HUMBER

ROBOTICS 1

LESSON 02 – Part II

Robotic Coordinate Systems & Motion Types

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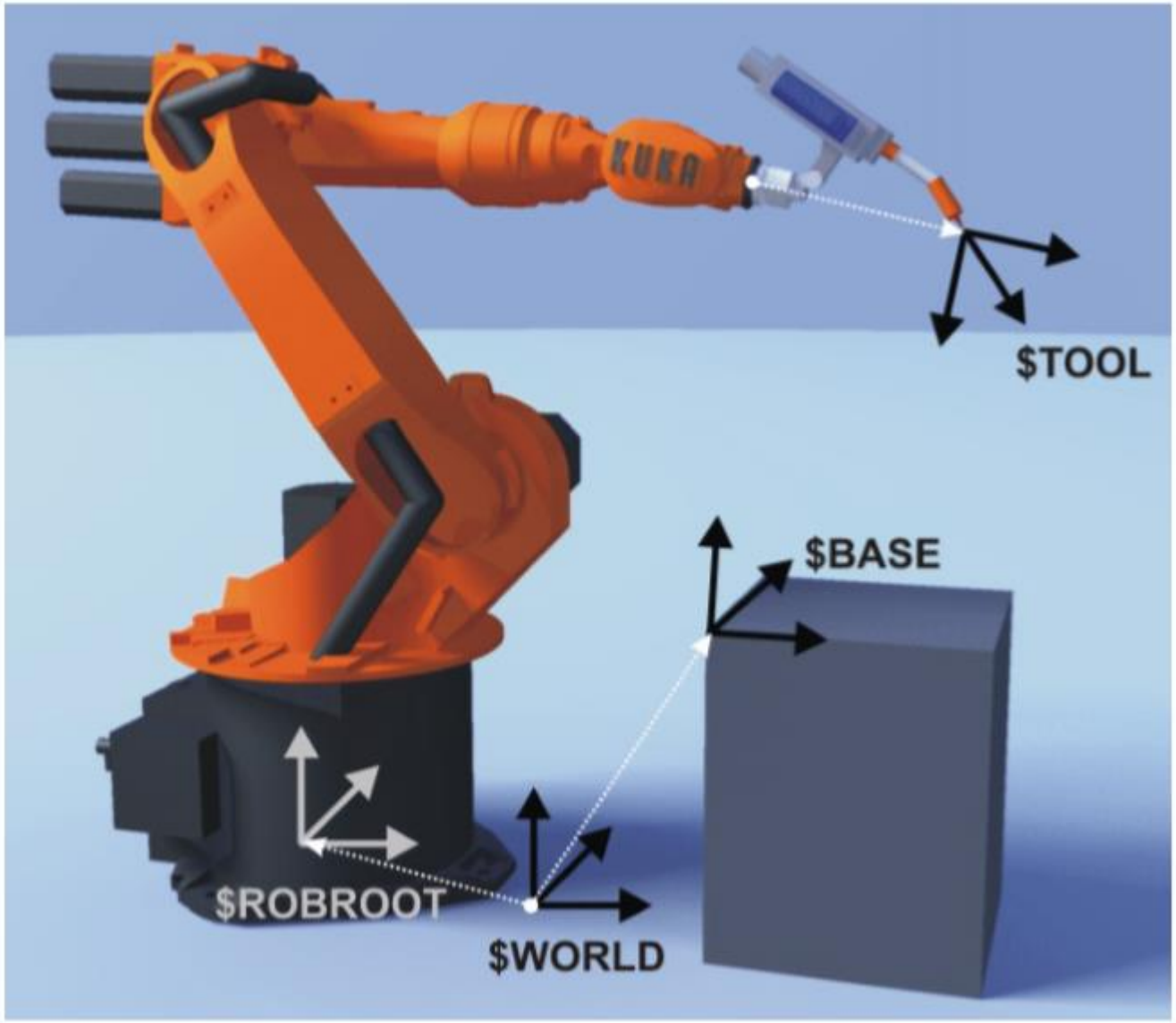
Resources: Text Book: Industrial Robotics (Larry T. Ross)-GW Publisher

