

**Thesis Report**  
**On**  
**“Path Planning and control of Mobile Robot using Fuzzy logic”**

**Bachelors of Technology**  
**In**  
**Mechanical Engineering**

**By**  
**Bhawesh Tibrewal**  
**Roll no: 110ME0339**  
**And**  
**Taras Kumar Swain**  
**Roll No: 110ME0338**

Under The Esteemed Guidance of  
**Dr. D.R.K.Parhi**  
**Department of Mechanical Engineering**



**Department of Mechanical Engineering**  
**NATIONAL INSTITUTE OF TECHNOLOGY ROURKELA**

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## DEPARTMENT OF MECHANICAL ENGINEERING



### CERTIFICATE

This is to certify that the thesis entitled “**Path Planning and control of Mobile Robot using Fuzzy Logic**” is the bona fide work of *Bhawesh Tibrewal and Taras Kumar Swain* under the Guidance of **Dr. D.R.K.Parhi** for the prerequisite for the award of the degree of **BACHELOR OF TECHNOLOGY** specialization “**Mechanical Engineering**” and submitted in the **Department of Mechanical Engineering** at **National Institute of Technology Rourkela**, for the period 2013-2014.

Dr. D.R.K Parhi  
Department: Mechanical Engineering  
National Institute of Technology,  
Rourkela.

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Taras Kumar Swain

110ME0338

Bhawesh Tibrewal

110ME0339

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## **Abstract**

In this paper study has been carried out to improve a steering technique for an self-directed bot to work in a real world atmosphere, which should be proficient of classifying and evading hindrances, precisely in a very busy a challenging atmosphere. In this paper better method is develop in circumnavigating mobile bot in afore said atmosphere. The action and reaction of the bot is addressed by fuzzy logic control scheme. The input fuzzy members are turn angle between the bot head and the target, distance of the hindrances present all around the bot (lef, rgh, and front, back).The aforesaid input members are sensed by series of infrared sensors. The obtainable FLC for steering of bot has been applied in all complex and hostile atmosphere. The outcomes hold good for all the above mention situations.

Key words: steering, real world atmosphere, fuzzy logic, mobile bot.

## INTRODUCTION

Since time ancient there has been a continuous effort to form and construct a **cognizant machine (bot)** that should be proficient of thinking like human beings, for this there is a incredible craze among the modern intellectuals, philosophers and researchers. Here we are mainly centering on botics and its latent utility in engineering, medical, industries, mines biomedical science and many more. So what is there in botics that has attracted thousands of intellectuals from various backgrounds and most probably each of them having dissimilar necessities .This is because bots can work as sentient as that of a human being ,more over it work with such inaccuracy that lef human being with wonder struck. Bots need very less human participations this is another big reward of adopting botics in real life. Now, we are moving towards self-sufficient mobile bot, i.e., it should be capable of doing things in an undefined and unmodified atmosphere and without human interventions. In simple words it should be capable of performing in a real world atmosphere. A well to do self-sufficient bot should be skilled of doing many things like,

- With no trouble it should be able gather info about the surrounding.
- It must travel from one endpoint to another with no human help.
- Must evade hindrance in its track.
- If essential act rendering to the circumstances.

Now the major focus is how to improve procedures for self-sufficient mobile bot steering. Evolving steering methods has apealed many researchers, students and become one of the major trends in steering botics. . This inclination is highly driven by the present thin void between the accessible technology and the new user presentation demands .One of the major difficult in industrialized botics is that lack of litheness, self-sufficiency, recurrent breakdown: usually, these bots only execute pre-programmed or pre-defined arrangements of actions in highly controlled atmospheres, and are not able to work in partly new or completely new atmospheres or to face unanticipated circumstances. In these situations they are no better than dead matter. Now in the existing market state there is a heavy struggle for complete self-sufficient bots. There are so many soft computing techniques used for mobile bot steering such as neural network and genetic algorithm, particle swarm optimization and are

also well-thought-out to be the best way for articulating the particular uncertainties in human mind. Now demand arises although there is lot of methods in steering of mobile bots then, why we are opting for, particularly, fuzzy logic control system. If steering is of so much importance then what is steering? How it works? To answer these questions we have to think very carefully; steering is the process of defining and continuing a specific track that is free of hindrances and enhanced one and leads to the final endpoint. Fuzzy logic control system provides a ideal platform in which human insight-based action can be easily accomplished. Using the fuzzy logic control arrangement, the way human being reasons and make judgment can be formulated and applied in botics by simple IF-ELSE rules and can be combine with easily comprehensible and natural linguistic illustrations. Localizing map and reasoning track preparation are the two most vital sub schemes for the fuzzy interface technique. These two sub scheme were combined and used in fuzzy logic control scheme as fuzzy rules set. The in-put to the fuzzy scheme is the acumen info by the sensors about the atmosphere and the out-put is in terms of signal control of the bot: slow, fast, lef turn, rgh turn, straight motion and heading angle.

