

# Specification of Robots

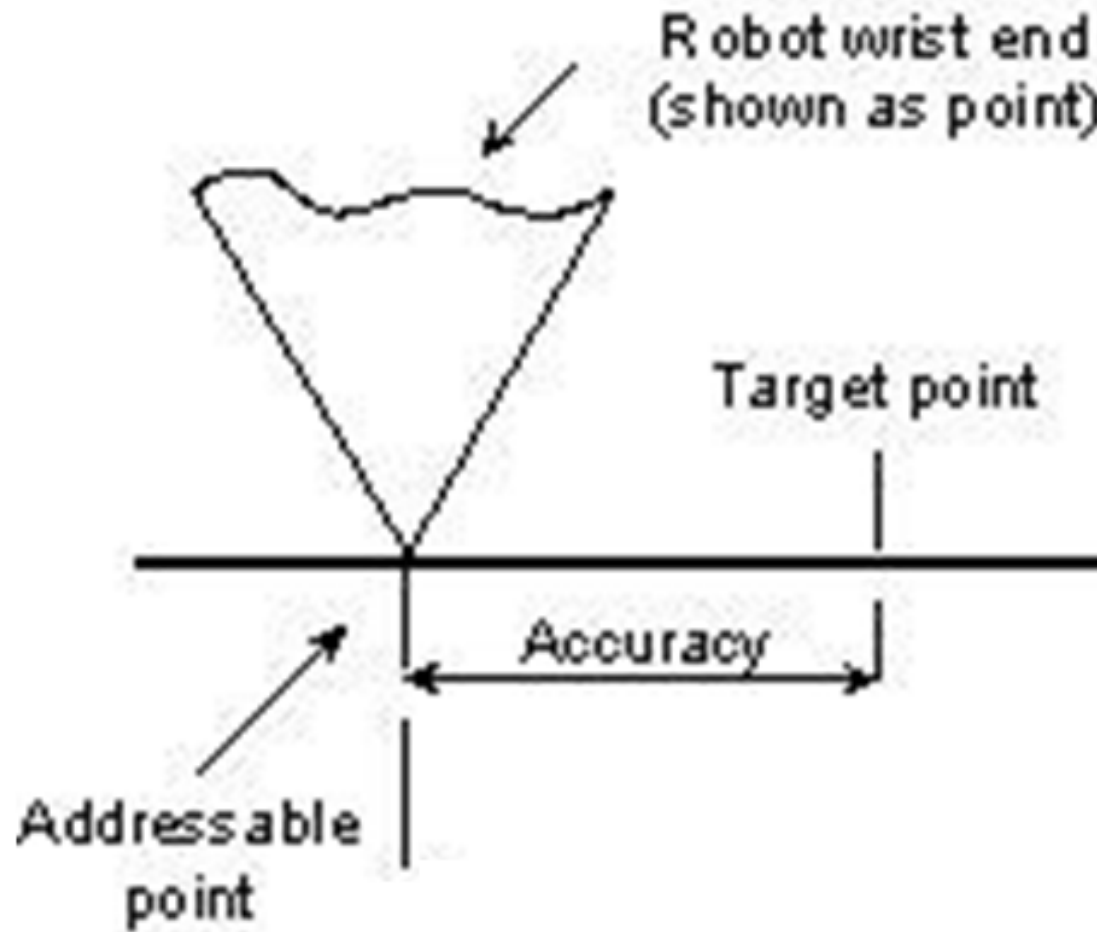
# Specification of Robots

- Accuracy
- Repeatability
- Resolution
- Compliance
- Axes or Degree of Freedom (DOF)
- Envelope
  - V-Reach
  - H-Reach
- Maximum Speed
- Payload
- Robot Mass

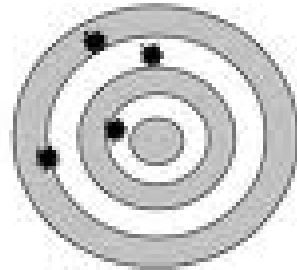
# Accuracy

- How close does the robot get to the desired point?
- When the robot's program instructs the robot to move to a specified point, it does not actually perform as per specified.
- The accuracy measure such as variance.
- The distance between the specified position that a robot is trying to achieve and the actual X, Y and Z resultant position of the robot end-effector.
- Accuracy refers to a robot's ability to position its wrist end at a desired target point within the work volume

