# CLASSIFICATION OF THE INDUSTRIAL ROBOT ARMS

**ÇETİNKAYA. Ö[1], KUŞÇU. H[2]**

*[1]Trakya University, Science Institute, Mechanical Engineering Division*
*MBS Student, Turkey, ozcan@cetinkaya.gen.tr*

*[2]Trakya University, Engineering and Architecture Faculty, Mechanical Engineering Division*
*Mechanical Theory and Dynamics Main Branch, Turkey, hilmi@trakya.edu.tr*

**Abstract**

*At the present time, as a parallel of the developments of the computer systems, computer added design (CAD) and manufacturing (CAM) systems are developed. At the computer added design systems, it is usually used one or more robotic arm (manipulator) which controls by a computer. There is a really wide field for the industrial robots in the medical, automotive, iron-steel, textile, transportation sectors, shortly, all the hard and dangerous works for human-being.*

**Keywords:** Robot, manipulator, unrestraint levels, working space.

## INTRODUCTION

In that work, it has been explained the classifications of the robotic arms which have used hard, dangerous and high level sensitive works, according to unrestraint levels, power supply which is used by the joint accelerators, control methods, sharpness grades and codification with double letters. According to those classifications, it has been explained the specifications of the robotic arms, usage fields, working spaces, advantages and handicaps against each other.

## EXPOSITION

Robot has a meaning of slave or working in Czech and Slovak languages. Robotic means the science of robot and it's named firstly by Issac ASIMOV.

Robots are very functional manipulators which are projected for moving some materials, hand tools or special equipments by giving then a series of preplanned duties. Need of industrial robot and their use is increasing by computer supported conception and parallelly computer supported production.

Most important feature that separates the robot from the other machines is; robots can be programmed several times and they have control system that provides to do more complex processes near by mechanic systems. In a word, robot is an industrial manipulator controlled by computer. Robot science is a branch of instruction that contains several engineering as electric and electronic engineer, mechanical engineer, computer engineer and math engineer. In examples; mechanical engineering is curious about robots dynamical and statically constitution, computer engineering is interested in software part of robots and electric engineering is concerned with perceptional concept of robots.

All the robots have a working space as to their organs and joints. That working space is the open place where robot's extremity functionary can move freely. By the help of robot manipulator's joint changes extremity functionary's position according to main shaft and find of inclination is forward kinematics; bye the position and inclination knowledges of extremity functioner, found of joint changes of robot manipulator is reverse kinematics. Kinematics is interested in act of objects. Robot's strength sped and acceleration analysis can be made by robot kinematics.

A robot is composed of prismatic (sliding) or revolving kind of joints which can move freely by themselves and organs which combine the joints

each other, revolving joint, (Fig. 1.) allows revolving between two organs. Prismatic joint, (Fig. 2.) allows linear movement joint angle is removement that consists of revolving in revolving joint.

Joints slip is removement that consists of linear movement between organs in prismatic joint.

Joint angle is the joint changity in revolving joints, joint slip is the joint changity in prismatic joints.

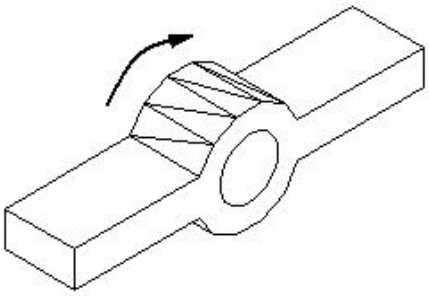

*Fig. 1. Revolving joint*

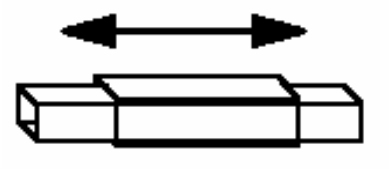

*Fig. 2. Prismatic joint*

Manipulators are accepted as open-tipped kinematics chain of bounded rigid things. While one tip of the chain is bound to main environment, the other tip is bound to tip functionary. Consequently, action of manipulator is everall of movements of each organs according to the others. Expressions which constitute this kinematics chain consist of homogeny transformation matrix that includes the location and inclination of robot for determining the manipulator movement, it is necessary to determine the inclination and location of rigid thing in space.

