Sensing

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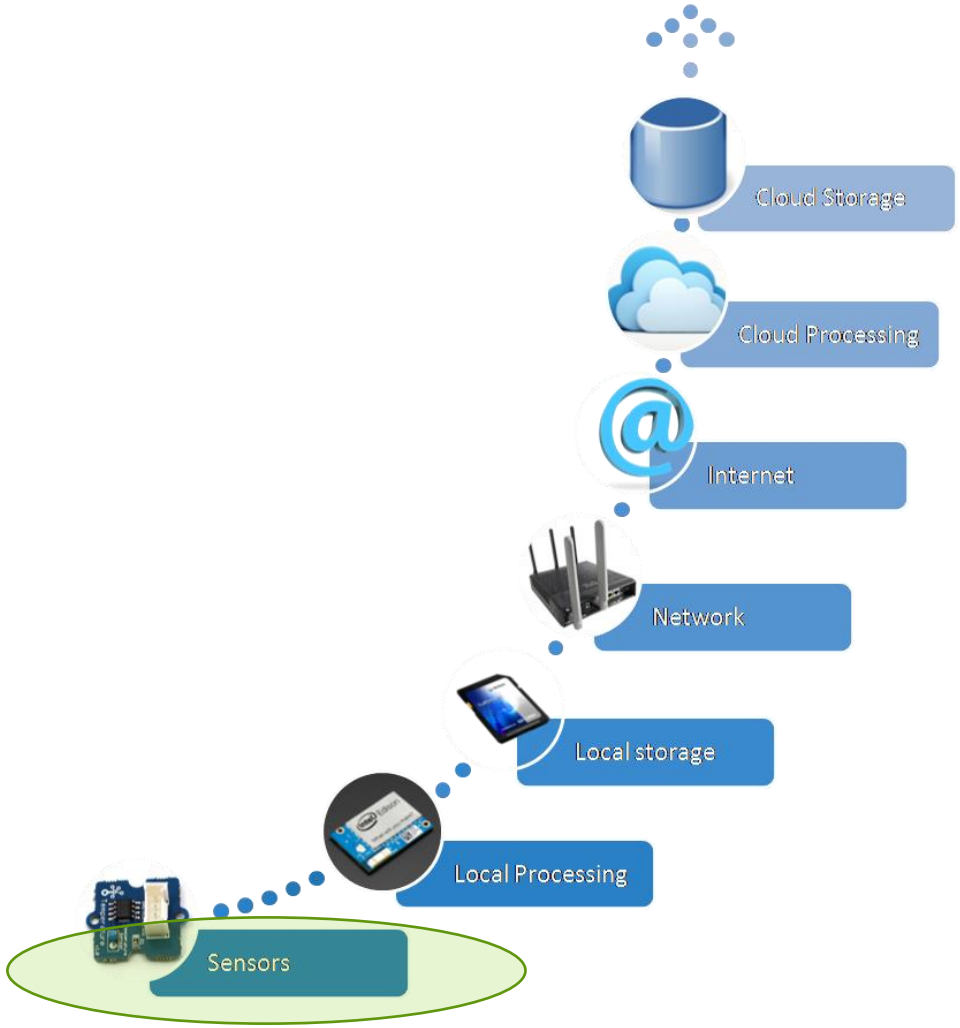
Outline

- Definitions
- Sensor Classification
- Sensor Characteristics
- Sensor Working Principles

Upstream Information Flow in IoT



- Sensing an inevitable process in IoT!

Source: http://ocw.cs.pub.ro/courses/_media/iot2015/courses/picture11.png?w=450&tok=584430