Robotic Coordinate System

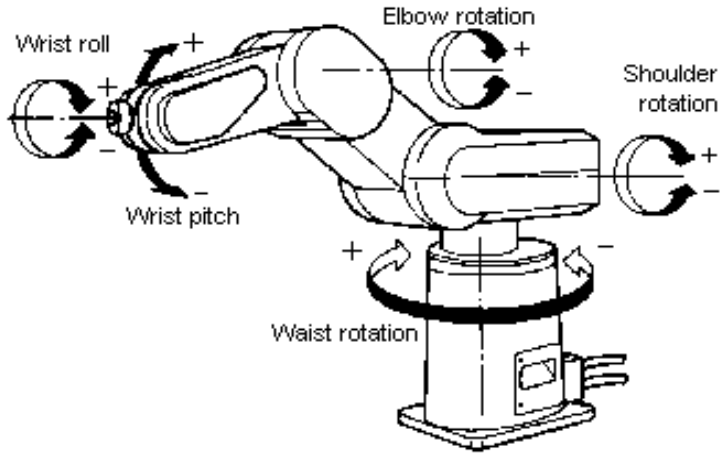
Robotic Coordinate System

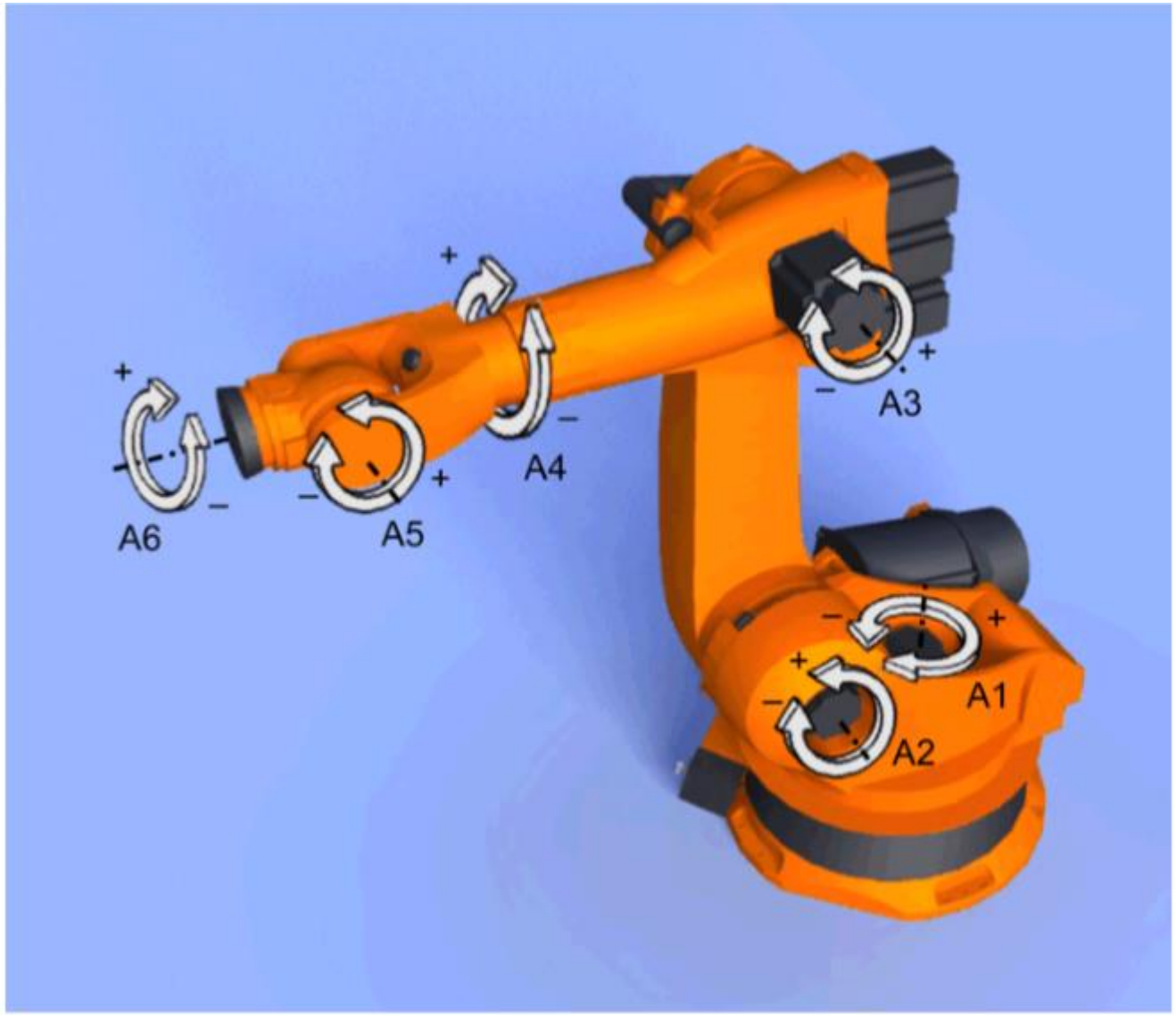
- Joint Coordinates System
- World Coordinate System
- Tool Coordinate System
- User Coordinate System