Inclination of rigid thing in Cartesian space, transformation matrix and the location of rigid thing are founded by locating vector. Six lack of restriction degree is enough for reaching at an any point in three dimension space. Redundance becomes at robots whose lack of restriction degree is more than six. Redundance can be defined as the place which is hatched by two different joints at the some time.

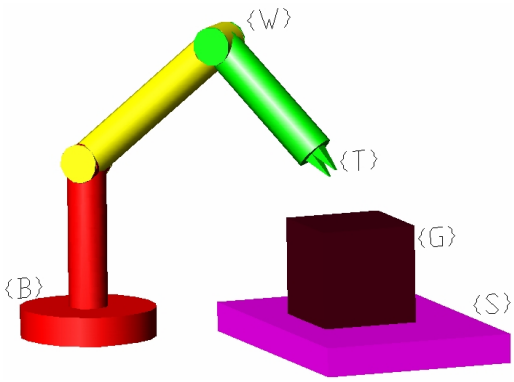


*Fig. 3. Robot and working space*

Basic frame {B} inactive part of robot, in other words, first hoop of kinematics chain.

Station frame {S} the frame where robot makes all actions.

Wrist frame {W} it is the last organ of manipulator and the last ring of the chain.

Tool frame {T} a suitable component is placed according to action that we want the robot to do.

Goal frame {G} the frame which is onto thing where the robot is going to operate.

## 1. Classification of robots

Robots are principally classified in two groups as serial and parallel robots. Serial robots are formed from a row of joints and organs which combine these joints each other. (Fig. 4.) Serial robots have an extensive working space and a few amounts of mechanical parts. Parallel robots come together more parallel organs between main frame and last functionary. (Fig. 5.) When these two robots are compared with their rate of carriable mass to mechanic constitution mass jobs and parallel robots are used for big mass jobs.

*Fig. 4. Serial robot*

*Fig. 5. Parallel robot*

Robots can be classified in five different classes according to their lack of restriction rate, source of power used for revolving joints, control methods, sharpness degree and two letter code.

### 1.1. Robots according to lack of restriction rate

Robots which are used industry are generally these six lack restriction rate robots. While classifying the robots according their lack of restriction rate, it's looked fort he functions of first three organs.

For example;

If first there organs have a prismatic joint, this robot is Cartesian robot. (Prismatic Prismatic Prismatic – PPP)

If the first organ has a revolving joint but the second and third have prismatic joint, this robot cylindrical robot. (Revolute Prismatic Prismatic – RPP)

If the first two organs have revolving, third organ has a prismatic joint and all joints are parallel to each other; this kind of robot is Scara robot. (Revolute Revolute Prismatic – RRP)

If the first two organs have revolving joint and the third organ has a prismatic joint this robot is spherical robot. Also if first three organs have revolving joint, this robot is revolving robot.

#### *1.1.1. Cartesian robot*

The robot which is projected as being prismatic joint of first three joints is Cartesian manipulator. That kind of robot has the eaest kinematics ordery. Although their mechanical constitution is well-made (strong) their activity skills in working space are quite Lowe Cartesian kind of manipulators are mostly used for carrying the things from somewhere to somewhere that have a high capacity and weight.

