

# Robotics Training Day 5

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# Lecture assignment - Fill the blanks

- Download the assignment: [https://oysamk-my.sharepoint.com/:b:/g/personal/mirka\\_leino\\_samk\\_fi/EZPBTQE5RbpLkaWTmAn8dbIBI9b8ySLiirxPBq0gTydeow?e=Y0I28n](https://oysamk-my.sharepoint.com/:b:/g/personal/mirka_leino_samk_fi/EZPBTQE5RbpLkaWTmAn8dbIBI9b8ySLiirxPBq0gTydeow?e=Y0I28n)
- Follow the webinar on Sensor integration in smart manufacturing robots and fill the blanks in the text
- 18 blanks to be filled
- The check and the correct answers are reviewed at the end of the webinar

# Sensor integration in smart manufacturing robots

# Safe robots rely on sensors

Traditional industrial robots:

- Own workspace
- Exact program
- Working blindly

New, safe robots rely on sensors:

- Vision
- Torque/force detection
- Position ensuring



# Sensor technologies used in robots

- Torque sensors
- Proximity sensors
- Position sensors
- Sensor arrays
- Vision systems
- Lidar sensors



A position sensor from ABB

# Sensors in industrial robots

With (smart) sensor technology industrial robots are more flexible than traditional industrial robots.

They can:

- choose paths
- perceive changes
- make judgments



# Force/torque sensors

- Robot's sense of touch
- Usually located between robot and tool / object
- Also integrated torque sensors
- Gives robot the possibility to feel the correct point
- The robot can turn the screw or bolt to just the right torque



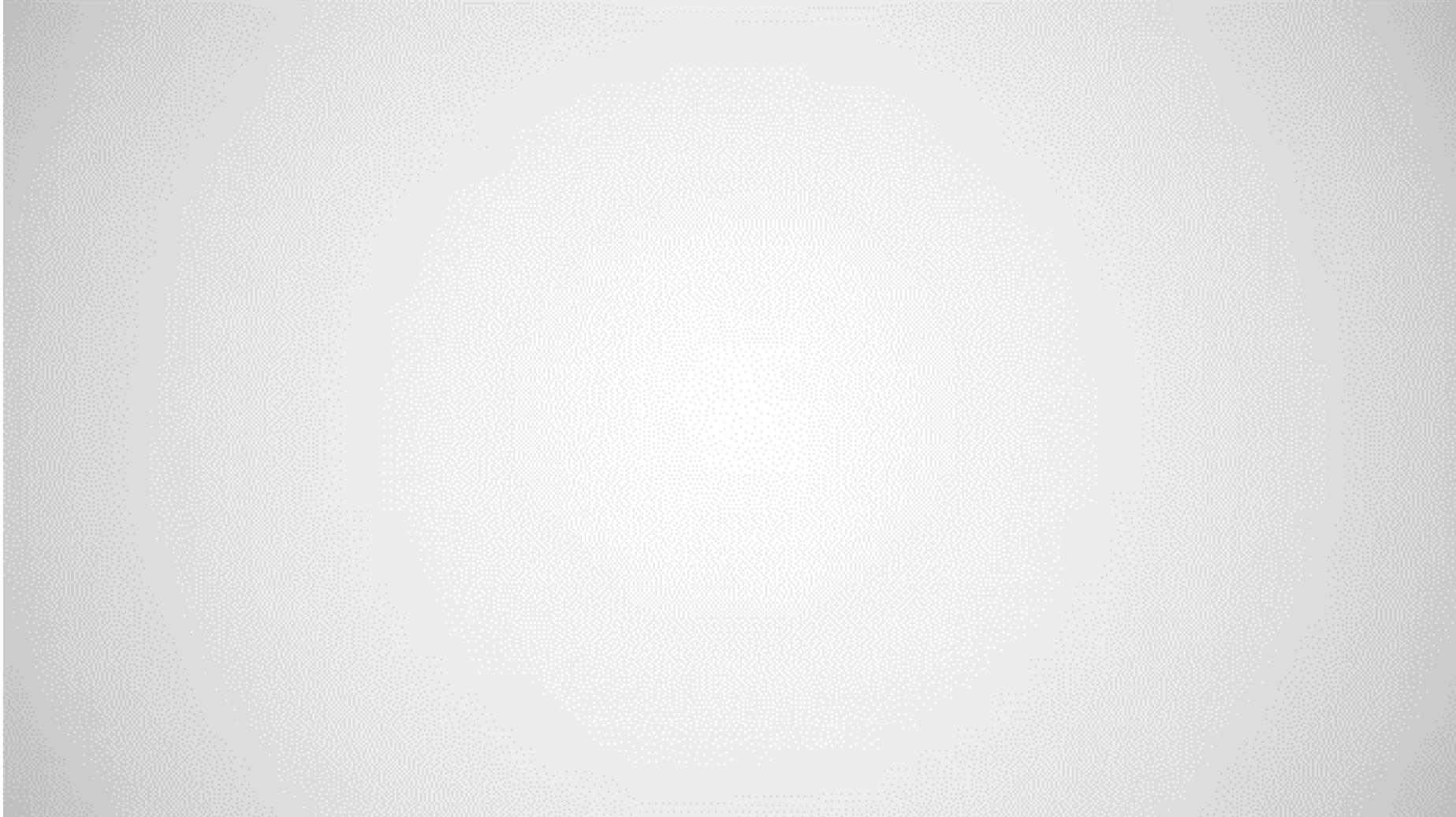
# Force/torque sensors

- Can be purchased as an accessory
- For example, Robotiq's FT 300 force sensor can be purchased as an accessory for various co-operation robots



Picture: Robotiq

# Torque sensor



<https://youtu.be/H8zni6Mkra0>

# Collision detection sensors

- Not a specific sensor
- Different sensor can be used for collision detection
  - Vision
  - Force / torque
  - Accelerometer
  - Capacitive
  - Tactile pressure recognition
  - Current feedback measurement

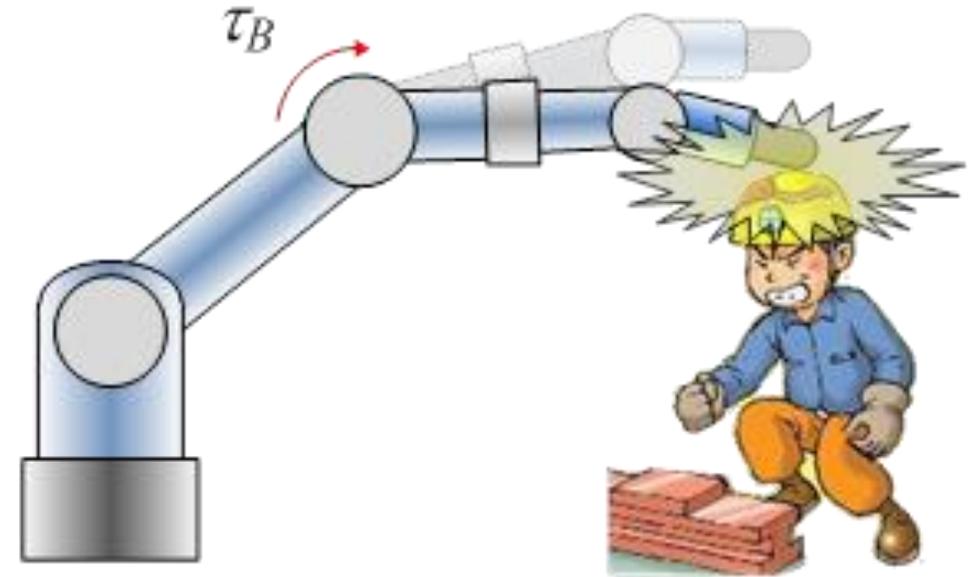


Image: <https://sites.google.com/a/webmail.korea.ac.kr/intelligent-robot-laboratory/manipulation/collision-safety>

