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Kinematics of a delta-2 robot

d9er0d , 24 November 2015 (created 17 June 2012)

A delta-2 robot is a parallel robot composed by two legs, each one has three rational joints but only the one attached to the fixed-frame (or top-plate) is not a passive joint. Therefore, to move the end-effector position (*TCP-0*) of the robot the two active joints must be controlled.

The delta-2 robot can be seen as a simplification of the delta-3 robot, and it is usually used in the packaging industry for pick products on a conveyor belt. You can see some models in Codian Robotics web page and a video of two delta-2 robots working in you tube.

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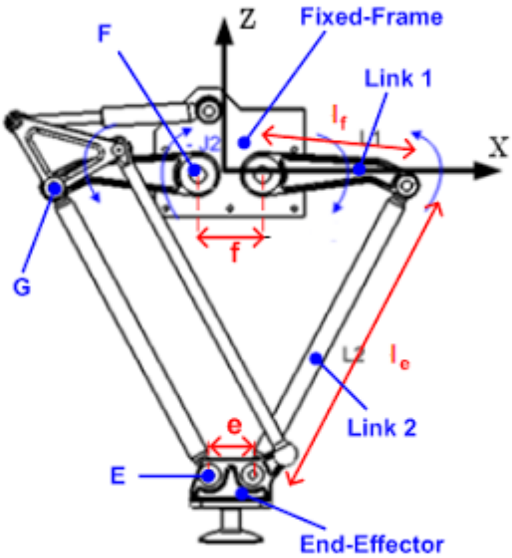
Due to its mechanical configuration this robot can only move its end-effector on plane XZ, see figure belowt. And its *TCP-0* is defined by *(x,0,z)*.

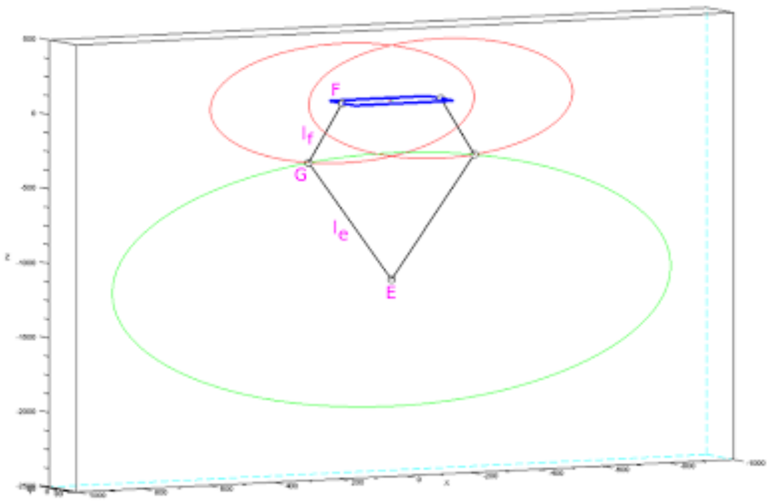


The kinematics of the delta-2 robot can be solved using a geometric method. For doing this, we model the robot (see figure abowe) using four kinematics parameters: r_f,l_f, l_e, r_e.
The parameter r_f is the distance between the center of the fixed-frame to the position of the active joint, r_e is the distance between the center of the end-effector (*E*) and the position of the passive joint (*F*), and l_f and l_e are the lengths of the links of a leg. And the link 1 and link 2 of a robot leg are connected in point *G*.

The algorithms for solving the Kinematics Problem of the delta-2 robot have been developed using Scilab.

Inverse kinematics

For knowing the joins (j_1, j_2) from the end-effector position (*TCP-0*) we must solve the inverse kinematics problem.

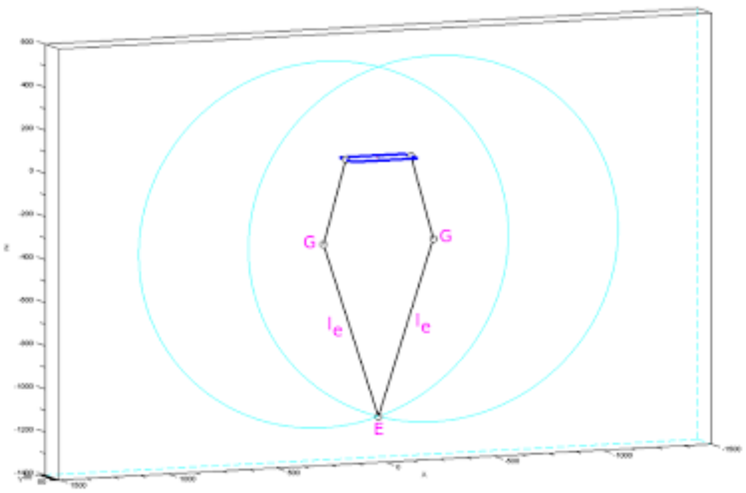


For obtain the joint value of a leg we need to calculate the point *G*, it is calculated by the intersection of two circle. The first circle (green) is defined by its center *E*, the position of the end-effector, and length of link 2 (l_e) as radius. And the second circle (red) has point *F* as center and the length link 1 (l_f) as radius.
Once you know position of *G*, the value of the joint is calculated as the angle defined by the axis X and the line that connect *F* with *G*, that's the real position of the link 1.

This method is applied independently for each leg of the robot.

Direct kinematics

And we can calculated the end-effector position (*TCP-0*) from the joint values (j_1, j_2) solving the kinematics problem.



The end-effector position (*E*) is obtained from the intersection of the two circles (cyan) defined by the link 2 of each robot leg. The center of each circles is defined by *G* and the radius by the length of the link (l_e). And the point *G* is calculated by trigonometry using the value of the joint, the length of the link 1 (l_f) and the position of *F*.