Joint Coordinates System

- The position of the robotic hand in space is defined by the rotation/translation of each joint
- Its allow independent control of each joint
- The precise positioning of the tool since the tool axis is changed in each movement of the joint

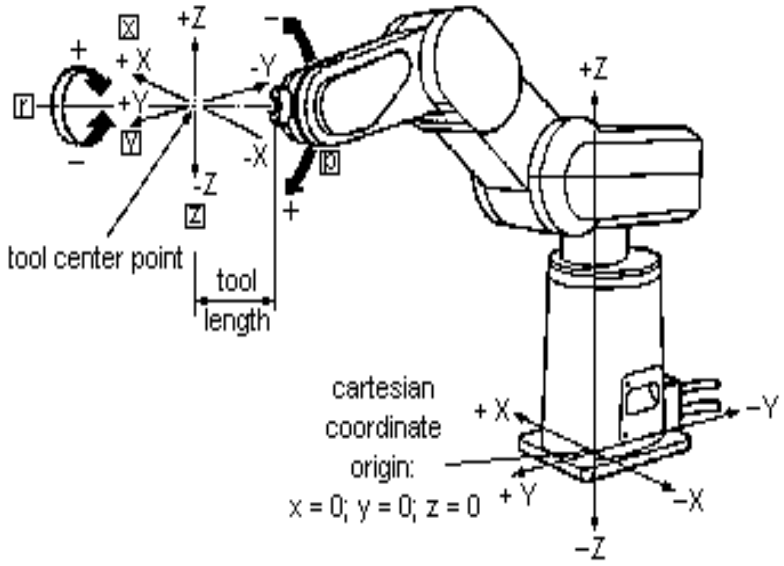




Resource: KUKA KRC4 Manual -"KUKA system Software 8.3"

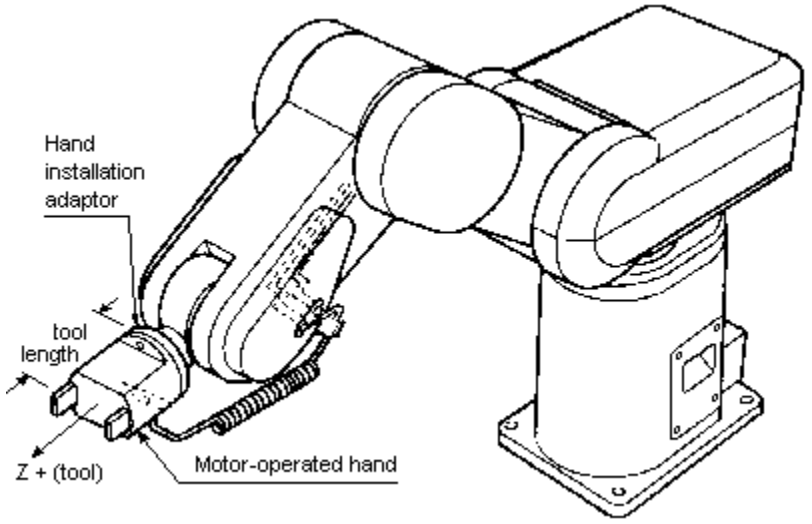
World Coordinate System

- The position of the tool frame is defined by the values of the three Cartesian coordinates X,Y and Z.
- Changing of values of one of these coordinates (X,Y or Z) causes the robot to move several of its joints at the same time
- The tool center point remain at the fixed position while changing the orientation of the tool axis
- This coordinate system is easy for teaching the robot



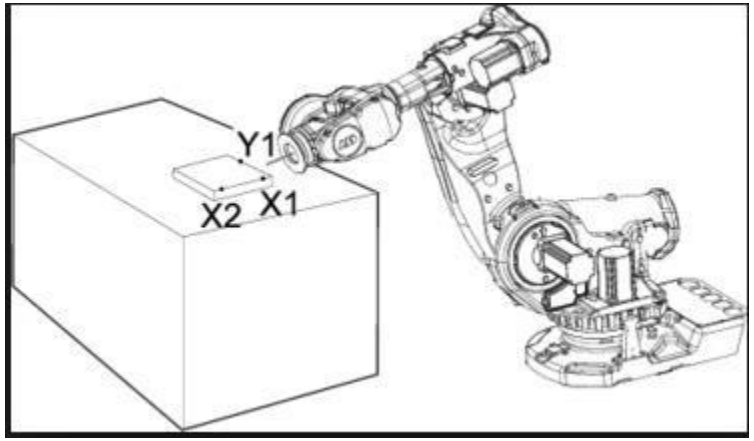
Tool Coordinate – Robotics II

- As with WCS , changing in one tool coordinate value results in movement of several robot joints.
- The tool axis direction remains fixed while the tool position changes.