# Vision: 2D or 3D cameras

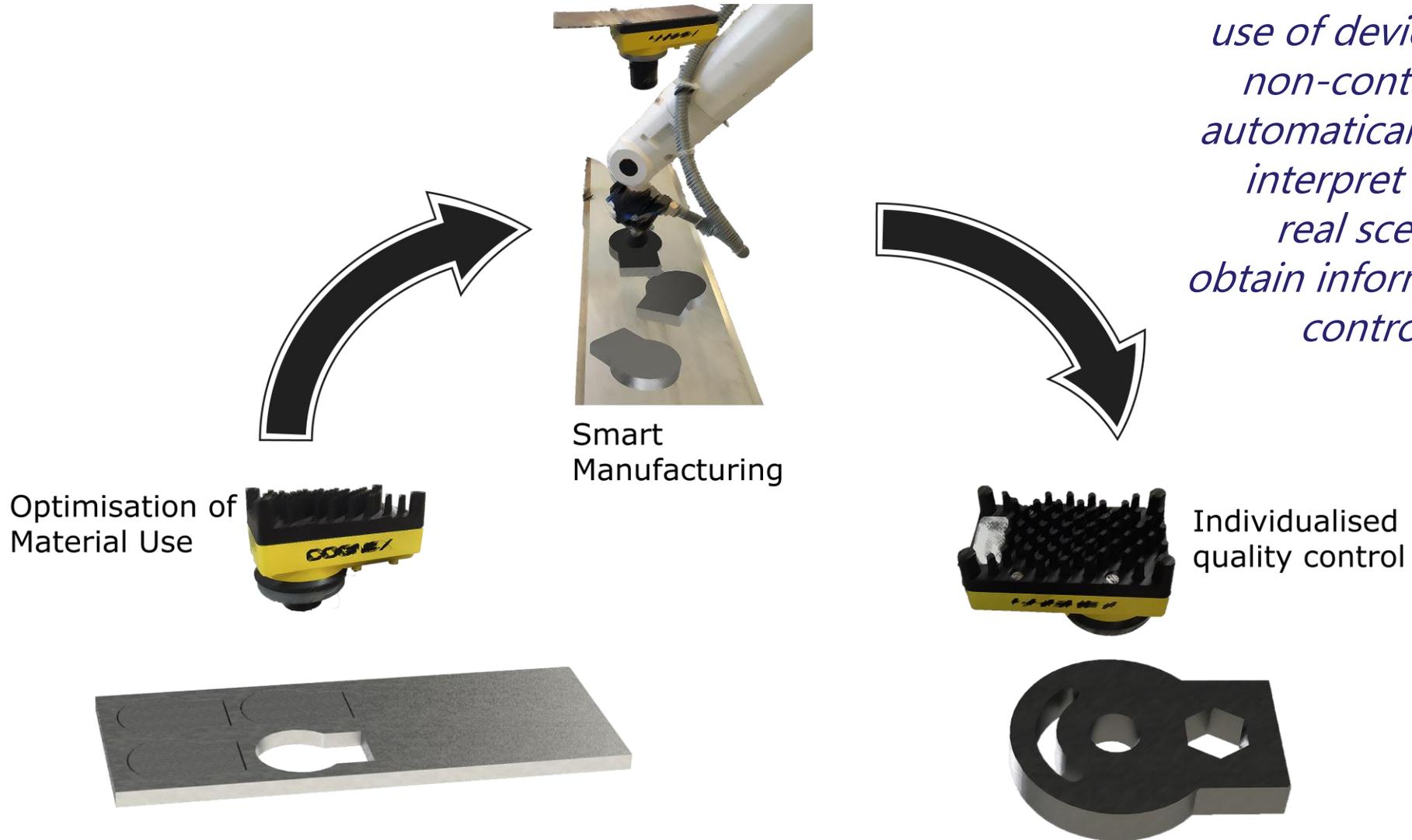
- Sight to the robot
- Location
- Quality inspection
- Sorting



# Machine vision



# Machine vision definiton

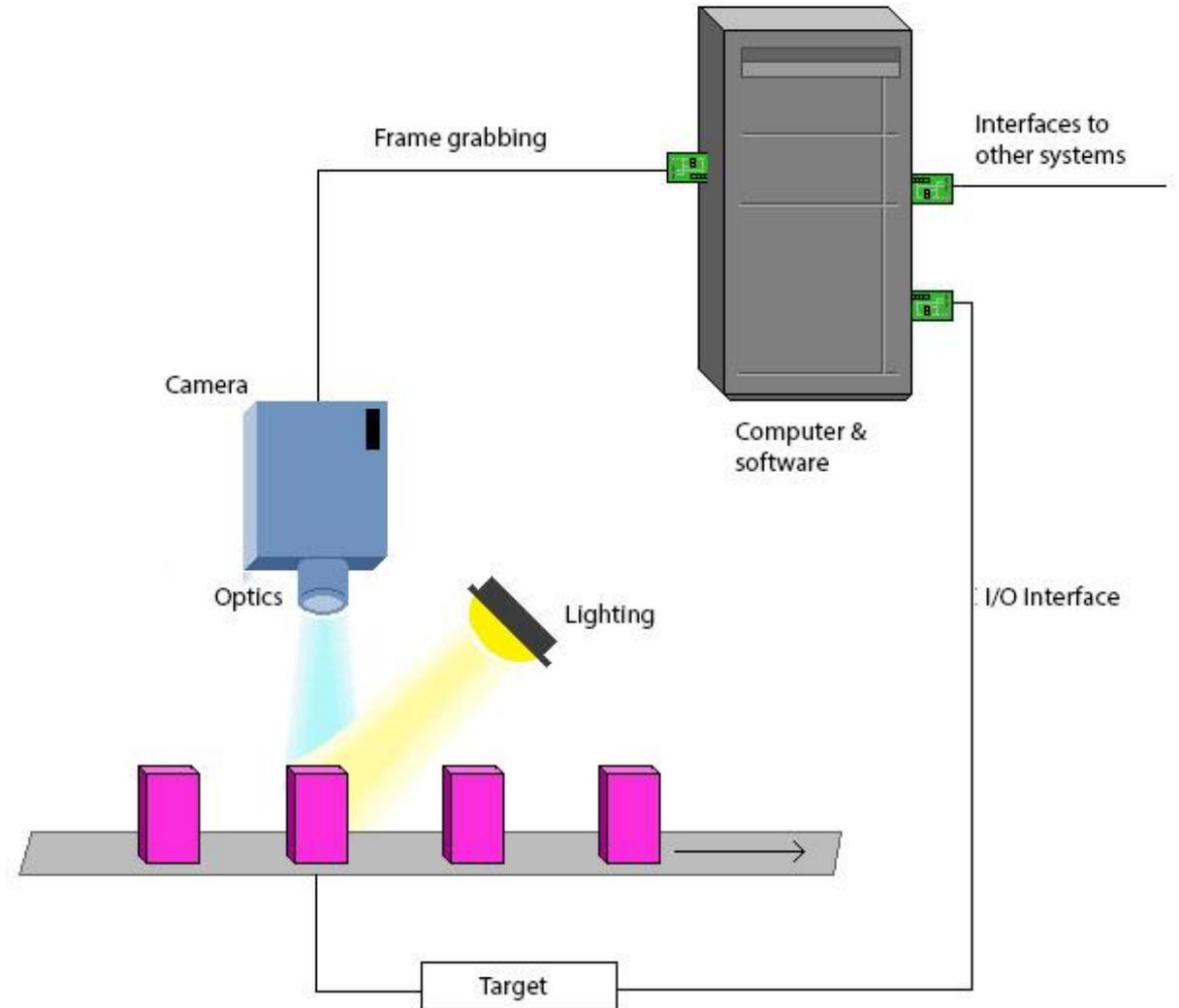


*Machine vision means the use of devices for optical non-contact sensing to automatically receive and interpret an image of a real scene in order to obtain information and/or control machines or processes.*

# Applying Machine Vision in visible light wavelengths

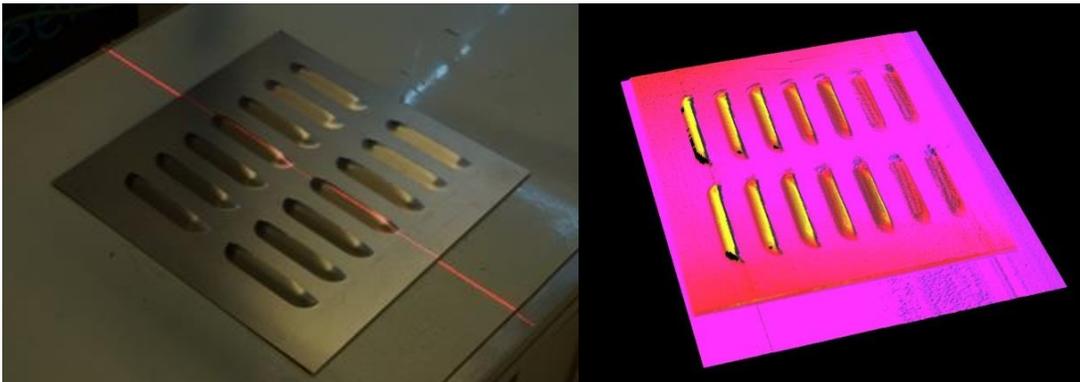
Traditional machine vision systems and smart camera solutions for product

- **Identification**
- **Measuring**
- **Sorting**
- **Robot guidance**



# 3D Imaging

- Shape inspection
- Volume measurement
- Control object slicing to same sizes
- Control robot bin picking or pick and place operations

