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Online Planning System for Serial Manipulator Multi Links

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Abstract:*This paper proposes an online system based on an intelligent method of a serial robot multi links. The suggested planning system is composed of multi links an individual fuzzy units which control separately each manipulator joint. The purpose of this paperis to move the arm from a desired source to a desired destination. Simulation results show that the robot reaches the goal point successfullywith minimum error in terms of path planning.*

Keywords:*Cartesian space, path planning, fuzzy logic, robot manipulator, multi links.*

I. Introduction

A robot controller is a mobile chain of connections interconnected by joints. One end is settled to the ground, and a hand or end effector that can move openly in space is joined at the other end [1]. Most automated controllers are solid strong with capable engines, solid adapting frameworks, and to a great degree exact models of the dynamic response [2].

Robotics is a comparatively new field of modern innovation that crosses traditional engineering limits. [3].

By ignoring the forces and moments that cause motion of the structure kinematic analysis of the mechanical system of a robot concerns the description of the motion with respect to a fixed reference Cartesian frame. It is significant to recognize kinematics and differential kinematics. Kinematics describes the analytical relationship between the joint positions and the end-effector position and orientation with reference to a robot manipulator[4].

There are several robot motion planning methods such as artificial potential field method, configuration space method, and method based on the fuzzy logic [5, 6, 7, and 8].

Wang, [9] presented a paper utilizing neural networks for a robot armon three dimensionspath planning. They documented that it is sophisticated to find a good path when the robot is in a difficult dynamic change condition. Algorithms for the device to do path planning and trajectory prediction were described.

Kermiche et al., [10] demonstrated fuzzy logic control of planar robot in the presence of fixed obstacle. They presented solution for the problem of learning and controlling a two-link plan robot manipulator in the presence of fixed obstacle.

Koker et al.,[11] presented neural network based inverse kinematics solution of a robotic manipulator. Inverse kinematics problem is generally more complex for robotic manipulators.

In this paper, a Cartesian space path planning using fuzzy logic method is presented for multi links industrial robots operating.

II. Fuzzy Logic

Fuzzy control teaching are finished up by fuzzy math system.Fuzzy relation technique recreates the individual's reasoning, and investigations fuzzy data. It is not necessary to know the definite model of the object to be controlled. It can meet the real-time prerequisites for robot movement planning. It has a good real-time capacity, Figure (1) shows structure of fuzzy inference system (FIS) [12].

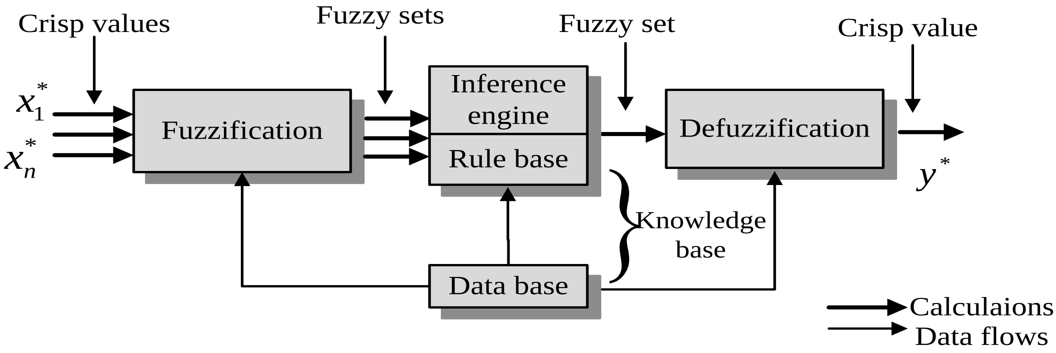


Figure 1: Structure of fuzzy inference system (FIS) [13].

III. Kinematics Model

Kinematics is the technology of motion that treats motion without reverence to the forces which cause it [14].

3.1 Forward kinematics of manipulators

Forward kinematics is an extremely essential issue in the investigation of mechanical control. This is the static geometrical issue of processing the position and orientation of the end-effector of the manipulator. Specifically, the forward kinematic issue is to process the position and orientation of the tool frame relative to the base frame,given an arrangement of joint points, Figure (2) shows kinematic illustrate the actual instrument frame in accordance with the base casing as anelement of the articulationparameters [14].

