ACTUATORS AND SENSORS. PART 1

Lecture 12

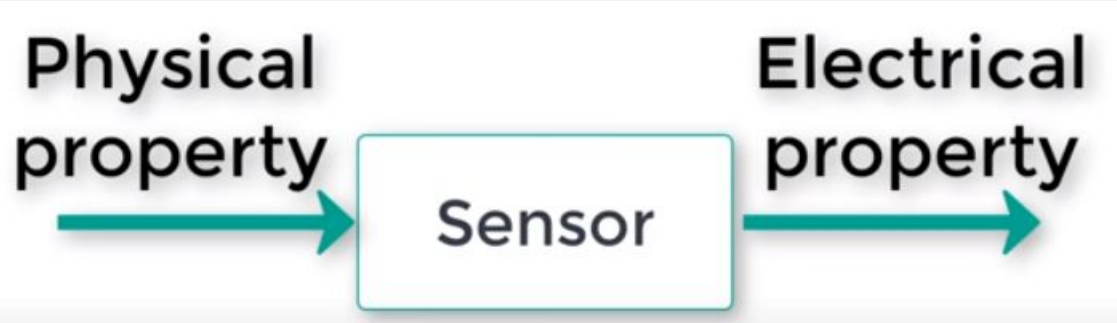
Irob 2305 Introduction to Robotics

OUTLINE

- Motivation, why robots need sensors?
- Difference between actuators and sensors
- Robotic sensor classification
- Sensor Performance
- Calculation of errors

Sensors in Robotics are primarily used for two different purposes:

- 1. Give the robot information about itself
- 2. Give the robot information about its environment

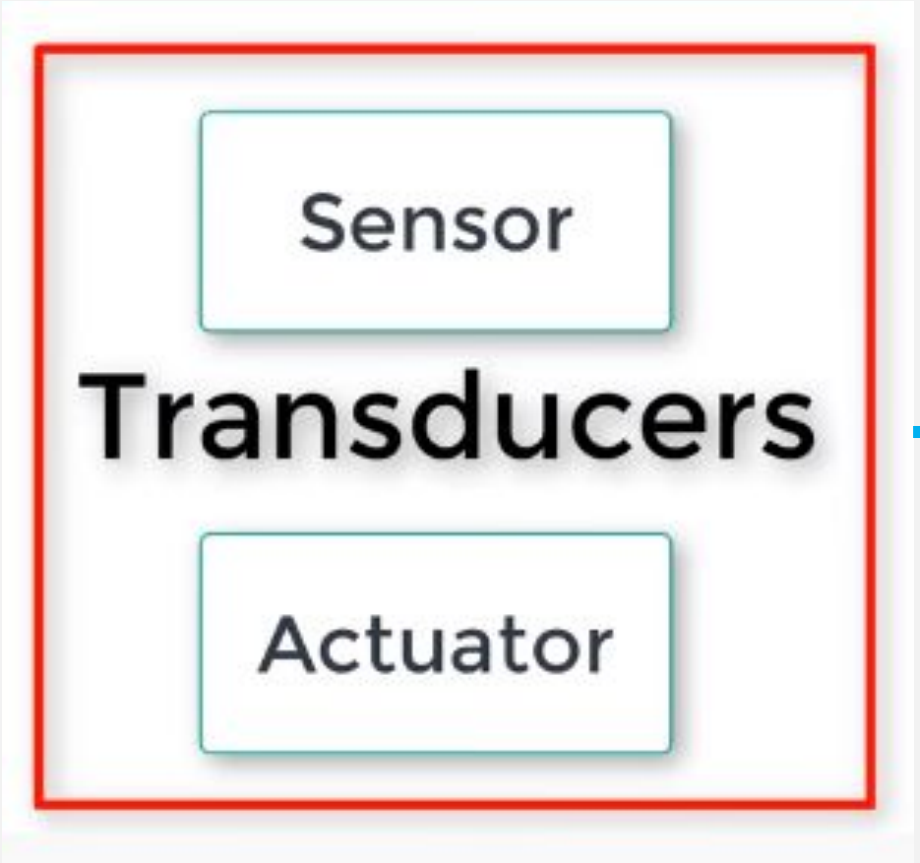


Examples:

Temperature sensors
Humidity sensors
Light level sensors

Examples:

DC motors
Servo motors
Stepper motors

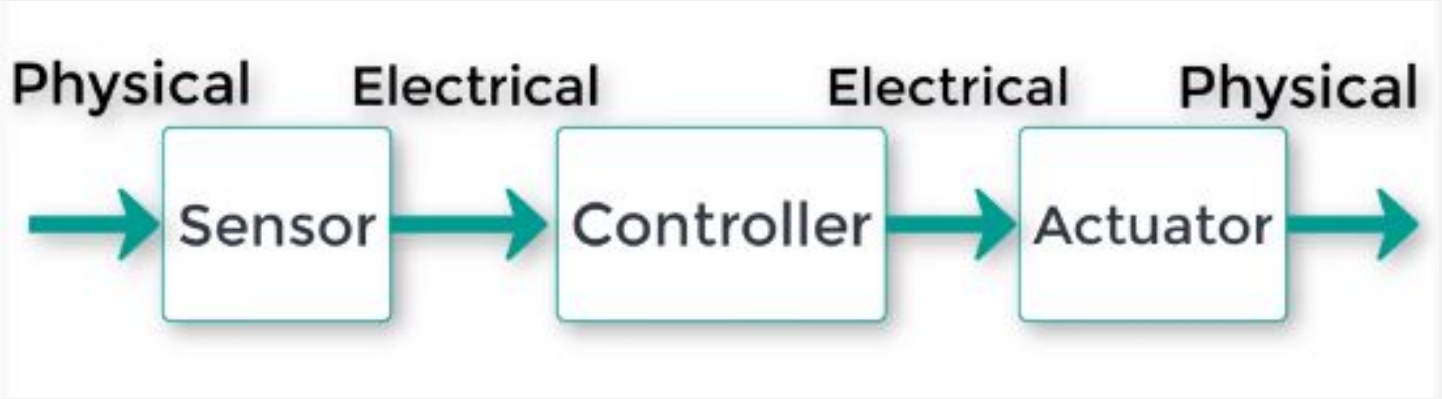


Any kind of device that converts one kind of energy into another

Sensors: input transducers

Actuators: output transducers

COMMON COMPLETE ROBOT SYSTEM



1. **Take in a physical property through the sensor;**
2. **Converting to electrical property which can be measured;**
3. **Do some calculations using that measurement**
4. **Adjust the electrical property using the actuator;**
5. **Affecting the physical world.**

CLASSIFICATION

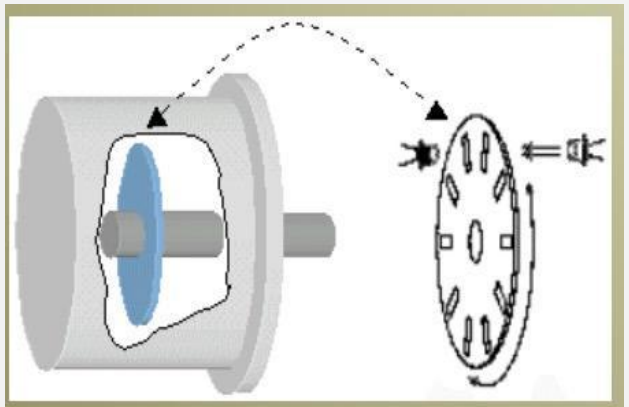
- Robot sensors can be classified into two groups:
- Internal sensors and external sensors

Internal sensors: Obtain the information about the robot itself.

– position sensor, velocity sensor, acceleration sensors, motor torque sensor, etc

acceleration sensors

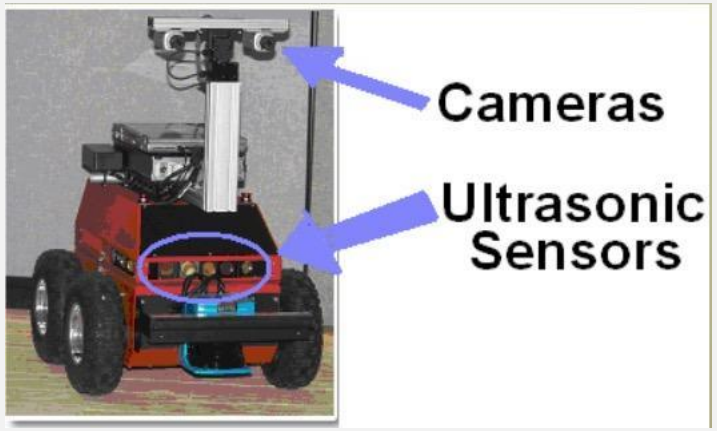
velocity sensor



optical encoder

EXTERNAL SENSORS

- External sensors: Obtain the information in the surrounding environment.
- – Cameras for viewing the environment
- – Range sensors: IR sensor, laser range finder, ultrasonic sensor, etc.
- – Contact and proximity sensors: Photodiode, IR detector, RFID, touch etc.
- – Force sensors: measuring the interaction forces with the environment, etc.