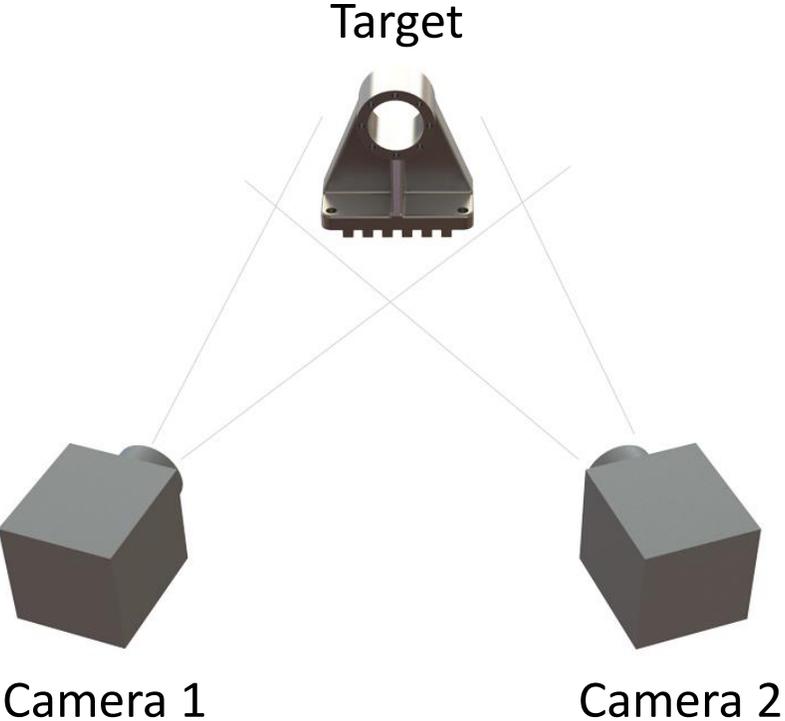


# 3D Imaging technologies

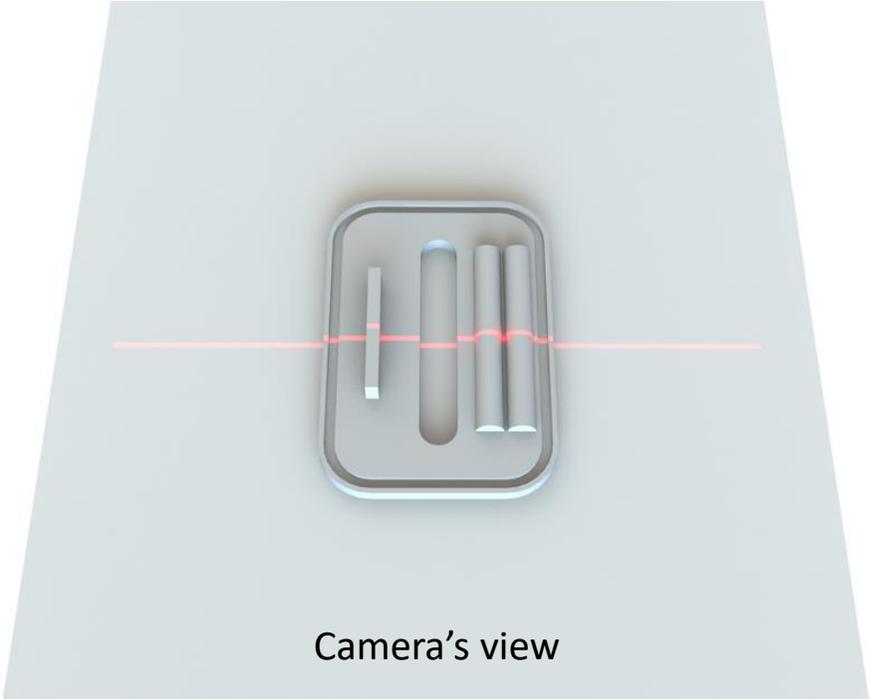
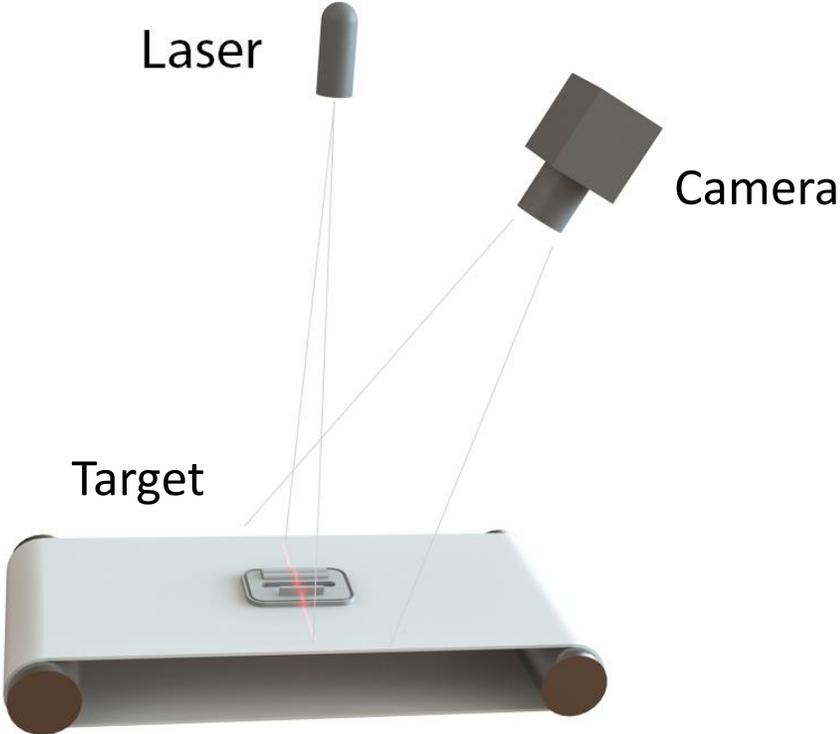
- The goal is to get a three-dimensional model of some existing, physical object
- There are many different imaging methods and each has its own pros and cons
- The main technologies are:
  - Stereo imaging
  - Techniques based on structural lighting
  - Time of Flight (ToF)



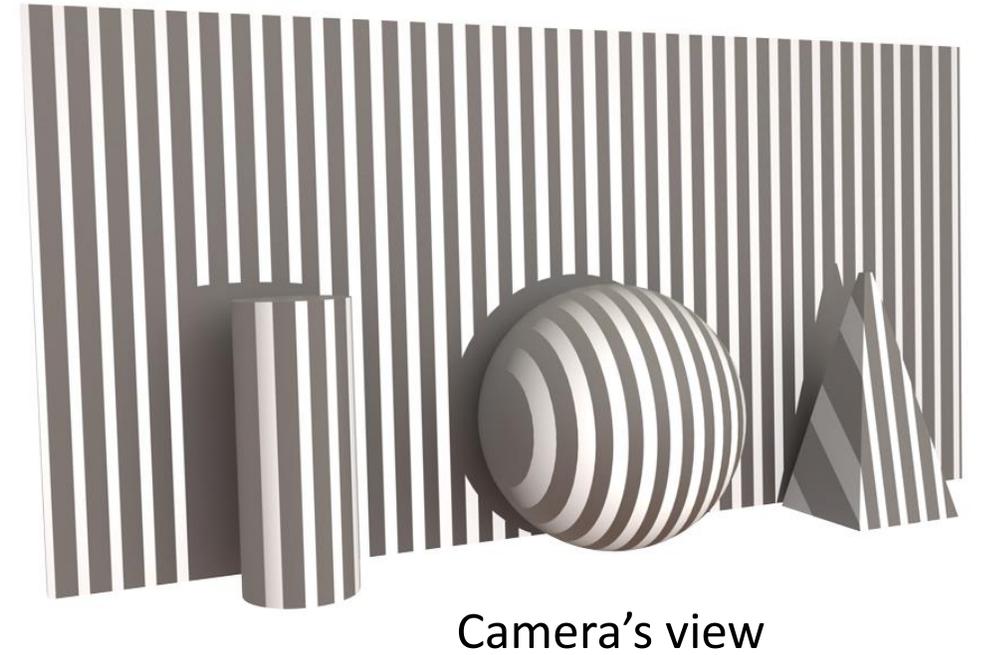
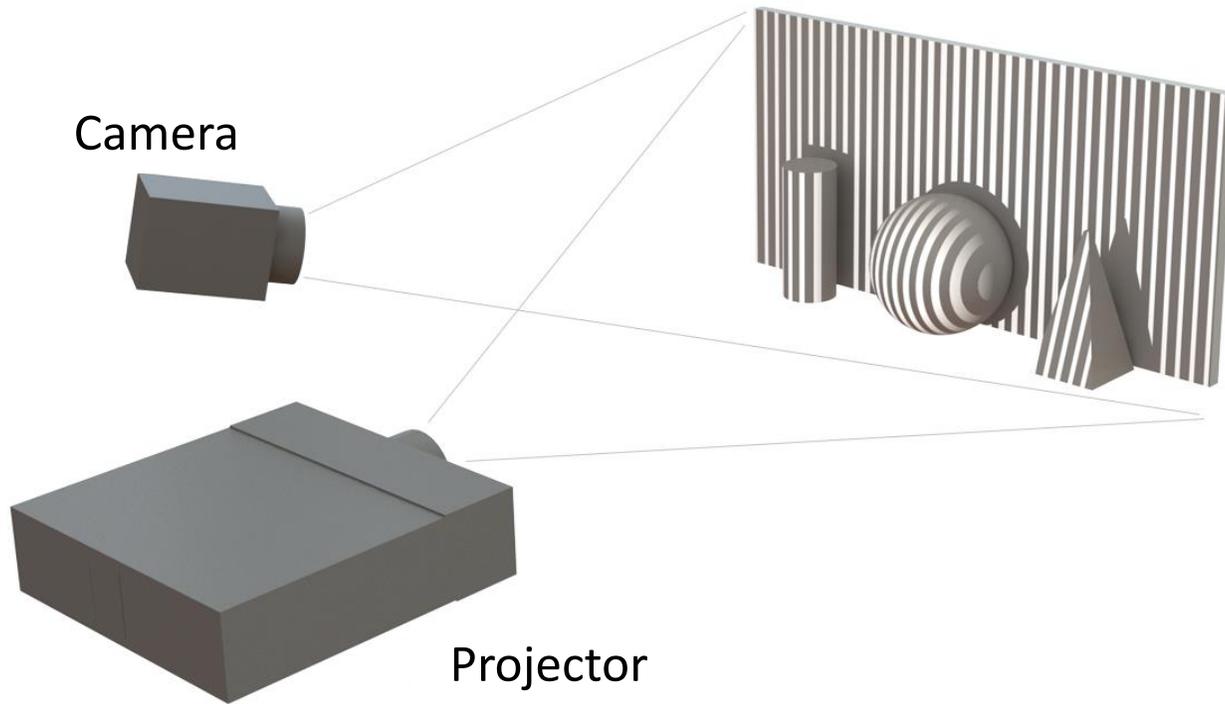
# Stereo imaging



