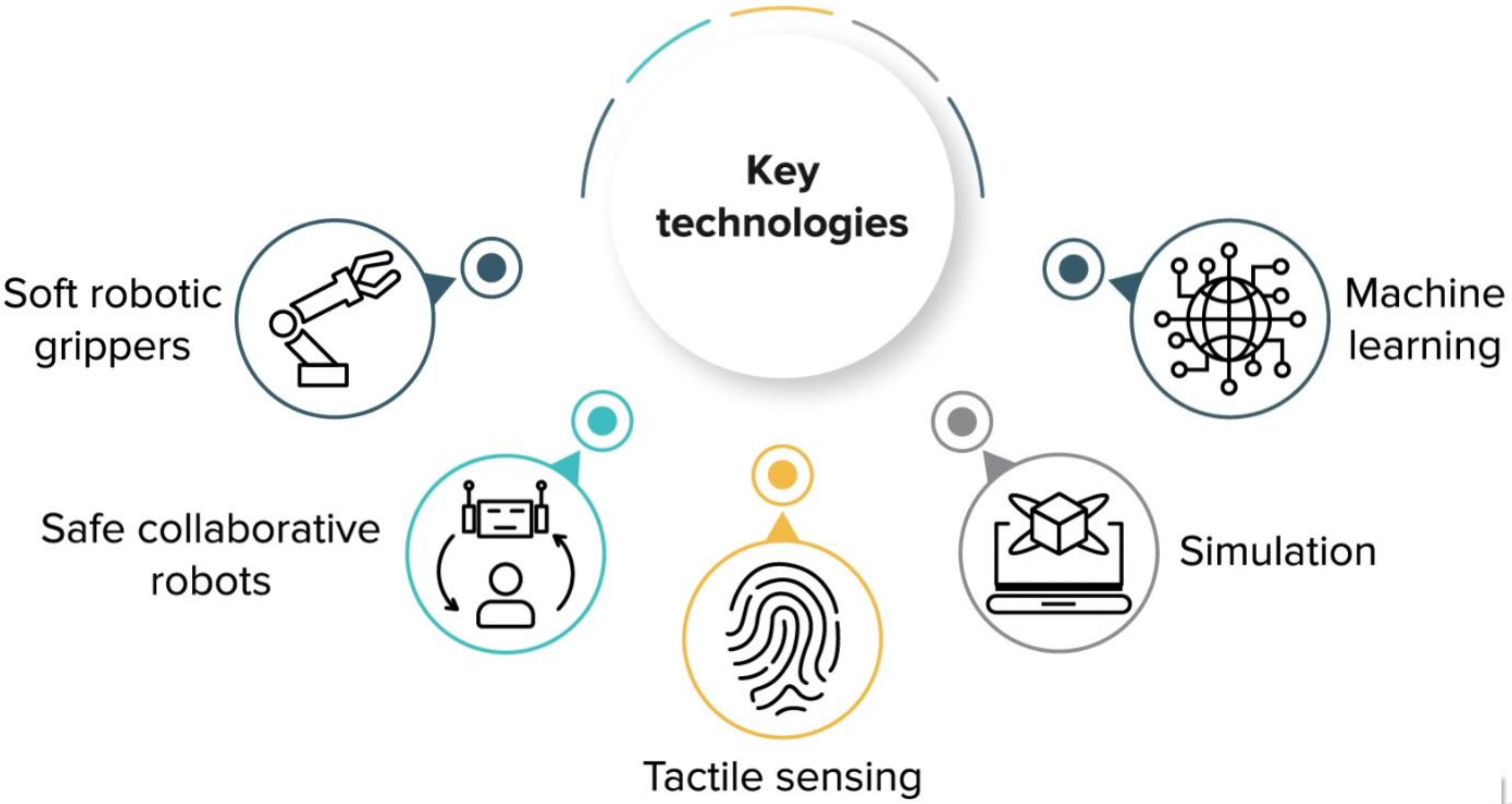
MTRN 3060: ROBOTICS and AUTOMATIONS
Week 13

MACQUARIE University
SYDNEY · AUSTRALIA

The present and future of Robotics
Review of the Unit

Fundamental Technologies in Robot Architecture

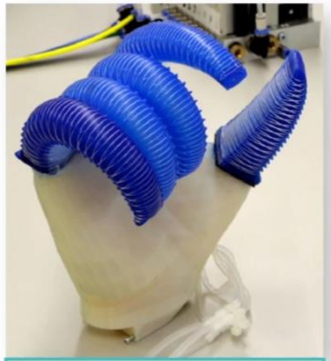


Soft Robotic grippers

Soft robotic grippers are fabricated with flexible and soft components that:

- Have the ability to conform mechanically to the shape of the object that they are grasping
- Have the potential to grasp and manipulate a larger variety of objects while outsourcing part of the complexity involved in planning and control to the mechanical and often passive adjustment capabilities

Jamming gripper



RBO hand

mGrip

Soft robotic grippers are especially useful for picking up and moving objects gently or with force.

Source: Brown, A. (2020, April 22). Seven big advances in soft robotic grippers. *The American Society of Mechanical Engineers.* https://www.asme.org/topics-resources/content/seven-big-advances-in-soft-robotic-grippers

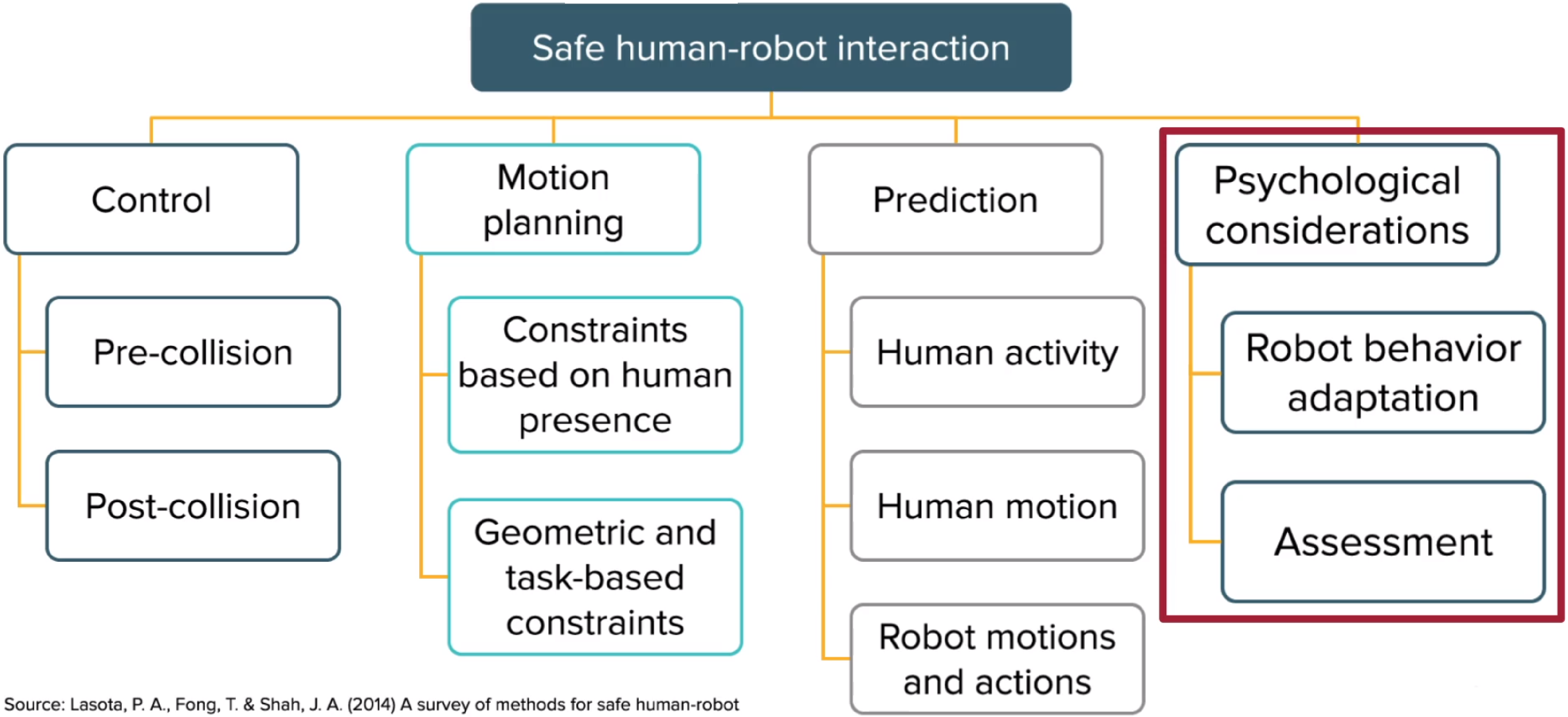
https://www.youtube.com/watch?v=guDIwspRGJ8&ab_channel=Clone

Safe collaborative robot

A self-collaborative robot, often referred to as a collaborative robot or cobot, is a type of robot designed to work alongside humans in a shared workspace or environment.

