Lesson 3 Brief Analysis of Inverse Kinematics

1.Inverse Kinematics Introduction

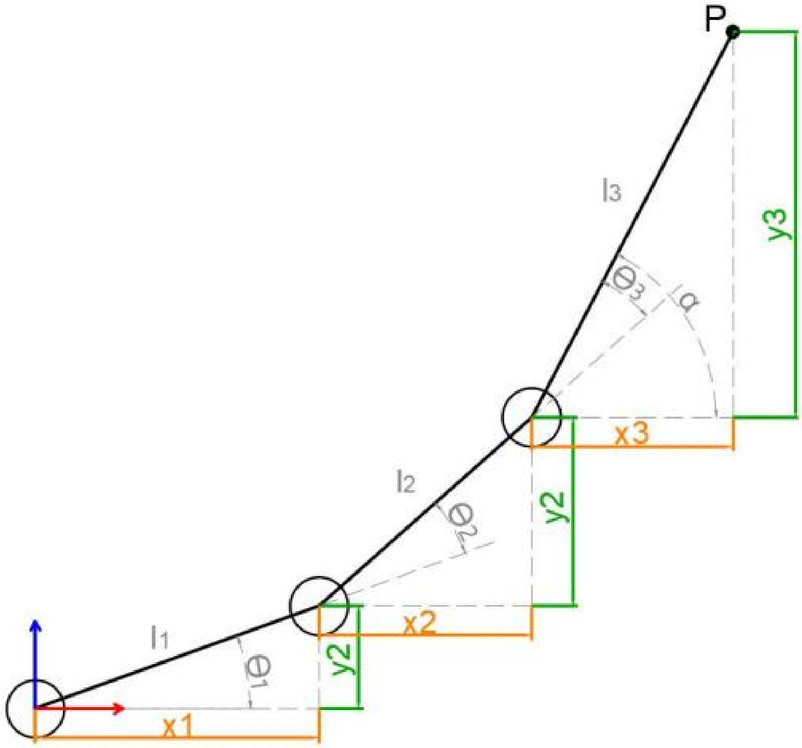
Inverse kinematics is the process of determining the parameters of the joint movable object to be set to achieve the required posture.

The inverse kinematics of the robotic arm is an important foundation for its trajectory planning and control. Whether the inverse kinematics solution is fast and accurate will directly affect the accuracy of the robotic arm's trajectory planning and control. Therefore, for the six-degree-of-freedom robotic arm, a fast and accurate The inverse kinematics solution method of is very important.

2.Brief Analysis of Inverse Kinematics

For the robot arm, the position and orientation of the gripper are given to obtain the rotation angle of each joint. The three-dimensional motion of the robotic arm is more complicated. In order to simplify the model, we remove the rotation joint of the station so that the kinematics analysis can be performed on a two-dimensional plane.

Inverse kinematics analysis generally requires a large number of matrix operations, and the process is complex and computationally expensive, so it is difficult to implement. In order to better meet our needs, we use geometric methods to analyze the robotic arm.



We simplify the model of the robotic arm, remove the base pan/tilt, and the actuator part to get the main body of the robotic arm. From the figure above, you can see the coordinates (x, y) of the end point P of the robotic arm, which ultimately consists of three parts (x1+x2+x3, y1+y2+y3).

Among them θ1, θ2,θ3 in the above figure are the angles of the servo that we need to solve, and α is the angle between the paw and the horizontal plane. From the figure, it is obvious that the top angle of the claw α=θ1+θ2+θ3, based on which we can formulate the following formula:

$$x = l_1 \cos\theta_1 + l_2 \cos\left(\theta_1 + \theta_2\right) + l_3 \cos\left(\theta_1 + \theta_2 + \theta_3\right)$$

$$y = l_1 \sin\theta_1 + l_2 \sin(\theta_1 + \theta_2) + l_3 \sin(\theta_1 + \theta_2 + \theta_3)$$

Among them, x and y are given by the user, and l1, l2, and l3 are the inherent properties of the mechanical structure of the robotic arm.

In order to facilitate the calculation, we will deal with the known part and consider the whole:

$$\mathrm{m} = l_3 \cos(\alpha) - x$$
$$n = l_3 \sin(\alpha) - y$$

Substituting m and n into the existing equation, and then simplifying can get:

$$l_2 = (l_1 \cos\theta_1 + m)^2 + (l_1 \sin\theta_1 + n)^2$$

Through calculation:

$$\sin\theta_1 = \frac{(-b \pm \sqrt{b^2 - 4ac})}{2a}$$

We see that the above formula is the root-finding formula of a quadratic equation in one variable:

$$a = m^2 + n^2$$
$$b = \frac{-n \cdot \left(l_1^2 - l_2^2 - m^2 - n^2\right)}{l_2}$$
$$\mathrm{c} = \left(\frac{l_1^2 - l_2^2 - m^2 - n^2}{2l_2}\right)^2$$

Based on this, we can find the angle of θ1, and similarly we can also find θ2. From this we can obtain the angles of the three steering gears, and then control the steering gears according to the angles to realize the control of the coordinate position.

3.Inverse Kinematics Program Position

The inverse kinematics program has been packaged, and the path can be found in /home/pi/ArmPi/ArmIK. For detailed code descriptions, please refer to the corresponding program comments.