

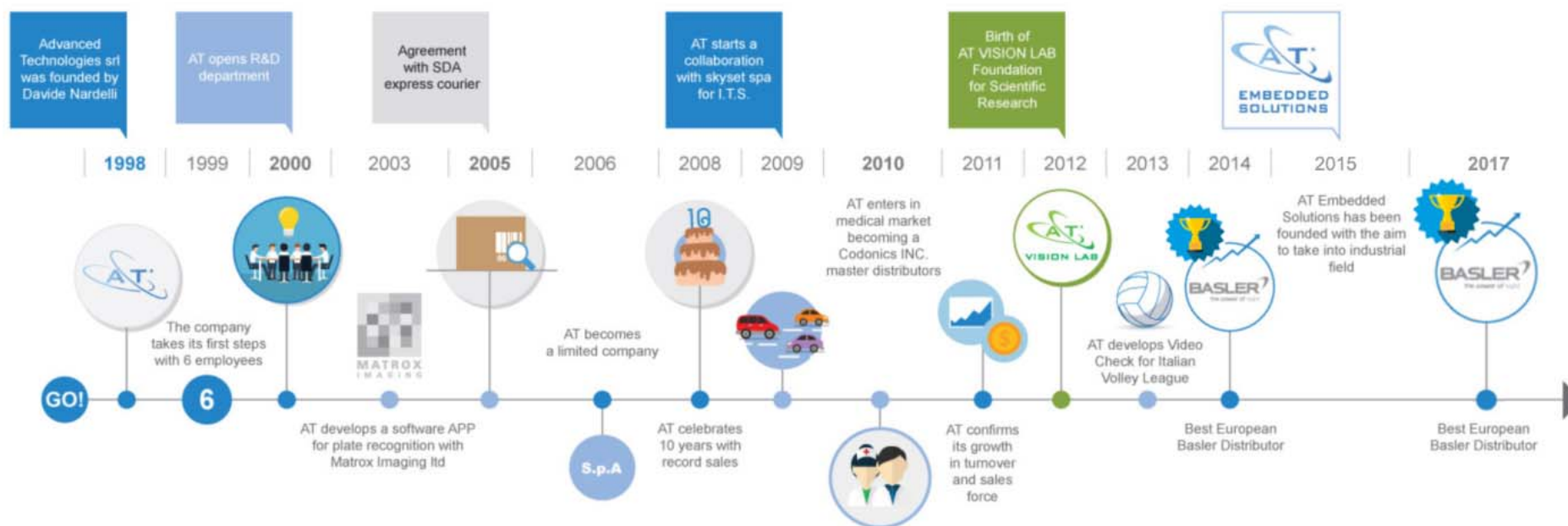


ADVANCED TECHNOLOGIES

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)