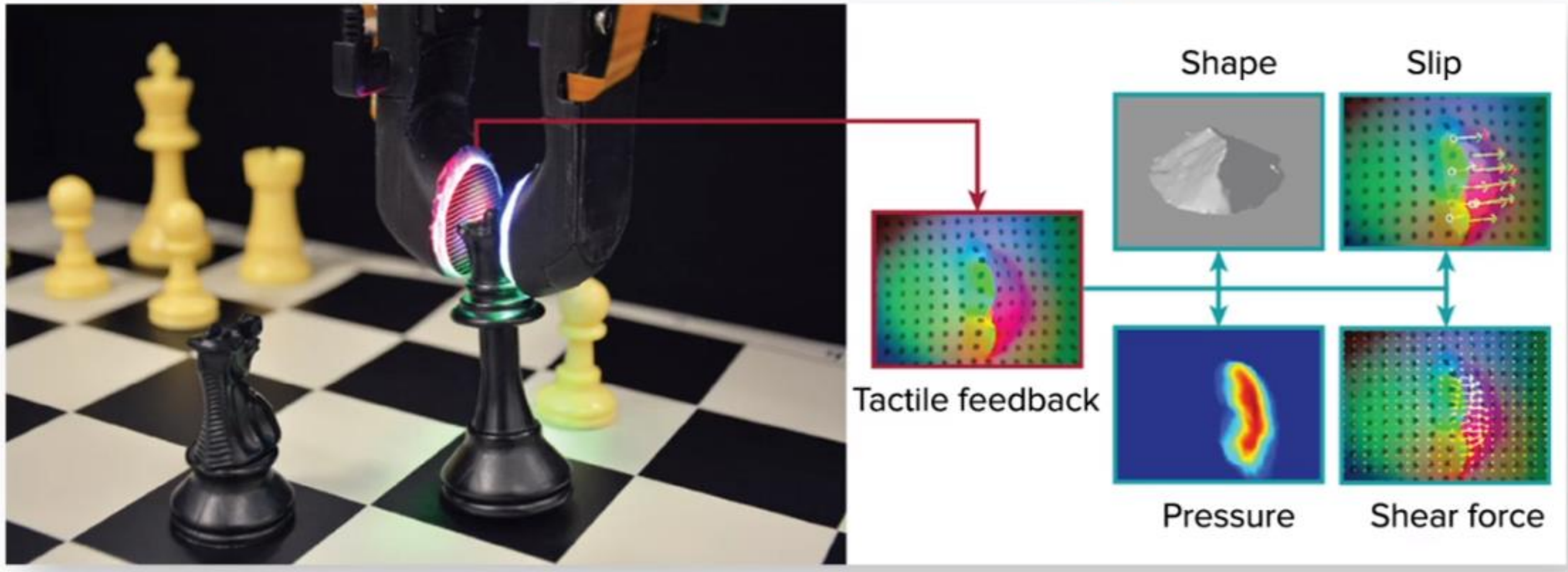
These robots are intended to enhance productivity, improve efficiency, and reduce the risk of workplace injuries by working collaboratively with human operators. They can be a valuable addition to various industries looking to automate tasks while maintaining a safe and flexible work environment.

Safe collaborative robots built with soft components or low-torque actuators can enable a collaborative work environment between humans and robots that promotes a flexible and human-centered workforce where robots extend human capabilities



Source: Lasota, P. A., Fong, T. & Shah, J. A. (2014) A survey of methods for safe human-robot interaction. *Foundations and Trends in Robotics, Vol. 5*, No. 4, 261–349.

Tactile Sensing



Provides accurate and timely feedback on physical interaction with the environment

Supports control in closing the gap between the robot's intended and actual manipulation behavior

Provides support in unstructured settings where handling a large degree of uncertainty and variability in object geometries, materials, and configurations is required

Source: Rodriguez, A. (2021, May 26). The unstable queen: Uncertainty, Mechanics, and Tactile Feedback. *Science Robotics* *6*(54), eabi4667. DOI: 10.1126/scirobot

Simulation

- It is a key tool to build and verify complex systems
- Complete simulation environments can:
  - Simulate the dynamics of a robot
  - Simulate the dynamics of any environment
  - Simulate the robot’s sensing of that environment

contactile

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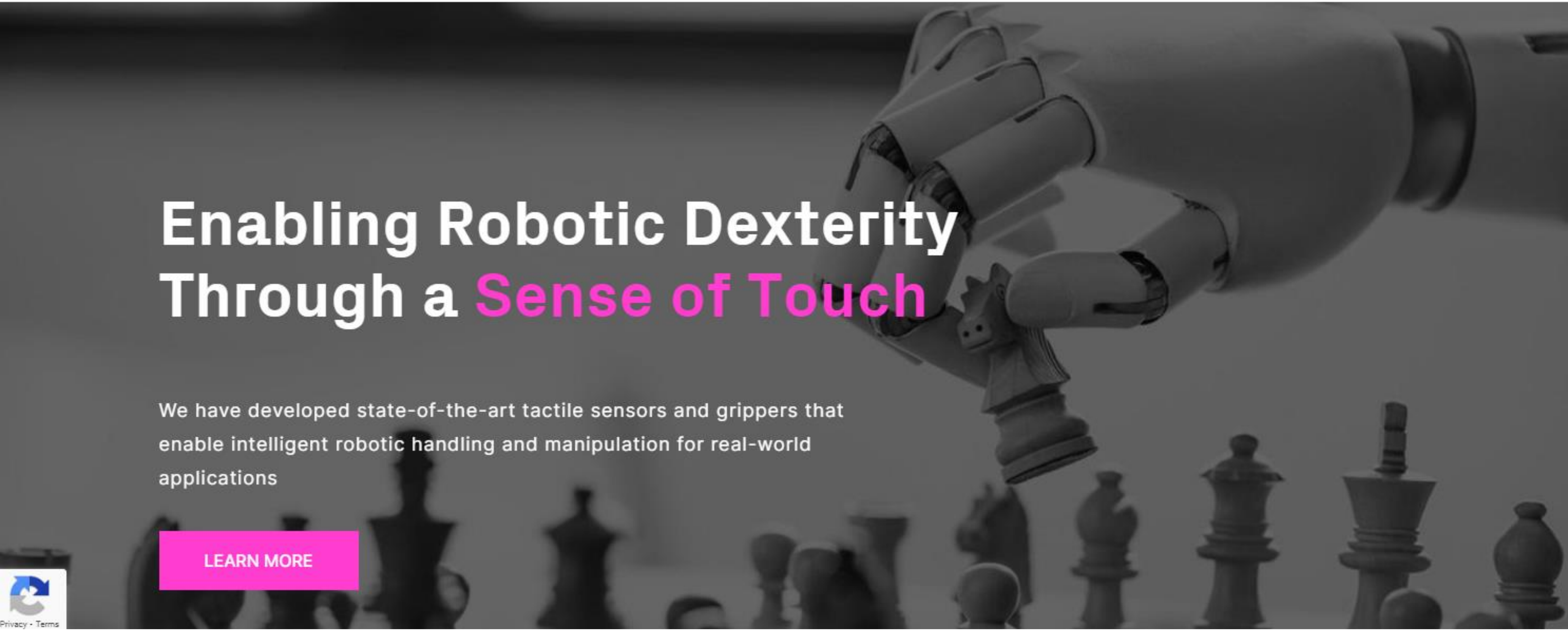


Enabling Robotic Dexterity Through a Sense of Touch

We have developed state-of-the-art tactile sensors and grippers that enable intelligent robotic handling and manipulation for real-world applications

LEARN MORE

Privacy - Terms

Simulations

Generates fast, inexpensive, and large amounts of training data for machine learning systems	Accelerates and reduces the cost of the engineering design cycle by enabling the virtual integration of complete systems	Provides accelerated and safe verification environments for complex robotic systems with retaining full control over perturbation and uncertainty	Facilitates the understanding of human-robot interaction by providing a flexible and safe environment to test different strategies

Machine Learning

- Enables the ability to process raw sensor data and make decisions from experience rather than from programmed human insight
- Learning can permeate all aspects of the development of robotic systems, including design, perception, planning, control, human-robot interaction, etc.

Limitations of Machine learning

If machines are to learn from experience in the real world, efficient algorithms that can learn from few examples are needed

If machines are to learn from experience in simulated environments, this learning needs to be transferred to the real world

If learning is to be deployed at scale, algorithms that can learn from fleets of robots beyond just individual experience are required

If machines are to have long life spans, algorithms that continuously adapt to the inevitable, gradual aging of machines are required

Discussion

We touched upon several exciting topics in robotics: soft robotics, safe-collaborative robots, tactile sensing, machine learning, and simulation. For this group discussion, pick one of the aforementioned topics or a topic of your choosing that was not heavily discussed within this course. Find a published news article (or academic article) on this topic. This can be an industrial application, product release, research result, etc.

With your selected article, please write a response that addresses the following points:

1. **List** the topic of your choosing, which may either be one of those listed above or a different topic entirely.

2. Briefly **summarize** the article, making note of the key takeaways and/or capabilities.

3. **Connect** the topic and article to some of the fundamental technologies or areas discussed within this course.

