DEVELOPMENT OF HEURISTIC ALGORITHM FOR MOBILE ROBOT PATH PLANNING USING POTENTIAL FIELD ALGORITHM WITH EXPERIMENTAL STUDY

Paramasivam. C

Asst.Prof., Dept. of Mech. Engg.,
Thiagarajar College of Engineering, Madurai, India
Mail: cpmech@tce.edu

Abstract Now-a-days, the Robotic applications are gradually becoming a part of lives. The major bottlenecks of these robotic systems are the complex implementation procedure, lack of ability to perceive and adapt to unpredictable environment. An autonomous robot applications, different types of heuristic methodologies are proposed by researchers like reinforcement learning algorithm, potential field algorithm and wave front algorithm. Here, a potential field heuristic algorithm is experimentally studied using Mobile robot for its path planning in order to complete certain task and the observation are tabulated.The analysis of variance statistical test isalso adopted to check the reliability and stability of the methodologies proposed.

***Keywords**: Path Planning, Heuristic Algorithm, Potential Field Algorithm, Obstacles*

I. INTRODUCTION

The important metrics of the robot path planning is the total distance from starting to target position and the time taken to reach the target. In order to complete a specified task, different types of sensors like touch sensors, IR and RF sensors used for acquiring the information from the robot's environments. Apart from the regular contact and non-contact sensors, other miscellaneous sensors like computer vision is also used in robot environments. Computer vision is a process of automatic acquisition of images by camera and their automatic image analysis to extract the needed data for controlling a task. Hence, any work update to improve the requirement of path planning may be appreciated.

II. EXPERIMENTAL SETUP

Here, the working environment is assumed to be known and fixed as 2 m x 3 m (length x breadth) rectangular plane area. In this experimental study, three different environmental configurations were made for conducting experiments based on the number of the obstacles and its locations. The schematic diagram of the experimental configurations with three obstacle setup is shown in Figure 2.1.

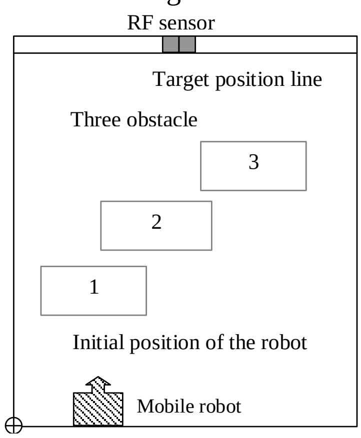

Figure 1.1: Experimental environment with three obstacles

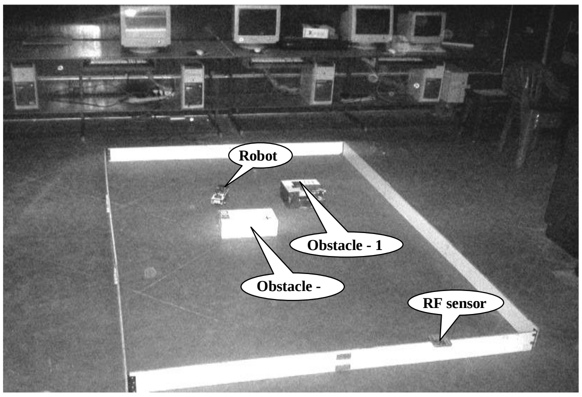

Figure 1.2:Photograph of Actual experimental setup

The shape of the obstacle may not be a constraint during the real time application, but here only regular geometry is taken in to consideration. The mobile robot used for this experiment is provided with two IR sensors to detect the obstacle within the working area and one RF sensor is used to represent the target, which is placed on the target within the working area.

III. POTENTIAL FIELD ALGORITHM FOR PATH PLANNING WITH OBSTACLE AVOIDANCE TASK WITH IR AND RF SENSORS

Here, the mobile robot is represented as a point in space configuration as a moving particle under the influence of a signal produced by the sensors located on the target line (RF sensor) and located on the robot to detect the obstacles (IR sensor). The goal always generates an attractive potential, which pulls the mobile robot towards the target and the obstacles always produces, a repulsive potential which pushes the robot away from them.

3.1 Attractive potential by target

The IR sensor is used to detect the obstacles and the RF sensor is used to identify the target. The attractive potential is the signal level from the RF sensor which logically attracts the mobile robot to the goal position and it has the relation given in Equation 1.