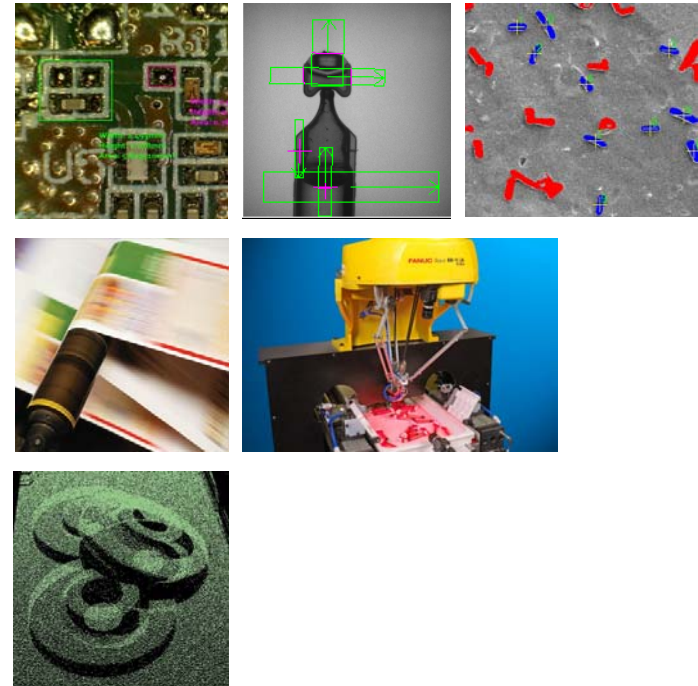
or

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

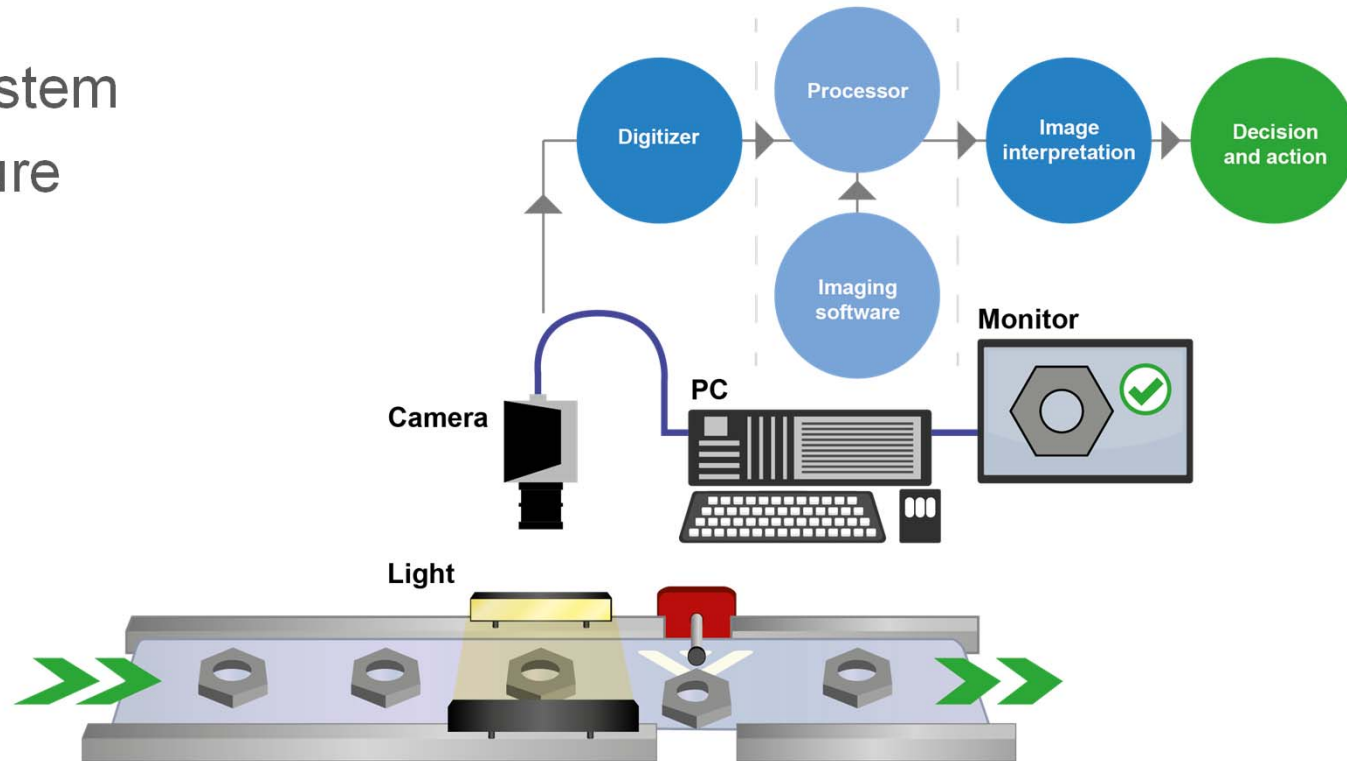
The brain of a vision system is mainly based on
[Image Processing algorithms.](#)

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






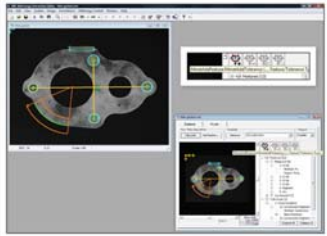
«Vision Components»

Smart Sensor



Designed to perform single functions, eg: Barcode reading, OCR

Vision Components

<p>Light</p> 	<p>Lens</p> 	<p>Camera</p> 
<p>Frame Grabber</p> 	<p>Computer</p> 	<p>Image Processing software</p> 

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: **eg measurement of an object with a precision of 0.1mm**
- 2. You must define the "field of View" where there is the object : **eg 100x50mm**
- 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: **eg. 200pcs / 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

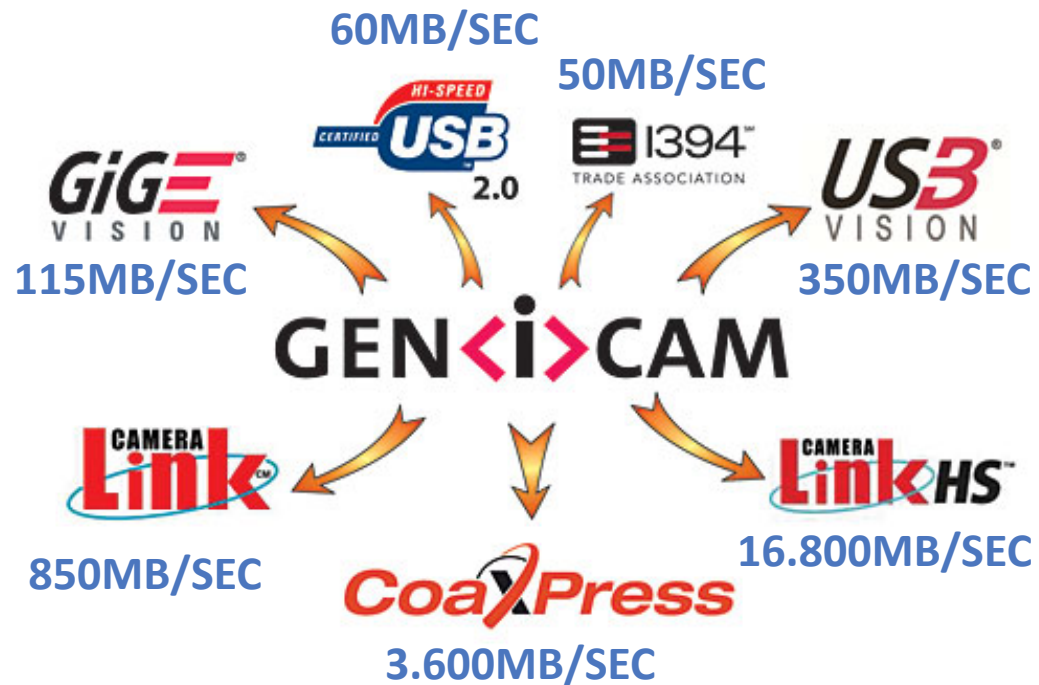
Resolution: 2000x1000 pixel equal to 2MP
Speed: 200FPS
Total Throughput: 400MB/sec