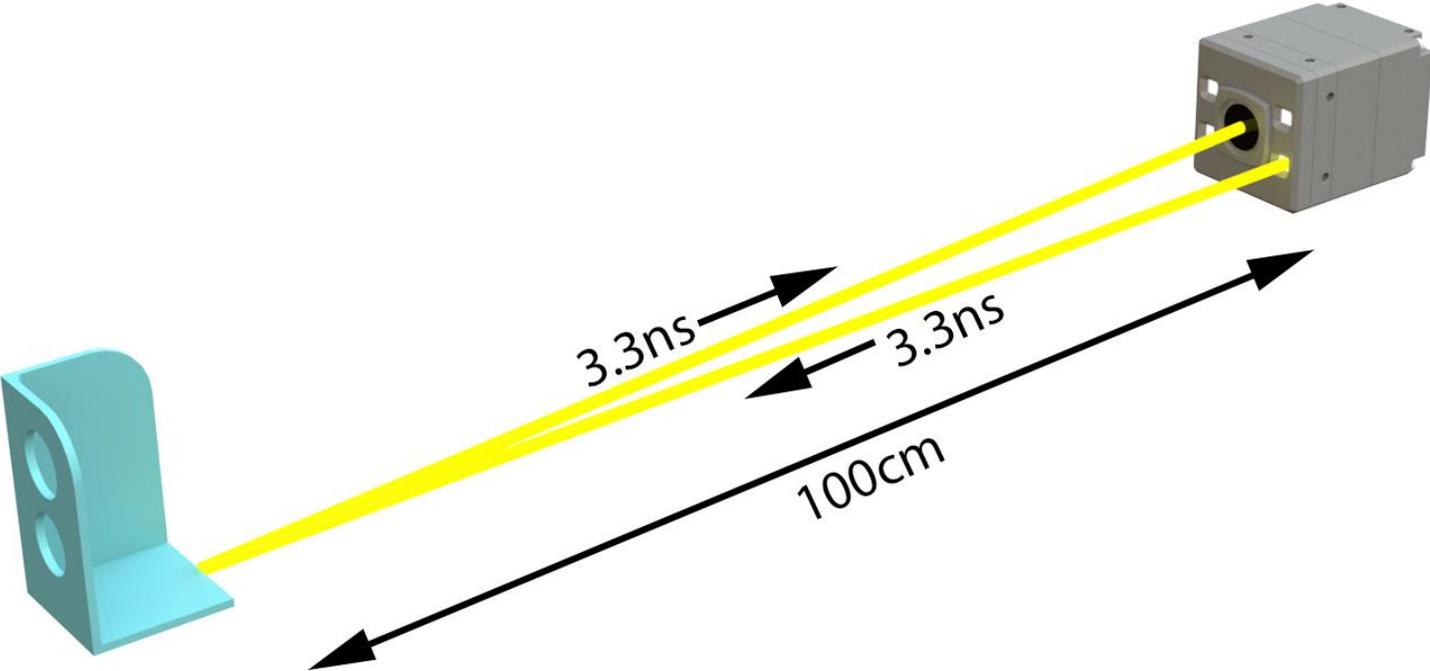
# Structural lighting with laser line



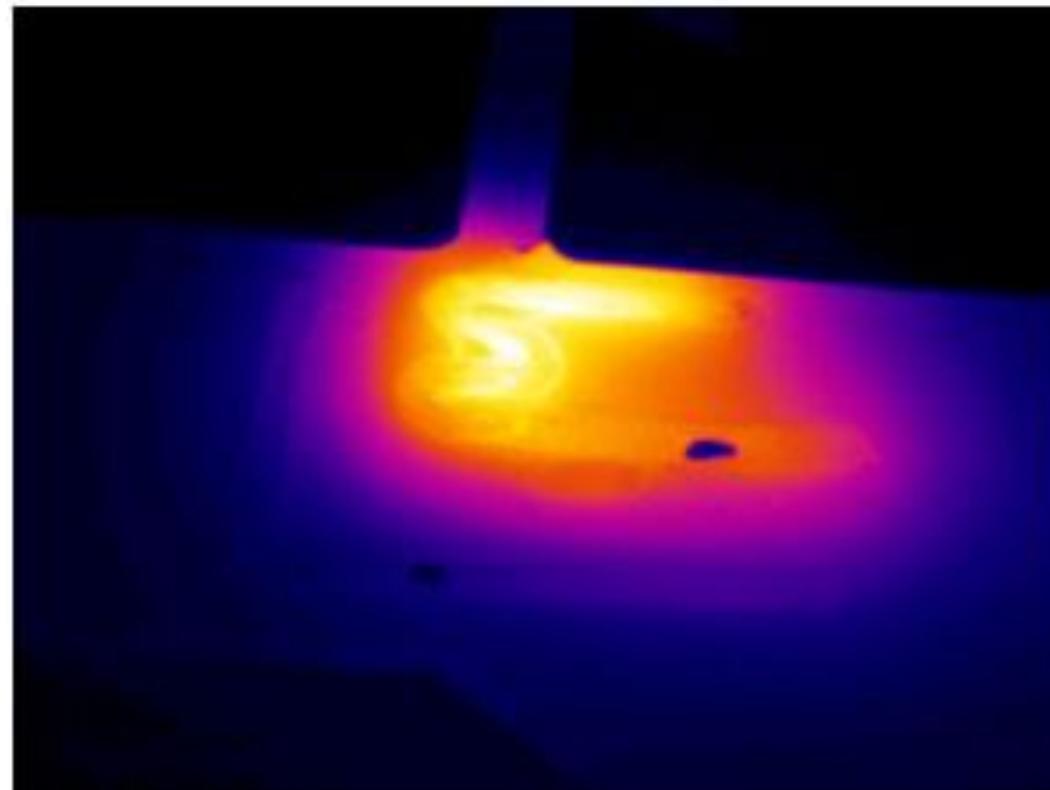
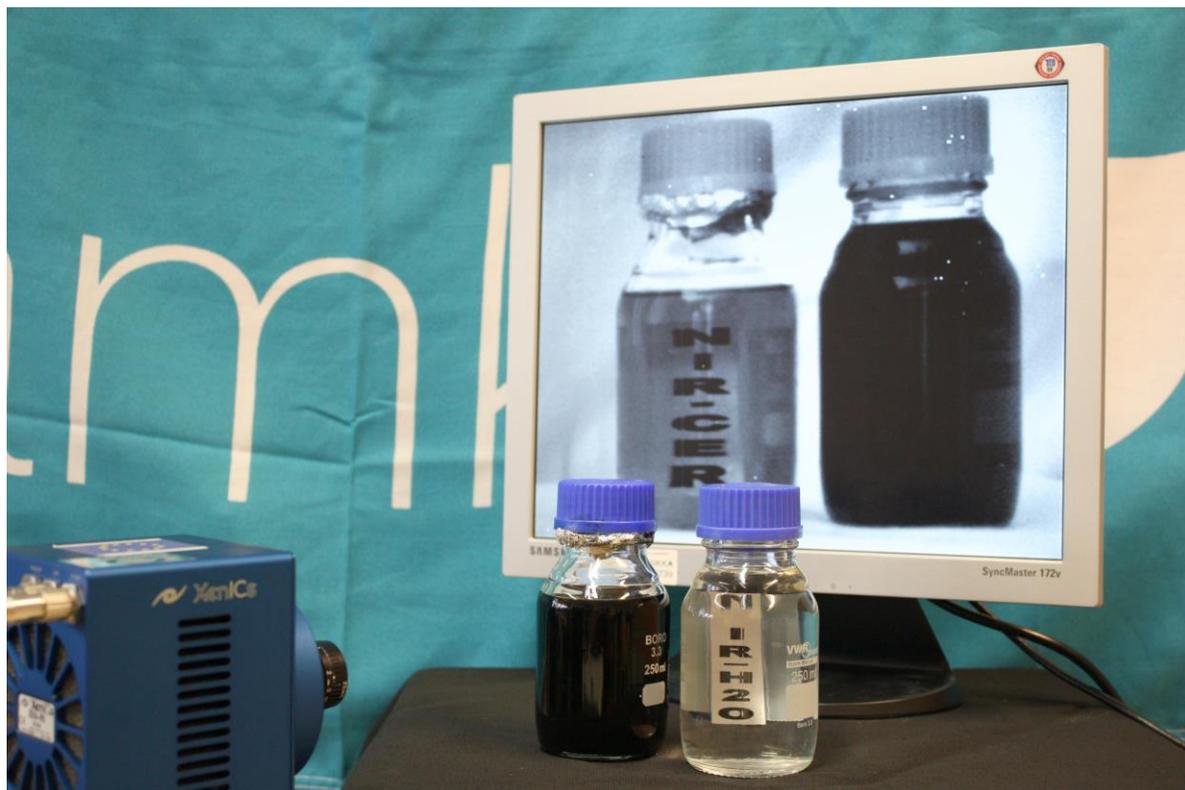
# Structural lighting with lighting pattern projection