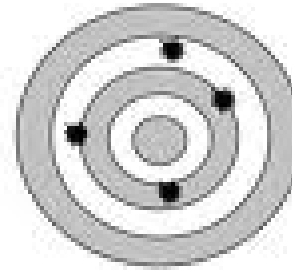
# Accuracy



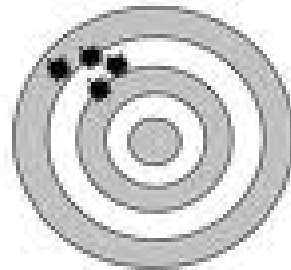
# Accuracy & Precision



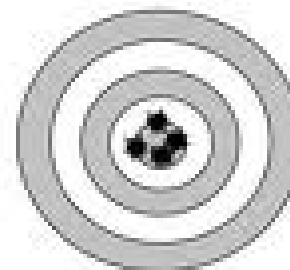
Not Accurate  
Not Precise



Accurate  
Not Precise



Not Accurate  
Precise



Accurate  
Precise

# Accuracy

- The final accuracy of a robotic system depends on its
- Mechanical inaccuracies
  - caused mainly by backlash in the manipulators joints and bending of the links.
- Computer control algorithms
  - due to round-off errors in the computer when integer representation is used
- System resolution
  - Inaccuracy due to resolution is considered to be  $1/2$  BRU (Basic Resolution Unit)
  - BRU - Smallest Allowable position increment through program

# Repeatability

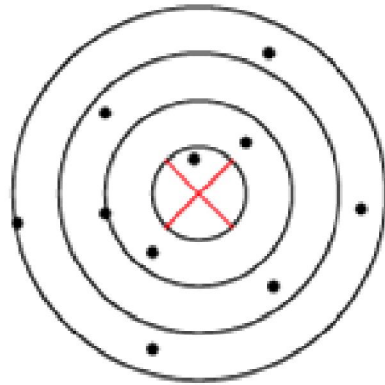
- The ability of a robot to return repeatedly to a given position.
- It is the ability of a robotic system to repeat the same motion or achieve the same position number of times all with equal environmental conditions.
- Repeatability is a measure of the error or variability when repeatedly reaching for a single position.
- Although a target is always missed by a large margin, if the same error is repeated, then we say that the repeatability is high and the accuracy is poor.
- Repeatability is the positional deviation from the average of displacements.

# Repeatability

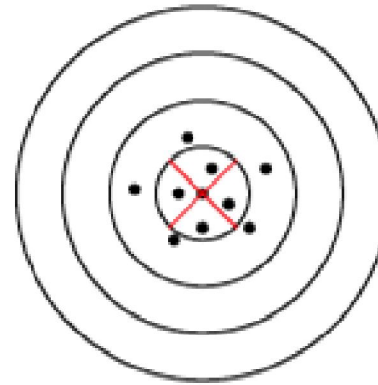
- A heavier weight causes larger deflections of the robot links and larger load on the joints, which degrade the accuracy, while the repeatability value is almost independent of the gripper load.
- It is normally measured in hundredths of an inch.
- Repeatability is often smaller than accuracy.

# Accuracy & Repeatability

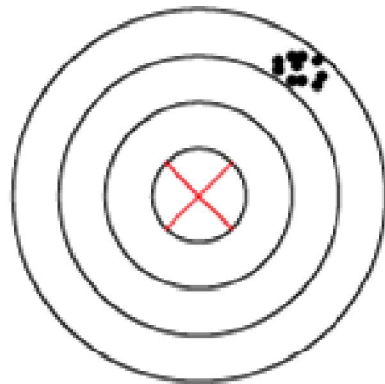
Repeatability and Accuracy over 10 measurements