In this case the speed in "FPS" imposes the acquisition standard
GigE, USB3, CameraLink, CoaxExpress

Modello	Risoluzione HxV	Risoluzione	Sensore	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

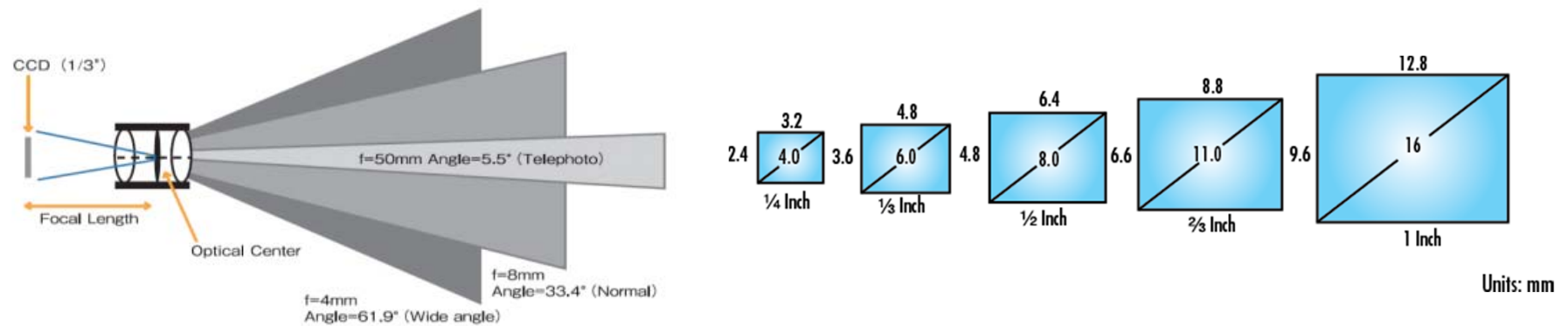
Bandwidth



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

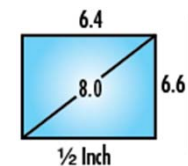
$$f = h \frac{D}{H}$$

h = the horizontal dimension of the sensor (eg sensor 1/2" = 6.4mm)

D = working distance (let's assume 188mm)

H = horizontal dimension of the working area (eg 100mm)