# Time of Flight (ToF)

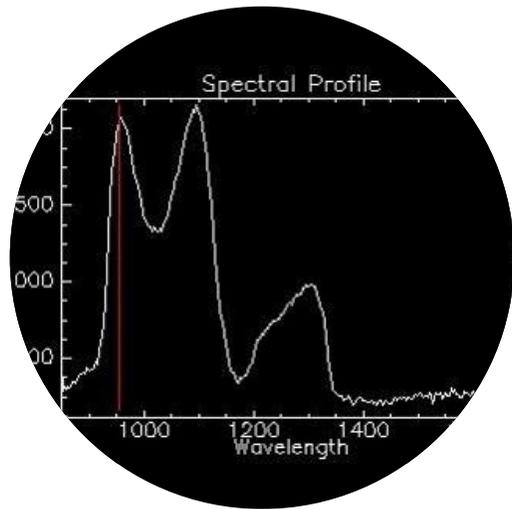


# Infrared Imaging

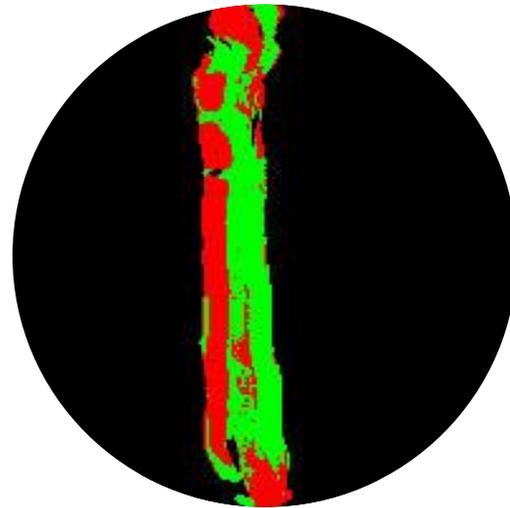


# Spectral Imaging

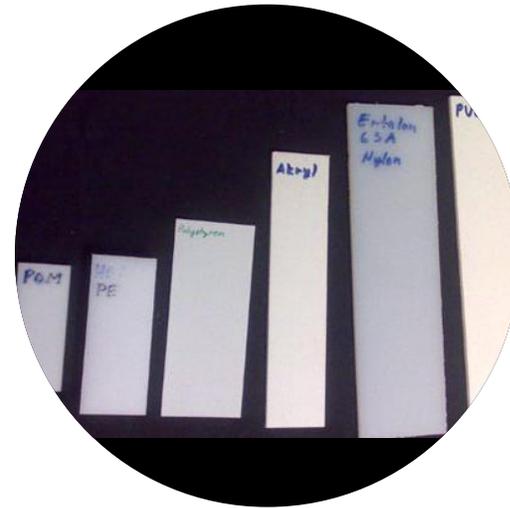
An innovative combination of spectroscopy, machine vision and signal processing.



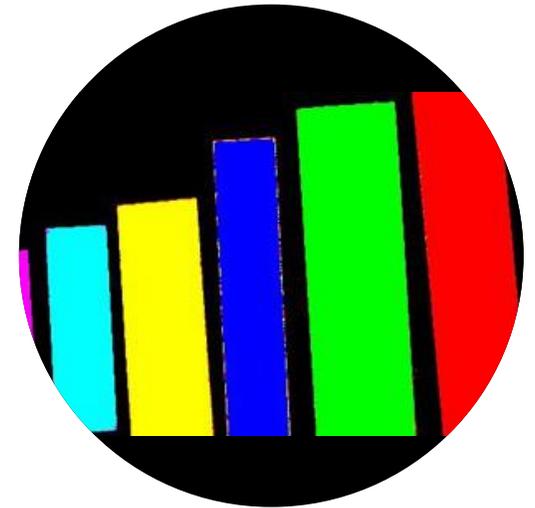
Spectrum of a pixel  
= Intensity of  
reflected light as a  
function of  
wavelength



Visible light  
spectral imaging  
  
Colour  
identification /  
verification



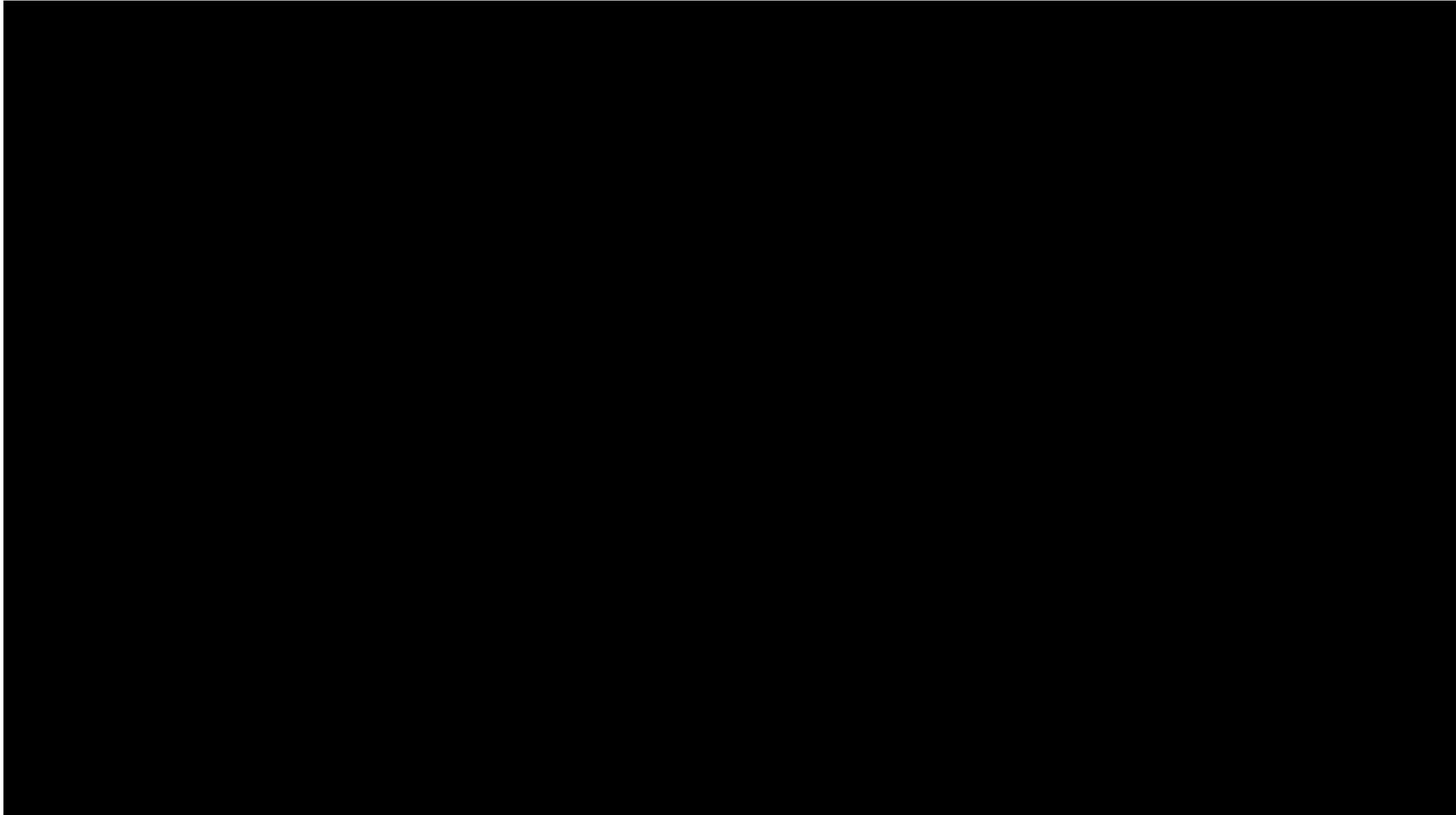
Near infrared  
spectral imaging  
  
Material  
identification



Sorting substances

# Examples of machine vision in robot controlling

# Smart camera controlled robot application for organizing playing cards



<https://youtu.be/bjQ7F3MqTco>

# Flexible and product-independent 3D machine vision-controlled collaborative robot application for the food industry



<https://youtu.be/qhqYnSEwe8I>

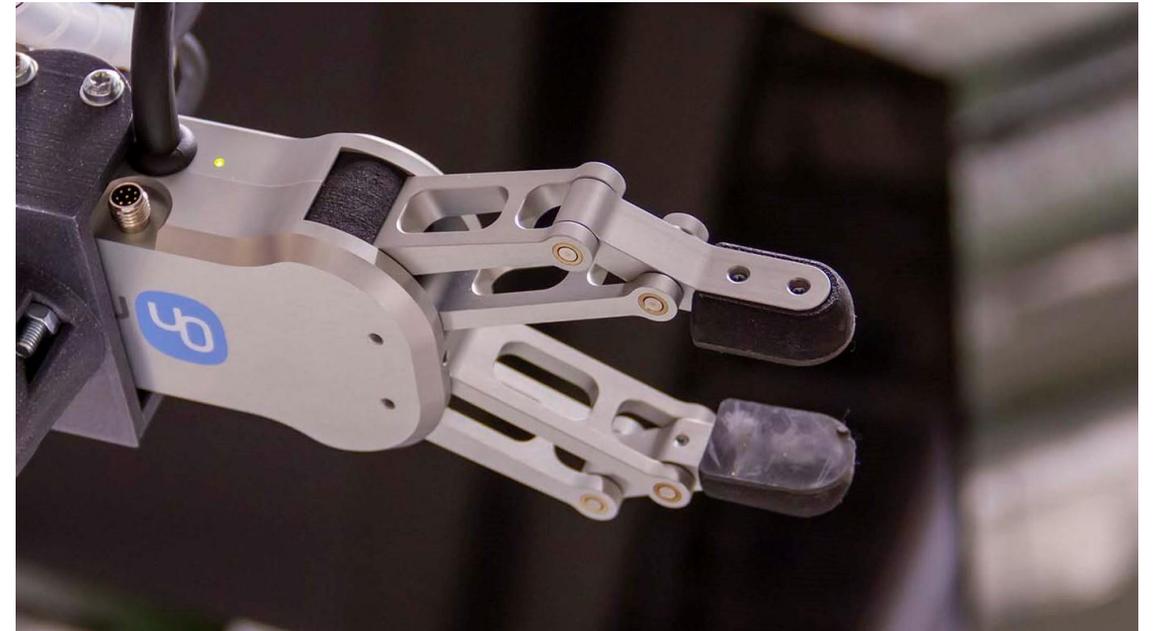
# 3D machine vision controlled bin picking of metal pipes