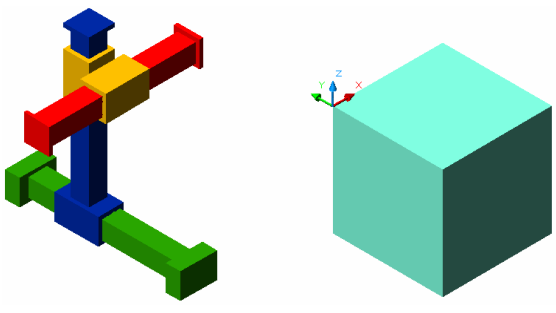

*Fig. 6. Cartesian robot and working area*

#### *1.1.2. Cylindrical robot*

A kind of manipulator which is constituted from joints that first joint is revolving, the second and third joints are prismatic kinds. Although their mechanical constitution is well-made, their wrist location line changes according to horizontal action. So as Cartesian robots, they are used for carrying the things that have high capacity and weight. Hydraulic cylinder is usually used as movement at prismatic joint.

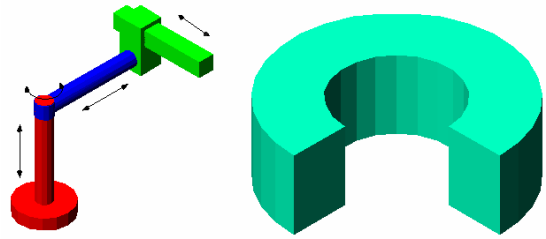

*Fig. 7. Cylindrical robot and working area*

#### *1.1.3. Spherical robot*

In spherical manipulator, first two joints are formed by revolving joints and the third joint is formed by prismatic joint. Although their mechanical constitution is not well-done than Cartesian robot, their activity skills in working space are rather high.

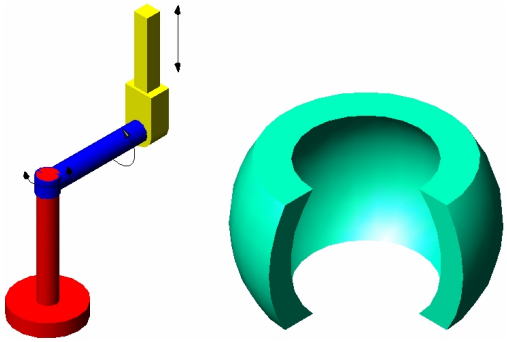

*Fig. 8. Spherical robot and working area*

#### *1.1.4. Revolving robot*

Manipulator whose first three joints have revolving joints is revolving manipulator. These robots have the highest activity skills in working space. It is the most skillful manipulator. In Project of the manipulator human arm was referenced.

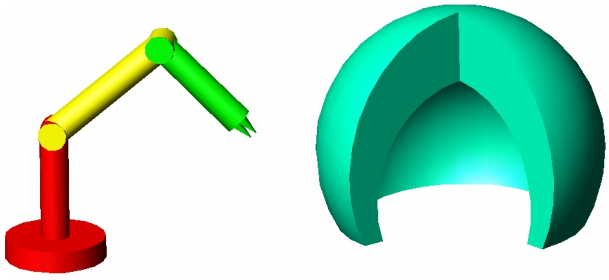

*Fig. 9. Revolving robot and working area*

***Chart 1.*** *Advantages and disadvantages of robot orderies*

| Robot | Advantages | Disadvantages |
|---|---|---|
| Cartesian | Their kinematics equations simple.<br>Mechanical constitutions are well-made.<br>In each point of the working space, their huge sized activity skills are same.<br>It is easy to add new things, because they have a simple kinematics constitution. | Size of working space is smaller than robot's size.<br>Robot can't reach its own main body.<br>It is difficult to protect the prismatic joints from dusts in environment. |
| Cylindrical | Because the main frame is revolving, speed of tip functionary is high.<br>Their kinematics equations are simple.<br>They have an extensive working space as to Cartesian robots. | They have a small working space as to spherical robots.<br>Huge sized activity skills change according to arm length. |
| Spherical | They have an extensive working space | Due to their kinematics equations are complex, their control is difficult, too.<br>Huge sized activity skills are different at each point. |
| Revolving | They have a very extensive working space.<br>It is easy to move the joints whose all are revolving. They are very pliant and fast. | Huge sized activity skills are different at each point.<br>Due to their kinematics equations are complex, their control is difficult. |

### 1.2. Robots as their controlling methods

Robots are classified in two groups as their controlling.