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



Design a vision system - 2D

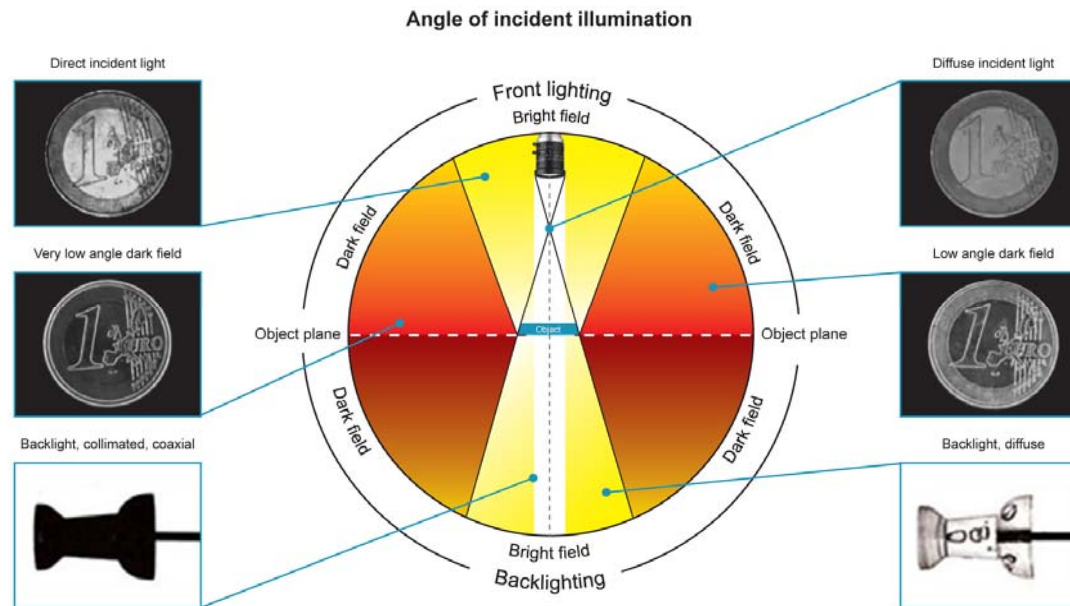
Step 3: Choosing the right lighting

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



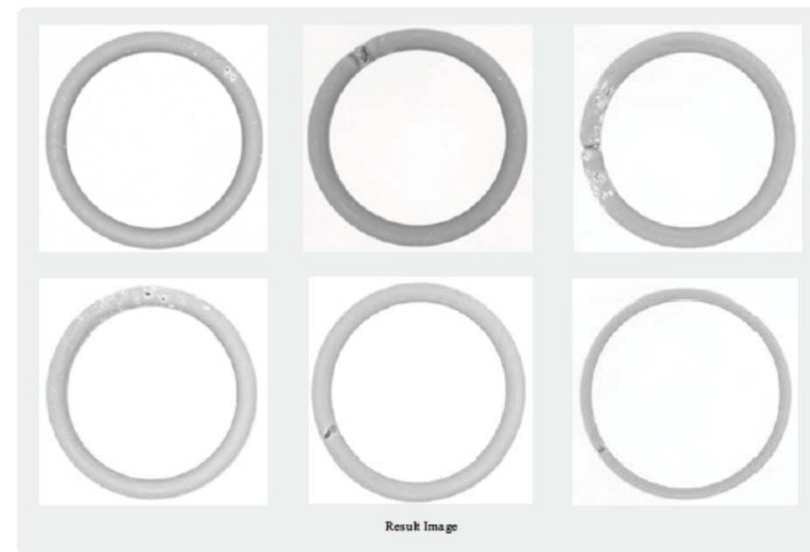
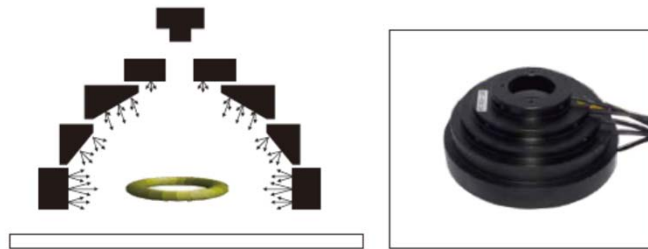
Design a vision system - 2D