The chief goal of this paper on fuzzy logic control scheme is to convey sensitive steering techniques is to allow self-sufficient units, so that with comparatively low-cost sensors and actuators, to perform tough tasks in an entirely unstructured or unidentified atmospheres. Fuzzy Logic control methods have a wide range of potential application fields, this include the study in to the completely unreachable or hazardous atmospheres, industrial automation, biochemistry and also biomedicine. In this research, the development of Fuzzy Logic Control scheme for result and control approaches necessary for autonomous control of mobile bots plays a vibrant role.



## 2. Literature review

Fuzzy logic is a mathematical preparation that provides data about the ambiguity in a given formless atmosphere, was recognized in [1]. Demirli and Turks, [2] describes about a technique which is founded on fuzzy model of sonar sensor which produces its data from experimentation and relate the aridness and wetness of a specific surface. Zhou, Meng [3] worked on how to progress the humanoid gait using a distinct method called FRL mediator with fuzzy evaluative rejoinders.

Parhi [4] have designate about the progress of control method for an self-sufficient mobile bot to circum steering in a real world situation, it should be accomplished of avoiding problem in its track it may be organized or formless, in a eventful and randomly changing atmosphere. Steering means governor of a machine from its initial point to its finish point in a specific area subsequent a track that is encompasses of either a curvature or a sequence of jointed curve sections [5] and also grows a steering technique called as “practical or straight decomposition.”

Pratihara and Bibel [7] have industrial an hindrance dodging methodize .For collision-free track for various bots by incomes of genetic-fuzzy schemes. Pradhan et al. [6, 8] have used likely field technique to circum steering mobile bots. They have exposed their consequences in imitation and the consequences are in consensus with the molds made. Fraichard and Garnier [9] had obtained motion switched design method for a car or it might be any kind of four wheeler automobile which is exactly envisioned to travel in a lively and partly known surroundings. They have used fuzzy logic method, which mainly includes of sets of fuzzy rules indoctrination the sensitive conduct of the automobile. They have positively steering the car-like automobile with use of fuzzy logic control method. In case of android soccer, fuzzy logic is very much vital, fuzzy logic has been used in many instances but it is specially applied in separate bot performances and movements, in particular for gunfire and hindrance avoidance [13], [12]. Graded fuzzy regulator is applied in behavior-based design [11], and fuzzy logic in willing plan assortment [10]. In the above case an widespread fuzzy behavior-based design is projected and applied on a bot soccer scheme. The fuzzy behavior-based regulator design is completely used for accomplish a team of soccer androids, by decomposing the entire team into dissimilar roles, each role into dissimilar insight based performances, and then performances into activities. The bot soccer scheme

provides a extremely formless and lively atmosphere forth numerous mobile androids to function in an unknown atmosphere. Basically it is based on a multivalent atmosphere where androids need to collaborate or contest with one another or with the contradictory team to attain certain jobs. All the consequences are well agreement with the prospects and it is highly changed fuzzy logic controller in case of mobile botsterring .In another case dissimilar qualities like steering angle, hindrance distance, speed are measured as fuzzy logic performances, and fuzzy logic control scheme is applied to attain numerous desire conduct to attain the goal of target seeking in [14].Here fuzzy control is accepted to organize the dissimilar scheme conduct in reply to the atmosphere. It is founded on the detail that a fuzzy scheme is sub-divided in to small fuzzy control scheme instead of having a large unify fuzzy control scheme. It works on the foundation of insight based act. Fuzzy control is proprietary by the use of philological rubrics to operate and tool human info in controller schemes so as to grip the doubt current in the atmosphere [15].Levitt and Lawton [16] well-defined the aim of steering control as provided that answers to the following questions:

- Present location of the bot?
- Location of the others with reference to the bot?
- How to grasp to other positions from the present position.
- How to choose a crash free track?
- Whether it is able, to locate hindrance or not?
- Track followed is improved or not?

To address both subjects a mobile android must have a way to observe its atmosphere. And lot of exertion is given on the overhead core questions in botics.