# Smart tools for smart robots

# What is a robot tool?

- A mechanical part that a robot moves from one point to another
- With the tool, the robot does something
- There are a lot of different tools and more are being planned all the time
- The most commonly used tool is some kind of gripper or gripper
- The tool can also be a tool involved in a specific process or job, such as a welding torch or paint sprayer



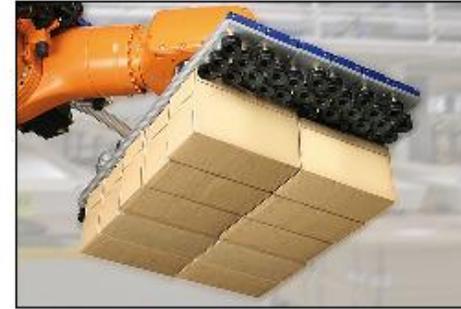
# Tool features

- The tool or gripper should be as light weight as possible
- The robot's payload is divided between the tool and the part
- The tool should be very versatile when used with many different pieces
- When designing, it is worth considering how the gripper affects the workpiece
  - possible deformations caused by gripping forces



# Classification of grippers

- Vacuum gripper
- Pneumatic grippers
- Hydraulic gripper
- Servo-electric grippers
- Grippers that open and close
- Two- or more-finger grippers
- Smart sensed grippers



Vacuum Gripper



Pneumatic Gripper



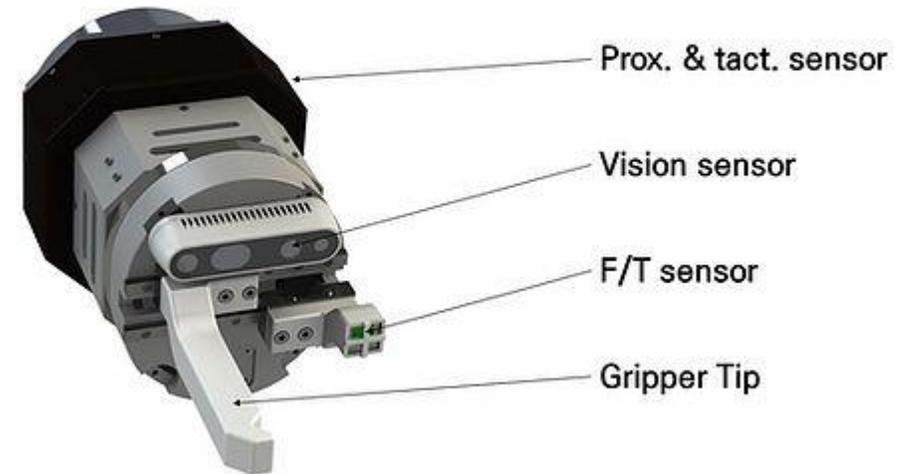
Hydraulic Gripper



Servo-Electric Gripper

# Smart grippers

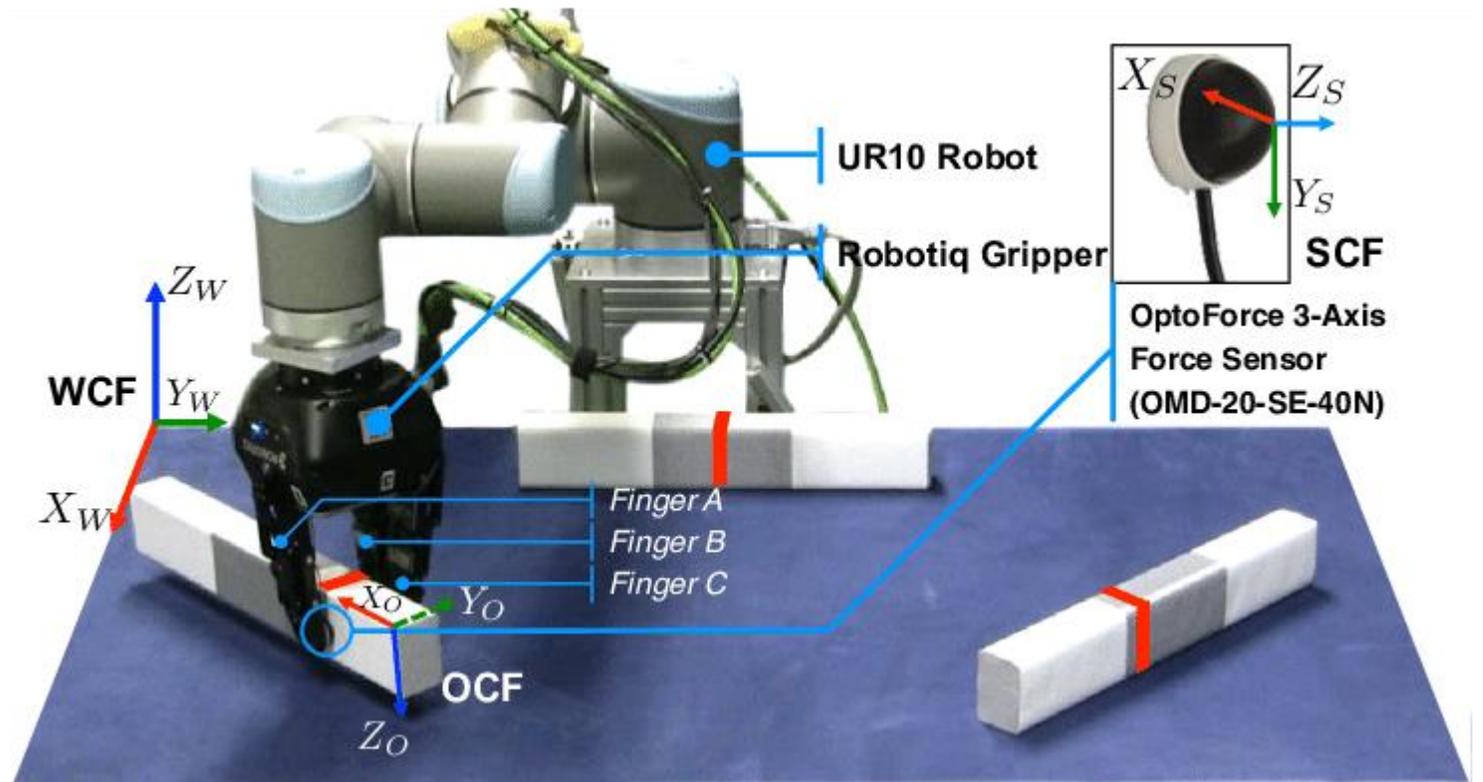
- Smart grippers are coming to the market right now
- Monitor the success of the work steps
- Prevent unnecessary interruptions
- Identify error situations
- Information about the internal state of the gripper



Picture: Aidin Robotics

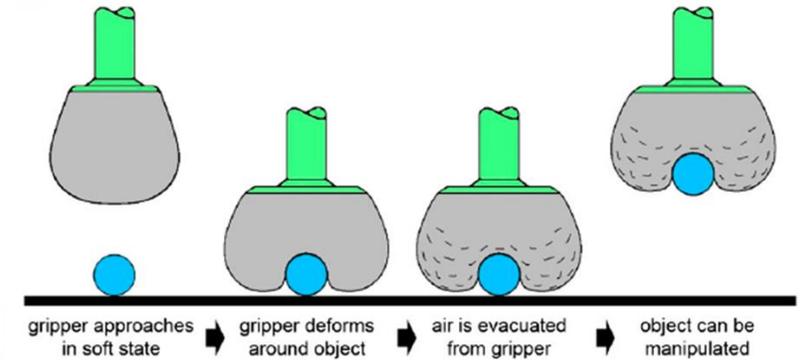
# Sensors used in grippers

- Infrared or color sensors
- Ultrasonic sensors
- Encoders
- Mechanical switches
- Optical sensors
- Acceleration sensors
- Force/Torque sensors
- Proximity sensors
- Tactile sensors