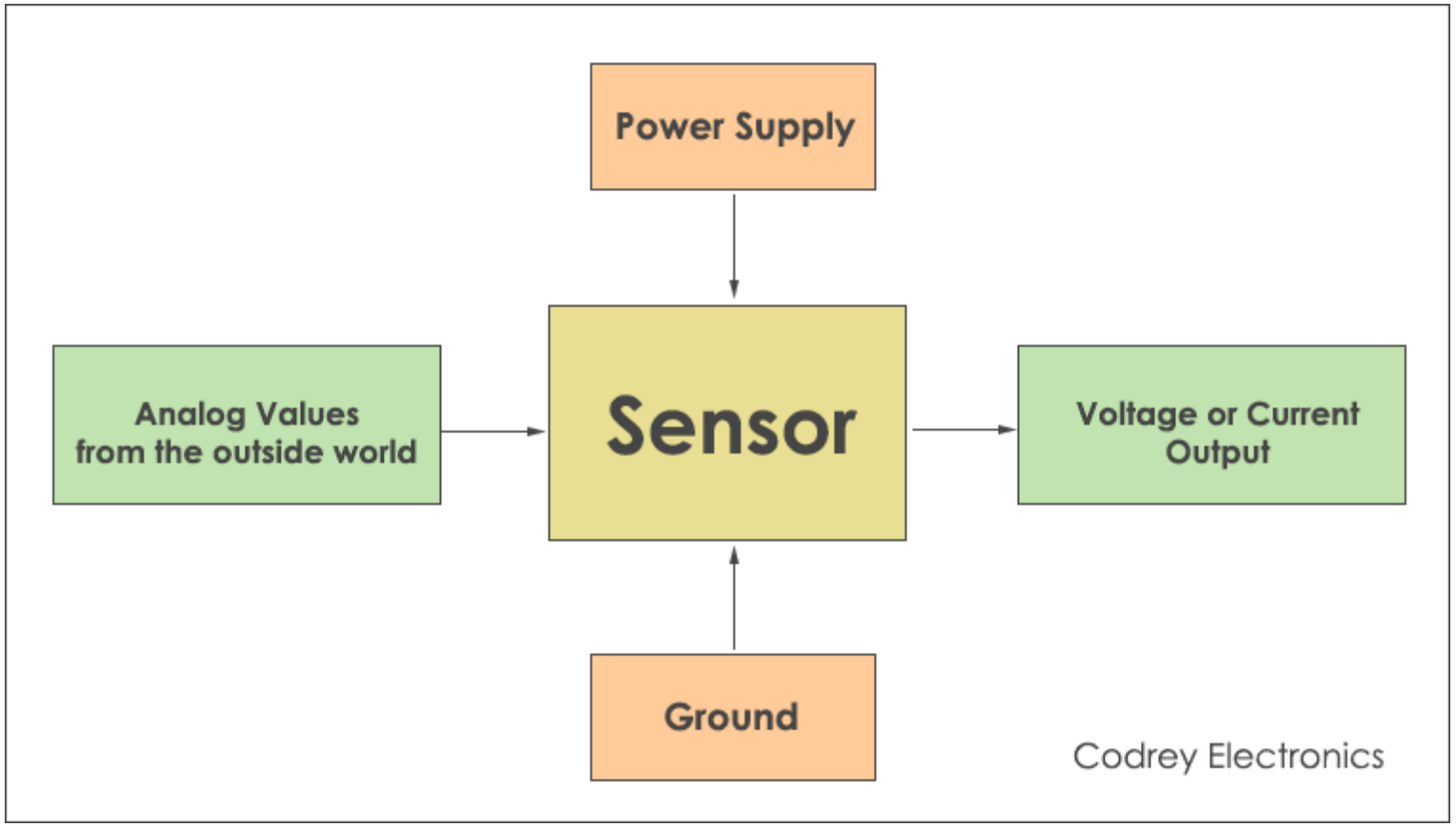
What is a Sensor?

- A sensor detects (senses) changes in the ambient conditions or in the state of another device or a system, and forwards or processes this information in a certain manner [1].

- "A device which detects or measures a physical property and records, indicates, or otherwise responds to it" [2]. – Oxford dictionary

References
1. http://www.businessdictionary.com/definition/sensor.html
2. https://en.oxforddictionaries.com/definition/sensor

Block Diagram



Source: https://www.codrey.com/electronics/different-types-of-sensors/

Sensors

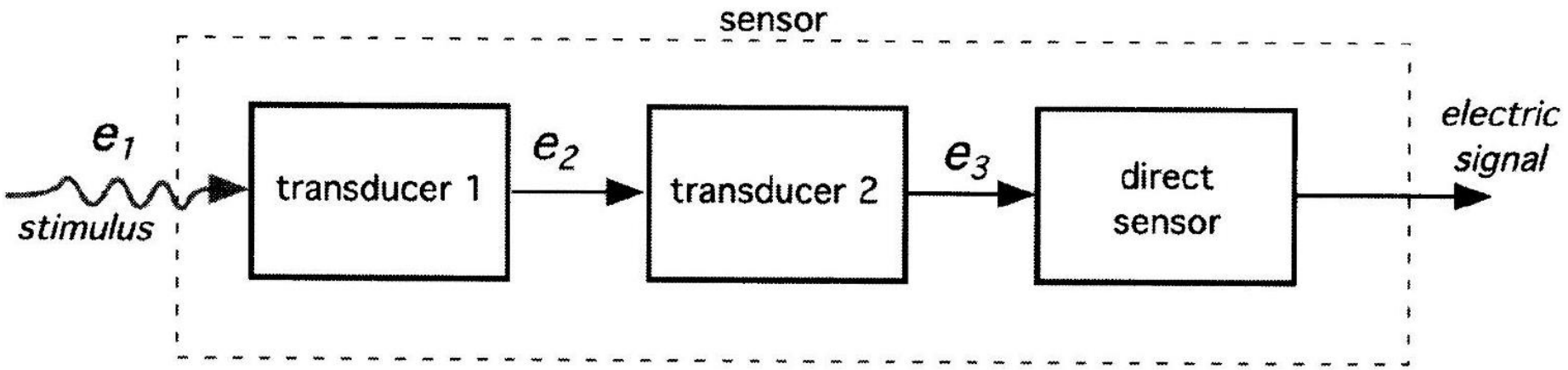
- Perform some input function by sensing or feeling the physical changes in characteristics of a system in response to some stimuli

- Example: In a temperature sensor, heat is converted to electrical signals

Transducers

- Convert one form of energy into another
- Example: In a sound system, a microphone converts sound waves into electrical signals, which are then amplified by an amplifier and a loudspeaker converts the electrical signals back into sound waves
- It is a collective term that includes both sensors and actuators

