Inverse Kinematics – IK module

The aim of the inverse task of kinematics is to determine the values of configuration coordinates, i.e. articulated variables on the basis of the known position and orientation of the effector coordinate system with respect to the basic system. The inverse problem does not have an unequivocal solution, which means that for a given point in the xyz space there may be several combinations of configuration coordinates. An example of two different solutions for reaching the set point by the working tip of the robot in one plane is shown below in Fig. 5.2.

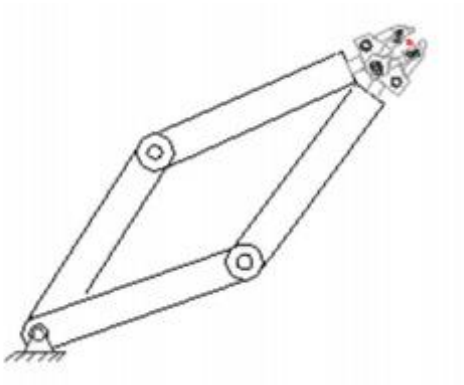


Fig. 1.1 Configurations of the articulated variables of the plane robot for a given point

It is possible to solve the reverse problem both analytically and using numerical method. Therefore, the following division of methods for solving inverse kinematics can be made:

- analytical methods:
  - geometric method,
  - algebraic methods
- Numerical Methods:
  - with the use of Jacobian,
  - algorithms for iterative solving of the inverse task

IK module - geometric method

The IK module calculates the inverse kinematics of the robot with the geometric method according to the algorithm Fig.1.2

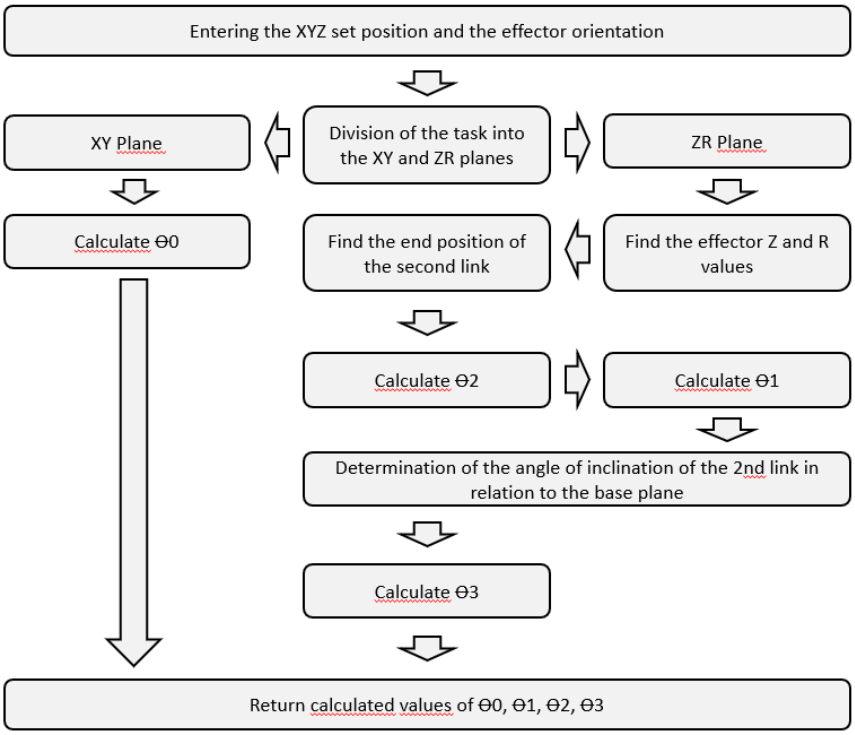


Fig. 1.2 IK algorithm

Selected calculation steps based on the above algorithm for the system shown in Fig. 1.3 are shown below.

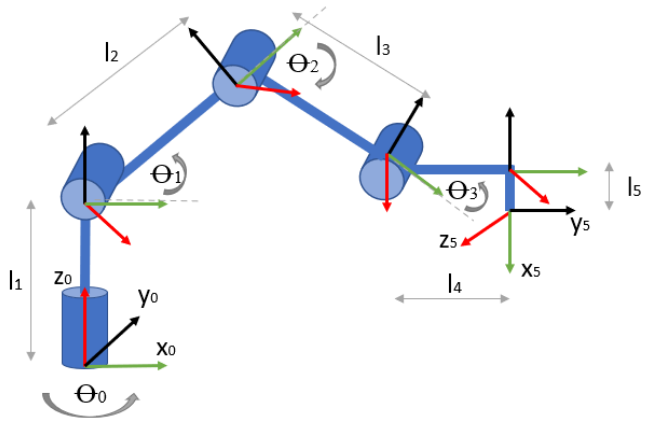
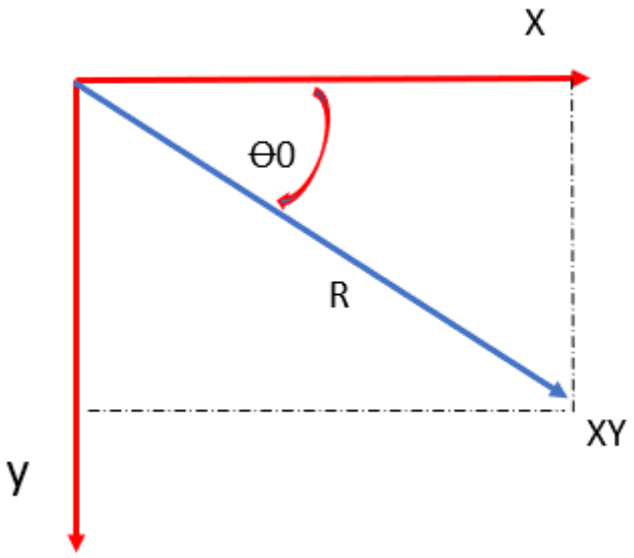