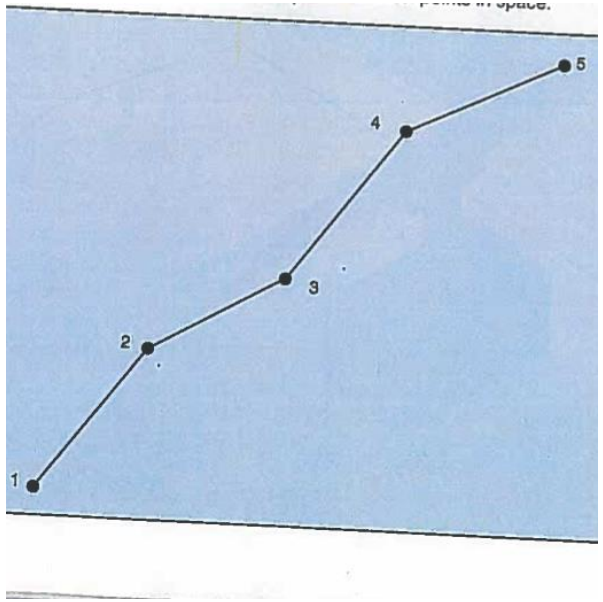
User Frame Coordinate – Robotics II

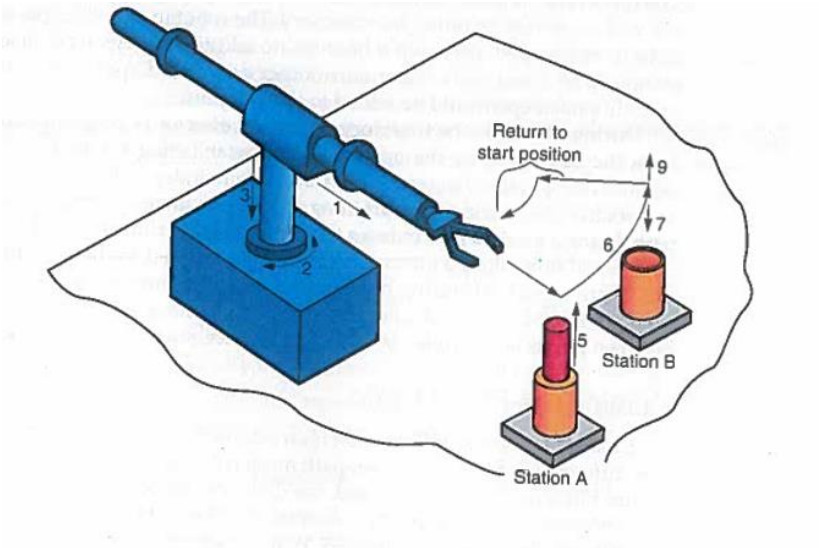
- Custom define axes
- Easy motion with oblique or inclined objects