Sensor – Energy Converter



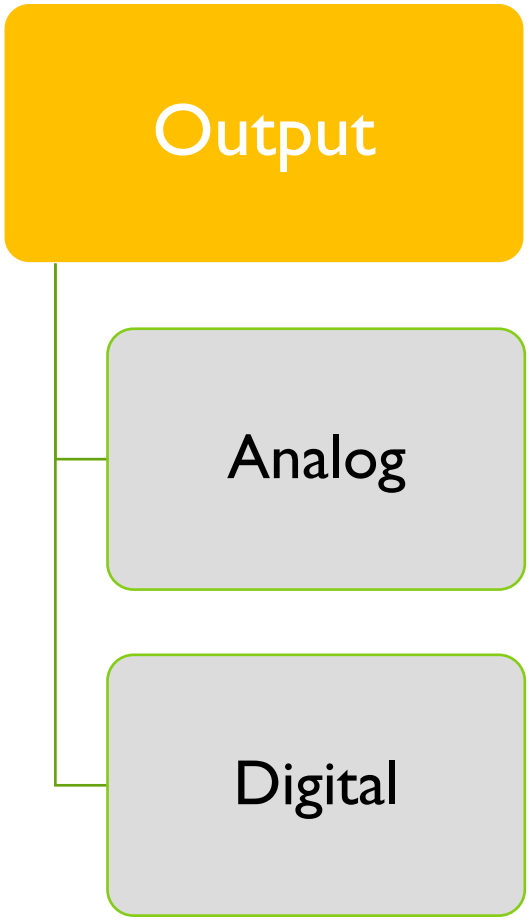
Source: https://www.philadelphia.edu.jo/academics/kaubaidy/uploads/Sensor-Lect2.pdf

- A sensor may incorporate several transducers. The last part is a direct sensor producing electrical output
- Example: A chemical sensor produces electrical signal in response to a chemical reaction. It may have two parts: first one converts the energy of a chemical reaction to heat (transducer) and the other part (thermopile) converts the heat into an electrical signal
- Direct sensor and Indirect Sensor

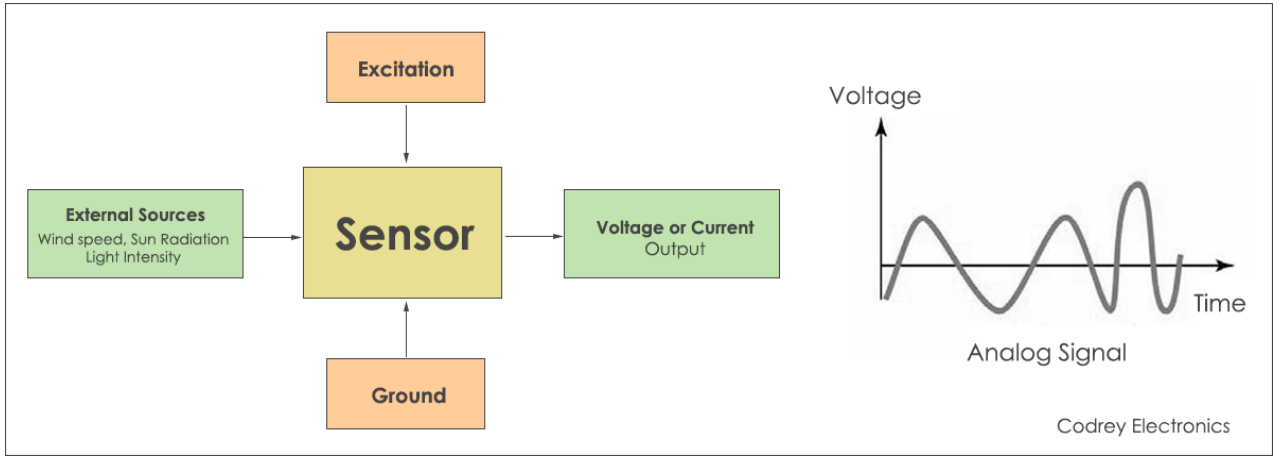
Sensor Features

- Sensitive only to the measured property (temperature sensor only senses the ambient temperature)
- Insensitive to any other property encountered in the system
- Does not influence the measured property