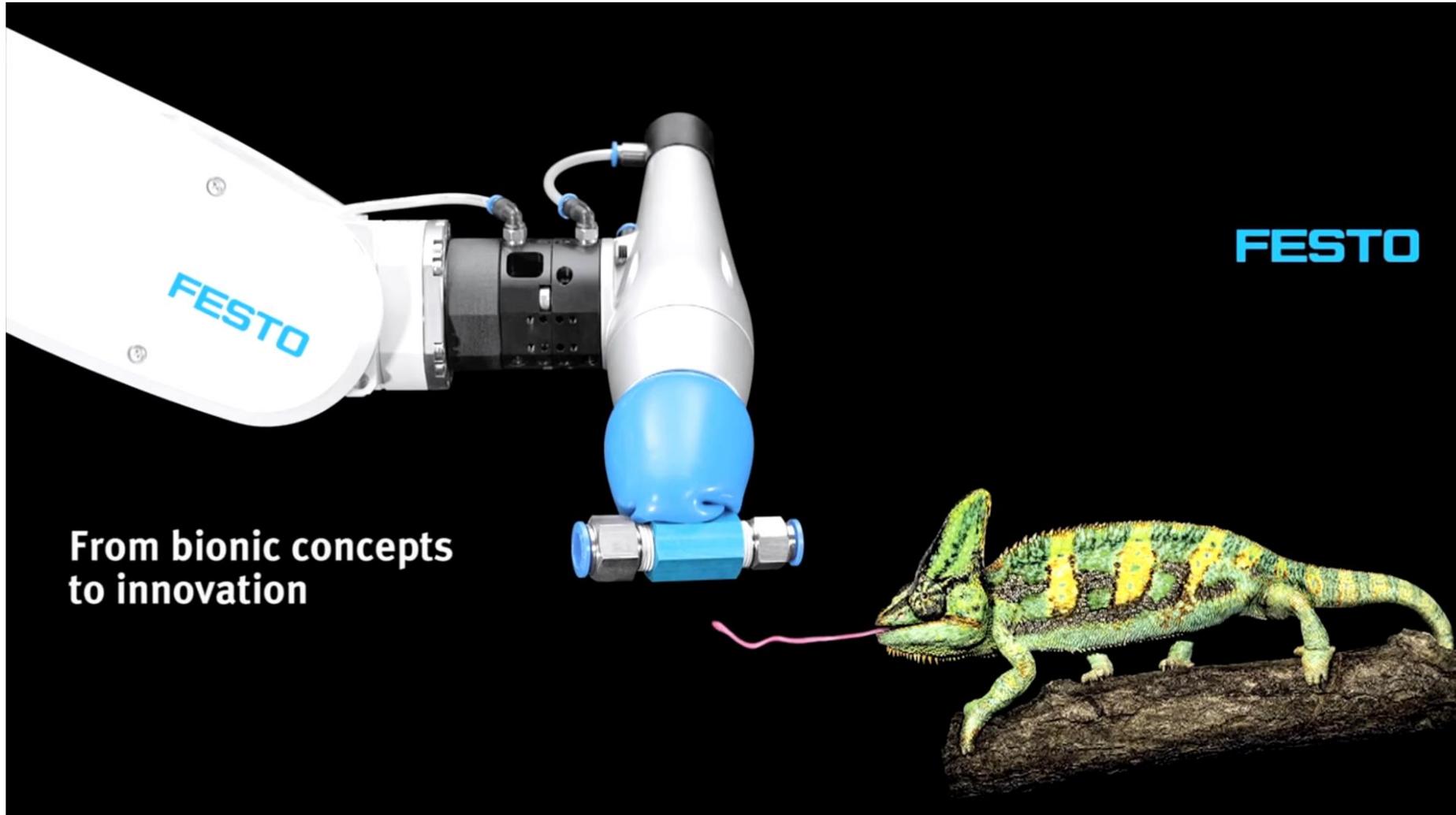
# Flexible tools

- The soft suction gripper is shaped according to the shapes of the body
- Multi-cup vacuum gripper from which the required number of suction cups can be used
- Vacuum gripping system for multi-piece

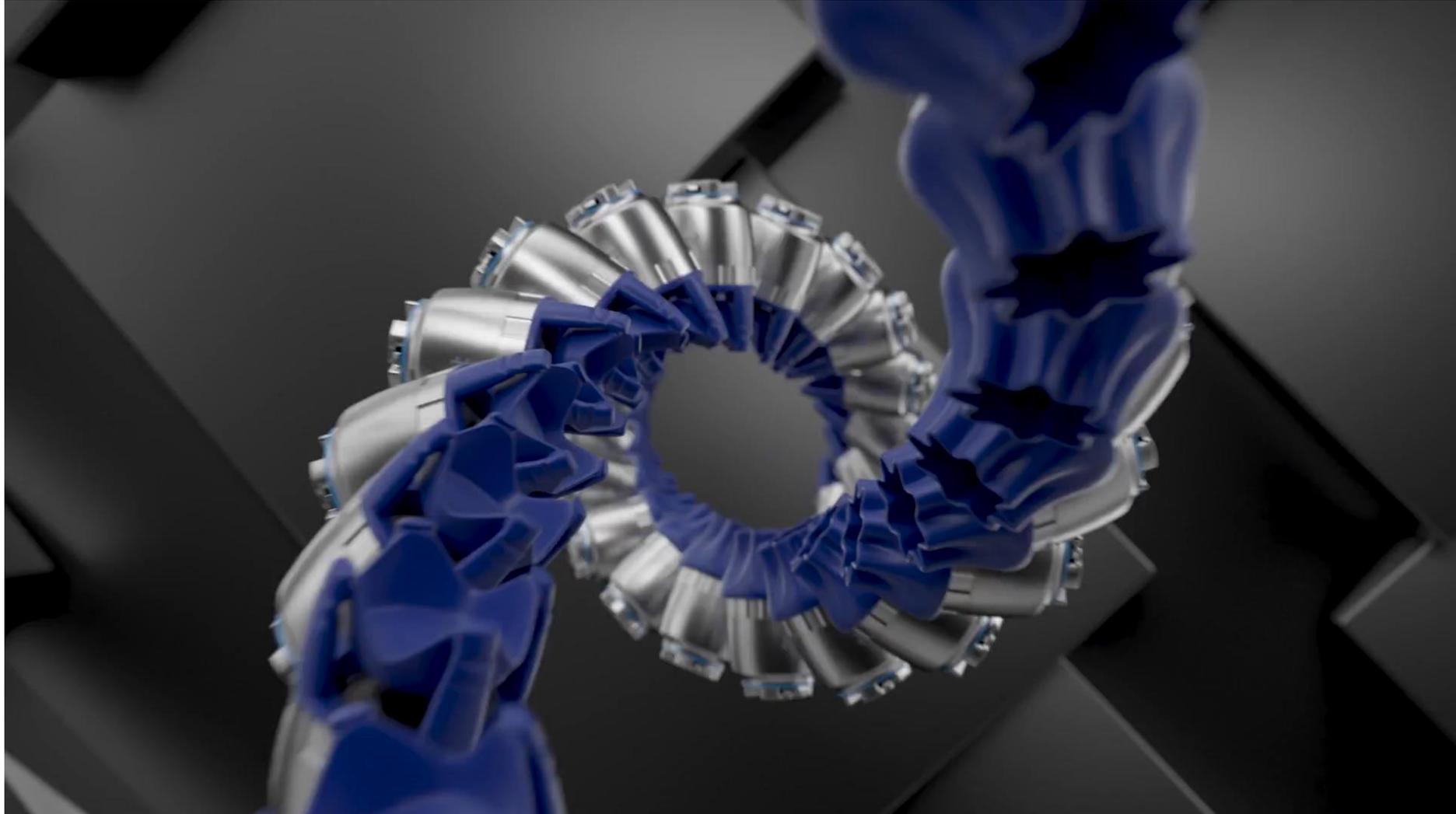


# Examples of flexible grippers

# Adaptive shape gripper



# Soft gripper



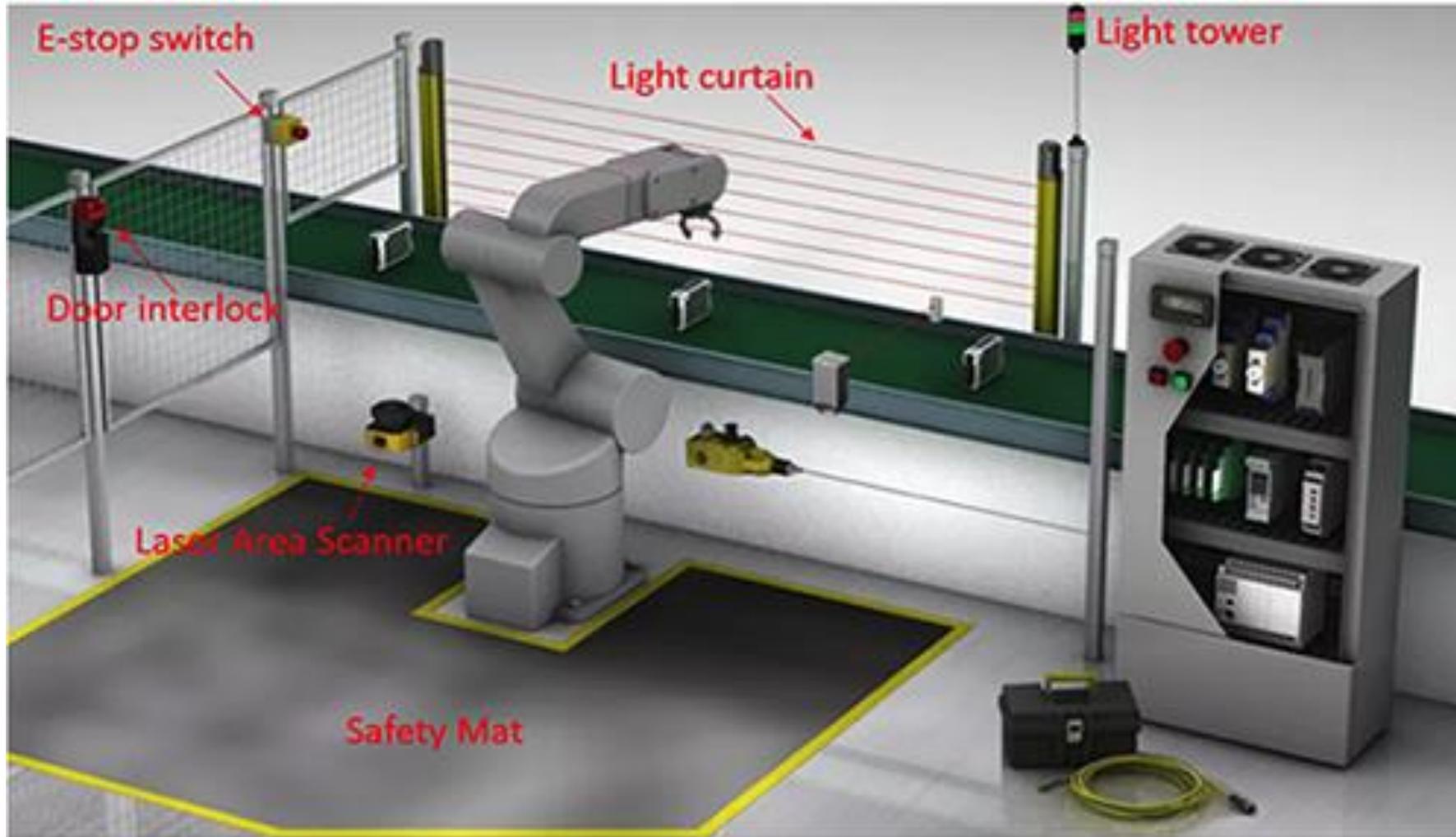
# Safety in Robotic systems

- From a safety perspective, a robot is a challenging system
- The movements are:
  - Wide
  - Three-dimensional
  - Unpredictable
- A person unknown to the robot cannot guess how the robot moves