Fig. 1.2 Scheme

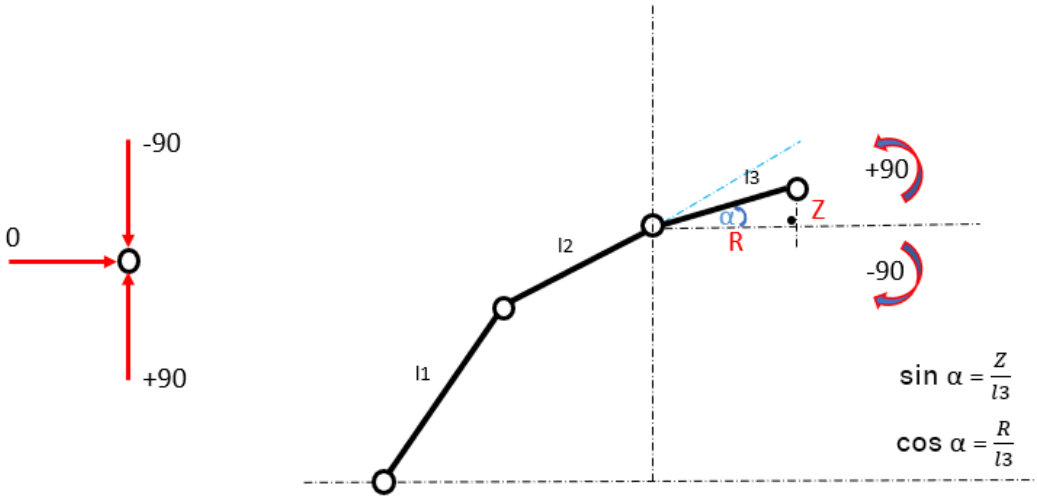
Division of the task into the XY and ZR planes

XY plane -> Calculate Θ0 and determine R



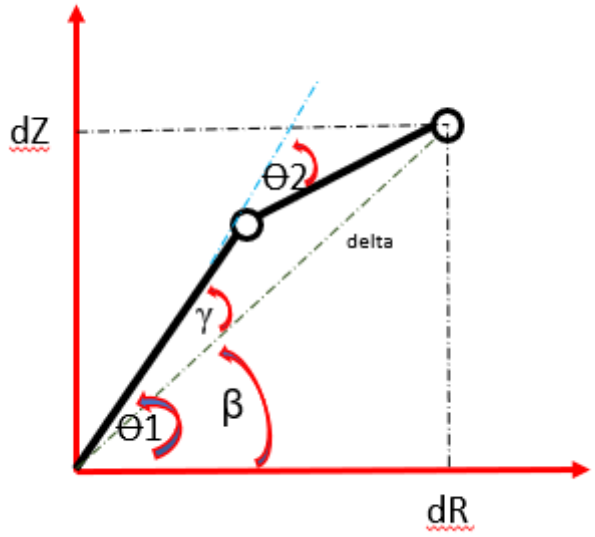
$$\Theta 0 = \operatorname{arctg}\frac{dy}{dx}$$

ZR plane -> Find the effector Z and R values and subtract the calculated values from the Z R of the system



$$Z = \mathrm{l3} \sin \propto$$
$$\mathrm{R} = \mathrm{l3} \cos \propto$$

ZR PLANE -> Calculate Θ1 and Calculate Θ2

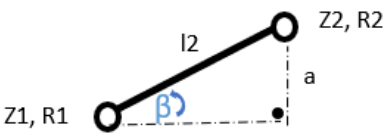


$$dR^2 + dZ^2 = L1^2 + L2^2 - 2L1L2\cos(180 - \Theta 2)$$

$$cos\Theta 2 = \frac{dR^2 + dZ^2 - L1^2 - L2^2}{2L1L2} = L$$

$$\Theta 2 = \text{arctg}\frac{\pm\sqrt{1-L}}{L}$$

ZR PLANE -> Determination of the angle of inclination of the 2nd link
in relation to the base plane and calculate Θ3



$$\sin\alpha = \frac{a}{l2}$$

$$\alpha = \arcsin\frac{Z2-Z1}{l2}$$