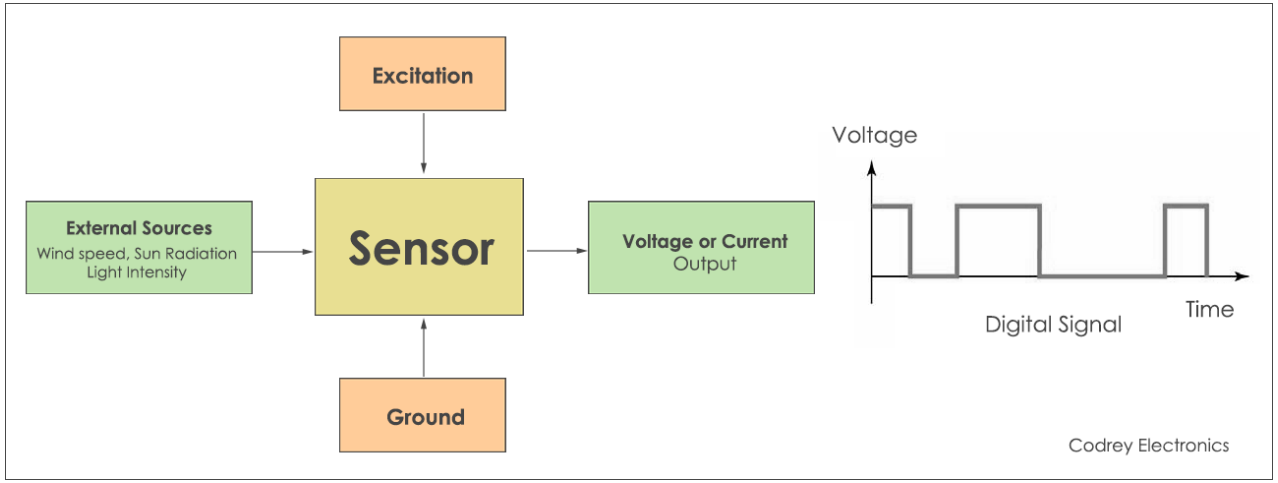
Types of Sensors



Sensor Classes (Based on Output)

