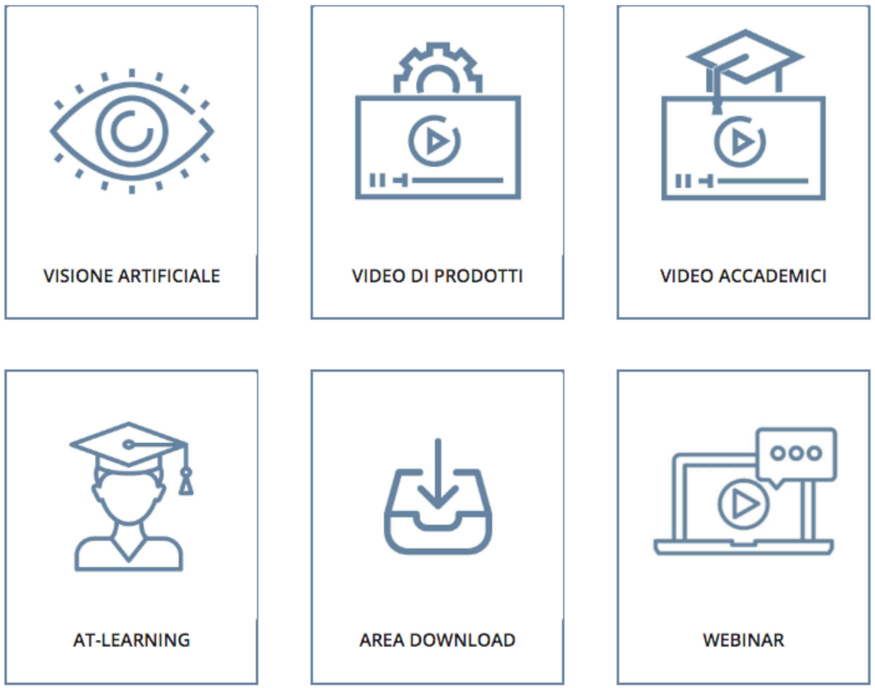
AT Vision Academy

- AT Vision Academy is a section of the www.adv-tech.it site dedicated to promote Artificial Vision contents



AT Vision Academy

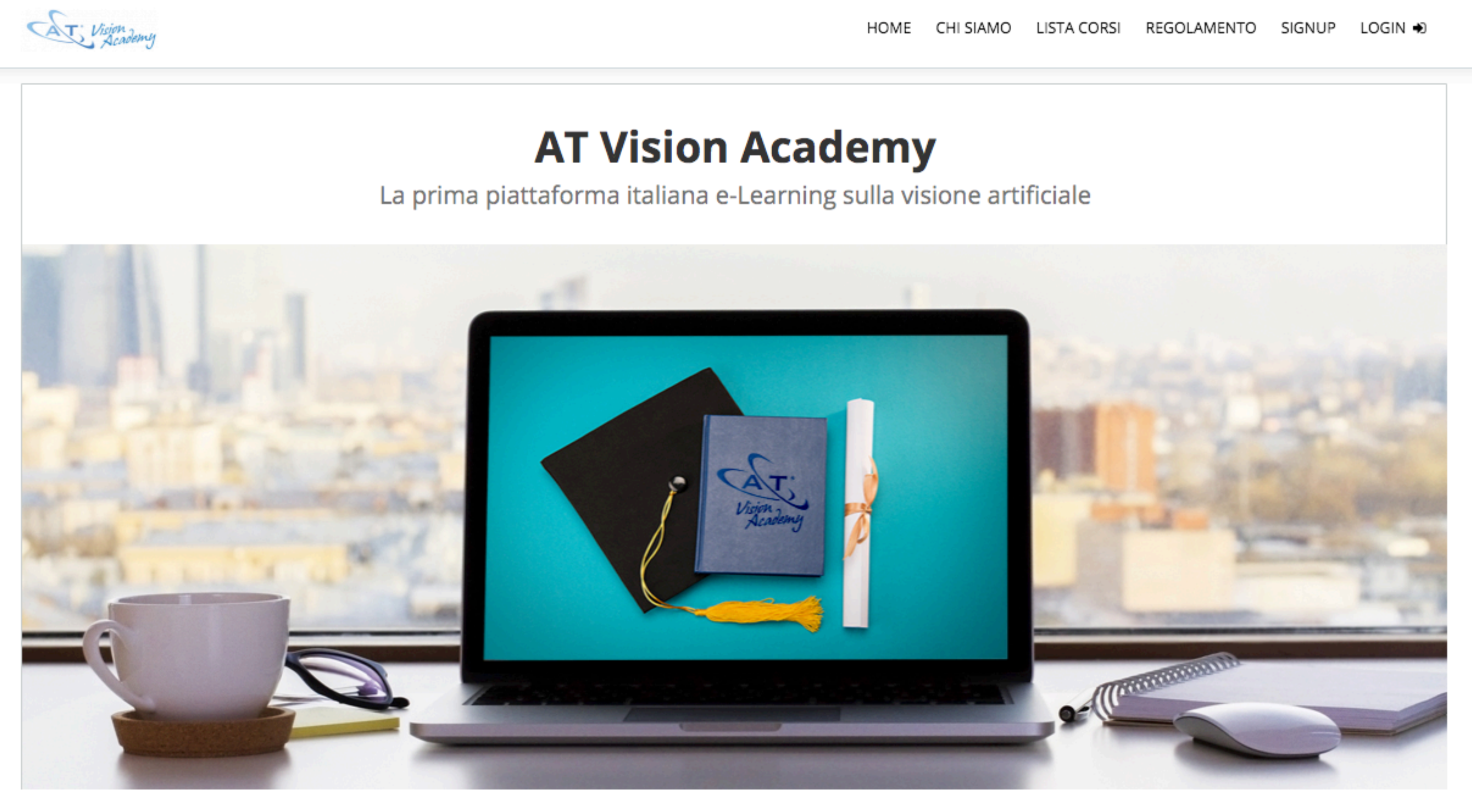
- Within AT Vision Academy you can access these sections:



AT-Learning

- The first Italian e-Learning platform dedicated to the Artificial Vision with basic, intermediate and advanced training about technologies, techniques and software used in Machine Vision
- At the end of each session you will have the opportunity to check your skill and you can have a test that allow you to get the training certificate.

AT-Learning


HOME
CHI SIAMO
LISTA CORSI
REGOLAMENTO
SIGNUP
LOGIN
AT Vision Academy
La prima piattaforma italiana e-Learning sulla visione artificiale

Conclusion…

An Industrial Vision professional
must develop transversal technical skills

Mathematics – Computer science – Electronics
– Optical Physics

If you are interested in a company internship write to: job@adv-tech.it

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