Hard vs. soft automation

The main difference between hard and soft automation is that **hard automation requires physical changes to improve functionality while soft automation machines are programmed through a computer interface**.

Examples of hard automation include automotive assembly line robots and dedicated CNC machines for machining specific parts.

Examples of soft automation include industrial robots with vision systems for pick-and-place tasks and collaborative robots (cobots).

Hard vs. soft automation

Hard automation

- Has more protection against human error
- Constrains the user from doing something that would put the system in danger

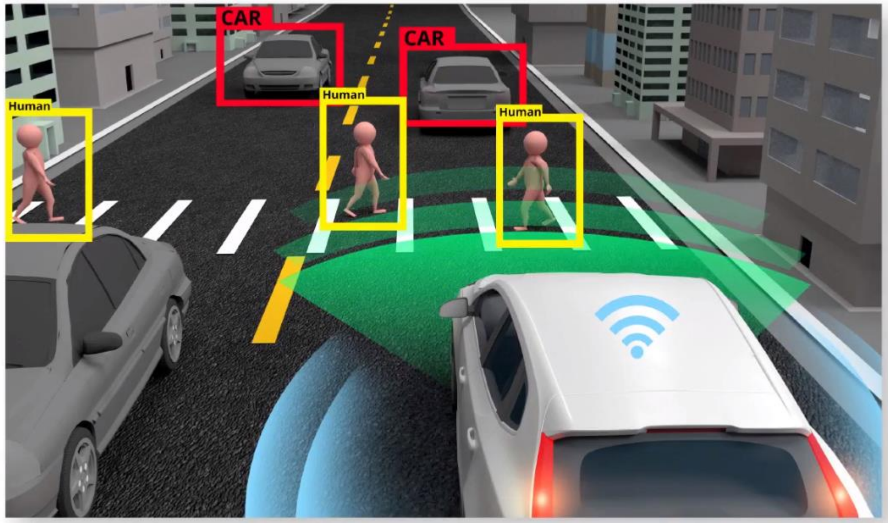
Soft automation

- Considers automation as an aid
- Provides an alert when the user is about to do something that may be dangerous
- Allows the user to proceed to override those warnings if they choose to
- Allows for more creative, human problem solving
- Provides the user access to the full capabilities of the system

Sociotechnological Considerations

Societal Challenges

- Many societal challenges can be addressed by recognizing the complementary and collaborative relationship that humans share with robots and then designing accordingly
- These challenges will be insufficiently addressed if automation is considered only as a substitute for humans



Reduces fatalities due to car accidents

Tackles congestion problems in cities all around the world

If robots are employed as personal augmentation systems, they can:

- Improve humans' well-being
- Help humans thrive into old age

If robots are employed as orderlies, they can:

- Make emergency rooms safer and more efficient

Robot’s Limited Role in Daily Usage

The functionality of simple robots, such as Roomba, is not much different from that of other household appliances

Most robots are restricted to simple, rule-based behaviors

Our interaction with robots is limited to screen taps and simple commands

Most robots work in factories in cages

Their functionality is restricted to simple, information-based tasks

Examples:

- Adaptive cruise control is used while commuting, but it is switched off in traffic
- Siri is asked about weather updates, or Alexa is asked to add milk to the shopping list, but humans do the actual shopping
- Roomba is not judged harshly when it gets stuck on the carpet or when it misses a spot, as it is a simple machine

New-Age Robots

Intelligent robots are defined by their ability to transcend today's limitations.
Example: robots delivering packages or shopping at grocery stores

Working robots

No longer considered mere tools

Will become more human-like in a specific way, depending on their successful behavior toward humans

Considered new social entities

Mediated at all stages by social interaction rules

The way to build this new breed of robots is to rethink what we expect from the technology

Trained dogs

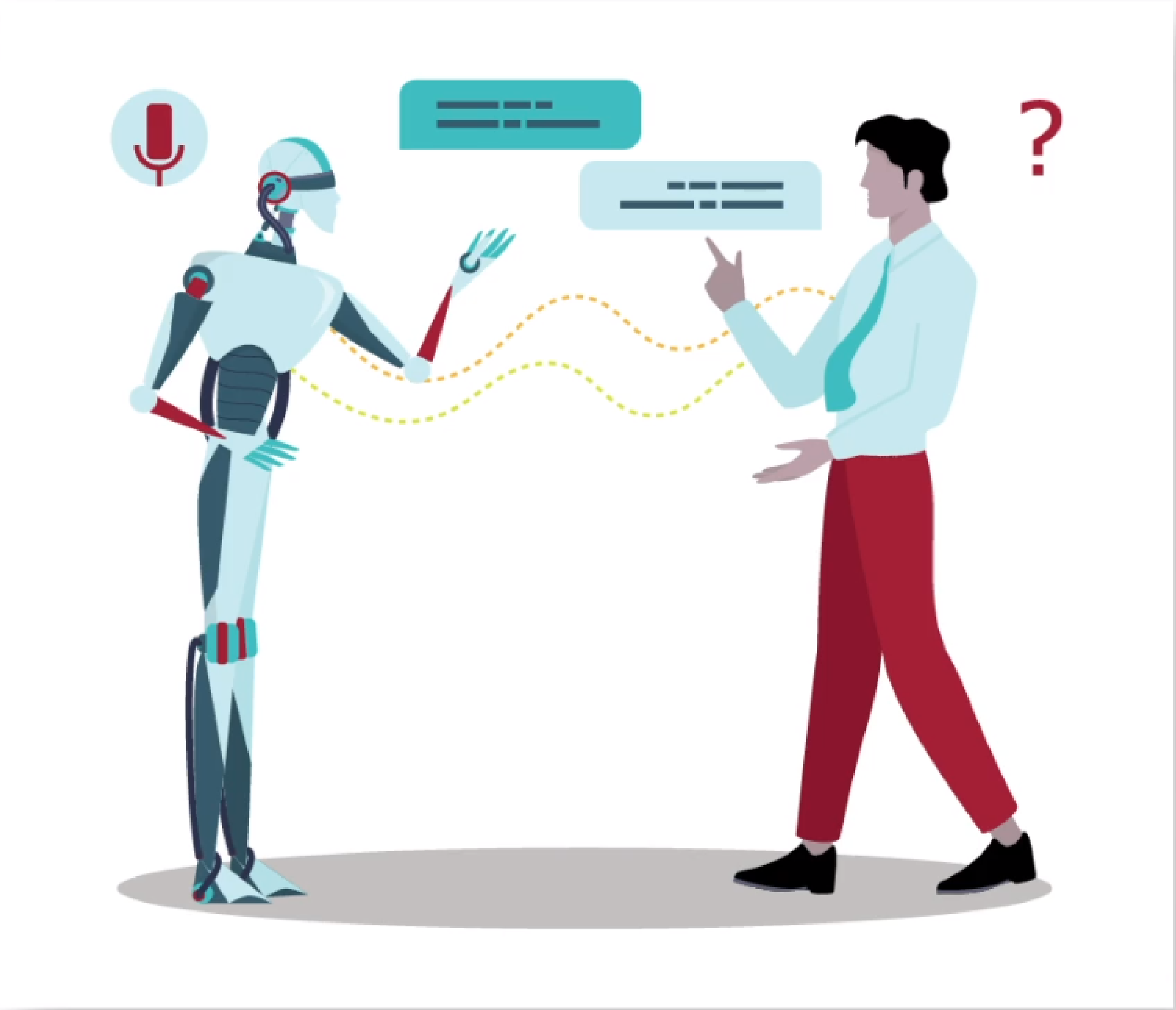
- They do not require commands at every step and are guided by a human handler at a higher level
- The handler uses subtle hand gestures indicating areas for attention, and then the dogs can act on their own
- The dogs have their own set of social norms for interacting with people
  - **Example:** If the dogs wear vests, it is to remind people not to touch or interact with them
  - In challenging spaces, the dogs are put on a leash so that their behavior can be tightly controlled

Effective human-robot collaboration:

- Requires us to rethink the roles of humans and robots
- Requires us to rethink the roles of the technology and society, for example in relation to:
  - How robots deal with bystanders as they make their way through neighborhoods
  - How these new technologies impact different social groups

Safety-Critical Systems: Example

Working robots



- Will need to work within the social norms and abide by the rules and regulations for their safe use
- Will be safety-critical consumer products operating within uncontrollable and unpredictable environments
- Will be interacting with people who are not experts

Important Checklist

- Reconsider the place of technology in everyday lives
- Make changes individually and as a society to incorporate robots into the world
- This partnership requires new human-robot languages and norms in order to be effective
- Rethink our infrastructure
- Understand that robots are commodities, they will not be available to everyone
- Be clear about industry's ethical responsibilities
- It will take deliberative collective change to incorporate robots in everyday life

Discussion-ilearn submission

This activity focuses on considering the future relationships between humans and technology.