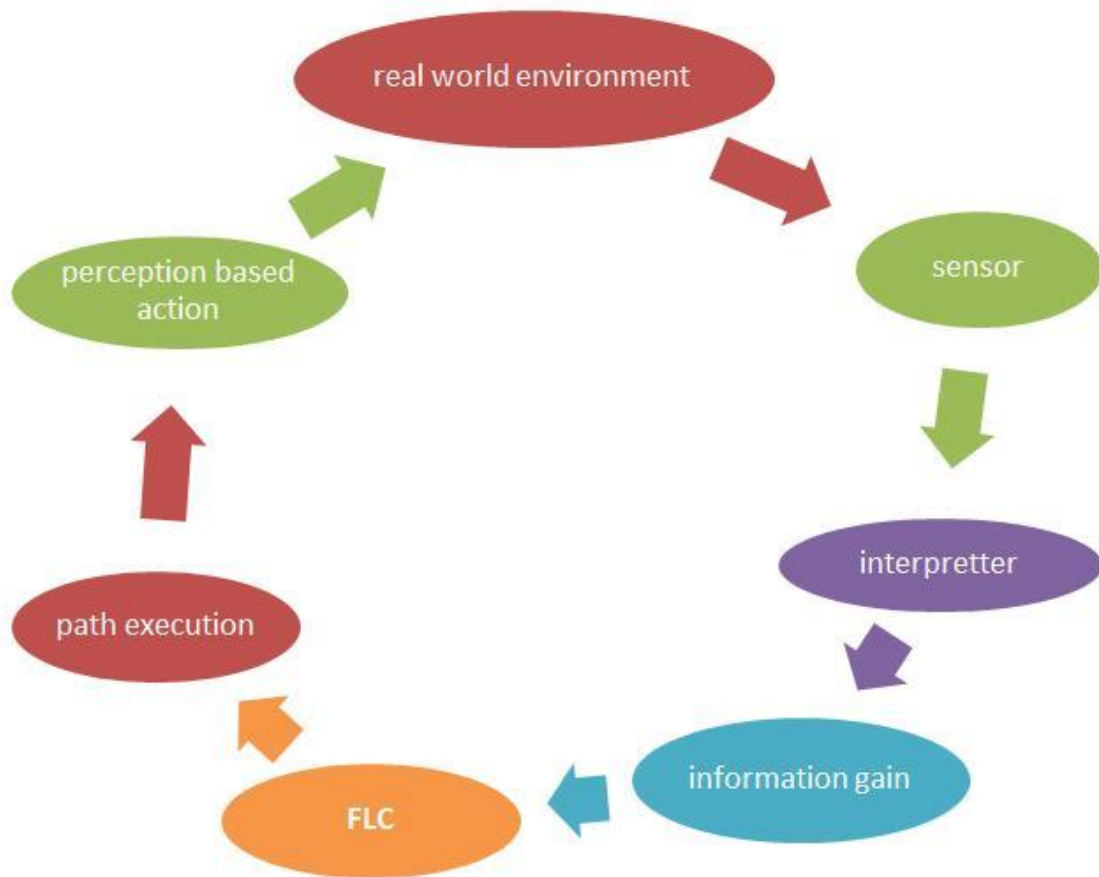
### 3. Developing a fuzzy interface for hindrance avoidance

Fuzzy logic is lengthily used in mobile botsteering. In fuzzy logic, fuzzy logic regulators include dissimilar heuristics control devices in dissimilar form e.g. if-then, else-if etc. rubrics which help to shape an effectual bot having dissimilar feasibly like qualitative and quantitative functionality with control flow devices. Controller should be as brainy as human or in a better way to evade interjects which happens while execution of tivities to reach to the terminus. There may be dissimilar types of hindrances on the track and hence it should deliver an efficient instrument to classify the hindrances and take action consequently. The demonstrating of numerous types of imprint and doubt is allowable by fuzzy logic and hence it allows to proficient calculation and to assimilate symbolic cognitive in a usual framework of the scheme. There are dissimilar flow controls in fuzzy logic control scheme and is shown in the fig-1. The first step in this control procedure is the fuzzy controller will study the atmosphere below which it is kept, and this is to be talented by a number of infrared sensors. After this the info will be convey to the fuzzy logic control scheme through the info extraction scheme. Now The major decision has to be taken by the fuzzy logic controller for hindrance avoidance and track charting. This info has to be approved to the bot using sure type of tour. The bot will shadow a specific track rendering to the info given by the fuzzy logic controller.

Now it's the time for hindrance avoidance, the motion of the bot is wholly insight based action, if he noticed any hindrance in its track then he have to track a collision free track which is definite by the fuzzy logic controller. Now this has to be shadowed till the bot reaches to its endpoint. The whole flow chart is shown in fig-1

Rendering to the info learned by the sensors, the sensitive performances are defined by the fuzzy logic controller scheme/fuzzy logic procedure to preserve the speed the rate of the two driving wheels of the planned mobile bot. The planned fuzzy scheme contains of four components: fuzzification, fuzzy rule, fuzzy interface, and defuzzification. The inputs for the fuzzifier are the info gain by the sensors; now this info is also input to the fuzzy set distinct in; the well-defined fuzzy set is describe by dissimilar fuzzy member purpose like near, med, far, lef\_obs, rgh\_obs, front\_obs, head\_anleg and the control parameters slow, med, and fast.