Robotic Motion

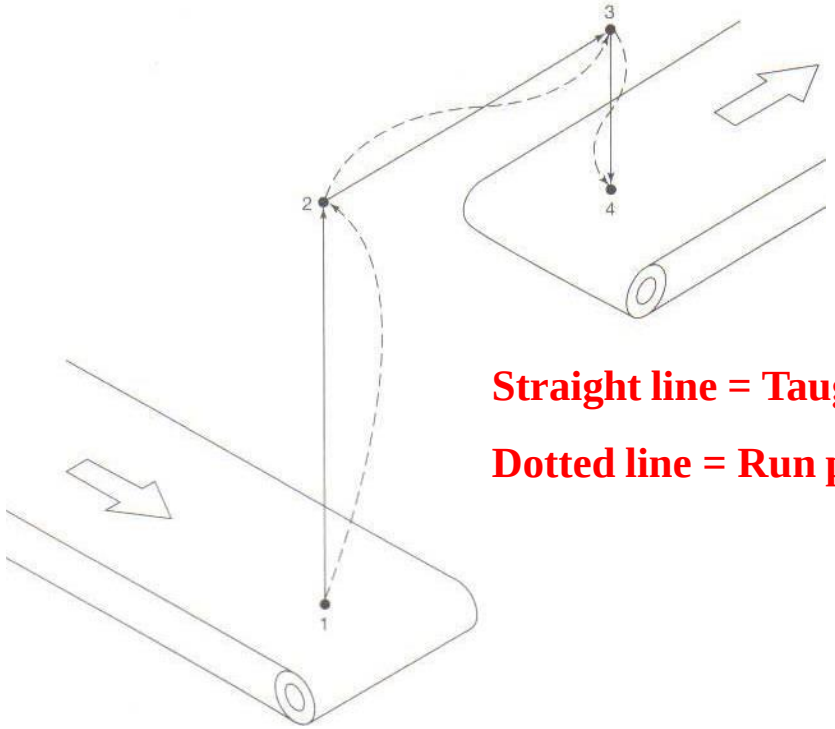
Point to Point Motion





Point-to-Point (Joint)

With point-to-point programming, the robot moves from one discrete point to another within its working envelope. Motion between the points is typically not in a straight line, and the orientation of held objects may vary as the joint actuators operate independently to arrive at their new positions. Robot movement between points can result in a safety hazard for personnel and equipment because is difficult to predict the exact path.



Straight line = Taught path

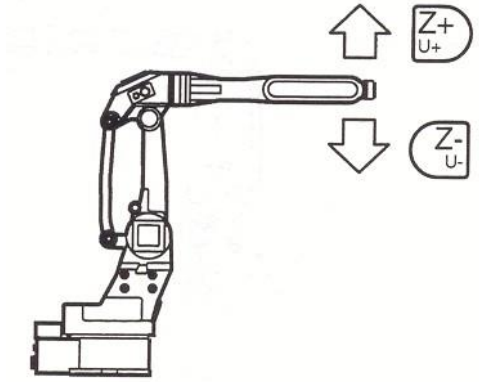
Dotted line = Run path

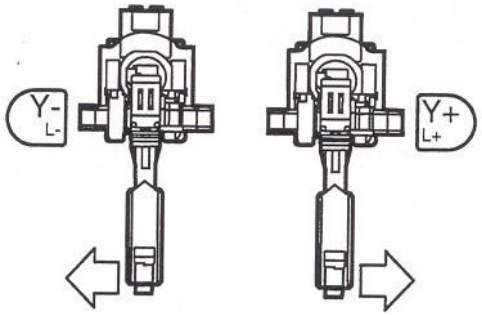
When a point is recorded with a joint motion type the robot records the location of each axis. When that point is called during the running of a program each axis is taken back to that recorded position. How the robot moves when getting to that position will change from when the program was taught. No control of the path between points is used.

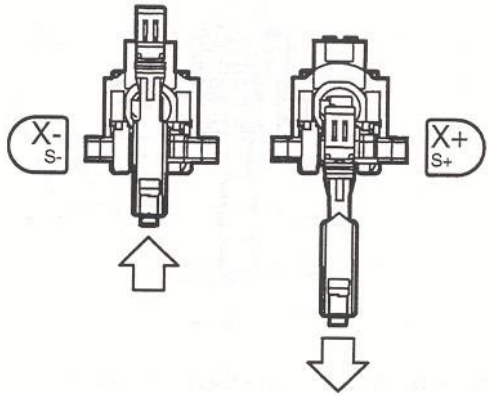
These points are typically used when path is not a concern. Quick movements in open space away from tooling or fixtures.

Point-to-Point (Linear)

Points are taught the same as joint movement, but are given a linear designation. During the running of the program the robot moves not at each axis point but in a straight line. This means the robot will move between points in a straight line.