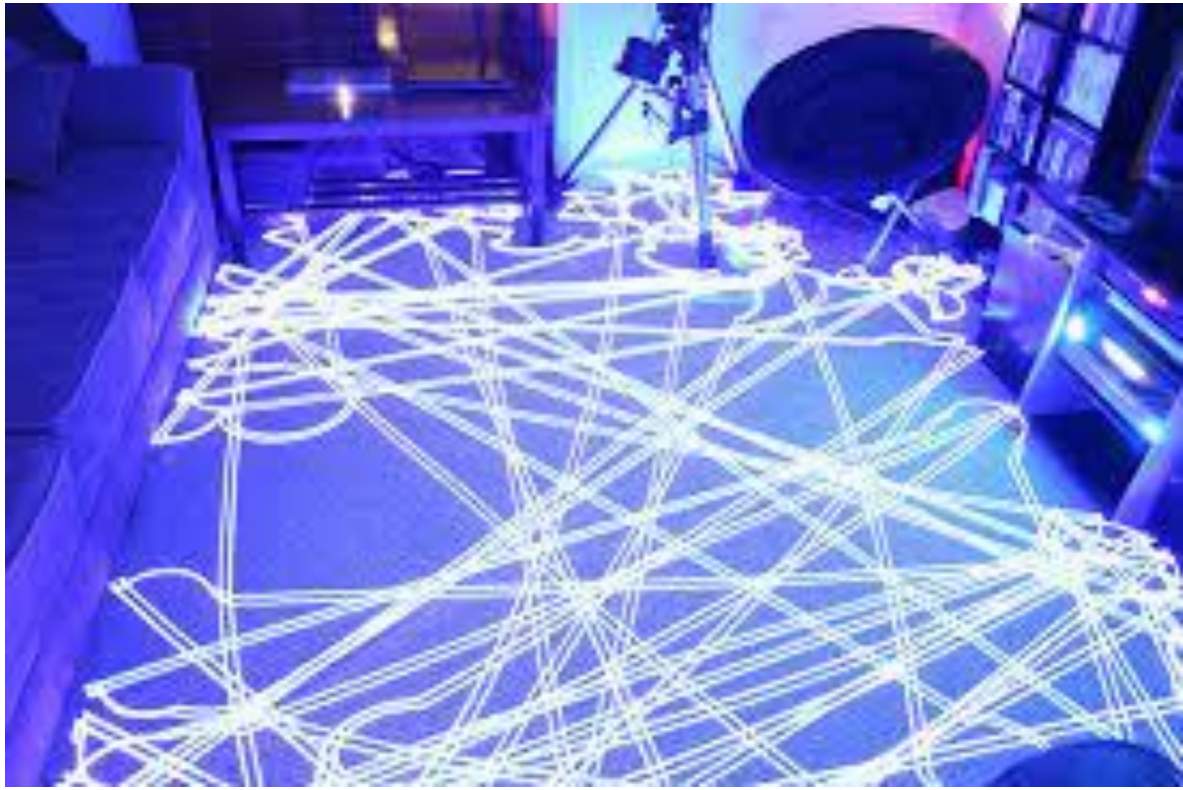
- **Envision and describe** a future robotic system that regularly interacts with humans or society more broadly. This could be an existing application that you imagine integrating more tightly with people or a novel application from your imagination.
- **Describe** the roles of both the human and robot in this partnership. Discuss each of their responsibilities, the strengths each brings in accomplishing the task, and how they may communicate with each other.
- **Discuss** any particular aspects of the partnership you think would have to be re-thought with respect to how people may currently envision this human-technology relationship. For example, does a new protocol or infrastructure need to be used?

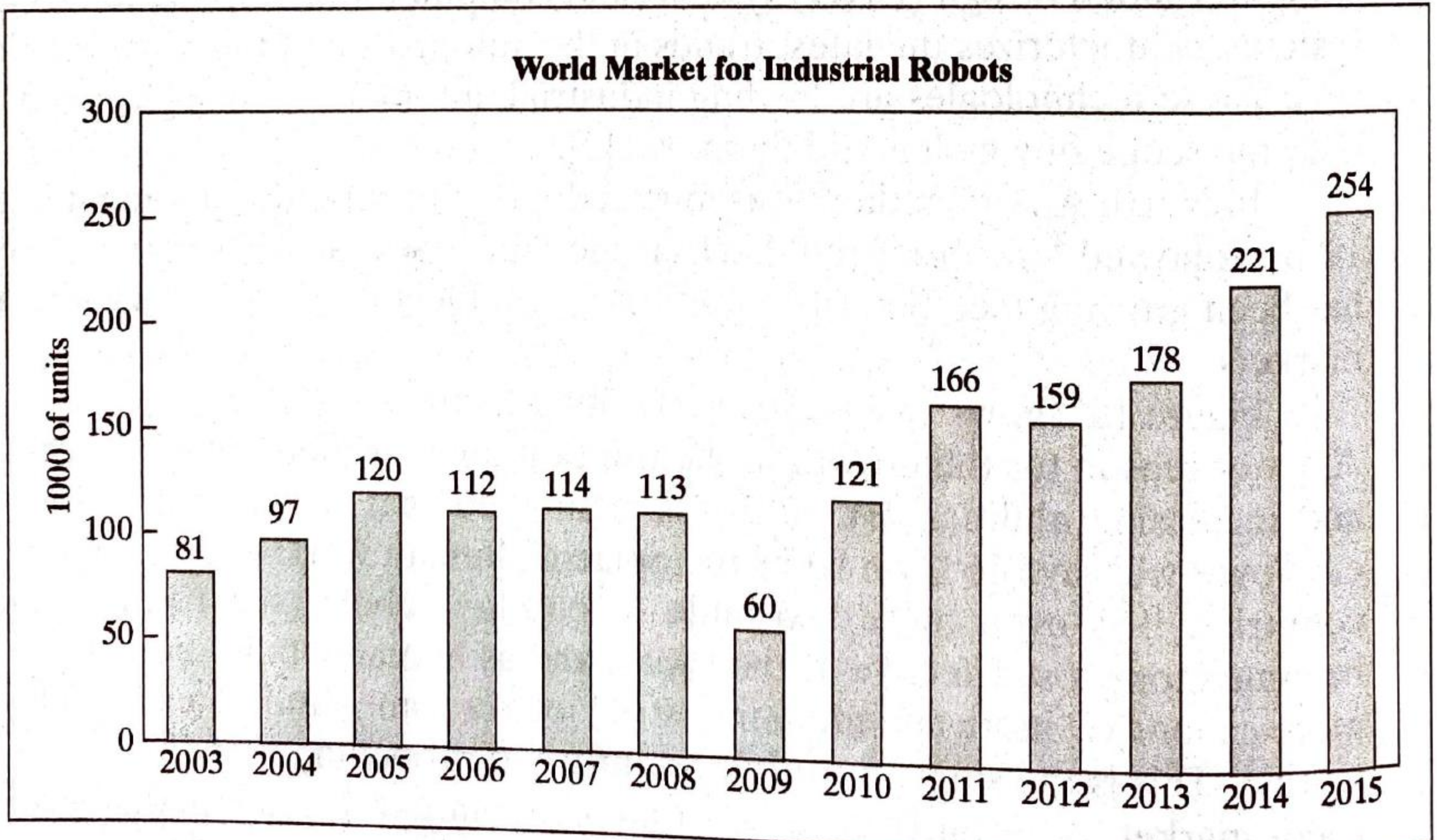
Review the Unit

Catalyzers of Innovations in Automation

MORE THAN 1 M in OPERATION

MORE THAN 10 M in OPERATION




World Market for Industrial Robots
1000 of units
300
250
200
150
100
50
0
81
97
120
112
114
113
60
121
166
159
178
221
254
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