Attr = function of {Ir, Rf} (1)

where,

Attr = attractor
Ir = Signal from the IR sensor
Rf = Signal from the RF sensor Example: (0, 1) and (1, 1)

3.2 Repulsive Potential by Obstacles

The repulsive potential is the potential which logically pushes the mobile robot away from them and it has the function shown in Equation 2.

Refl = function of {Ir, Rf} (2)

where,

Refl = Reflector
Ir = Signal from the infrared sensor
Rf = Signal from the RF sensor Example: (0, 0) and (1, 0)

The above attractor and reflector functions are works based on the signals from the IR and RF sensors. The following combinations of functions are obtained using the attractive and repulsive potentials:

Attr = {Ir, Rf} = [(0, 1) (1, 1)]
Refl = {Ir, Rf} = [(0, 0) (1, 0)]
If,
(0, 1) = Obstacle is not detected and target reached
(1, 0) = Obstacle is detected and target not reached

(1, 1) = Both obstacle and target are detected
(0, 0) = Obstacle and target are not detected
The mobile robot can take decision based on the sensor input using above four possible combinations. If the repulsive potential is identified, the robot will take the move reverse function and moves in the reverse direction and then take turn left (or) turn right function based on random number generated. If the generated random number value is greater than 0.5, the robot will take forward right turn function, otherwise it will take forward left function. The same function is repeated until the mobile robot receives the signal from RF sensor, which is placed on the target line. An exclusive software code has been written in order to implement the potential field algorithm for the mobile robot.

IV. RESULTS AND DISCUSSION

The potential field algorithm is implemented for path planning task with obstacle avoidance. Three different experimental configurations were assumed and the experiments have been conducted within the pre-defined working environment.

4.1 Path Planning Experiment with One Obstacle

In this setup, only one rectangular block size 300 x 100 x 100 mm (length x breadth x height) obstacle is placed on the working area. The dimension of a mobile robot is 100 x 200 x 100 mm (length x breadth x height). The initial location (centroid coordinate points) of the mobile robot is (500, 200) mm and centroid coordinates of the box obstacle is fixed as (600, 1000) mm with reference to the lower left corner of the working environment. The observation of this experiment is presented in Table 4.1. The distance, time taken and average speed of the mobile robot with in the environment is also observed and shown in Table 4.2. The corresponding path produced by the mobile robot from starting to target point for all four runs with average run is shown in Figure 4.1. Similarly, the experiment are conducted with two and three obstacles separately.

Table 4.1: Path of mobile robot with one obstacle

Description of the points (a)	Location of the mobile robot in mm (b)									
	First Run		Second Run		Third Run		Fourth Run		Average run	
	X	Y	X	Y	X	Y	X	Y	X	Y
Starting point	500	200	500	200	500	200	500	200	500.0	200.0
Via points	500	530	500	540	500	540	500	520	500.0	532.5
	610	520	600	530	620	510	610	530	610.0	522.5
	720	640	710	630	700	630	720	620	712.5	630.0
	780	520	770	540	780	520	780	530	777.5	527.5
	880	650	900	660	890	650	900	640	892.5	650.0
Target Points	890	2880	900	2880	890	2880	900	2880	895.0	2880.0

Description of the points (a)	For X – coordinates in mm (c)					For Y – coordinates in mm (d)				
	M	SD	SE	95% CI		M	SD	SE	95% CI	
				LL	UL				LL	UL
Starting point	500.0	0.00	0.00	500.00	500.00	200.0	0.00	0.00	200.00	200.00
Via points	500.0	0.00	0.00	500.00	500.00	532.5	7.50	3.75	525.15	539.85
	610.0	8.16	4.08	602.00	618.00	522.5	7.50	3.75	515.15	529.85
	712.5	9.57	4.79	703.12	721.88	630.0	5.00	2.50	625.10	634.90
	777.5	5.00	2.50	772.60	782.40	527.5	7.50	3.75	520.15	534.85
	892.5	9.57	4.79	883.12	901.88	650.0	5.00	2.50	645.10	654.90
Target Points	895.0	5.77	2.89	889.34	900.66	2880.0	0.00	0.00	2880.00	2880.00

Table 4.2: Distance, time taken and speed of the mobile robot with one obstacle

Particulars	Run - 1	Run - 2	Run - 3	Run - 4	Run average
Distance to target position in mm.	3131.44	3094.24	3144.22	3083.54	3110.88
Time taken to reach in sec.	75	77	80	74	76.50
Average Speed robot in mm/sec.	41.75	40.18	39.30	41.67	40.67