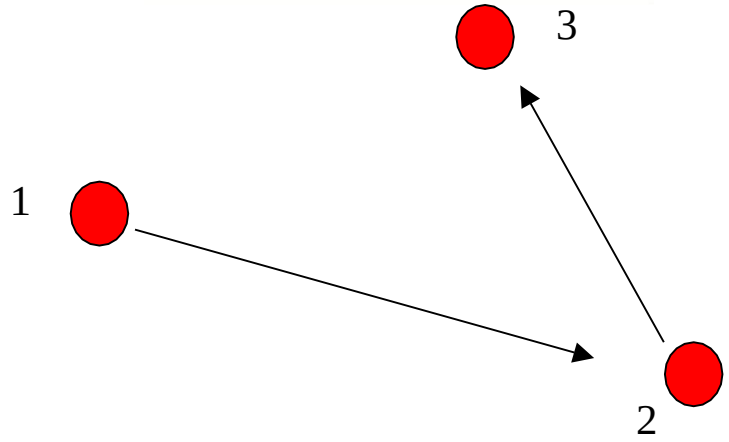




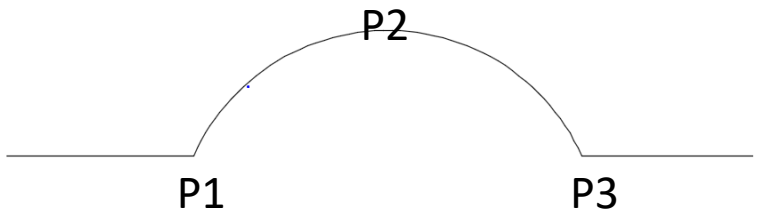


As shown in the photos above when running a program all movements are straight lines. This is of great benefit when performing tasks where the path the robot moves between points must be controlled. Linear movements do not take into consideration any end of arm tooling.

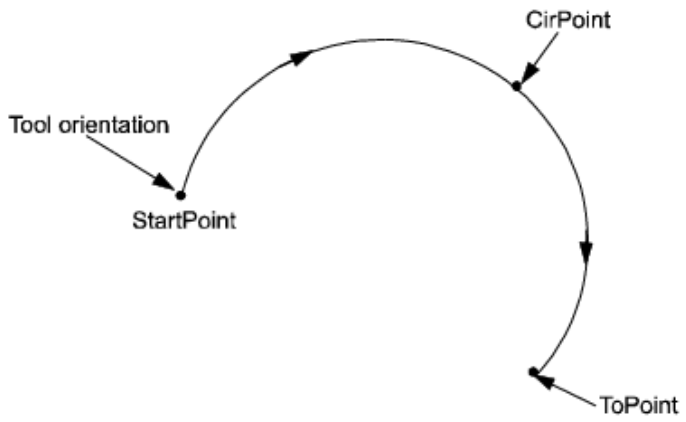
It should also be mentioned that faults could be generated if the robot can not move between points in a straight line without hitting an axis limit.



Circular Path MOVE C



Move J P1
Move C P2, P3



Speed Control

When moving between taught points the way the robot moves is not all we need to be concerned with. During programming we must also select the speed that we want the robot to move at. A speed is set at or before each point. This set speed can look a few different ways depending on robot and motion type. The robot will have a limits you must work within. Detailed moves should be done at a slower speed, transfers at a higher speed.

When changing speed 2 options normally exist:

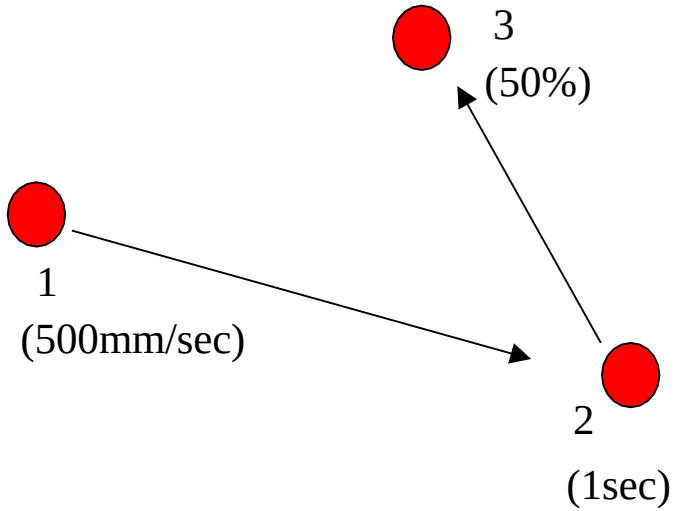
1. Each point is assigned a speed. The assigned speed is how quickly the robot will move to the point from the previous point.
2. A speed override is changed and all points or all point on an assigned axis are ran at the override speed. The override speed is normally a percentage of maximum speed.

The point speed has a few different options.