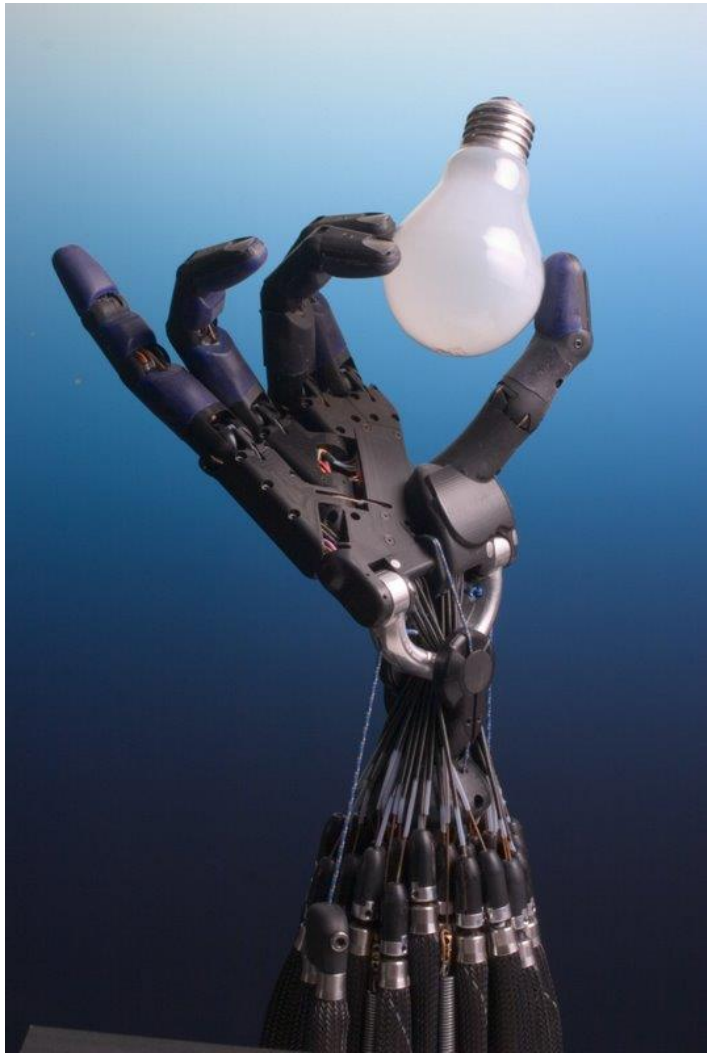
Design and development of robots

SENSORS

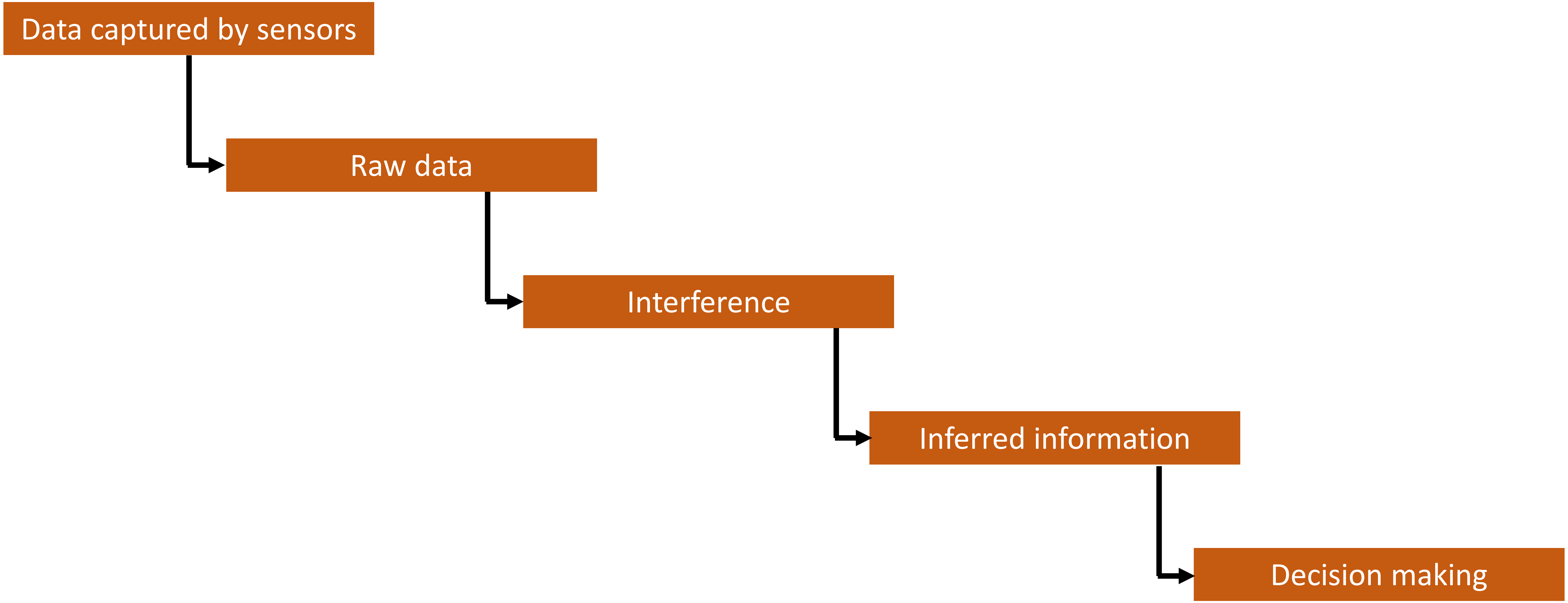
- **Haptic Sensors**
- **Vision Sensors**

ACTUATORS

- **Integrated robot hardware**
  - Grippers
  - Arm manipulator
  - Mobility platform
- **Low-level motors**



Sensing and perception



Different ways to collect information

1) Filtering

The robot can aggregate information either over time or across sensors to make a more complete estimate

The complete shape of an object is constructed when all the frames are joined

2) Prior

The robot can use a model of its expectations of what to perceive to make better sense of the raw information it is capturing

A large data set of object shapes, which robot expects to see in its word, makes it possible to infer a reasonable completion of the shape.

Common transducers for sensing

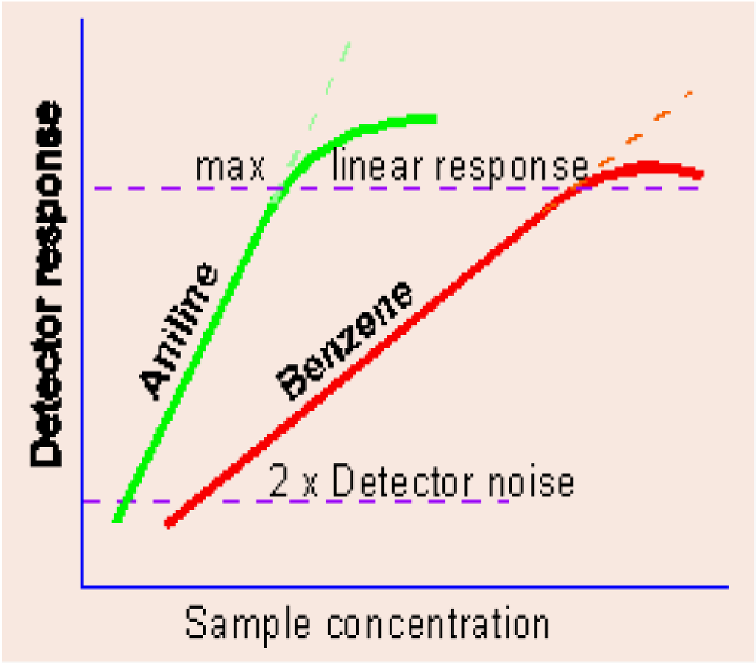
Strain gauge	Hall effect sensor	Photo resistor
The strain gauge is one of the most important tools of the electrical measurement technique applied to the measurement of mechanical quantities.	A **Hall effect sensor** (or simply Hall sensor) is a type of sensor which detects the presence and magnitude of a magnetic field using the Hall effect.	Change its electrical resistance depending on the amount of ambient light
Used in force/torque sensors	Used in encoders	Used in force/torque sensors

Span or Dynamic Range (bandwidth)

If in a measuring instrument the highest point of calibration is X_2 units and the lowest point is X_1 units.

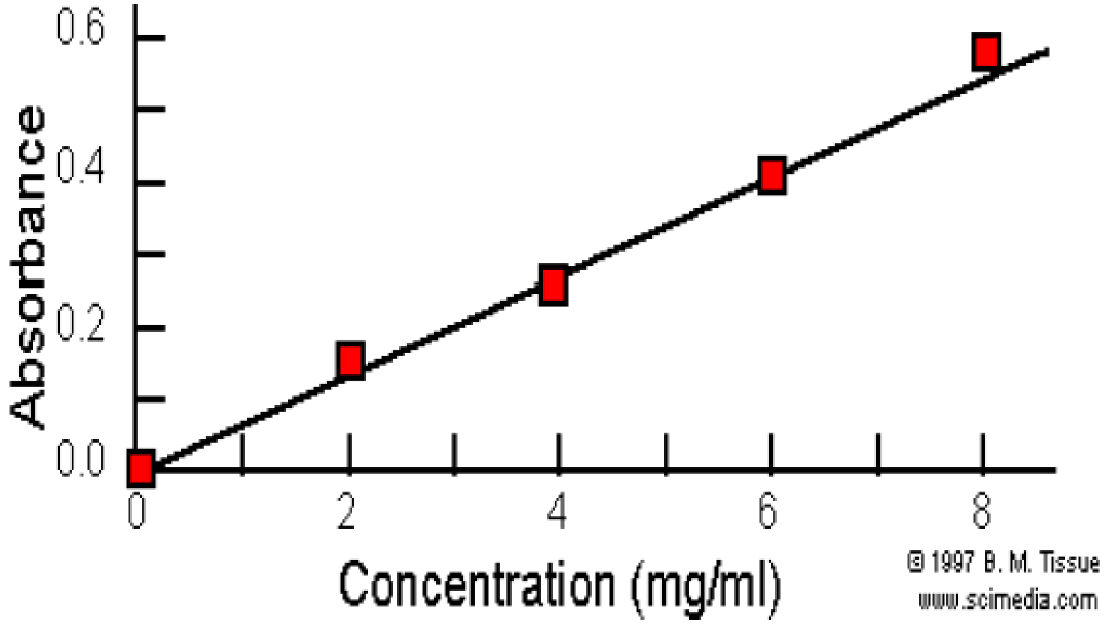
- Instrument range is X_2 units
- Instrument span is $(X_{2-} X_1)$ units

- Span or range: The difference between the highest and lowest scale values of an instrument
- Bandwidth: The range of scale values over which the measurement system can operate within a specified error range (also used as another word for span)