M – Mean; SD – Standard Deviation; SE - Standard Error; CI – Confidence Interval; LL – Lower limit; UL – Upper Limit

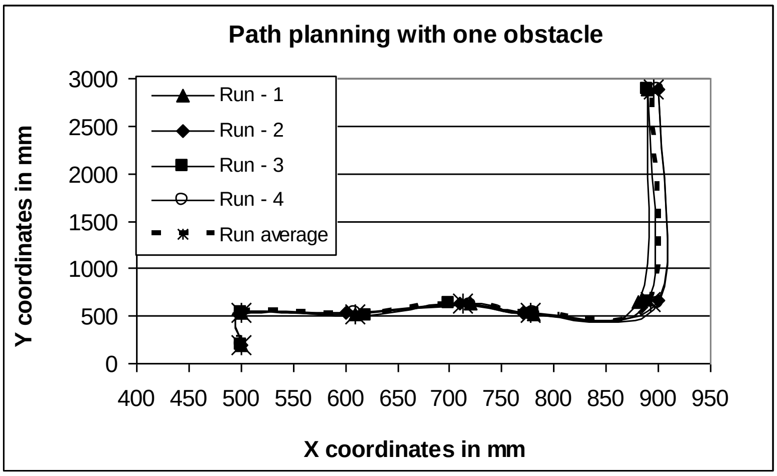

Figure 4.1: Mobile robot path plan with one obstacle

Table 4.3: Distance, time taken and speed of the mobile robot with two obstacles

Particulars	**Run - 1**	**Run - 2**	**Run - 3**	**Run - 4**	**Run average**
Distance to target position in mm.	3706.13	3748.41	3771.29	3749.83	3741.84
Time taken to reach in sec.	94	97	96	95	95.50
Average Speed robot in mm/sec.	39.43	38.64	39.28	39.47	39.18

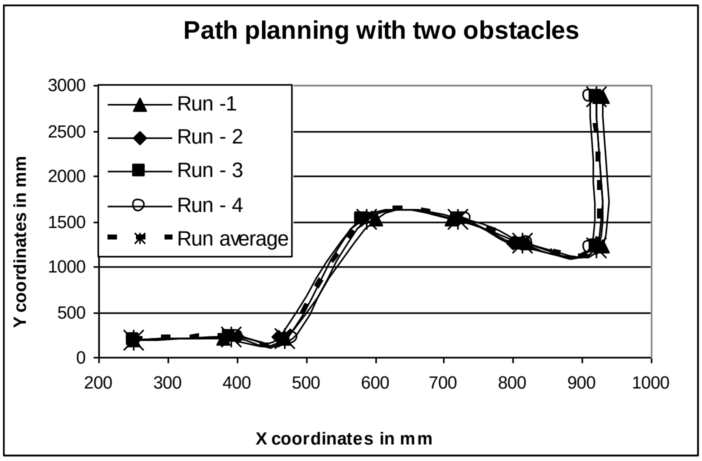

Figure 4.2: Mobile robot path planning with two obstacles

Table 7.22 Distance, time taken and speed of the mobile robot with three obstacles

Particulars	Run - 1	Run - 2	Run - 3	Run - 4	Run average
Distance to target position in mm.	3701.43	3725.84	3746.48	3714.22	3719.49
Time taken to reach in sec.	119	122	124	123	122.00
Average Speed robot in mm/sec.	31.10	30.54	30.21	30.19	30.48

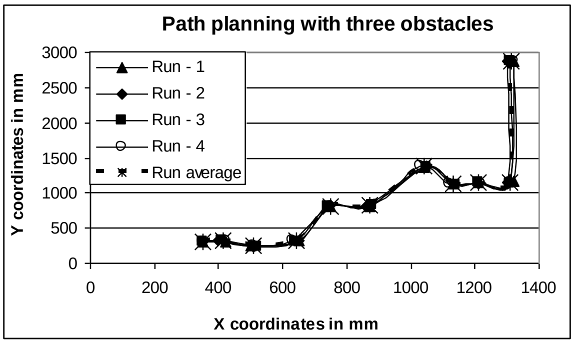

Figure 7.13 Mobile robot path planning with three obstacles

V. CONCLUSION

An experimental procedure for the development of path to be followed by a mobile robot using potential field algorithm is proposed. The path planning with obstacle avoidance task with IR and RF sensors is done and the corresponding observations are tabulated. The analysis of variance statistical test isalso adopted to check the reliability and stability of the methodologies proposed.

VI. REFERENCES

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