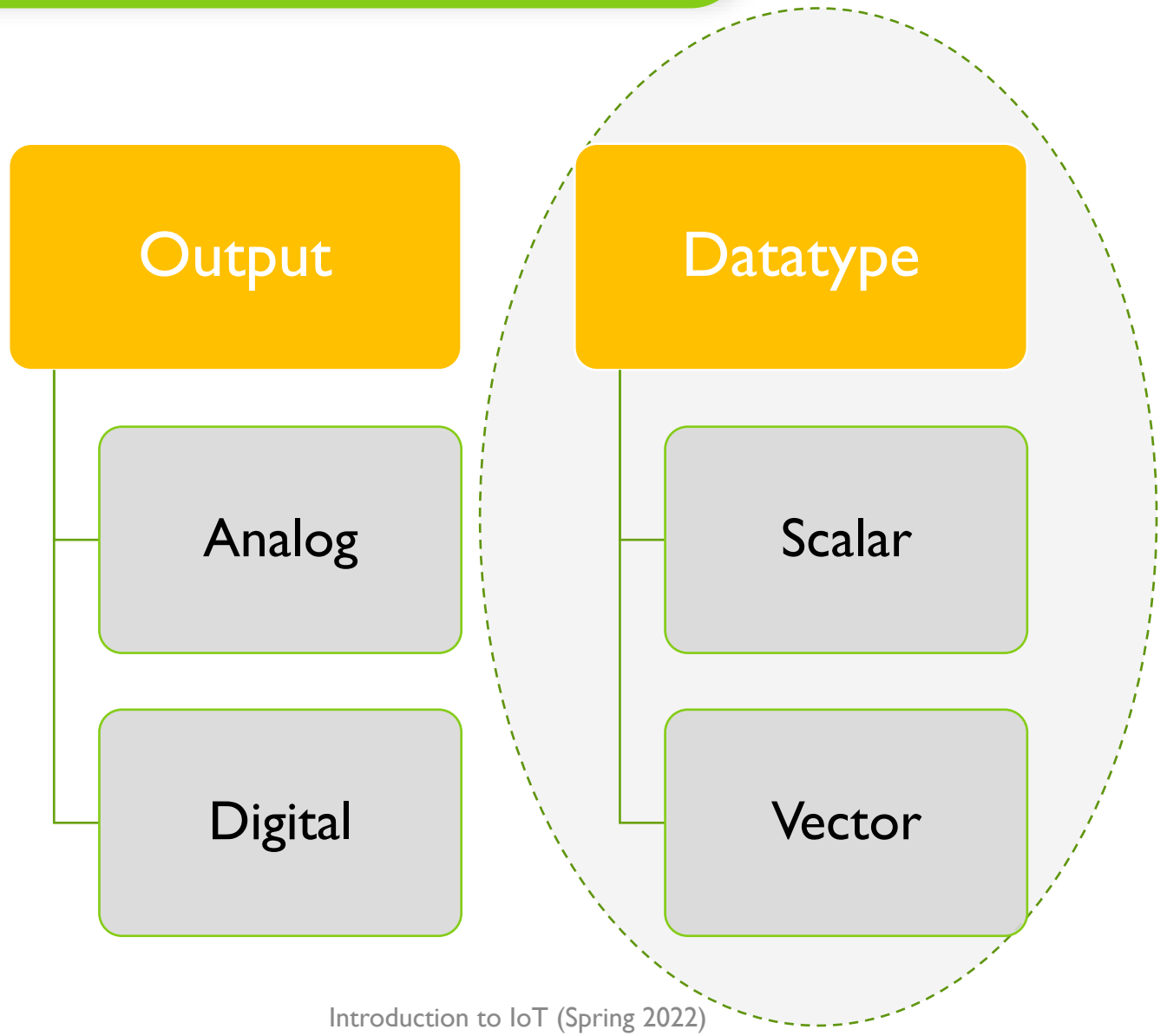


Analog Sensor



Digital Sensor

Types of Sensors



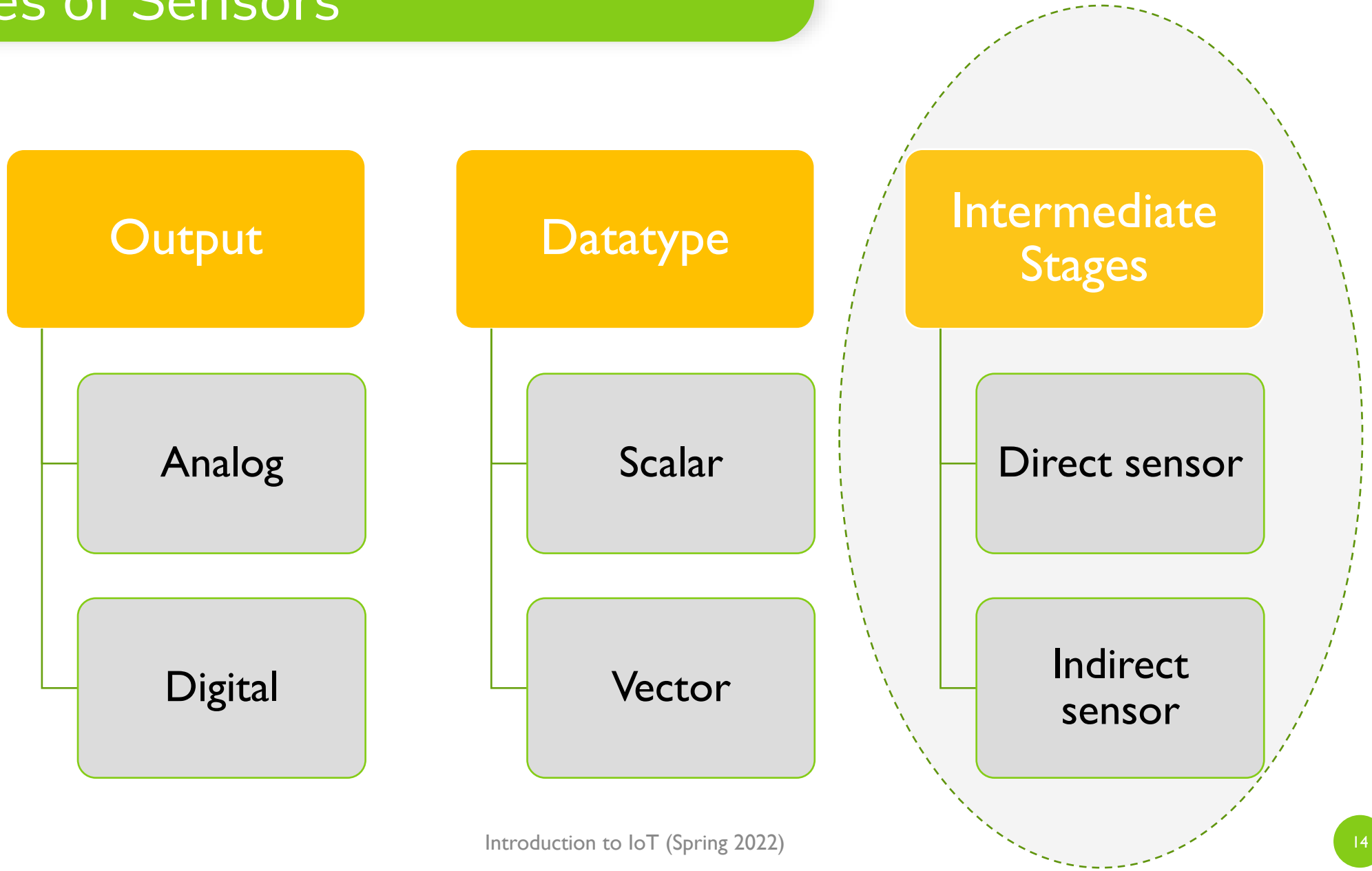
Sensor Classes (Based on Data Type)

- Scalar Sensor: Produces output voltage which is proportional to the magnitude of the quantity measured
  Physical quantities: temperature, color, pressure, etc

- Vector Sensor: Produces output voltage which is proportional to the magnitude, direction and the orientation of the quantity measured (Camera sensor)