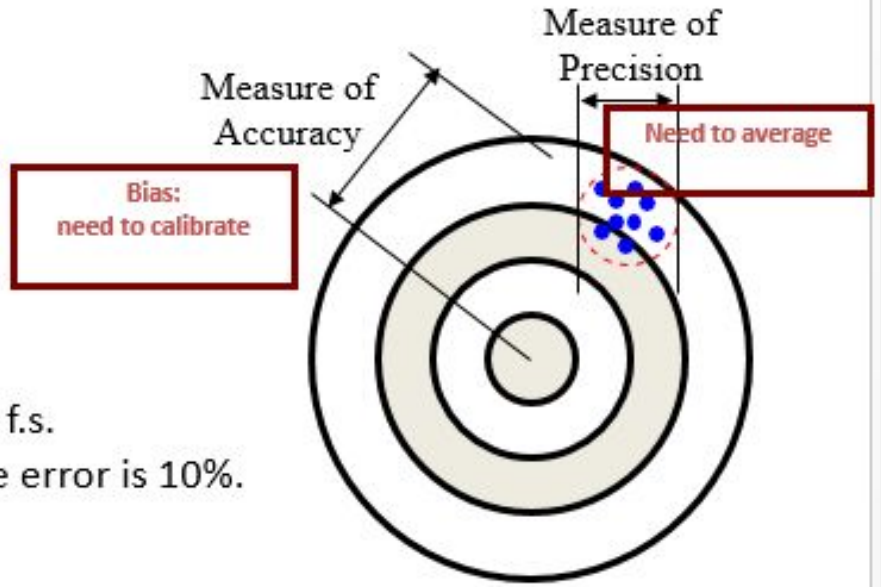


Evaluation Criteria for Sensors

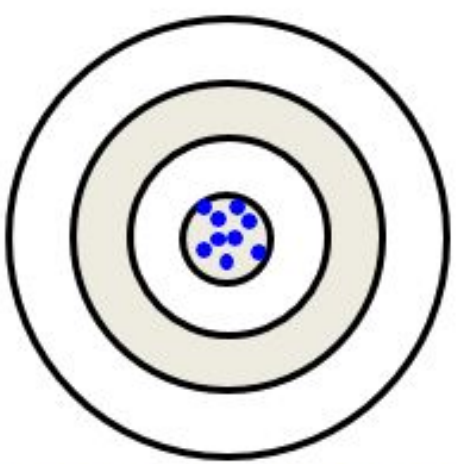
1. **Sensitivity** - how sensitive is the sensor
   - usually max. sensitivity that provide linear accurate signals.
2. **Linearity** - operation is linear to the input.
3. **Range** - difference between max. & min. value.
4. **Response time** - faster than the sampling time in micro-processor.
5. **Accuracy** - different between measured and actual.
6. **Repeatability** - ability to repeat between several measuremets.
7. **Resolution** - a measure of the number of measurementy.
8. **Type of output**.
9. **Physical consideration** - weight and size.
   - reliability.
   - interfacing.

Static characteristics of instruments

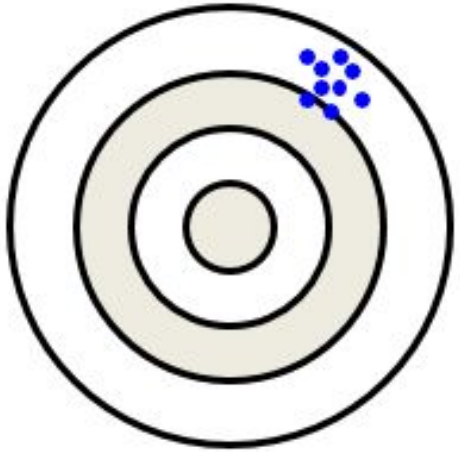
- **Accuracy**: closeness to correct value
- **Precision**: indication of spread of readings
  - Repeatability/reproducibility: variation of a set of measurements made in a short/long period of time