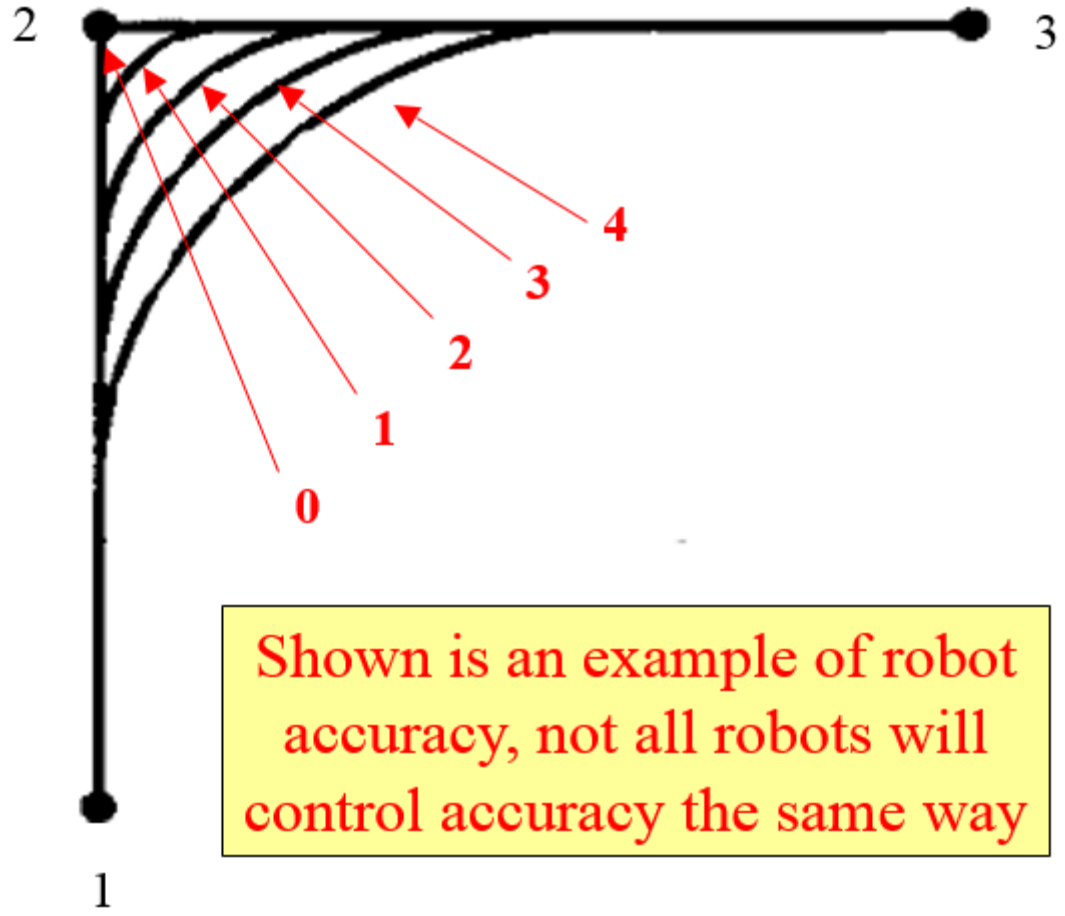
Distance / Time: the robot will travel so far in so much time. (500mm/sec)

Time: The robot will take a preset amount of time to move to the next point. (1sec)

Percentage: The robot will move at a percentage of full speed to the next point. (50%)



Accuracy



Shown is an example of robot accuracy, not all robots will control accuracy the same way

Accuracy

Most robot manufactures also allow for the programmer to set the accuracy that each accuracy level represents. This is a software setting done through the pendant.

Accuracy Level	Distance
1	1mm (stop point)
2	3mm
3	5mm
4	10mm
5	12mm

A stop point means that the robot will actually stop at the point to the assigned accuracy

Unfortunately some limitations do apply to these accuracy settings. Normally a minimum and maximum setting are offered. The robot is also not capable of being more accurate than the feedback and drive system will allow.

Accuracy Vs. Repeatability

A robots accuracy and repeatability are one of the largest determining factors in how useful or productive a robot is going to be.

The terms accuracy and repeatability are used almost interchangeably within the automation industry. As a technologist working in the robotic industry you will need to know the difference and can use context to determine which is intended.

Accuracy:

> The capability of the manipulator to position the end effector at a specific predetermined location in space upon getting instruction from the controller.

Repeatability:

> The ability of the manipulator to repeatable position the end effector to the same preprogrammed position under the same conditions.

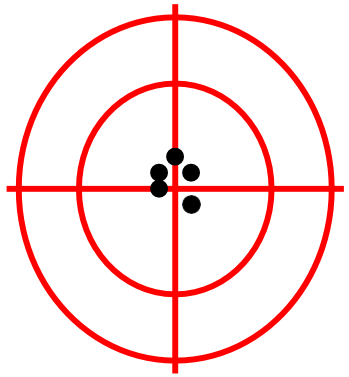
These 2 definitions sound almost the same and that is why the terms are confused in industry. The description and pictures on the next page may help to describe the relationship between the 2 terms.