Step 3: Choosing the right lighting

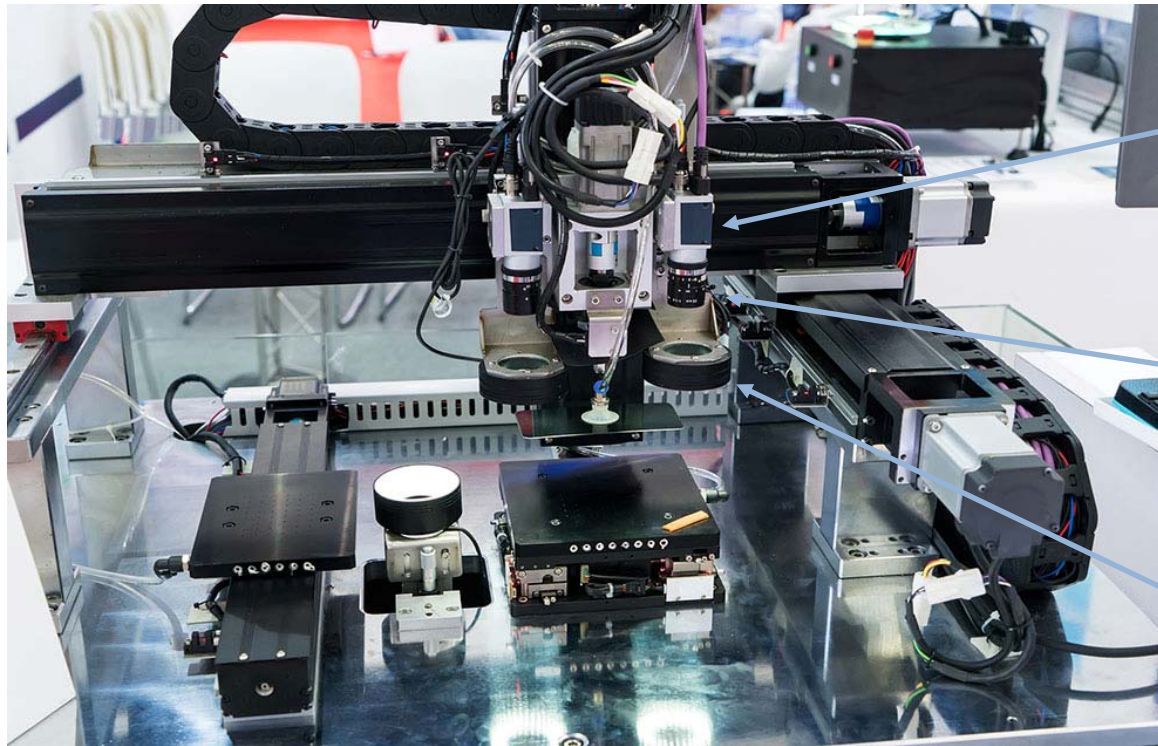


Design a vision system - 2D

Step 3: Choosing the right lighting



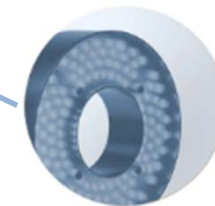
Industrial Vision Systems



Camera



Lens



Light

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 Modifica Cerca Visualizza Formato Linguaggio Configurazione Strumenti Macro Esegui Plugin Finestra 2 X
cm_20190507_181958.txt cm_20190507_180614.txt cm_20190507_175231.txt cm_20190507_173954.txt cm_20190507_172623.txt cm_20190507_172131.txt mdiggrab.cpp
1 /*****
2 */
3 * File name: MDigGrab.cpp
4 *
5 * Synopsis: This program demonstrates how to grab from a camera in
6 * continuous and monoshot mode.
7 */
8 #include <mil.h>
9
10 int MosMain(void)
11 {
12     MIL_ID MilApplication, /* Application identifier. */
13     MilSystem, /* System identifier. */
14     MilDisplay, /* Display identifier. */
15     MilDigitizer, /* Digitizer identifier. */
16     MilImage; /* Image buffer identifier. */
17
18     /* Allocate defaults. */
19     MappAllocDefault(M_DEFAULT, &MilApplication, &MilSystem,
20     &MilDisplay, &MilDigitizer, &MilImage);
21
22     /* Grab continuously. */
23     MdigGrabContinuous(MilDigitizer, MilImage);
24
25     /* When a key is pressed, halt. */
26     MosPrintf(MIL_TEXT("\nDIGITIZER ACQUISITION:\n"));
27     MosPrintf(MIL_TEXT("-----\n\n"));
28     MosPrintf(MIL_TEXT("Continuous image grab in progress.\n"));

```

C++ source file length: 1,721 lines: 54 Ln: 4 Col: 3 Sel: 0|0 Windows (CR LF) UTF-8 INS

Design a Vision System - 2D - Imaging Libraries

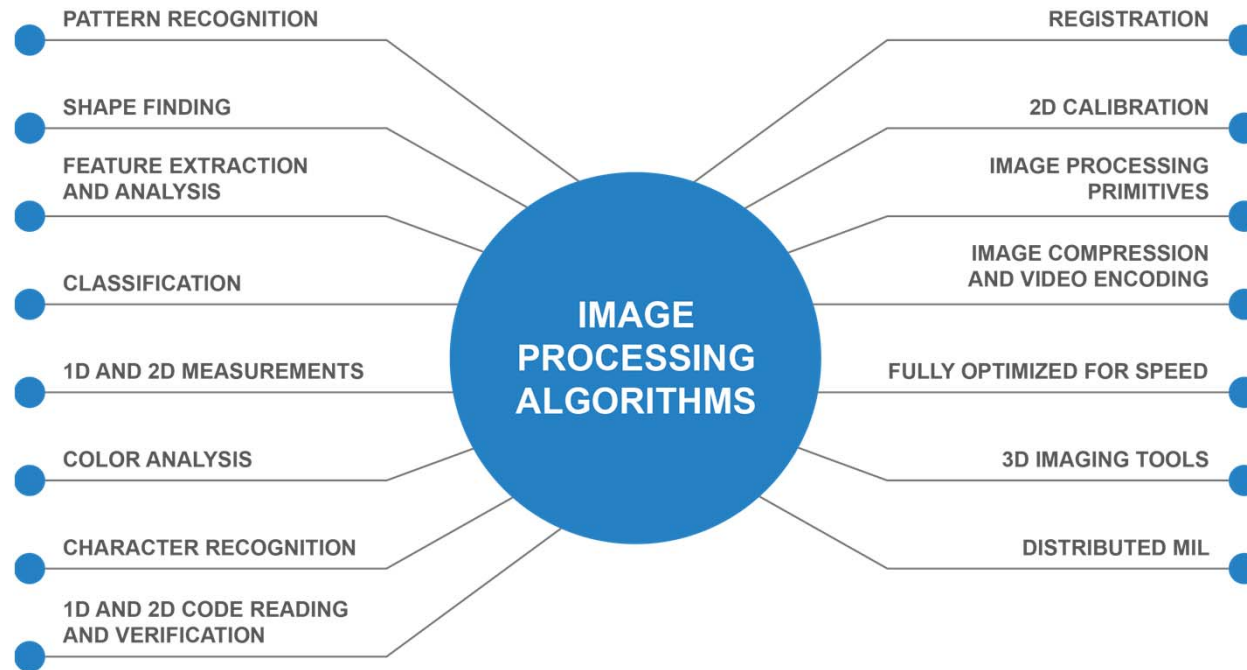