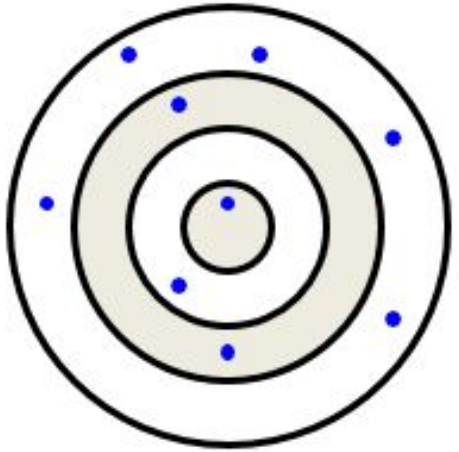
Accuracy is often quoted as a % of full-scale (f.s.) reading.
Example: pressure gauge, range 0-10 bar with accuracy ±1% f.s.
This means ± 0.1 bar, or if you are reading 1 bar, the possible error is 10%.



High accuracy, high precision



Low accuracy, high precision



Low accuracy, low precision

DEVICE ERROR

- Absolute Error (E_A):

  E_A = measured value – true value

  E_A = Y-X
- Relative Error (E_R):

  $E_R = |E_A/X|*100\%$
- Example: X = 20 °C, Y = 21.3 °C , find E_R ?

  $E_A = 21.3 – 20.0 = 1.3.$

  $E_R = 1.3/20 *100 = 6.5\ \%.$

TOLERANCE (LIMITING ERROR)

- For certain devices (components) we use Tolerance instead of Error.
- A resistor has a tolerance of 5% and a nominal value of 1000 Ω:

  This means that the actual value of this resistor fall in this range: (950 – 1050) Ω.

  5*1000/100 = 50 Ω.

  1000 – 50 = 950.

  1000 + 50 = 1050.

ACCURACY & INACCURACY

- Definition: A measure of how close the output of the Instrument (measured value - Y) to the true value - X.
- Absolute Accuracy:

$$A_A = 1 - \left| \frac{Y - X}{X} \right|$$

- Relative Accuracy:

$$A_R = A_A \times 100 = 100 - \left| \frac{Y - X}{X} \right| \times 100 = 100 - E_R$$

- Example: X = 20 °C, Y = 21.3 °C , find A_A &A_R ?

  E_A = 21.3 – 20.0 = 1.3.

  E_R = 1.3/20 *100 = 6.5 %.

  A_A = 1-0.065 =0.935.

  A_R = 93.5%.

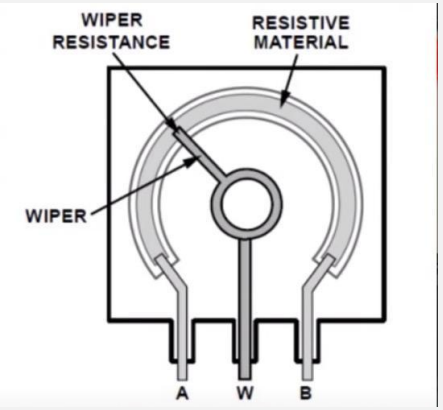
- Inaccuracy (Uncertainty) = 1- A_A.

  = E_R/100.

- **Note**: Inaccuracy is often given as a percentage of full scale (f.s) reading of an instrument.