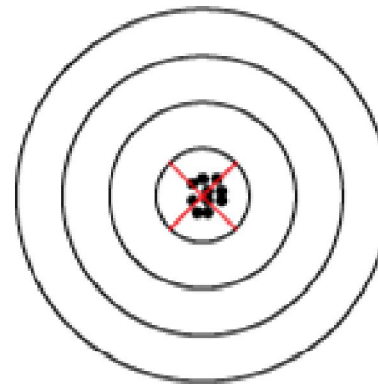
Bad repeatability and bad accuracy



Bad repeatability and good accuracy



Good repeatability and bad accuracy

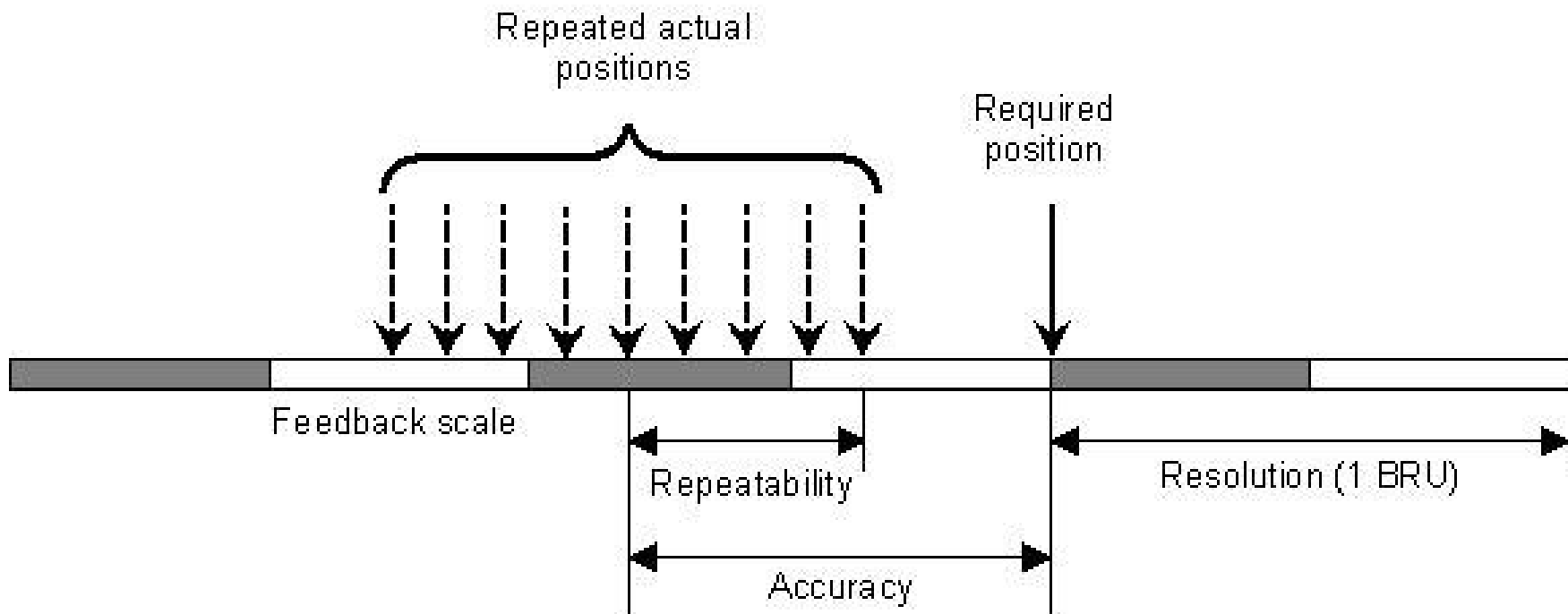


Good repeatability and good accuracy

# Resolution

- The smallest increment of motion or distance that can be detected or controlled by the robotic control system.
- The programming resolution is the smallest allowable position increment in robot programs and is referred to as the basic resolution unit (BRU).
- The control resolution is the smallest change in position that the feedback device can sense.

# Resolution, Accuracy, and Repeatability



# Compliance

- Displacement of the wrist end in response to a force or a torque exerted against it.
- High compliance means that the wrist is displaced a large amount by a relatively small force.

