Coordinate systems for industrial robots

Bhavin C. Shah
Research Scholar, Department Of Electronics & Communication Engineering, Jodhpur National University, Jodhpur, Rajasthan
mr.bhavin@hotmail.com

***ABSTRACT*— For any industrial robot there has to be certain coordinate system for proper functioning of program. The coordinate system as defined by geometry are Cartesian Coordinate System, Polar Coordinate System, Cylindrical or Spherical Coordinate Systems. Industrial robots used for medium payload has 6 Degrees of freedom & uses mostly Cartesian Coordinate System. There are various coordinate system in industrial robot which follow any of the three coordinate system & widely used among it is Cartesian coordinate system. The coordinate system used in industrial robots are Robroot, World coordinate system, Tool Coordinate System, Flange coordinate system & Base coordinate system.**

I. INTRODUCTION:

Cartesian coordinate system is a system that uniquely specifies each point in plane by a pair of numerical coordinates, i.e. the signed distances to the point from two fixed perpendicular directed lines. Each reference line is known as coordinate axis and the point where they meet is known as its origin (0, 0). The coordinates can also be defined as the perpendicular projections of the point onto the two axes also known to as signed distances from the origin[1].

Fig 1 & 2 shows the illustration of Cartesian Coordinate System. Fig 1 shows the point of intersection in space such as (-3, 1), (2, 3) & (-1.5, -2.5). Fig 2 shows the circle whose radius is 2 & centered at origin & illustrates the equation for the coordinate system as $X^2 + Y^2 = 4$. Cartesian coordinate system resembles the X, Y & Z plane in 3 Dimensional plane which can help in finding the effect of the point of intersection of that axes in space i.e. in Z plane. This gives the translational motions to the industrial robots i.e. X, Y & Z.

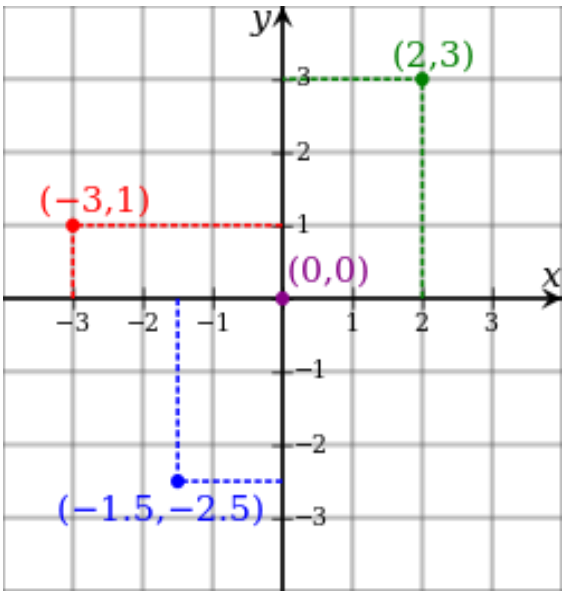

FIG.1: ILLUSTRATION OF CARTESIAN COORDINATE SYSTEM

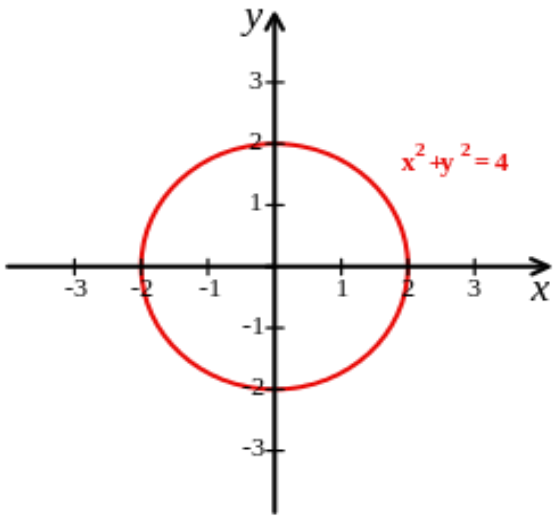

FIG.2: ILLUSTRATION OF CARTESIAN COORDINATE SYSTEM

Polar coordinate system is a 2D coordinate system . Here each point on a plane is found by a distance from a reference point and an angular distance from a reference direction[2].