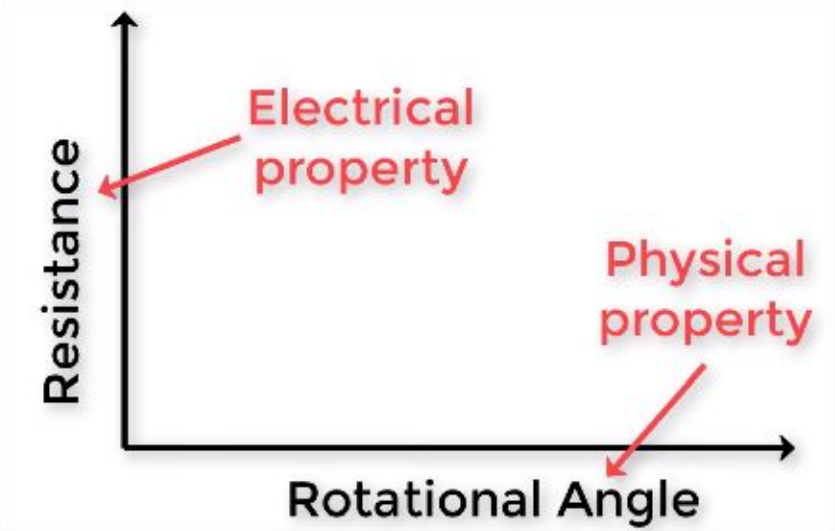
ANALOG SENSOR: POTENTIOMETER

- Analog sensor for measuring the rotational position
- Potentiometer = varying resistance
- Resistance changes with the position of the deal
- Converts rotational angel (physical input) to resistance (electrical output)

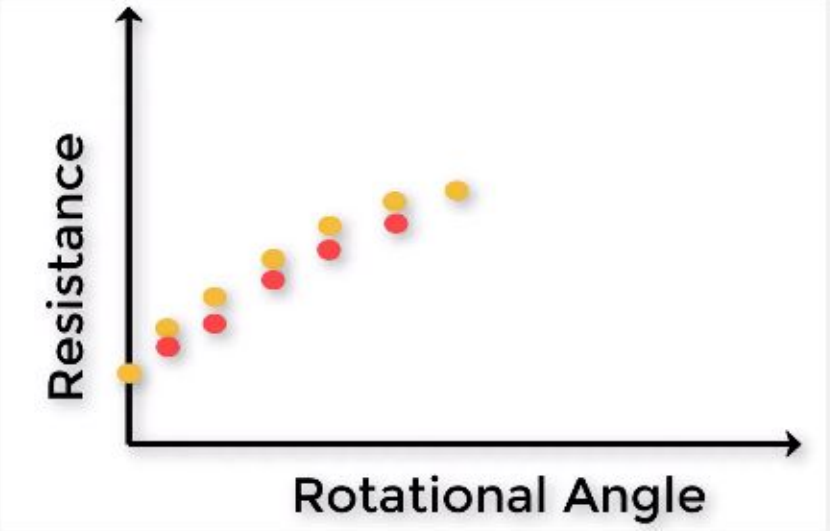


SENSOR RESPONSE CURVE FOR POTENTIOMETER

- Used to define different kind of properties of sensor including errors.