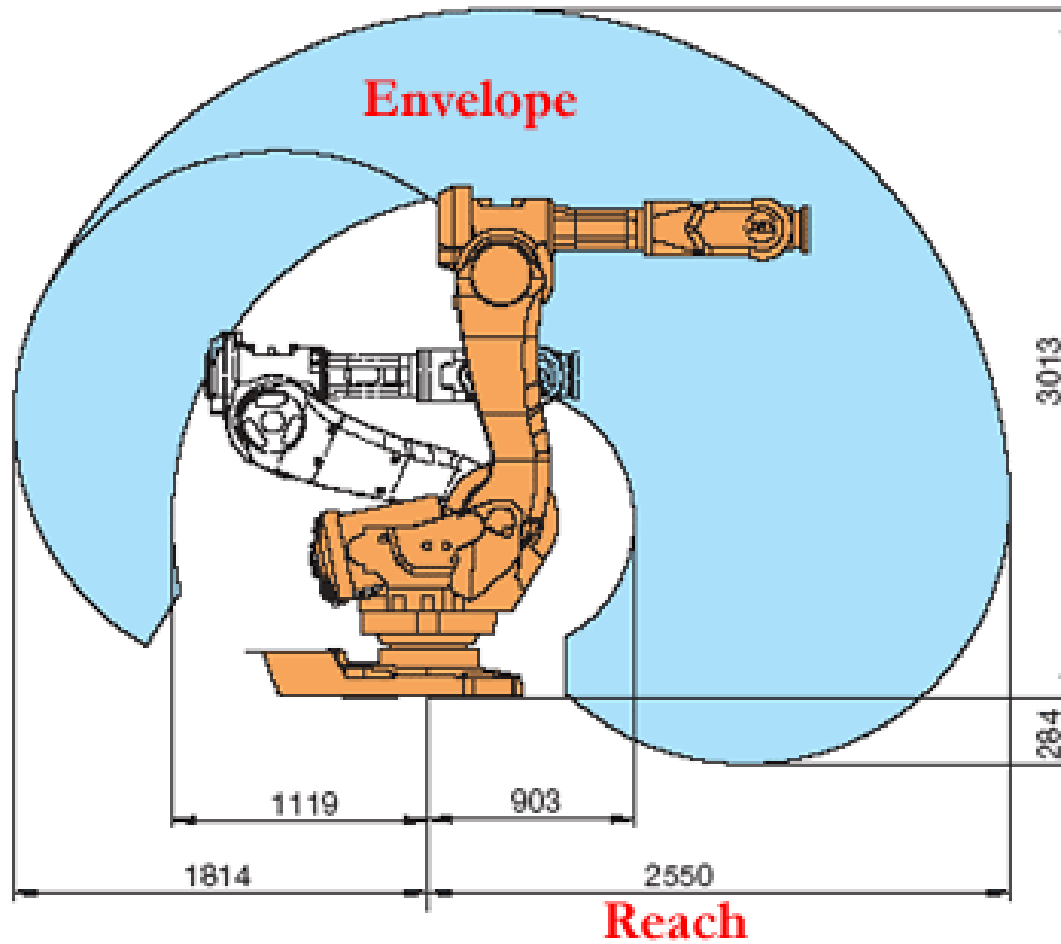
# Axes or Degree of Freedom (DOF)

- Each joint or axis on the robot introduces a degree of freedom.
- Each DOF can be a slider, rotary, or other type of actuator.
- The number of DOF that a manipulator possesses is the number of independent ways in which a robot arm can move.
- 6 degrees of freedom are enough to allow the robot to reach all positions and orientations in 3D space.

# Envelope

- A three-dimensional shape that defines the boundaries that the robot manipulator can reach.
- Also known as reach envelope.
- Maximum envelope: the envelope that encompasses the maximum designed movements of all robot parts, including the end effector, workpiece and attachments.
- Restricted envelope is that portion of the maximum envelope which a robot is restricted by limiting devices.
- Operating envelope: the restricted envelope that is used by the robot while performing its programmed motions.

# Envelope



# Reach

- The maximum horizontal distance from the center of the robot base to the end of its wrist.
- V-Reach refers to the height of the robot when it extends upwards from the base.
- H-Reach measures the distance of the fully extended arm - from the base to the wrist.

# Maximum Speed

- Each axis moves at a different speed.
- They are listed as degrees traveled per second.
- The maximum speed is the theoretical values which does not consider under loading condition.

# Payload

- The weight capacity of each robot manipulator is its payload.
- The maximum payload is the amount of weight carried by the robot manipulator at reduced speed while maintaining rated precision.

# Robot Mass

- Every robot has a specific weight or mass.
- This number only indicates how much the robot manipulator weighs.
- It does not include the weight of the robot's controller.

# Classifications based on characteristics

- Multiple task capability
- Level machine intelligence
- Kinematic structure
- Geometric dexterity
- Mobility
- Actuator modules
- Payload capacity
- Precision, Accuracy Repeatability
- Sensory capability
- Operational envelopes
- Application groups

# Based on coordinate systems

- Cartesian coordinate
- Cylindrical coordinate
- Spherical or polar coordinate
- Jointed arm coordinate

Based on pair of joints which provide degree of freedom

- R-R-R
- R-P-P
- P-R-R
- P-P-P

R – Revolute

P - Prismatic

# Based on end-effectors

- Mechanical type
- Magnetic pick up
- Vacuum or suction pick up

# Based on number of fingers

- Two fingered
- Three fingered
- Multi fingered

## Based on methods of specifying robot movement

- Fixed sequence
- Variable sequence
- Playback robot
- NC robot
- Intelligent robot

# Based on type of control system

- Non-Servo Controller (bang-Bang type)
- Servo controller (Proportional feedback type)

# Based on sensory systems

- Simple and blind robot
- Vision robot
- Moderately intelligent robot

# Based on industrial applications

- Part handling
- Tool operating robot
- Assembly robot.

# Based on specific ask they perform

- Casting
- Investment casting
- Pick & place operation
- Forging
- Machine tool loading
- Welding
- Spray painting
- Inspection and assembly
- Education & training