  Physical quantities: Sound, image, velocity, acceleration

Types of Sensors

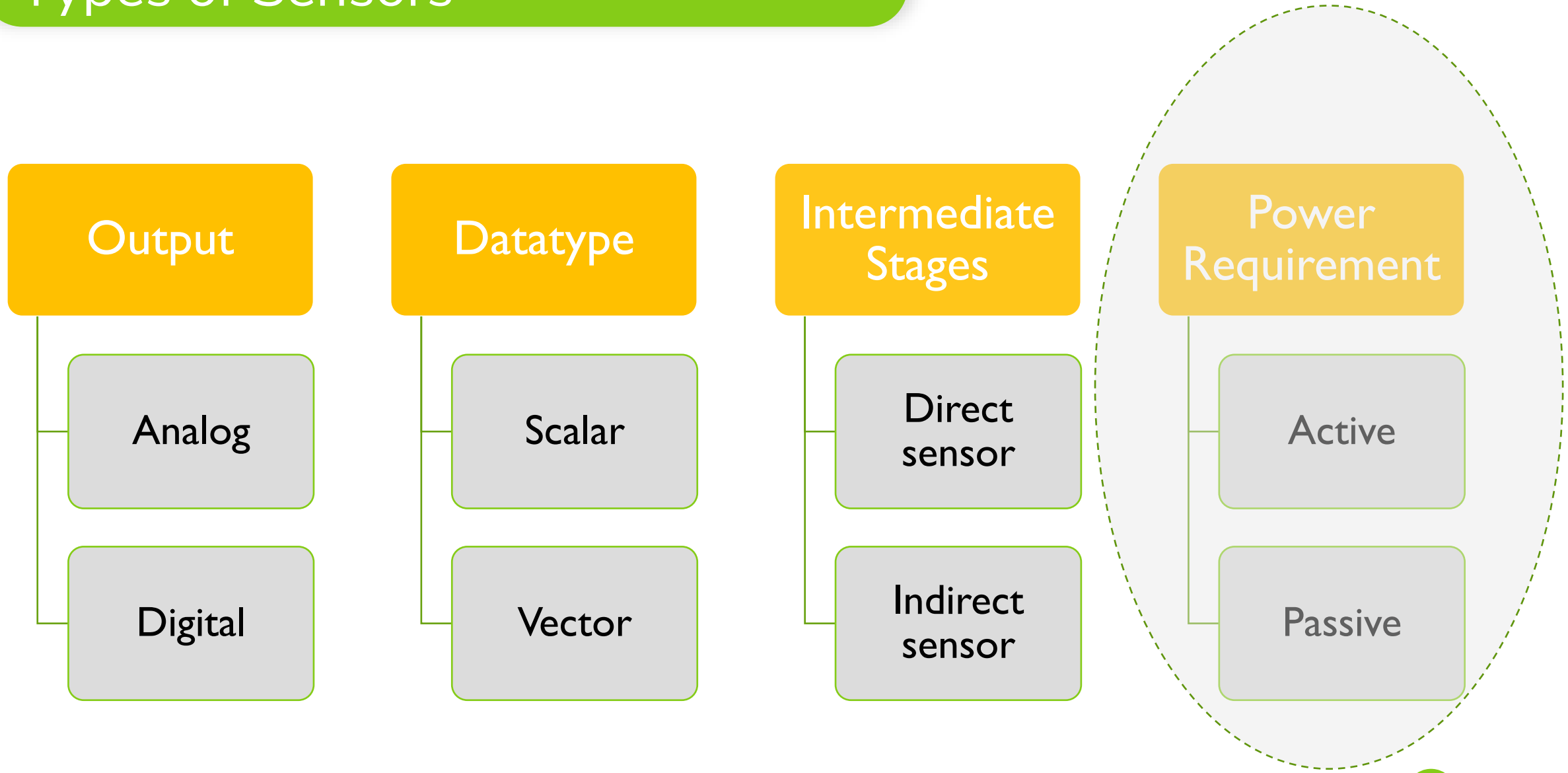


Types of Sensors

- Direct Sensor:
  Converts a stimulus into an electrical signal or modifies an electrical signal by using an appropriate physical effect
  Example: Thermocouple

- Indirect Sensor:
  Includes one or more transducers for multiple conversion steps before a direct sensor generates an electrical output