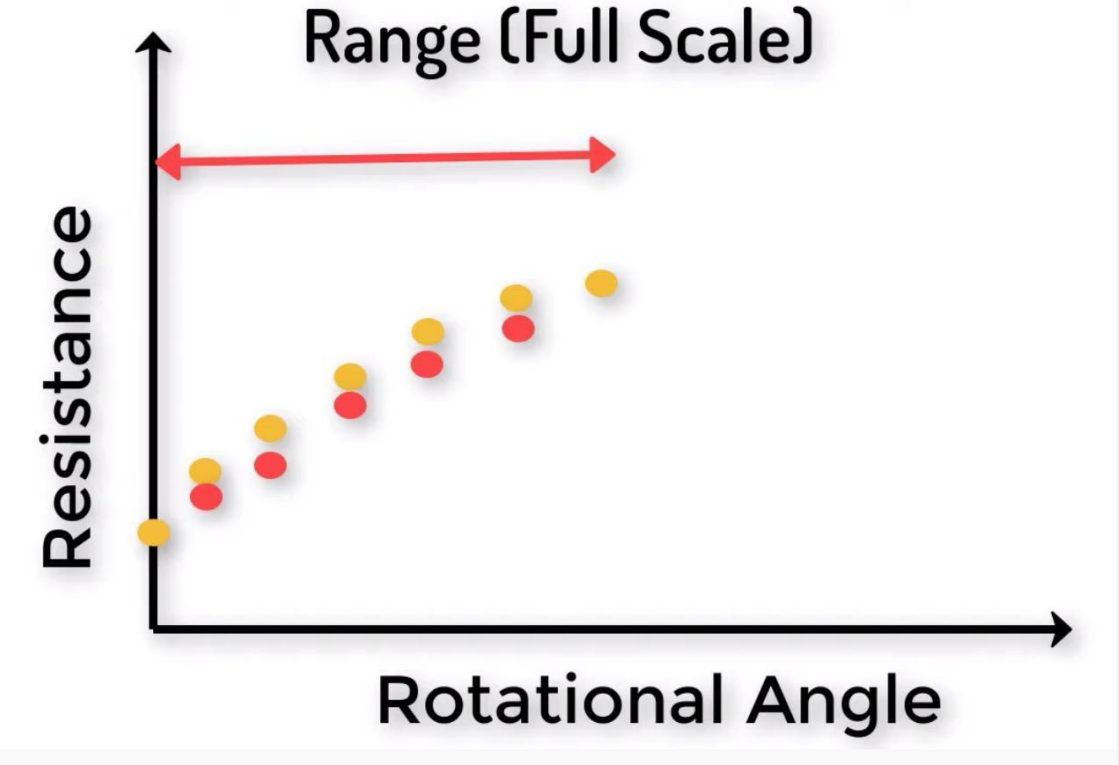
Initial position



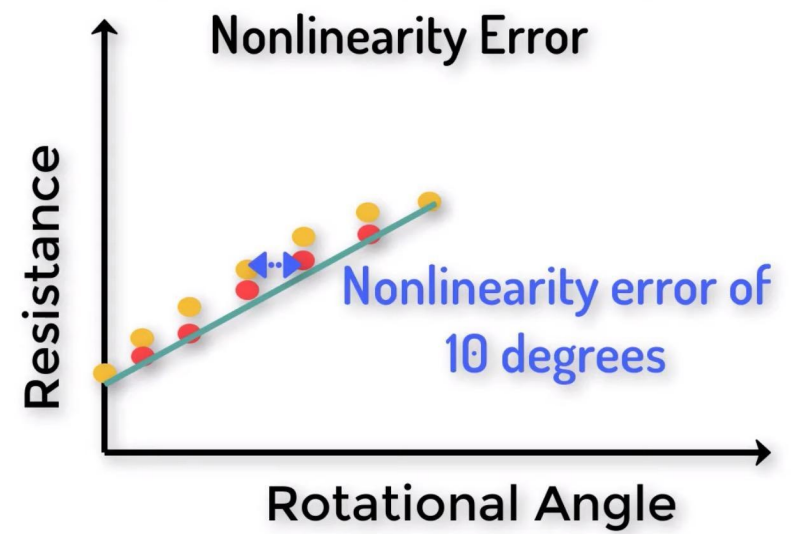
After several experiment by rotating the position

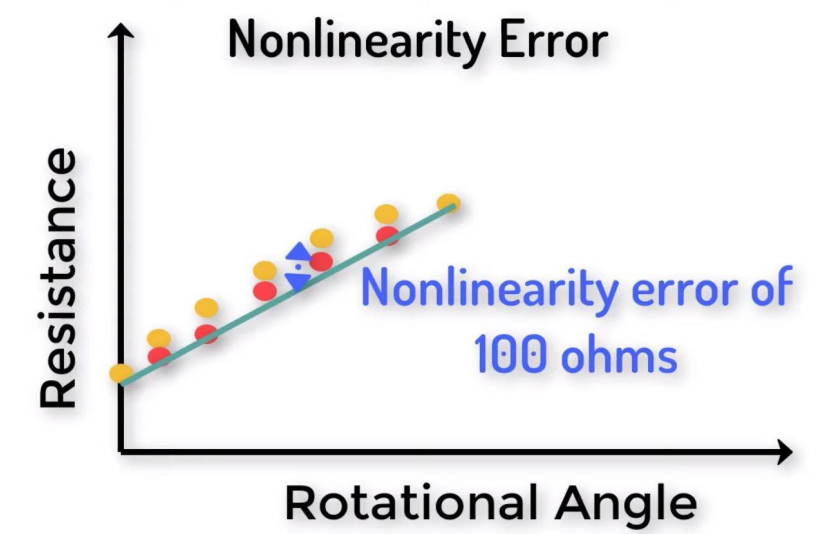
RANGE (FULL SCALE)