Calibration: standard curve

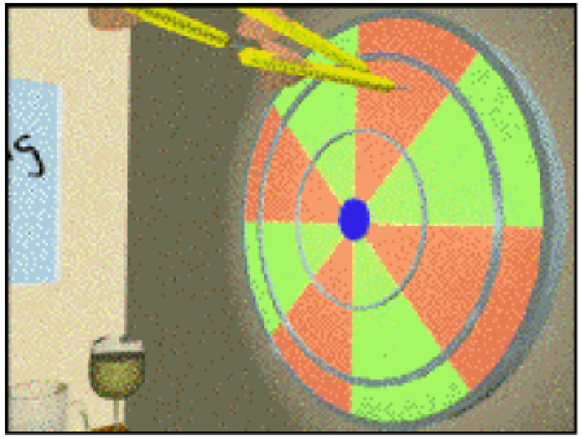
- A process of adapting a sensor output to a know physical or chemical quantity to improve sensor output accuracy i.e. remove bias
- A working or standard curve is obtained by measuring the signal from a series of standards of known concentration. The working curves are then used to determine the concentration of an unknown sample, or to calibrate the linearity of an analytical instrument-for relatively simple solutions

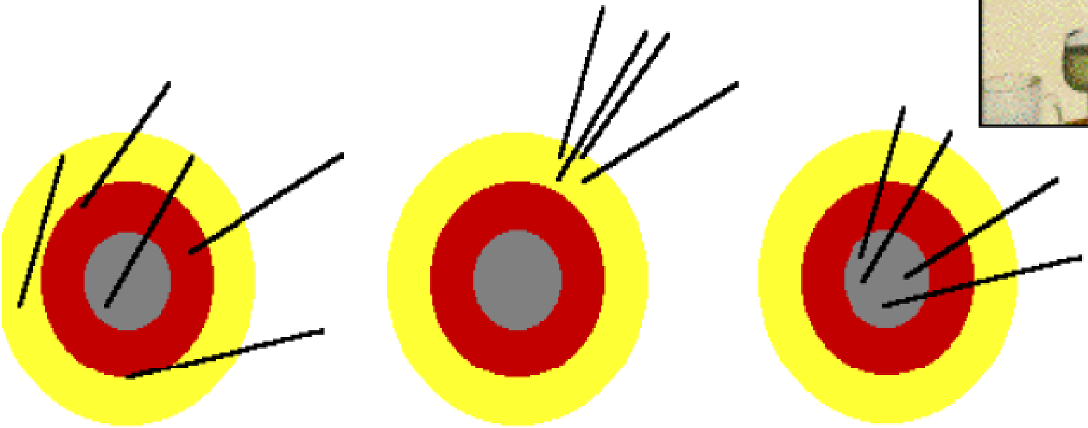


From C.Ming Lee's lecture notes, NTU

Precision or repeatability

- The difference between the instrument's reported values during repeated measurements of the same quantity. Typically determined by statistical analysis of repeated measurements



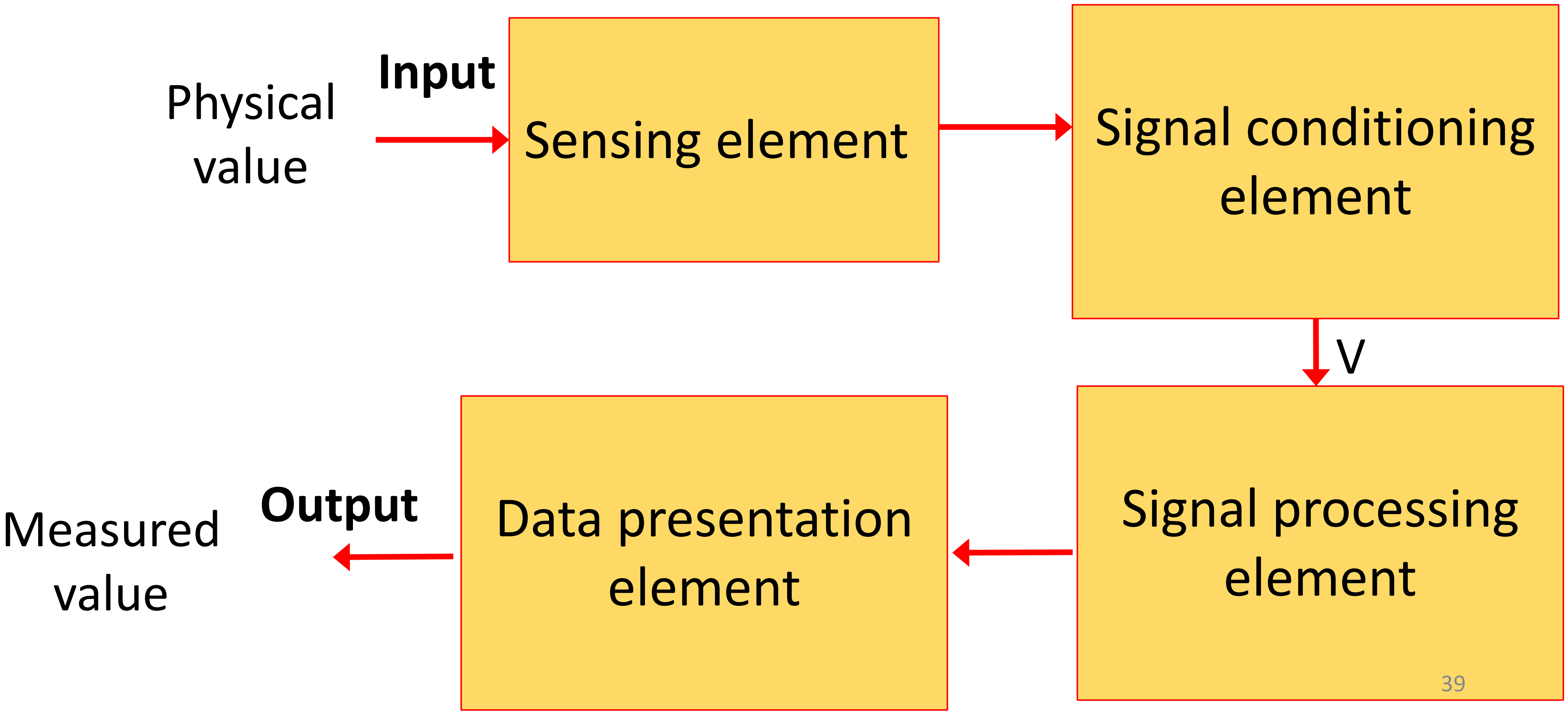


good accuracy poor precision | poor accuracy good precision | good accuracy good precision

From C.Ming Lee's lecture notes, NTU

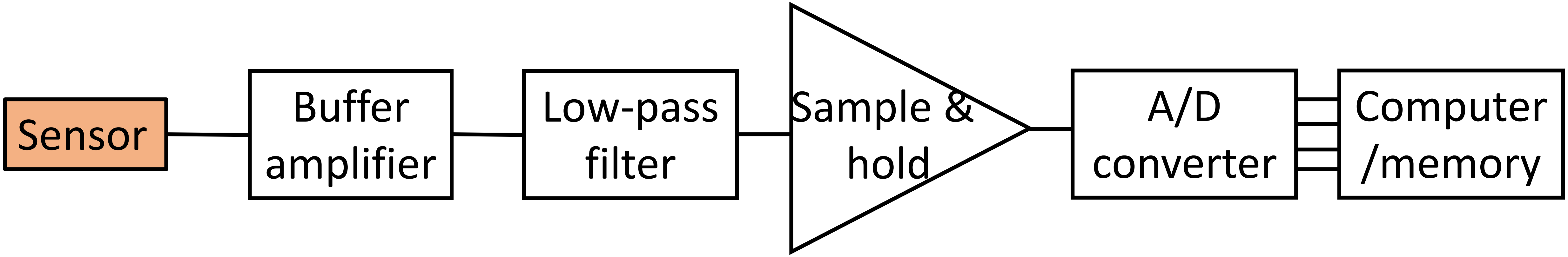
Basic sensing elements

General structure of a measurement system



Data acquisition system components

1) Buffer amplifier
2) Low-pass filter
3) Sample and hold
4) Analog-to-digital convertor
5) computer