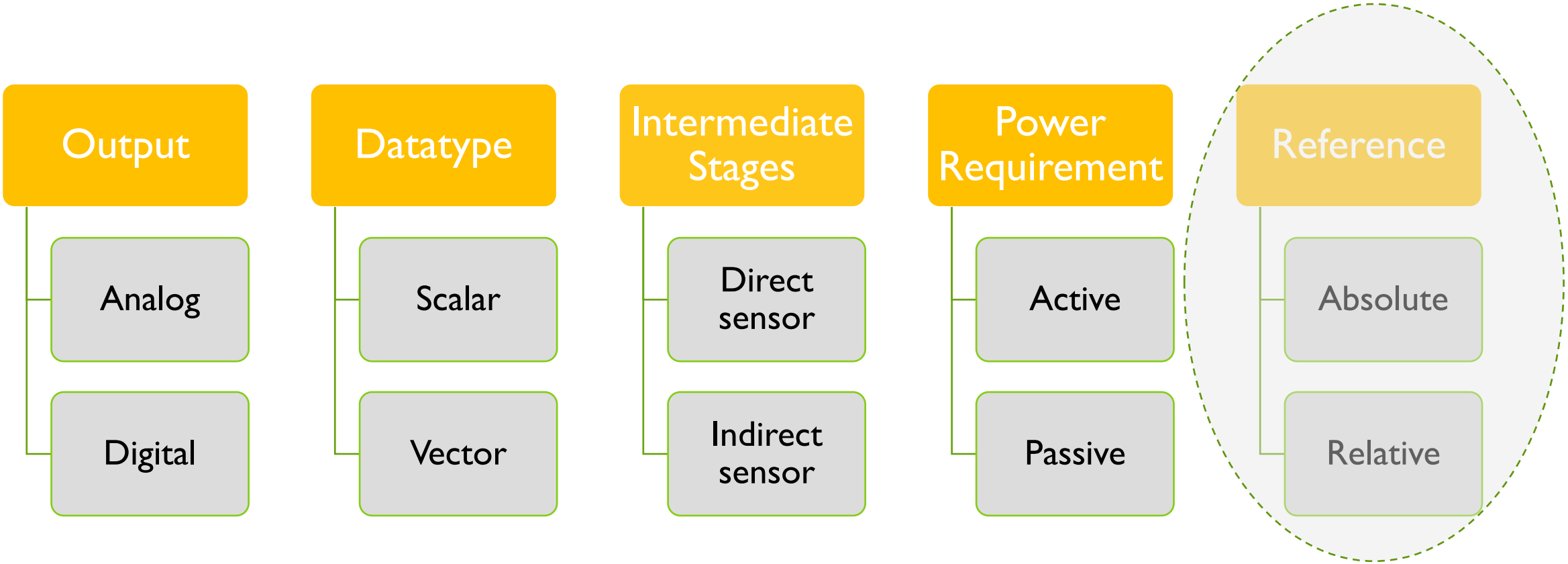
Types of Sensors



Types of Sensors

- Passive Sensor:
  Does not need any additional energy source and directly generates an electrical signal in response to external stimulus.
  Most passive sensors are direct sensors as defined earlier.
  Example: Thermocouple, photodiode, piezoelectric sensor
- Active Sensor:
  Requires external power for its operation, which is called an excitation signal.
  Example: LiDAR, GPS, infrared sensor

Types of Sensors

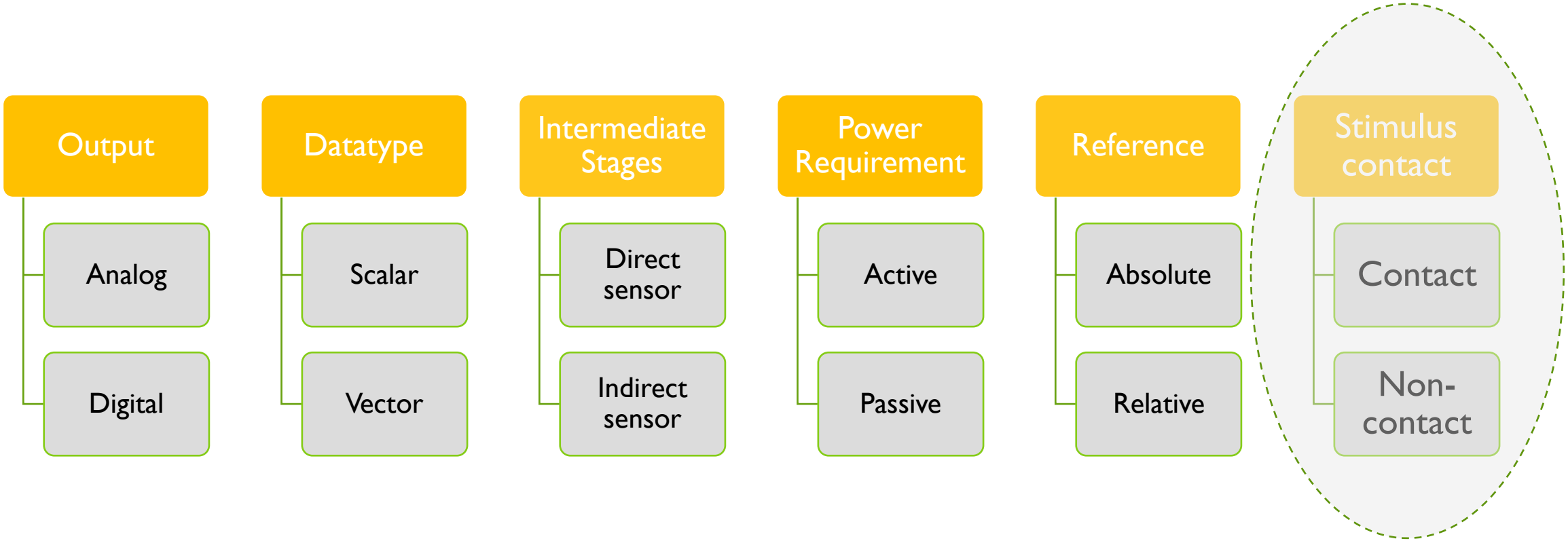


Types of Sensors

- Absolute Sensor:
  Detects a stimulus in reference to an absolute physical scale that is independent of the measurement conditions
  Example: Thermistor

- Relative Sensor:
  Stimulus is sensed with respect to a fixed or variable reference that is not an absolute value independent of measurement conditions
  Example: Thermocouple

Types of Sensors



Types of Sensors

- Contact sensor:
  Requires physical contact with the stimulus
  Example: strain gauges, temperature sensors

- Non-contact sensor:
  Requires no physical contact
  Example: optical and magnetic sensors

Sensor Characteristics

- Static Characteristics
  - ✓Range and Span
  - ✓Accuracy
  - ✓Resolution
  - ✓Precision
  - ✓Errors
  - ✓Sensitivity
  - ✓Linearity
  - ✓Hysterisis
- Dynamic Characteristics

Range and Span

- **Range**
  Minimum and Maximum value of a physical quantity that a sensor can measure
  Example: A Resistance Temperature Detector (RTD) for the measurement of temperature has a range of -200 to 800˚C

- **Span**
  Difference between maximum and minimum values of input measured
  In the above example, span of RTD = 800 – (-200) = 1000˚C