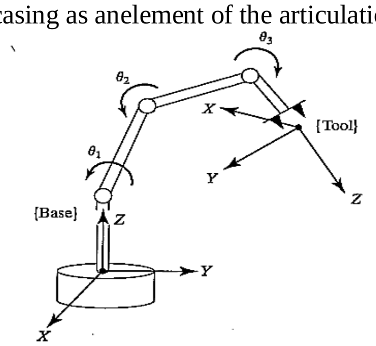


Figure (2):kinematic illustrate the actual instrument frame in accordance with the base casing as an element of the articulation parameters [14].

3.2 Inverse kinematics of manipulators

For the specified positions and orientations of the manipulator's end-effector with regards to the base frame, inverse kinematics is the resolveof most possible and feasible sets of joint variables [2].Welding and also certain types of assembly operations require that a specific path should be negotiated by the end-effector are numerous industrial purposes. To do this, it is it's important to find the corresponding motion of each joint, which will produce the desired tip motion. This is a typical case of inverse kinematic application [15], Figure (3) shows a given position and orientation of the tool frame, values for the joint variables can be calculated via the inverse kinematics [14].

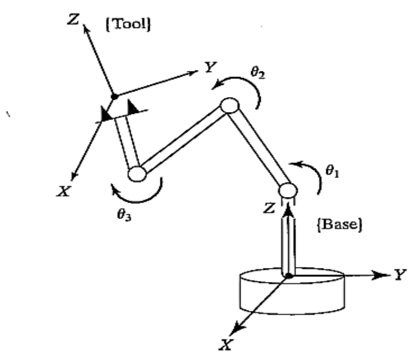


Figure (3): For a given position and orientation of the tool frame, values for the joint variables can be calculated via the inverse kinematics [14].

IV. Proposed Method

Our system proposes a structure of fuzzy logicto solve the problem of Cartesian space path planning. The suggested fuzzy consists of fuzzy blocks for several links robot manipulator as example. Each fuzzy block plans the motion of each robot link separately.A block of the inverse kinematics is needed to generate the new robot joint variable$(\theta_1(i+1),(\theta_2(i+1),(\theta_3(i+1))$ generate from the new Cartesian point$(x(i+1),y(i+1,z(i+1))$. Figure (4) shows structure of the suggested motion planning.

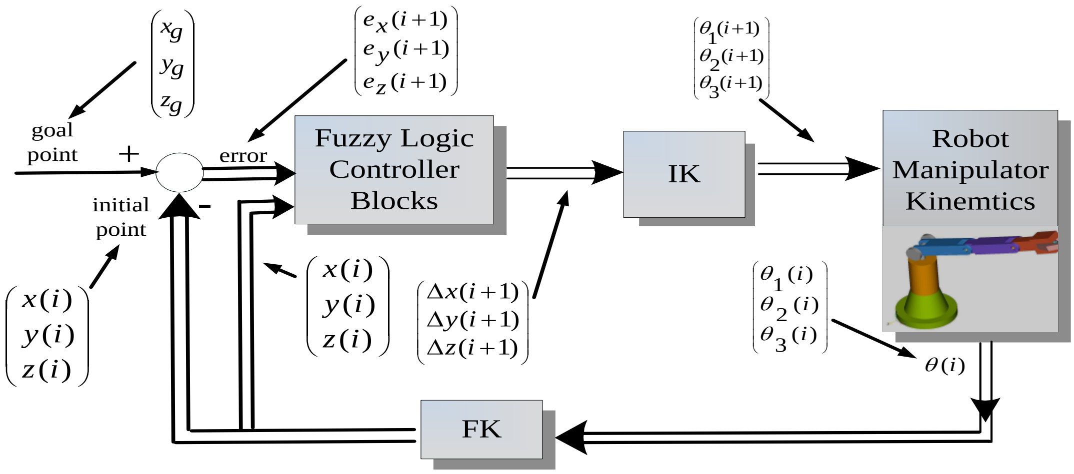
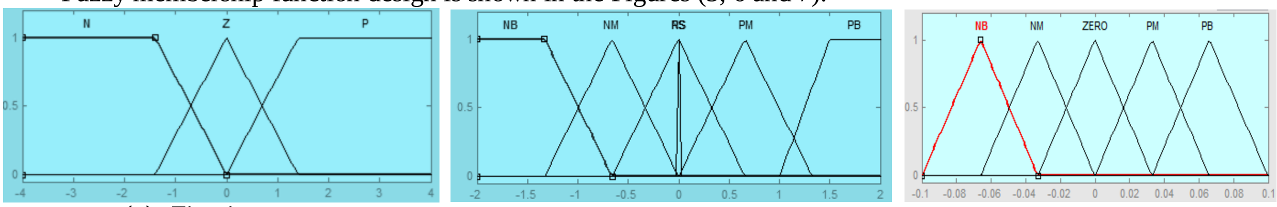