For the labs in this course to function properly both accuracy and repeatability and needed.

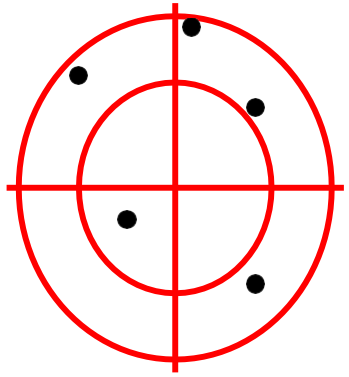
Accuracy Vs. Repeatability

Lets assume a robot holding a marker in its end effector is programmed to place 5 dots in the centre of a bulls eye. 4 possible scenarios with regard to accuracy and repeatability could take place:

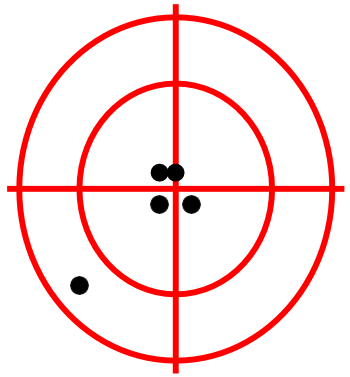
1. The robot is both repeatable and accurate



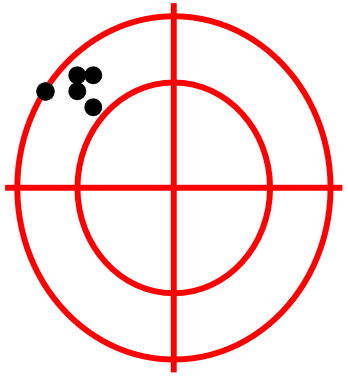
2. The robot is neither repeatable or accurate



3. The robot is accurate but not repeatable

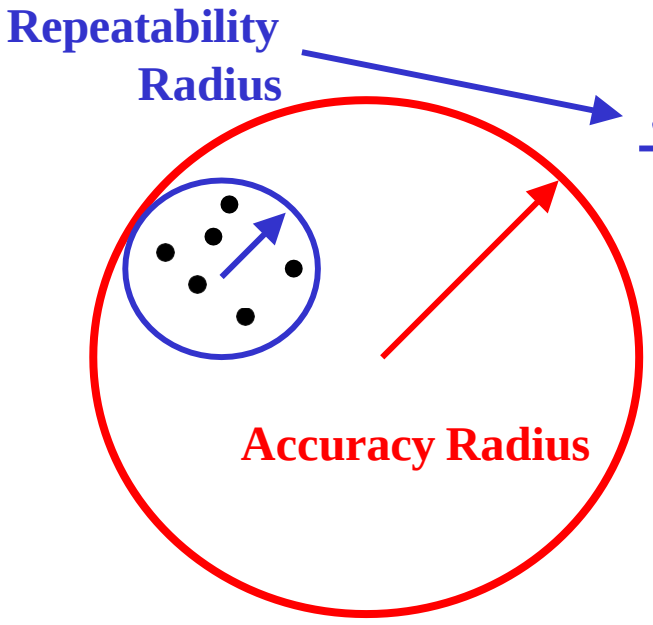


4. The robot is repeatable but not accurate



Robot Specifications

A robot that is completely accurate and repeatable would be fantastic but certainly not realistic. Robot manufactures realize that a certain amount of inaccuracy and error is unavoidable so to allow the end user to select the proper robot for their needs a specification sheet is produced for a robot. On this sheet a number for repeatability is given. A robots accuracy and control over that accuracy is discussed later.



LR Mate Series Robot Specifications

Items		100*i*B	200*i*B	200*i*B/3L
Axes		5	6	6
Payload (kg)		3-5	3-5	3
Reach (mm)		620	700	856
Repeatability (mm)		±0.04	±0.04	±0.04
Interference radius (mm)		180	180	180
Motion range (degrees)	J1	320	320	320
	J2	185	185	185
	J3	365	316	290
	J4	240	380	380
	J5	720	240	240
	J6	-	720	720
Motion speed (degrees/sec.)	J1	240	180	140
	J2	270	180	150
	J3	240	225	160
	J4	330	400	400
	J5	480	330	330
	J6	-	480	480