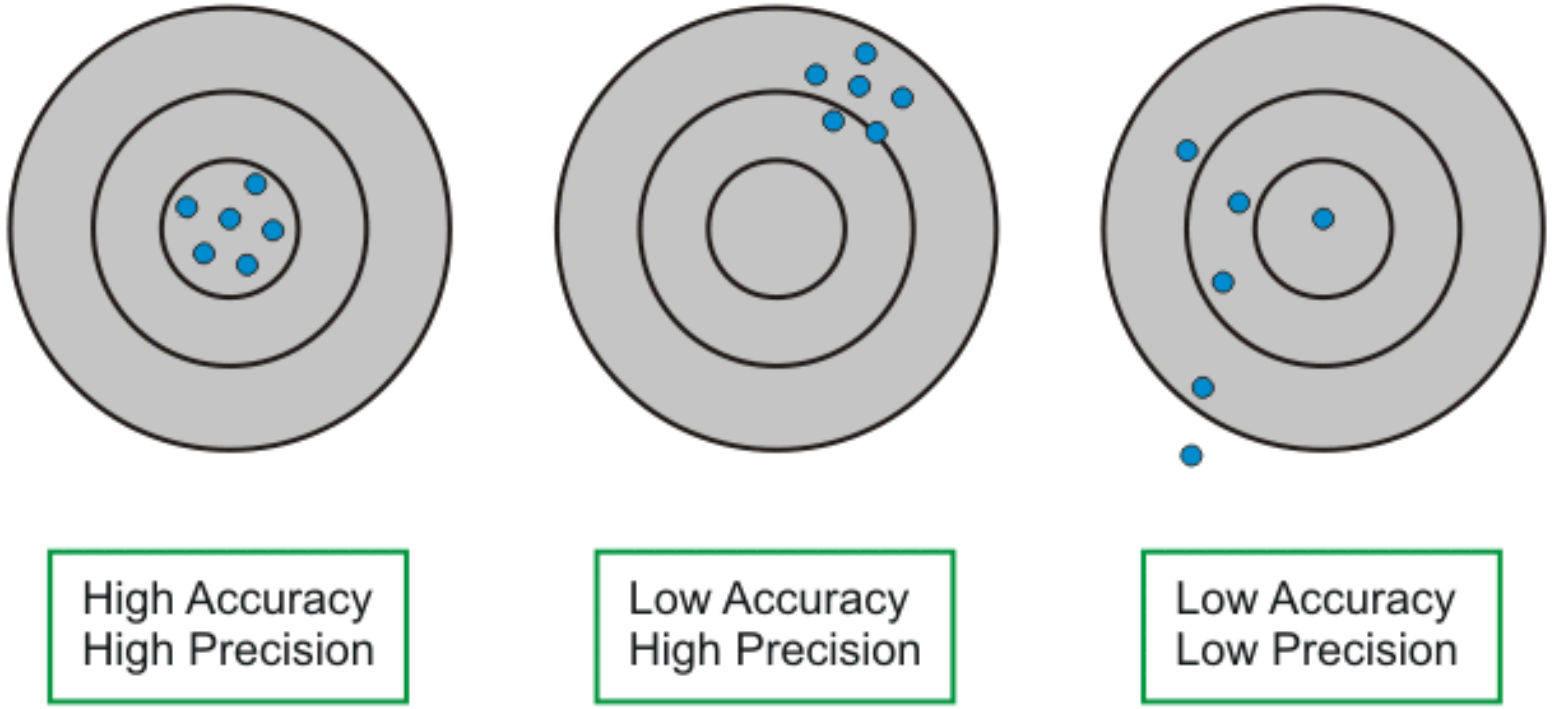
Accuracy and Resolution

- **Accuracy** is the capacity of a sensor to give results close to the **TRUE VALUE** of the measured quantity
  - Measured by absolute and relative errors
    ABSOLUTE ERROR = RESULT – TRUE VALUE
    RELATIVE ERROR = ABSOLUTE ERROR / TRUE VALUE

- **Resolution** is the minimal change of the input necessary to produce a detectable change at the output

Precision

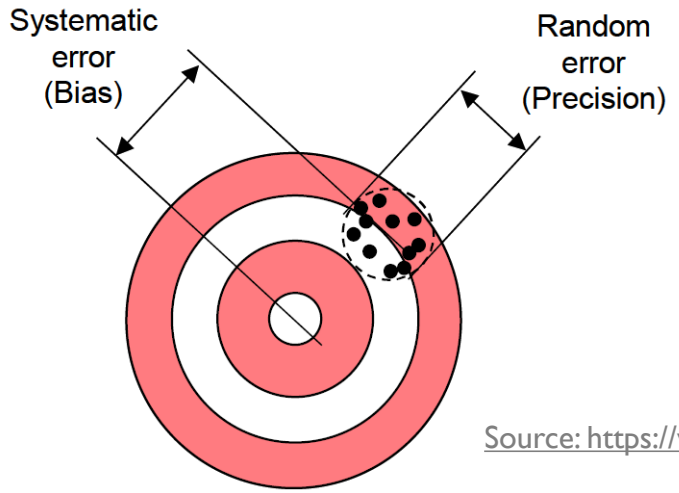
- Capacity of a sensor to give same reading when repetitively measuring the same quantity under the same prescribed conditions



Source: https://www.electrical4u.com/characteristics-of-sensors/

Errors

- Systematic Errors
  Due to interfering or modifying variables (e.g., temperature), loading, attenuation, etc.
- Random Errors
  A signal that carries no information such as environmental noise



Source: https://www.philadelphia.edu.jo/academics/kaubaidy/uploads/Sensor-Lect2.pdf

Thank You!