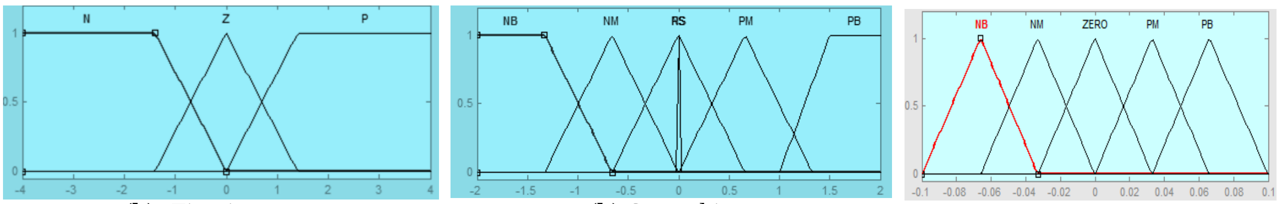
Figure (4): Fuzzy structure for online planning of a multilinks robot manipulator

Fuzzy membership function design is shown in the Figures (5, 6 and 7).



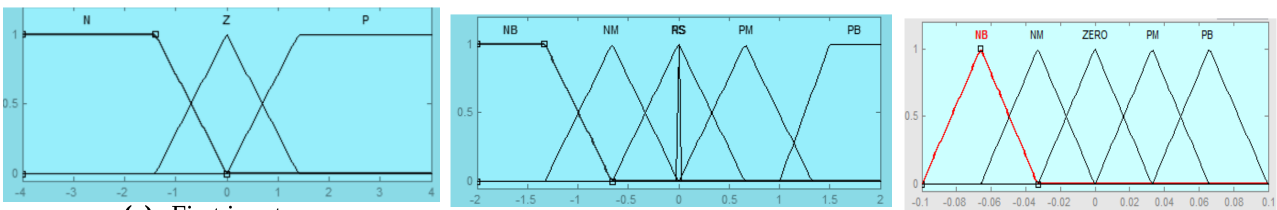
(a) First input **(b)** Second input **(c)** Output

Figure (5): Membership function plots of FB1



(b) First input **(b)** Second input **(c)** Output

Figure (6): Membership function plots of FB2



(c) First input **(b)** Second input **(c)** Output

Figure (7): Membership function plots of FB3

In these figures the design made for the robot manipulator in the computer modeling. The rules used for every fuzzy block to produce the proper output using the k Mamdani method. For example below the rules of the first fuzzy block for first link will be as:

If $(ex(i+1))$ is N) and (x(i)is NS) then $(\Delta x(i+1))$is NB)

If $(ex(i+1))$ is N) and (x(i) is PS) then $(\Delta x(i+1))$ is NB)

If $(ex(i+1))$ is N) and (x(i) is PB) then $(\Delta x(i+1))$ is NB)