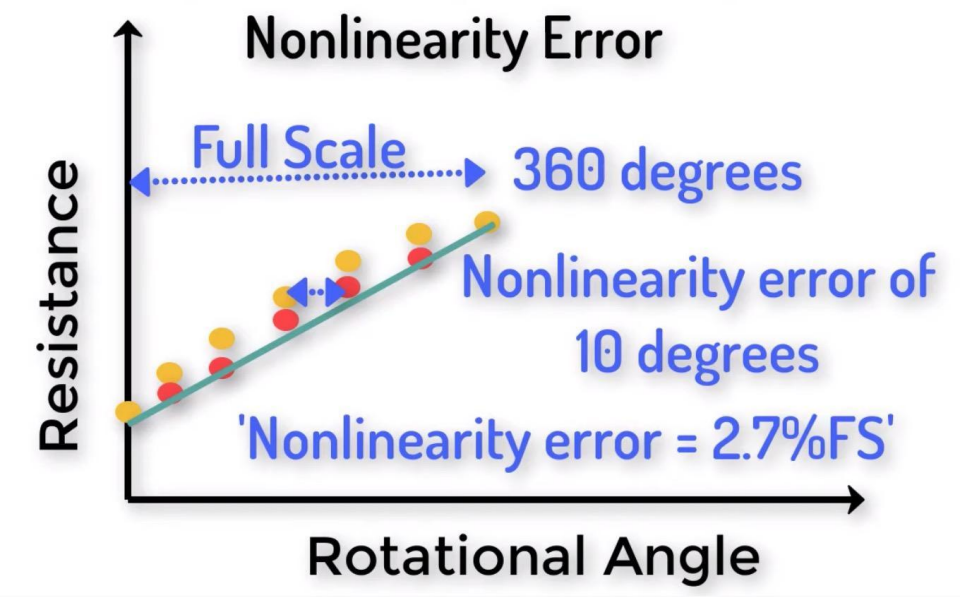
- The difference between the minimum angle and the maximum angle



NONLINEARITY ERROR

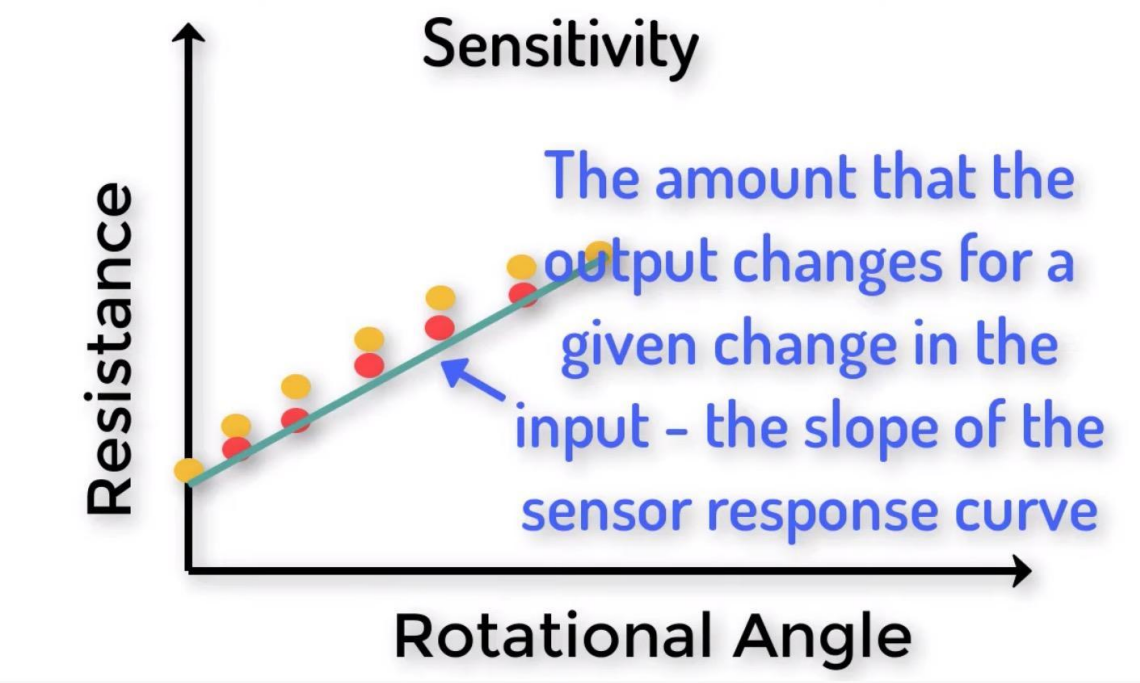






SENSITIVITY

- The amount of change in the output -> results from a particular change in the input



NEXT: WIDE RANGE OF SENSORS

SENSOR FUSION