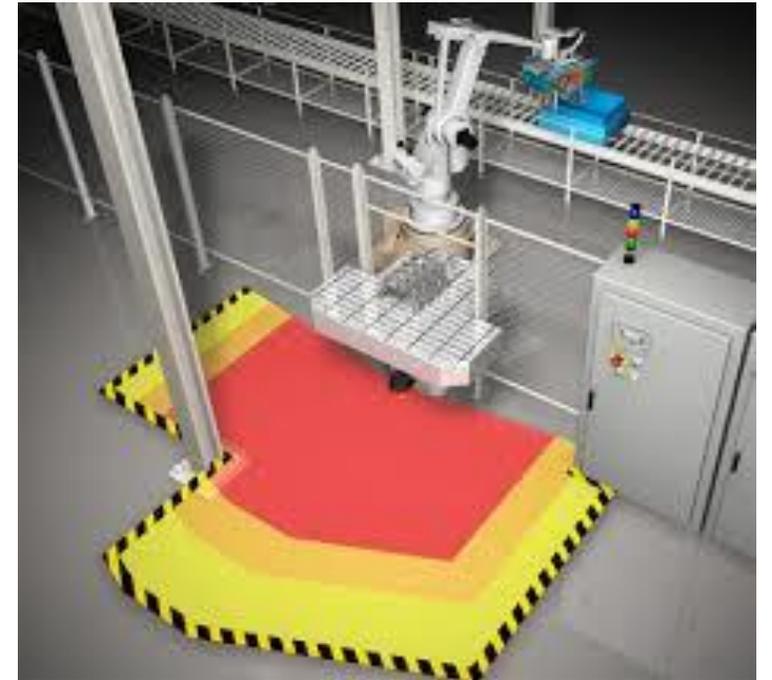
Picture: Sick

# Safety equipment of robotic systems



# Safety mat

- 10-15 mm thick, rubber mat
- When a person steps on the carpet, the mechanical contact is passed as control information to the robot
- The operating principle is:
  - Compressed air solutions
  - Optical fiber
  - Electromechanical solutions (most common): two metal plates, the contact of which can be detected electrically
- Allows the protection of very differently shaped areas
- Just becoming in more common use



Kuva: Rockwell Automation

# Safety scanner

- Optical safety device
- Measuring the time it takes of a light beam to reflect from an object
- The laser beam is reflected usually by a rotating mirror
- If the reflection is abnormal, there is something in the safety area
  - The angle of rotation of the mirror allows the scanner to determine the location of the object



Picture: Sick

# Safety scanner

- The advantage over a light curtain is the possibility to monitor multiple parallel entrances
- Operating range 1-7 meters, the warning area is ~10 meters
- Response time and resolution depend on the size of the monitored area
- Usage increased significantly in recent years



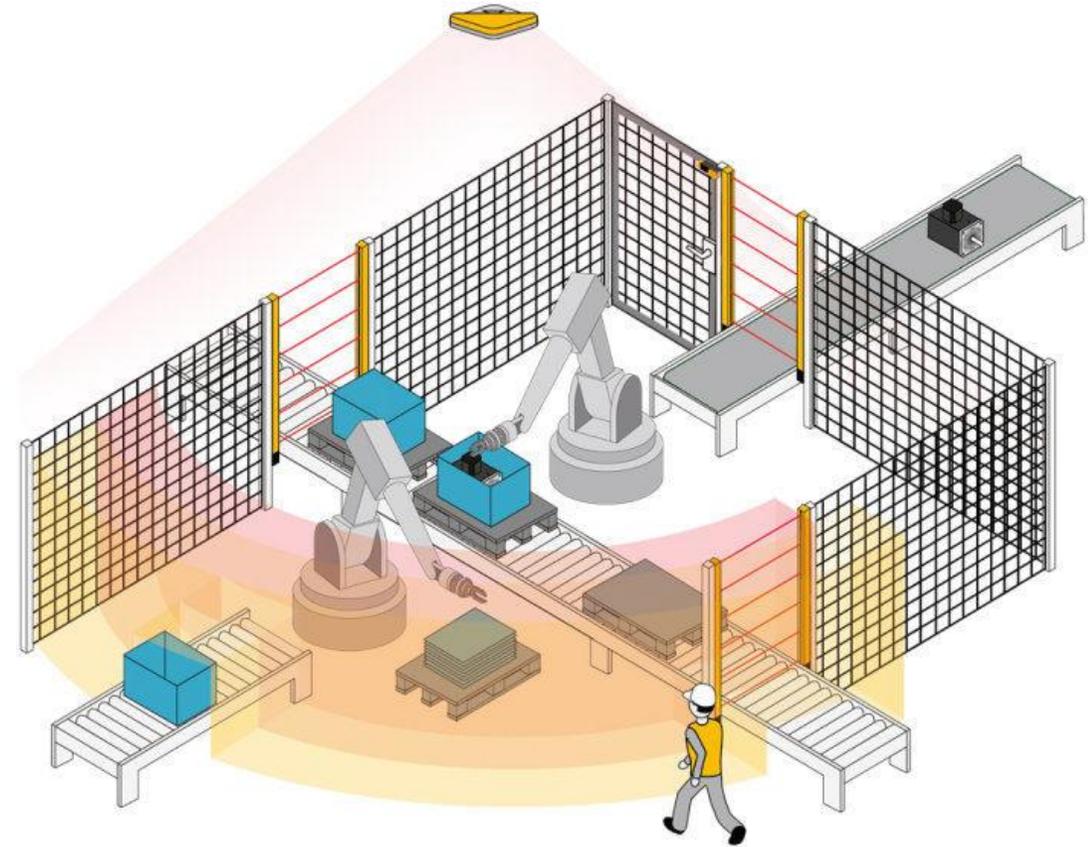
# Safety scanner

Commonly used:



# Machine vision based safety sensors

- Developed a lot in recent years
- Prices still high, but will certainly be used at least in challenging systems
- Usually based on 3D imaging techniques + analysis of the image changes
- The size and shape of the monitored area can be almost anything
- The response times are not yet that quick  
→ Warning and safety areas must be larger



Pilz SafetyEYE: up to 72 square meters observation at a time

# Sources of information

T. D. Nguyen, T. Kim, J. Noh, H. Phung, G. Kang and H. R. Choi, "Skin-Type Proximity Sensor by Using the Change of Electromagnetic Field," in *IEEE Transactions on Industrial Electronics*, vol. 68, no. 3, pp. 2379-2388, March 2021, doi: 10.1109/TIE.2020.2975503.

Aidin Robotics: <https://www.aidinrobotics.co.kr/>

Pilz SafetyEYE: <https://www.pilz.com/en-INT/eshop/00106002257092/SafetyEYE-Tools>

Robot Senses: Robots That Can See, Hear, Feel, and More: <https://www.edge-ai-vision.com/2020/04/robot-senses-robots-that-can-see-hear-feel-and-more/>

# Fill the blanks - answers 1

## Sensors

Industrial Robots have practically worked completely blind.

The new safe robots rely on a variety of sensors. The torque sensor, or in other words the force sensor, of course measures the force, but its significance when integrated into the robot comes from the fact that it gives the robot a sense of touch.

Position sensors are needed for the basic operation of robots.

They are attached to each robot joint. They measure the position of each joint and report it to the robot control.

# Fill the blanks - answers 2

## Machine vision

Machine vision definition says that machine vision means the use of devices for optical non-contact sensing to automatically receive and interpret an image of a real scene in order to obtain information and/or control machines or processes.

In a traditional machine vision system, there is a camera with the optics needed to capture just a specific subject.

3D imaging can be used for example in shape inspection and quality assurance, volume measurement and controlling of robot in bin picking or pick and place operations.

Long wave infrared imaging, which is usually known as thermal imaging, gives information that we can't get with our own eyes.

# Fill the blanks - answers 3

## Smart tools for smart manufacturing

The robot tool is actually the part of the robot that the robot moves while it is working.

The tool or gripper should be as light weight as possible so that the robot can handle also the parts not just the gripper alone.

Smart grippers can be used to monitor the robot's gripping and part handling functions.

Flexible grippers should be used when the shape of the part is difficult for a traditional gripper.

# Fill the blanks - answers 4

## Safety in robotic systems

From a safety perspective, a robot is a challenging system. The movements of the robot are wide, three-dimensional and unpredictable.

The advantage of a laser scanner over a light curtain is that a single scanner can monitor multiple parallel entrances.

# Thank you!

Questions?