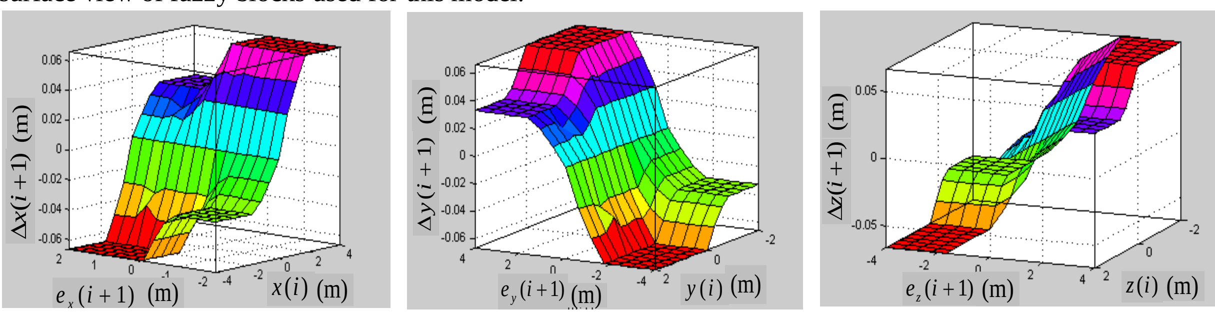
If (ex(i + 1)) is Z) and (x(i) is NS) then (Δx(i + 1)) is Z)
If (ex(i + 1)) is P) and (x(i) is NB) then (Δx(i + 1)) is PB)
If (ex(i + 1)) is P) and (x(i) is PM) then (Δx(i + 1)) is PM)
Also the rules of the second fuzzy block for second link will be as:
If (ey(i + 1)) is N) and (y(i) is PM) then (Δy(i + 1)) is NB)
If (ey(i + 1)) is Z) and (y(i) is NM) then (Δy(i + 1)) is Z)
If (ey(i + 1)) is Z) and (y(i) is NS) then (Δy(i + 1)) is Z)
If (ey(i + 1)) is Z) and (y(i) is PS) then (Δy(i + 1)) is Z)
If (ey(i + 1)) is Z) and (y(i) is PM) then (Δy(i + 1)) is Z)
If (ey(i + 1)) is Z) and (y(i) is PB) then (Δy(i + 1)) is PB)
Moreover the rules of the last fuzzy block for last link will be as:
If (ez(i + 1)) is N) and z(i) is NB) then (Δz(i + 1)) is NM)
If (ez(i + 1)) is N) and z(i) is NM) then (Δz(i + 1)) is NM)
If (ez(i + 1)) is Z) and z(i) is NB) then (Δz(i + 1)) is Z)
If (ez(i + 1)) is Z) and z(i) is NM) then (Δz(i + 1)) is Z)
If (ez(i + 1)) is P) and z(i) is NS) then (Δz(i + 1)) is PB)
If (ez(i + 1)) is P) and z(i) is PS) then (Δz(i + 1)) is PB)
The most used ways to compute the fuzzy intersection (fuzzy-AND) operation with respecttothe fuzzy rules are the minimum and product operators. The final output of every fuzzy block can be computed applying the center of gravity (COG) defuzzification method total rules.
$\Delta\theta^{crisp} = \frac{\sum_k b_k \int \mu(k)}{\sum_k \int \mu(k)}$, below Table (1) show list of symbols and meaning.

Table (1): List of symbols and meaning

Symbols	Meaning	Symbols	Meaning
N	Negative	PM	Positive Medium
Z	Zero	PB	Positive Big
P	Positive	FK	Forward Kinematics
NB	Negative Big	IK	Inverse Kinematics
NM	Negative Medium	FB	Fuzzy Block
NS	Negative Small	b_k	Center of membership function of the consequent of rule (k)
PS	Positive Small	$\int \mu(k)$	The area under the membership function
$e_x(i+1)$	The new x-axis error.	$z(i)$	The current z-axis value of the robot end effector.
$e_y(i+1)$	The new y-axis error.	$\Delta x(i+1)$	Represents the required change in x-axis for planning the robot motion to the next point (i+1).
$e_z(i+1)$	The new z-axis error.	$\Delta x(i+1)$	Represents the required change in x-axis for planning the robot motion to the next point (i+1).
x(i)	The current x-axis value of the robot end effector.	$\Delta y(i+1)$	Represents the required change in y-axis for planning the robot motion to the next point (i+1).
y(i)	The current y-axis value of the robot end effector.	$\Delta z(i+1)$	Represents the required change in z-axis for planning the robot motion to the next point (i+1).
FIS	Fuzzy Inference System		

V. Computer Modeling and Results

Modeling and simulation performed to test the total process of Figure (4). The signals used to mode the robot motion were. A multi links robot arm each other equal 0.45 m used for this model. Figure (8) shows surface view of fuzzy blocks used for this model.