The reference point is analogous to the origin of a Cartesian coordinate system and is called the pole. The ray from the pole in the reference direction is known as the polar axis. The distance from the pole is called the radius of the coordinate and the angle is called the angular coordinate or polar angle or azimuth. Fig 3 shows the polar coordinate system whose representation in 2D is given as (3.60º) & (4, 210º)[3].

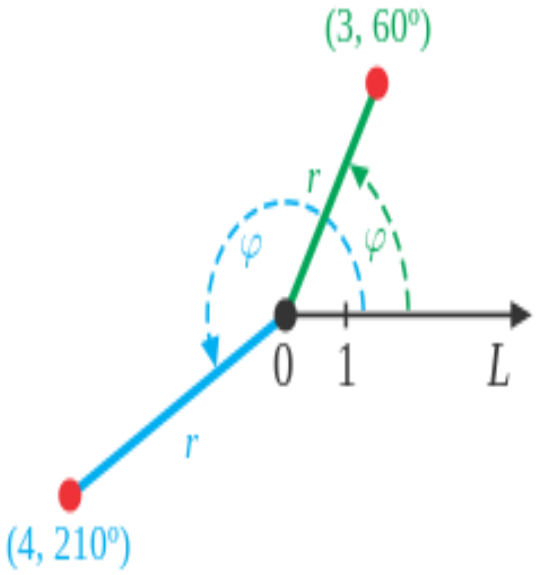

FIG.3: ILLUSTRATION OF POLAR COORDINATE SYSTEM

Spherical coordinate system is a 3D space where the position of a point is specified by the radial distance, its polar and azimuthal angle on a reference plane, that passes through its origin and is orthogonal to the zenith. The polar angle is also known as zenith angle, colatitudes, inclination angle, or normal angle. Spherical coordinate is denoted by (r, θ, φ)[4]

Fig 4 shows the illustration of spherical coordinate system where the X, Y,Z plane represents the (r, θ, φ) in 3D space & is resembling the radial distance, polar angle & azimuthal angle. Spherical coordinate can also be extended to higher standard polar form also referred to as Hyperspherical coordinate System[5].

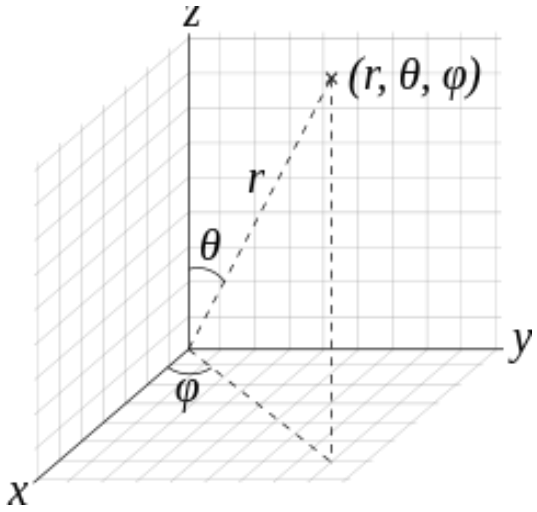

FIG.4: ILLUSTRATION OF SPHERICAL COORDINATE SYSTEM

II. ROBOT COORDINATE SYSTEM

The industrial robot coordinate system widely follows the Cartesian coordinate system. Most industrial robot comprisesof 6 Degrees of freedom i.e. 6 axis arm robot. The coordinate system for industrial robot are Robroot, World, Tool, Flange, Base coordinate system.

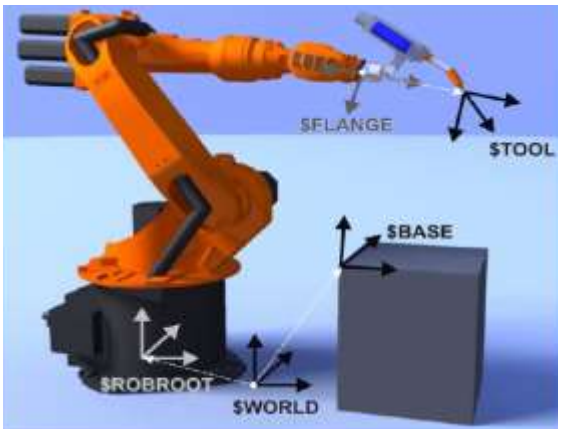

FIG.5: ROBOT COORDINATE SYSTEM

A. ROBROOT COORDINATE SYSTEM:

Robroot is the default coordinate system of the robot. Robroot defines the position of the robot relative to the World Coordinate System. The origin of the robot for Robroot Cordinate system is fixed in the robot base.