The screenshot displays a vision system software interface with the following components:

- Flowchart:** A logic flow starting with a 'Camera' step, followed by 'PatternMatching'. A decision diamond 'BottleLocated' leads to 'Feature', 'EdgeLocator', 'CapPlacement', 'CapPresent', and 'SealPresent' steps, which then converge to a 'Status' output.
- Image View:** A central window showing a camera image of a bottle cap with green bounding boxes around the cap's edges.
- Annotations Panel:** A list on the right side showing various detection steps like 'PatternMatching', 'Search regions', 'Model positions', 'Model boxes', 'Output coordinates', and 'Other step annotations'.
- Configuration Panel:** A section for 'PatternMatching' with 'General parameters' (Image: Camera Image, Uniform size: False, Master model: None) and 'Models' (Model1, Model2).
- Results Table:** A table at the bottom right showing detection results for Model1 and Model2.

Model	Occurrence Index	Score	X	Y	Angle	Execution Time
Model1	1	92.6515	149.644	292.607	0	0.000811629 s
Model2	1	97.1606	470.451	312.615	0	
Total found: 2						
Model1	1	91.8888	221.243	299.077	0	0.000795437 s
Model2	1	99.8761	519.512	305.642	0	
Total found: 2						
Model1	1	99.6099	172.488	308.36	0	0.000727934 s
Model2	1	94.3082	492.56	297.7	0	
Total found: 2						
Model1	1	90.8017	164.781	295.087	0	0.000753988 s
Model2	1	95.9918	475.207	294.951	0	
Total found: 2						
Model1	1	92.968	187.178	295.576	0	0.000707445 s
Model2	1	91.1958	479.017	304.927	0	
Total found: 2						

Design a Vision System - 2D

Step 4: Definition of Image Processing Algorithms