(a) (b) (c)

Figure (8): Surface View of: (a) FB1 (b) FB2 (c) FB3

The results of the computer modeling are shown in Figure (9) where the robot has to move from the start point ($x = 1.35$ m, $y = 0$ m, $z = 0$ m) to the goal point ($x = -1.35$ m, $y = -0.2$ m, $z = 0$ m) the error in reaching the goal after (200) program iterations was: $e_x = -0.0039$ m, $e_y = -1.1573 * 10^{-010}$ m, $e_z = 3.6937 * 10^{-018}$ m. Figure (10) shows the graphs of run1.

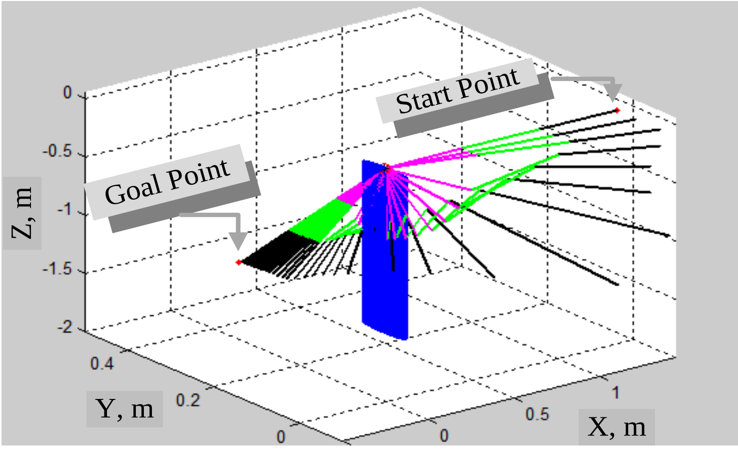


Figure (9): Multi links robot manipulator Cartesian space path planning using fuzzy logic of run1

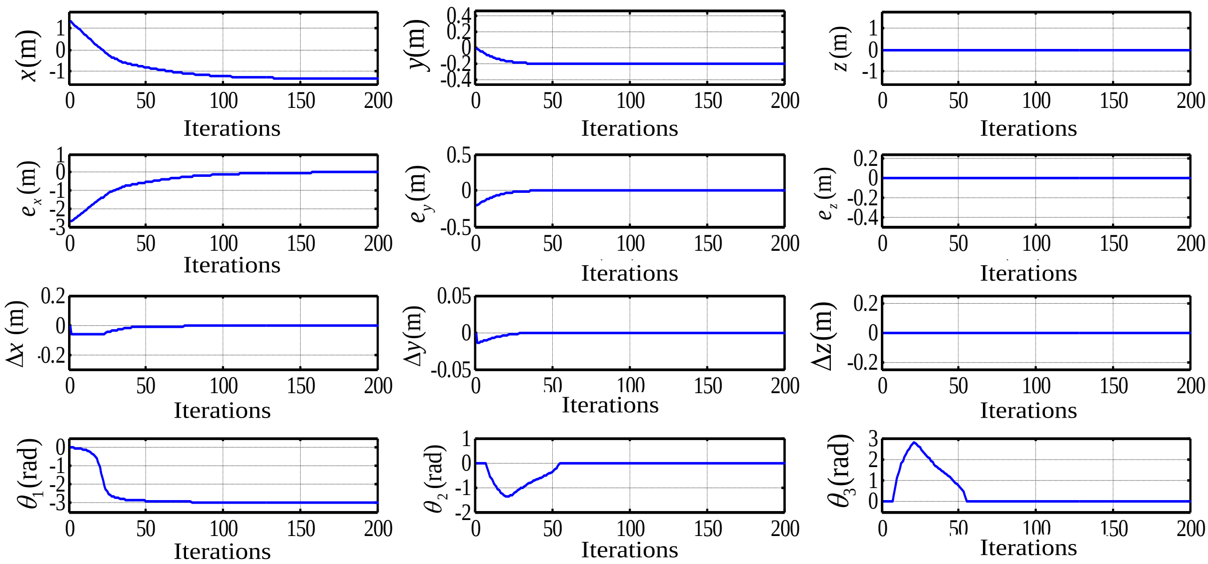


Figure (10): Change of Cartesian path planning parameters with program iteration index of run1

Furthermore, the results of run2are shown in Figure (11) where the robot has to move from the start point ($x = -1.35$ m, $y = 0.2$ m, $z = 0$ m) to the goal point ($x = 1.35$m, $y = 0$m, $z = 0$ m) the error in reaching the goal after (180) program iterations was:

$e_x = -0.0034$ m, $e_y = -5.4284 * 10^{-009}$ m, $e_z = 3.6937 * 10^{-018}$ m

Figure (12) shows the graphs of run2.