B. WORLD COORDINATE SYSTEM:

World Coordinate System in most cases is located in the robot base. World coordinate system is freely definable and uses the origin of Robroot & Base. It uses the

Cartesian coordinate system i.e. X, Y, Z plane to define the Translational Motion of the robot axes & A, B, C to define the Rotational Motion of the robot axes with regards to the translational motion of the robot axes where X//C, Y//B, Z//A.

FIG.6: WORLD COORDINATE SYSTEM

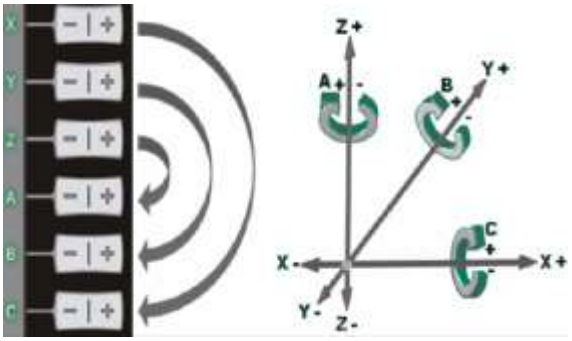

FIG.7: TRANSLATIONAL & ROTATIONAL MOTION RELATIVE TO WORLD COORDINATE SYSTEM

C. FLANGE COORDINATE SYSTEM:

Flange coordinate system is fixed at the robot flange & the origin is the center of the robot flange. It is used as the origin for the tool.

FIG.8: FLANGE COORDINATE SYSTEM

D. TOOL COORDINATE SYSTEM:

Tool coordinate system is freely definable. The origin of the tool coordinate system is called the Tool Center Point (TCP) and is used for tools.

FIG.9: TOOL COORDINATE SYSTEM

E. BASE COORDINATE SYSTEM:

Base coordinate system defines the position of the base relative to the World Coordinate System. Base coordinate system is freely definable and is used for tools & fixtures[6].

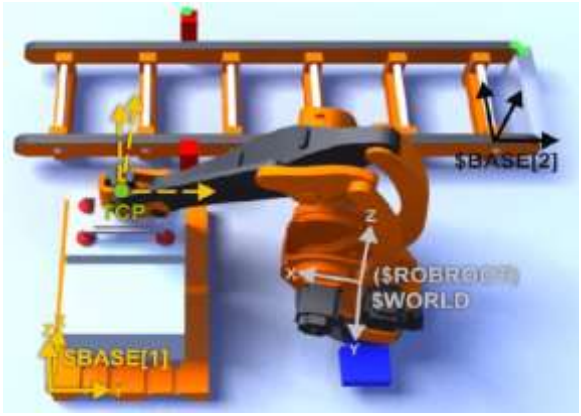

FIG.10: BASE COORDINATE SYSTEM

III. CONCLUSION

From the above discussion it is clear that Cartesian coordinate system is well suited and widely used coordinate system for industrial robots. The other coordinate systems may be used depending on the manufacturer's way of embedding the system, but due to 3D space of Cartesian coordinate system & the use of Translational & Rotational motion relative to World coordinate system, which is best suited for 6 axes industrial robot i.e. 6 D.O.F. industrial robot, Cartesian coordinate system is widely used for industrial robots.

IV. REFERENCES

[1] A Tour of the Calculus, David Berlinski

[2] *Brown, Richard G. (1997). Andrew M. Gleason, Advanced Mathematics: Precalculus with Discrete Mathematics and Data Analysis. Evanston, Illinois: McDougal Littell.*

[3] *David J. Griffiths (1999). Introduction to Electrodynamics. Prentice Hall*

[4] *Korn GA, Korn TM (1961). Mathematical Handbook for Scientists and Engineers. New York: McGraw-Hill. pp. 174–175.*

[5] *Sauer R, Szabó I (1967). Mathematische Hilfsmittel des Ingenieurs. New York: Springer Verlag. pp. 95–96*

[6] Use & programming of industrial robots, KUKA Gmbh