Design a Vision System - 2D

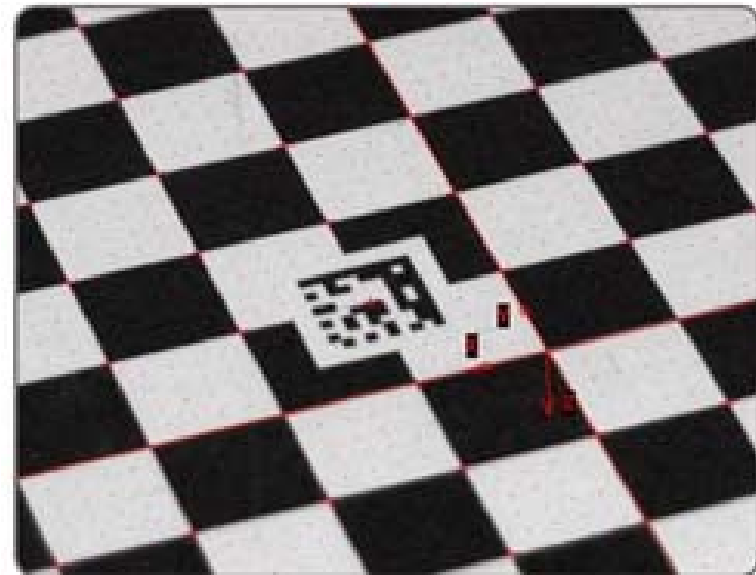
Definition of Image Processing Algorithms

- **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

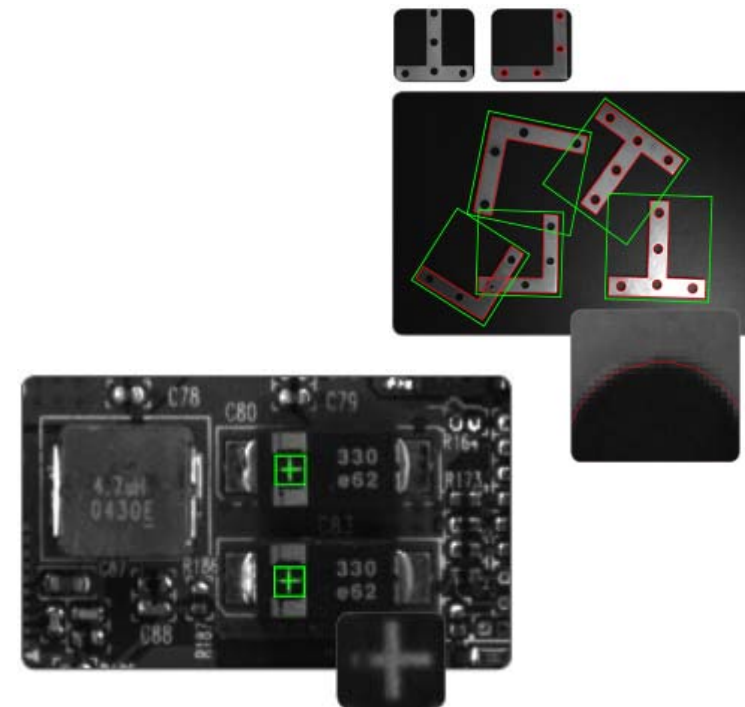
Definition of Image Processing Algorithms

- **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

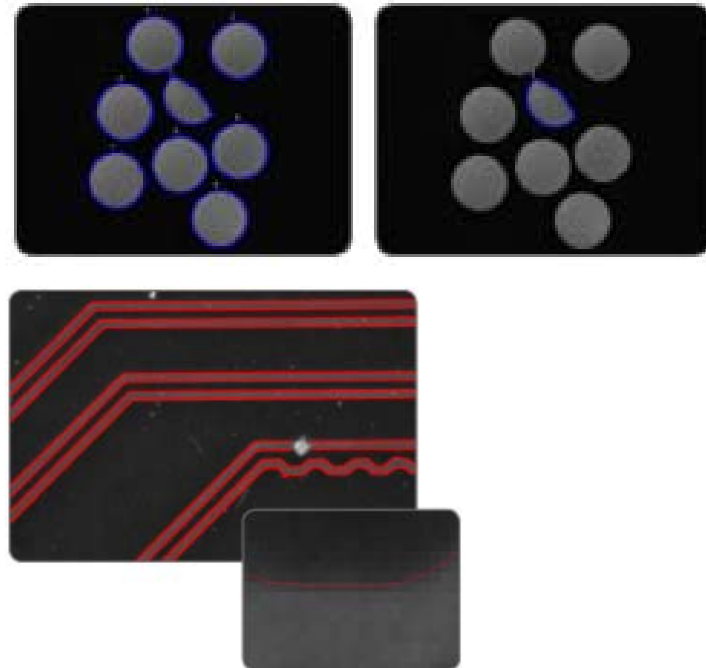
Definition of Image Processing Algorithms

- **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 **USB VISION** **GiGE VISION**
- 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 **USB** **GiGE**
VISION VISION
- Supports 6/8 cameras
- FanLess
- Expandable with FrameGrabber or GPU

Disadvantages

- Average CPU performances

Design a Vision System

Fase 5: Scelta dell'Hardware di acquisizione/elaborazione PC Server



Four Clusters with:
- One FPGA (Matrox Radiant 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

Bottle Inspection

Continuous

Monoshot

Trigger

Global results

Pass

Bottle located	Bottle Located
Cap verification	Cap OK
Seal verification	Seal OK

Benchmarks

Analysis time (ms)

11-18-19-30-22

Fail

11-18-19-30-23

Pass

11-18-19-30-23

Fail

11-18-19-30-24

Pass

11-18-19-30-24

Pass

11-18-19-30-25

Fail

11-18-19-30-25

Pass

11-18-19-30-26

Pass

11-18-19-30-26

Fail

11-18-19-30-27

Pass

1 - 40 / 300






... some application examples

Metrology 2

Continuous Monoshot Trigger

Your Company
Logo here

Inspection Results	
Part is flipped	<input checked="" type="checkbox"/>
	Perpendicularity of axes
	Horizontal Distance
	Vertical Distance

1-1/1

... some application examples

Perspective correction

Your Company