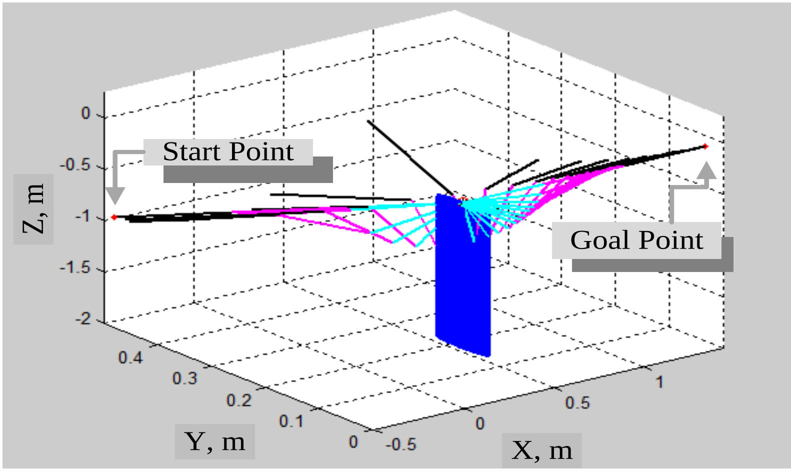


Figure (11): Multi links robot manipulator Cartesian space path planning using fuzzy logic of run2.

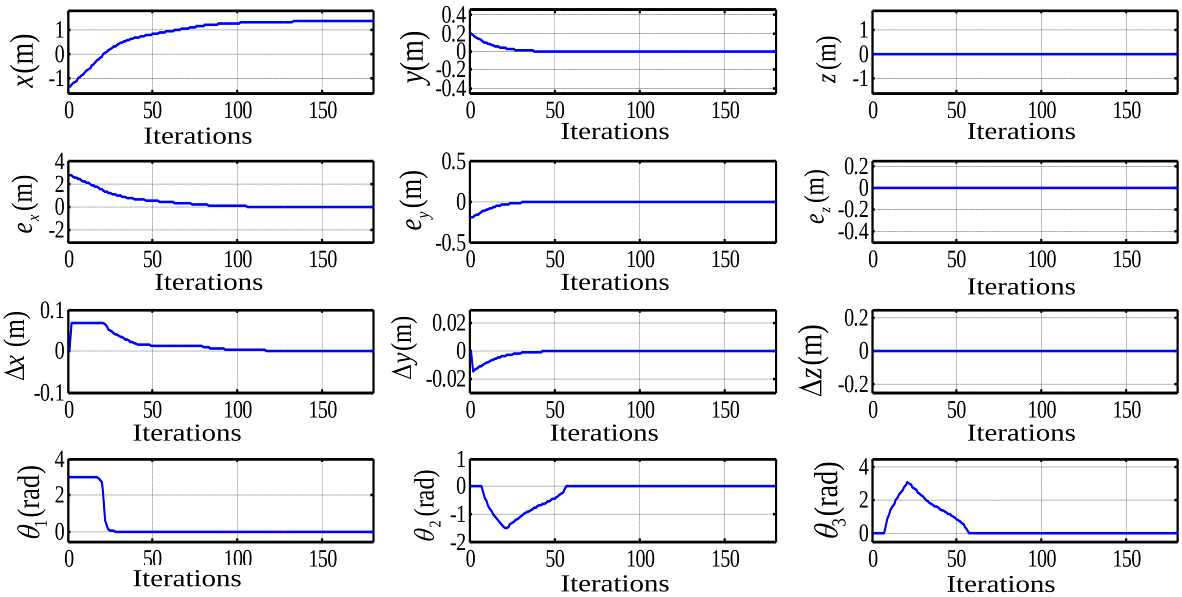


Figure (12): Change of Cartesian path planning parameters with program iteration index of run2

VI. Conclusion

Our planning system in Cartesian space showed good results since the error of reaching the goal point after program iterations was without motion oscillation of the robot near the goal point. In the first run, the robot moved from a desired point to a goal point with minimum error with program iterations (200).

In the second run the results showedalso a minimum error with less program iterations (180) in another start and goal point.

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