#### *1.2.1. Robots controlled from a point*

There isn't a determined working area for these kinds of robots. Lack of restriction degree is smaller than six and they usually used for carrying a thing from somewhere to somewhere. Robot is used by an operator.

#### *1.2.2. Continual trajectory controlled robots*

These kinds of robots are controlled as following a pre-determined trajectory. Robot is programmed by operator before start using. During the run of robot, operator doesn't interfere it this kind of robots periodically repeats the programmed action.

### 1.3. According to the power source that is used by robot movementers

Because the robots ought to do job which is given, it is important to stir up the joints in an appropriate order. Joint activity in these robots is achieved by electric motors, pneumatic cylinder and hydraulic cylinders.

#### *1.3.1. Stirring up with electric motor*

Special envisagement electric motors are used for stirring up the joints of this kind of robots. Because of the circular action of engine shaft, it's usually used for activity of revolving joints. So, Dc servo type motors whose revolving angle can be decreased under 1°, are used fort his arm. Dc servo type motors that they have redactor provide high torque with low voltage. It is easy to control.

#### *1.3.2. Stirring up with hydraulic cylinder*

This kind of robots joints are stirred with hydraulic cylinder. It is usually used to activate the prismatic joints because of the constitution of cylinder. They are used at hard Works in industry that they provide a high torque with low energy. Because their performance is not linear, their control is more difficult than electric engines.

### *1.3.3. Stirring up with pneumatic cylinder*

These kinds of robots are alike to hydrolic cylindiric robots, but their control is difficult. Because, air is used in pneumatic cylinder and air presume is not enough to provide the flux of cylinder but their constitution is simple. As hydraulic cylinder robots, these kinds of robots are used for activity of joints.

## 1.4. Robots according to their sharpness degree

It is separated into three groups as straightness, replacement, and resolution.

### *1.4.1. Resolution*

It is known that robots are controlled by control system. It is the arability of changing fort he signals that is sent to control system.

For example; a robot whose joints are placed by servo motor has a high. While a robot whose joints are placed by hydraulic cylinder has a low.

### *1.4.2. Straightness (Accuracy)*

There is a software which was prepared fort he control o robots by their control systems. We can control the robot by programmer it with this software of the program of tip functionary.

### *1.4.3. Replacement (Interconvertibility)*

Replacement is a special feature of robot that robots tip functionary comes to the same point after doing the jobs.

### *1.4.4. Classification made by two letters coding*

Huang and Milenkovic have improved a code formed from two letters for describe the robot types. According to that, first letter explains the property of first joint and the revolving comparing the second one. The second letter explains the third joint and the relation between second and third joints.

Used letters and symbols

S: slipping, slide (Fig. 10A)

C: upright turning at slipping axis (Fig. 10B)

N: upright turning at turning axis (Fig. 10C)

R: upright turning to slipping axis or parallel to turning axis (Fig. 10D)

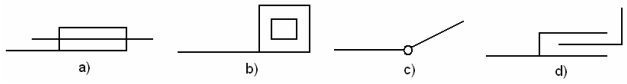


*Fig. 10. Symbols used at two-letter coding*

Huang and Milenkovic have used sixteen unit of two-letter combination for robot organs. All these compositions are useful and they aren't different. A useful organ must have an extensive sized activity skill in three dimension space; difference is that each organ is different from the other categories.