Contact and Non-contact Sensors

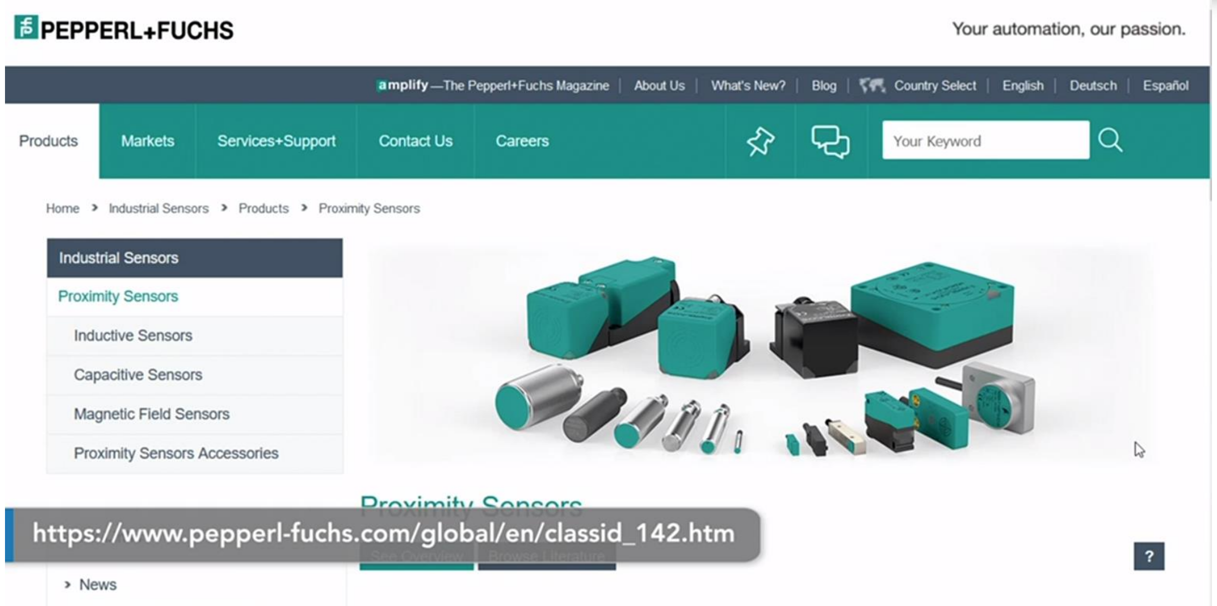
- Contact sensors must physically touch an object to sense it
- Non-contact sensors can sense without physically touching an object

Contact temperature sensor

Non-contact temperature sensor

Proximity Sensor

Detect a presence of an object without physical contact and then convert the signal into a electrical signal



Application of Proximity Sensor

When rapid response and high switching rates are needed

When the object has to be sensed through metallic or non-metallic barrier

When the object is too small, light weight or soft

Capacitive Proximity Sensors - 875c

https://literature.rockwellautomation.com/idc/groups/literature/documents/in/875cp-in001_-en-p.pdf

4 of 6 Automatic Zoom

Paper (1 ream, 500 sheets)	0.55
Wood	0.45
Stone	0.65
Ceramic tile	0.25
PVC	0.15

Environmental Factors

Capacitive sensors can be compromised by humidity and moisture on the sensor face. Oil or water droplets on the sensor face can cause the unit to become unstable. Dust and moisture in the atmosphere have less of an effect on unshielded sensors than on shielded models.

Mounting Considerations

The sensor must be securely mounted on a firm, stable surface, or support. A mounting configuration, which is unstable or subject to excessive vibration, may cause intermittent operation.

Shielded vs. Unshielded

Shielded sensors can be mounted flush with surrounding materials. Unshielded sensors must be mounted such that the area around the sensing face is free of any material, which could trigger the sensor. Minimum clearance in all directions should be equal to the diameter or width of the sensor.

Spacing Between Devices

When two shielded or unshielded sensors are facing each other, they must be mounted far apart to avoid interference. Minimum spacing should be eight times the housing diameter or width. When two shielded sensors are mounted side by side, the minimum distance between them must be greater than one diameter or width. When two unshielded sensors are mounted side by side, the distance between them should be at least four times their diameter or width. See Dimensions section for housing sizes.

M18x1	Y	Pico	18 (0.71)	[illegible]	[illegible]
	N	Cable		51.8 (2.04)	51.8 (2.04)
	N	Pico			
M30x1.5	Y	Cable	30 (1.18)	53.1 (2.09)	53.1 (2.09)
	Y	Micro			
	N	Cable		52.1 (2.05)	46.1 (1.81)
	N	Micro			
N/A	N	Cable	34 (1.34)	52 (2.05)	N/A
	N	Micro			

Dielectric Constants of Industrial Materials

This is a partial listing. For more information, see the CRC Handbook of Chemistry and Physics (CRC Press), the CRC Handbook of Tables of Applied Engineering Science (CRC Press), or other applicable sources.

Dielectric Constants

Material	Value
Acetone	19.5
Acrylic resin	2.7…4.5
Air	1.000264
Alcohol	25.8
Ammonia	15…25
Aniline	6.9
Aqueous solutions	50…80
Bakelite	3.6
Benzene	2.3
Carbon dioxide	1.000985
Carbon tetrachloride	2.2
Celluloid	3
Cement power	4
Cereal	3…5

Temperature measurement in Oil & Gas

The Oil & Gas industry is divided into the areas, “Upstream – exploration and support”, “Mid-stream – transportation” and “Downstream– processing”. Different requirements on the measurement technology used can be seen in each of these areas.

Resistance Temperature Detector (RTD)

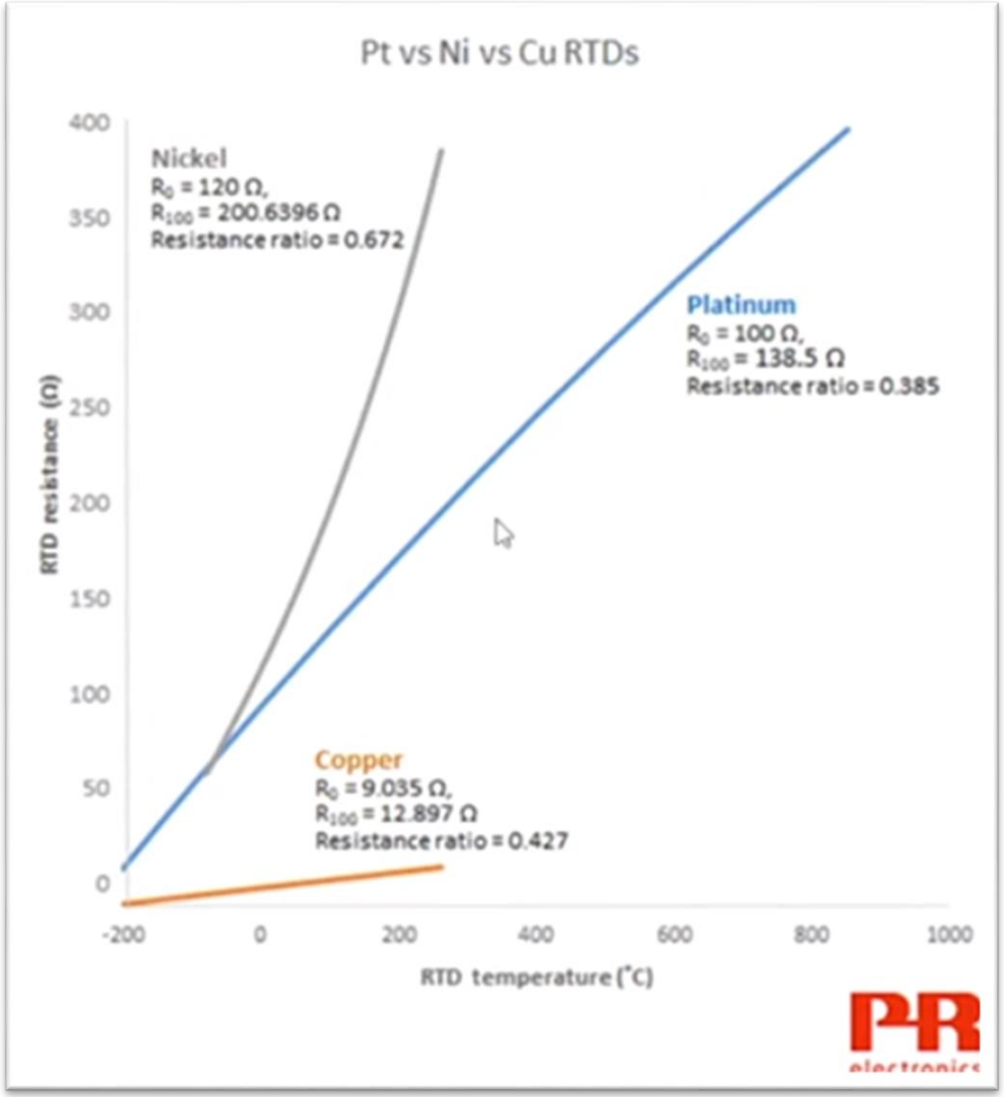
https://www.ia.omron.com/data_pdf/cat/e52_ds_e_22_3_csm227.pdf?id=3502