Logo here

Original Image:

Corrected Image:

Global results

Pass

Total pass	1
Total fail	0

Text Not Read

Decoded:

26PM30?

Text Read

Decoded:

PT6103A 12V 9826PM39

The corrected image is generated by the Camera step, using a Calibration file.

Benchmarks

Analysis time (ms)	22
Frame rate (fps)	0

ReadOriginal Fail

ReadCorrected Pass

... some application examples

Fruit Inspection

Continuous
Monoshot
Trigger

Your Company
Logo here

Color Match

Fail

Inspection Result: Not Ripe

Total Count: 1

Total Pass Count: 0

Total Fail Count: 1

Reset Counters

Display: Camera Image --- Click to change

--	--	--	--	--	--	--	--	--	--

Fail
Ripe Fail

--	--	--	--	--	--	--	--	--	--

<
>
1 - 1 / 1

... some application examples imaging swir

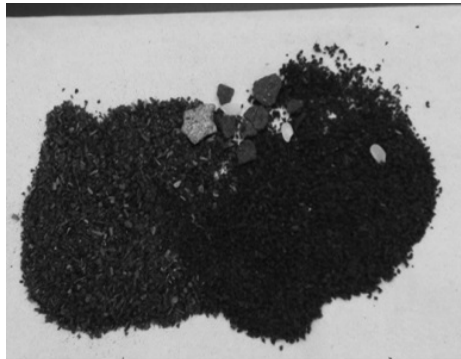
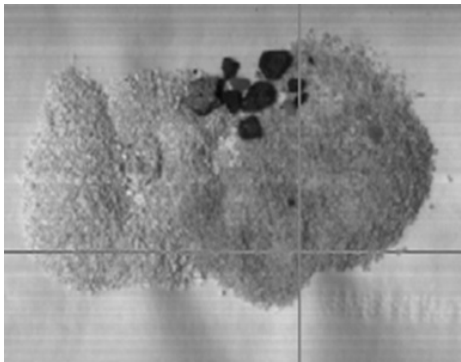
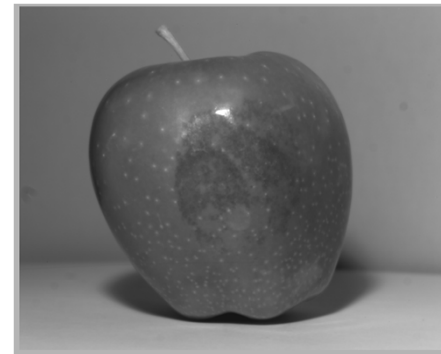


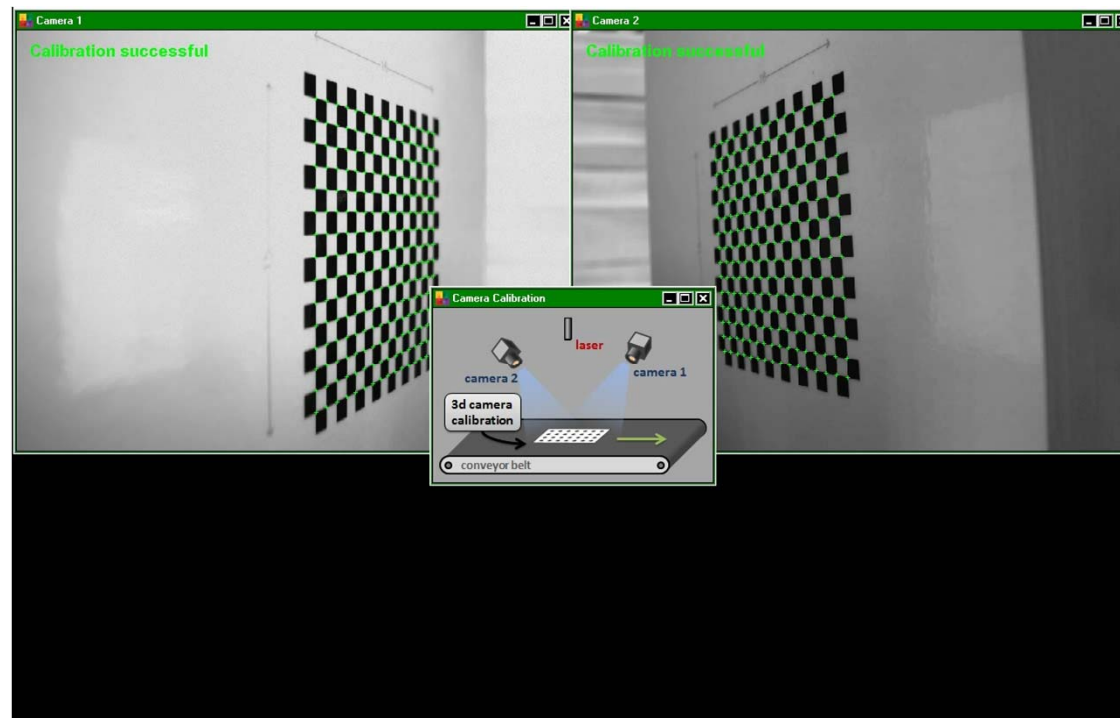
Image in the visible



Imaging SWIR



... some application examples



Target Markets



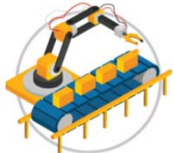
Automation



Automotive



Logistic



Packaging



Food & Beverage



Security



Medical



Sport



ITS



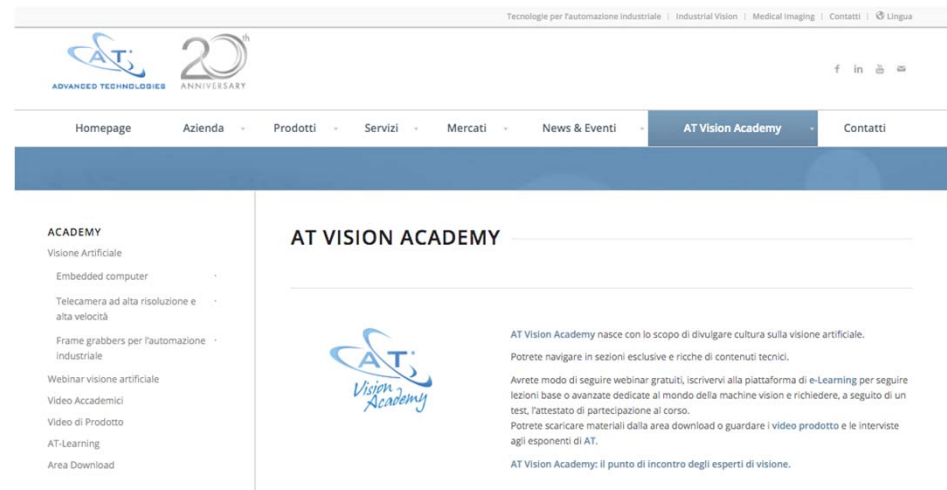


Making culture of the Artificial Vision

- 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.

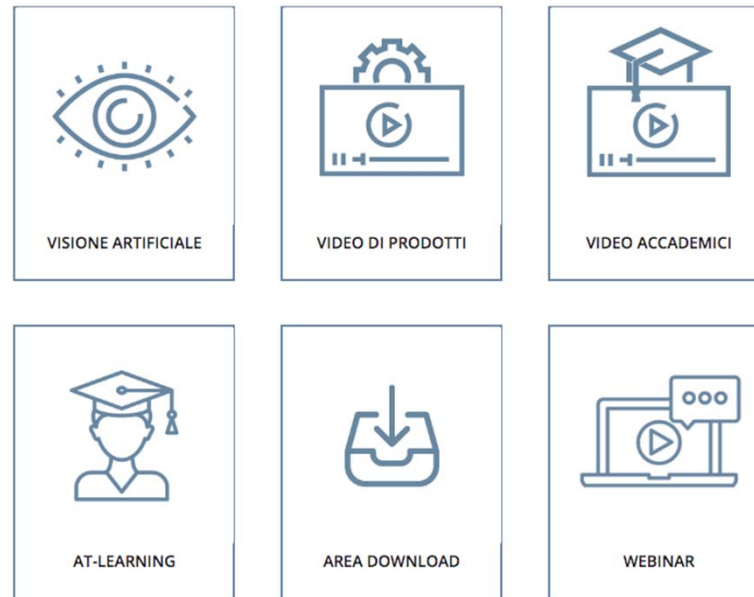
AT Vision Academy

- 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



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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



Sistemi di Visione



Sistemi di Visione



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