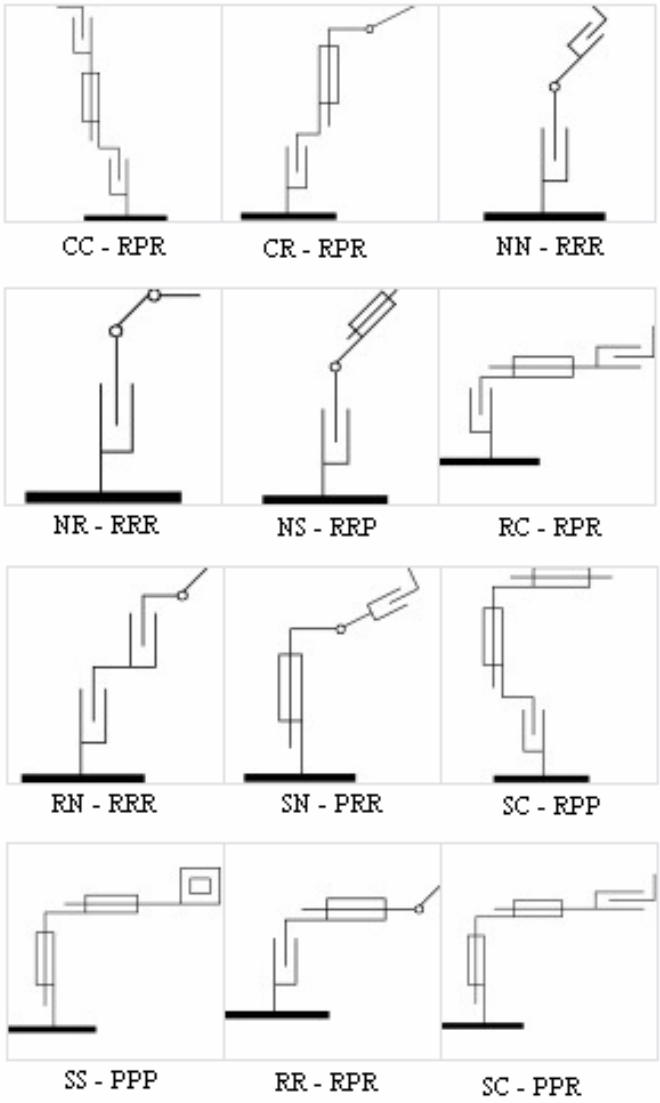


*Fig. 11. Symbolic figures which identifies the robots at two-letter*

Huang and Milenkovic haven't found useful the codes; CN, NC, RS and SR. RS and SR robots are usually used in industry although they don't find useful and different. The reason that these two robots don't find useful and different is because they rake the same area with CS robot.

## 2. Imitation

Imitation or simulation is an animation of physical activity by the help of programs which are recessory at computer atmosphere before acting a physical activity. Robot programs are tested with imitation programs before testing on true robots. There are advantages of testing the programs. If robot programmes are loaded to robot before testing by the help of imitation, robot can damage itself or environment. For this reason, testing robot programmes (after software) provides time and Money. A good robot imitation programme could modelise the position of organs, inclinations and environment.

### 2.1. Classification of robot imitation programs

It is separated in two class as online or offline.

#### *2.1.1. Online programming*

Online programming is realized when the robot is at production position. It is used to reach the tip functionary of robot at determined point.

#### *2.1.2. Offline programming*

Programming is done before producing the robot in offline programming and robot is produced after programming. This type of robotsa re wed at repeating process. If we want to do an other action with the robot, first we delete the old program and it is programmed again.

## CONCLUSION

In that work, it has been explained the structure of four types of robotic arms (manipulator) which have constituted the industrial robotic arms, working spaces, advantages and handicaps against each other. Furthermore, the work has revealed the classifications of the industrial robotic arms according to unrestraint levels, power supply which is used by the robotic accelerators, control methods, sharpness grades and codification with double letters.

## REFERENCE


[1] BİNGÜL, Z., KÜÇÜK,S., 2005. Robot Tekniği. Birsen Yayınevi, İstanbul

[2] ÖZOKLAV. H,1 986. Kinematik (Dinamik Cilt 1), Çağlayan Kitabevi, İstanbul

[3] http://www2.omu.edu.tr/akademik_birimler/muhendislik/elektr/Lego_sitesi4/DKin.htm

[4] http://www.antenen.com/htdocs/frame.html?gclid=CK3j8c_XnowCFQIrlAodvBUX

[5] http://www.robots.com/