1 of 58 170%

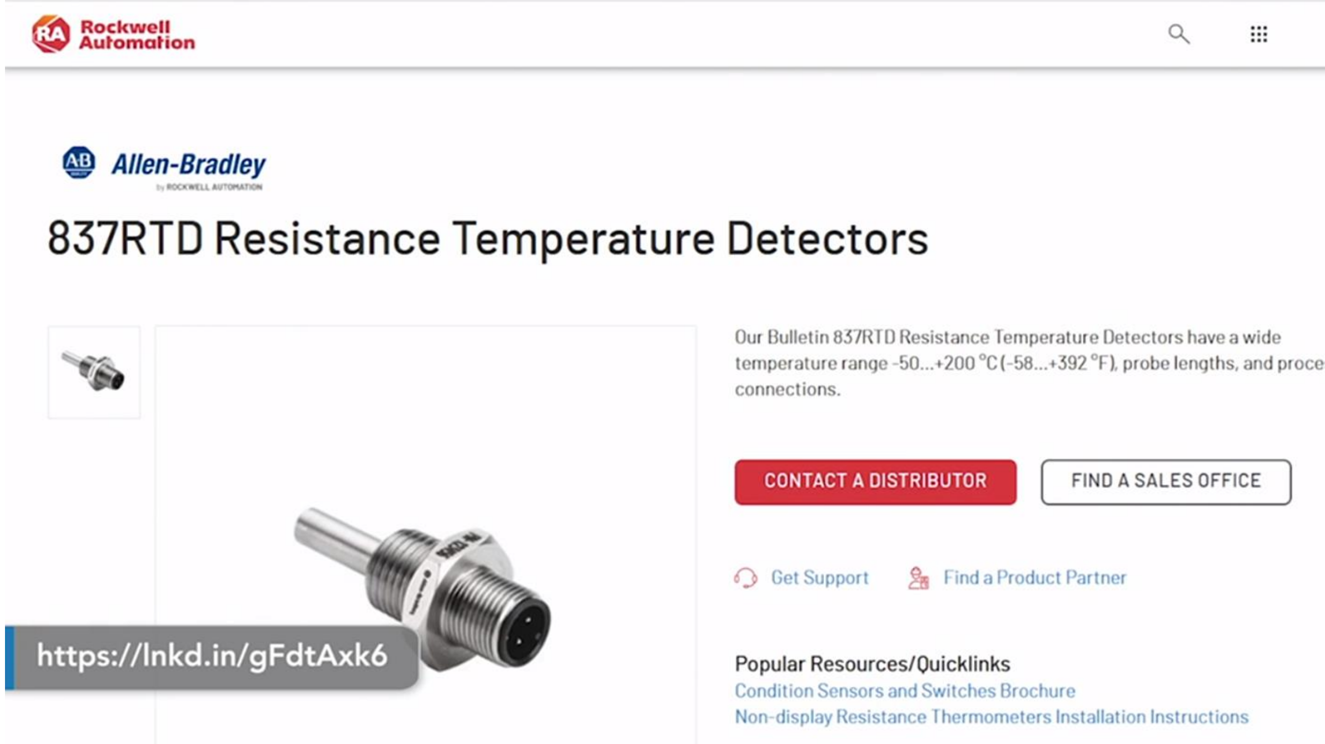
■ List of Models (Temperature Sensors)

Classification	Description	Model and appearance	Temperature range (See note 3.)	Element type	Conductor type	Class	Protective tubing material	Terminal type	Page
General-purpose Models	Sheathed platinum resistance thermometer	E52-P□AY	−196°C to 450°C	Pt100	3-conductor system	B	SUS316	Exposed lead wires	5
		E52-P□C-N	−196°C to 450°C				ASTM316L	Enclosed terminals	7
		E52-P□B-N						Exposed terminals	
	Standard platinum resistance thermometer	E52-P□C-N	0°C to 450°C				SUS316	Enclosed terminals	8
	Sheathed thermocouple	E52-CA□AY E52-IC□AY	0°C to 900°C	K (CA) J (IC)	Non-grounded type	2 (0.75)	ASTM316L	Exposed lead wires	11 to 12
		E52-CA□B-N E52-IC□B-N						Exposed terminals	16
		E52-CA□C-N E52-IC□C-N						Enclosed terminals	
	Standard	E52-CA□B-N					SUS316	Exposed	17

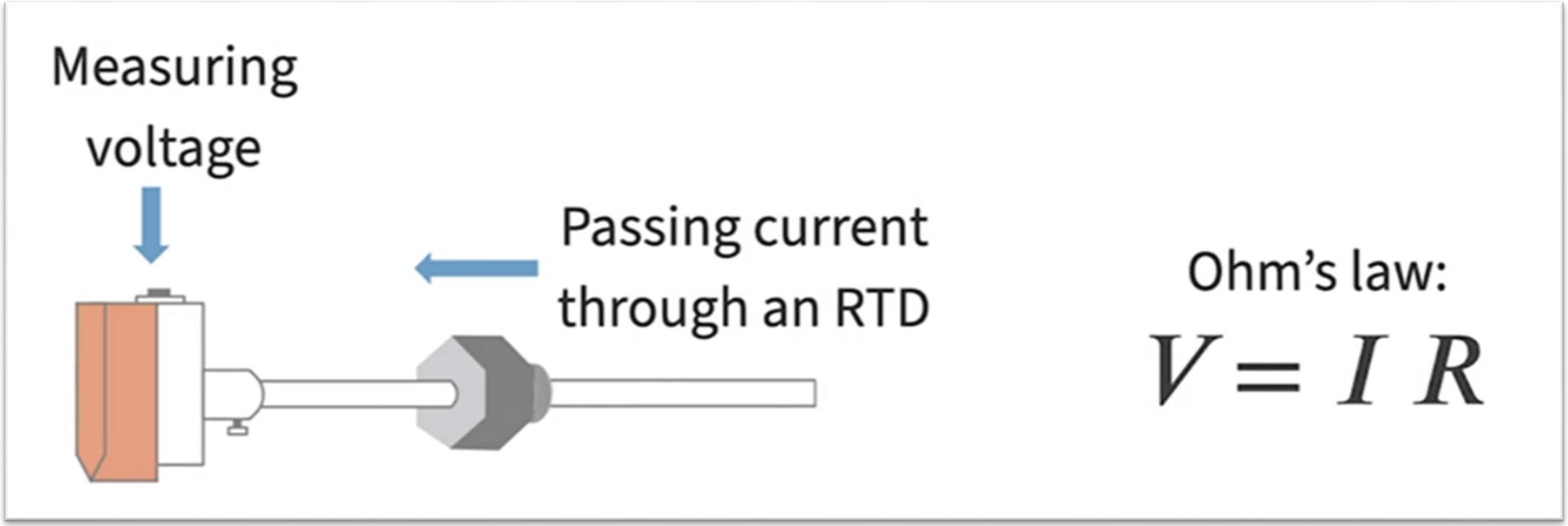
Resistance Temperature Detector (RTD)



Metal	Temperature Range
Platinum	-200°C to 850°C
Nickel	-100°C to 315°C
Copper	-75°C to 150°C

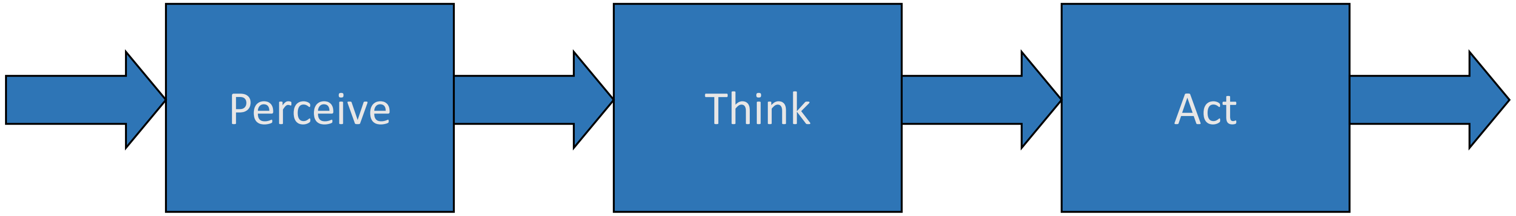


Operational principle of RTD

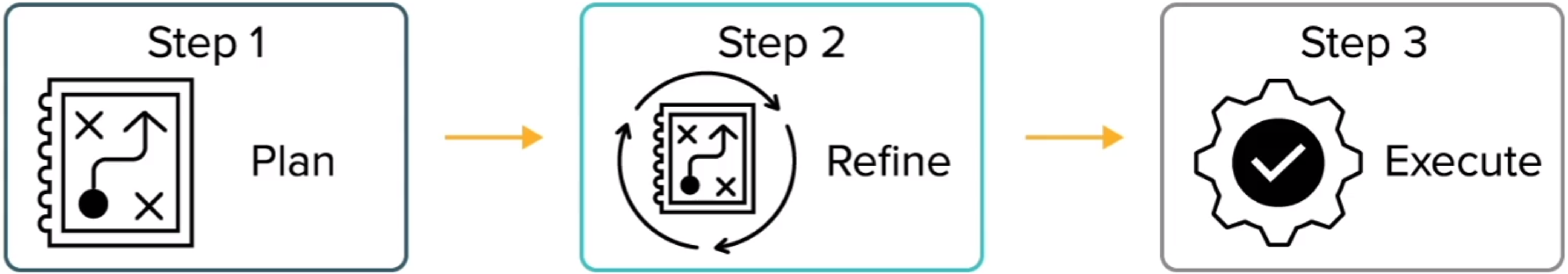


Level of planning

- Perceive-think-act model of intelligence
  (Kenneth Craik, 1943)



- This model was very influential in early AI



End of things 13