This associate purpose is used for fuzzify the velocity of the bot wheels say `lef_vel` and `rgh_vel` correspondingly, this specific thing is assumed from [4].



**Fig-1: flow chart showing the step involved in fuzzy logic control.**

The bot for which this fuzzy logic control scheme is improved is considered to be a hindmost wheel drive containing of two hindmost wheel namely `rgh` and `lefback` wheel. The bot has got some sequence of infrared sensors for gauging distance of hindrances as well as endpoint around it and classifying the target. The limits with which we are concerned are front hindrance distance (`F_OBS_D`), left hindrance distance (`L_OBS_D`), right hindrance distance (`R_OBS_D`), and finding the heading angle (`H_ANG`). The distance between the hindrance and the bot is consider to be safe up to a definite distance after which it starts differing from the original track this can be considered as a kind of revolting force acting between two bulks and the distance between the

target, and the bot is considered to be that of an attractive force ,which consequences in reaching to the final endpoint.

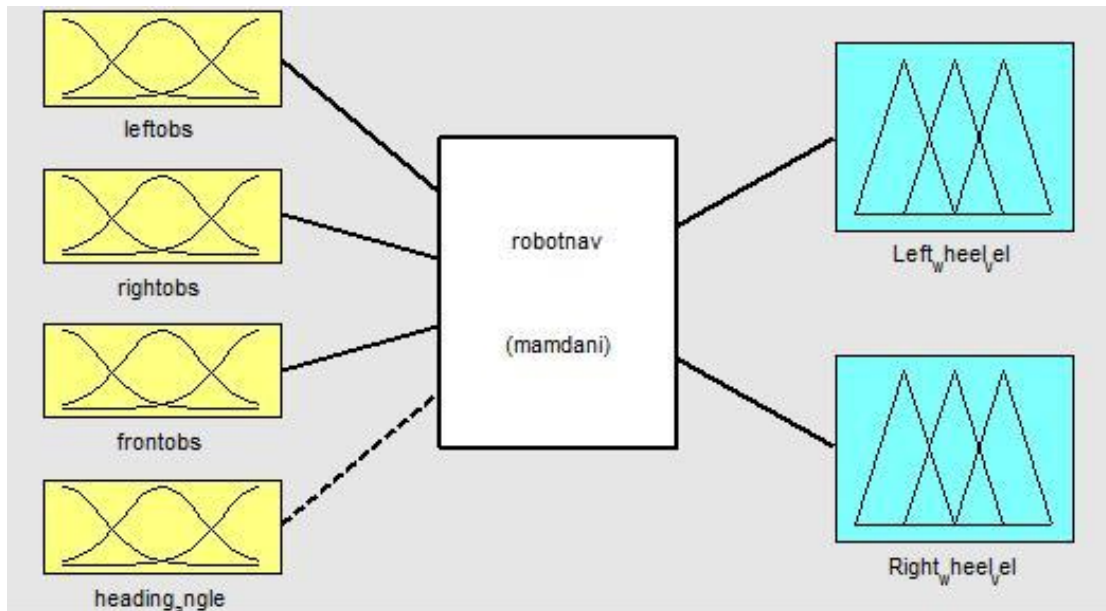
In this specific paper we are incorporating three kinds of member functions. They are Trapezoidal, Triangular and each having few parameters. The whole list is given below.

### **INPUT MEMBER FUNCTION**

<i>Fuzzy set</i>	<i>Member Functions</i>	<i>Parameters</i>
1. Lef_obs	2Trapezoidal	Near, Far
	1Triangular	Med
2. Rgh_obs	2Trapezoidal	Near, Far
	1Triangular	Med
3. Front_obs	2Trapezoidal	Near, Far
	1Triangular	Med
4. H_ang	2Trapezoidal	Positive, Negative
	1Triangular	Straight

### **OUTPUT MEMBER FUNCTION**

5. Lef_vel	2Trapezoidal	Slow, Med
	1Triangular	Fast
6. Rgh_vel	2Trapezoidal	Slow, Med
	1Triangular	Fast



**Fig2-fuzzy logic logic input and output member functions.**

Now going particulars in to fuzzy association functions each member function is describe by dissimilar control parameters e.g, consider one input member function called “lefobs”;here the limits that we are considering are: distance of hindrance from the bot to its lef,rgh,and front.If the hindrance is at a distance limit of 0-0.6m it is allocated as near, 0.6-0.9 it assign as med,0.9-1.0 it allocated as far. The same is relevant to “rghobs”,”frontobs”.Similarly the “heading angle”membership function is defined. Below are the shown member functions and its dissimilar parameters.

Dissimilar input and output fuzzy set is shown along with their member function

Input member functions

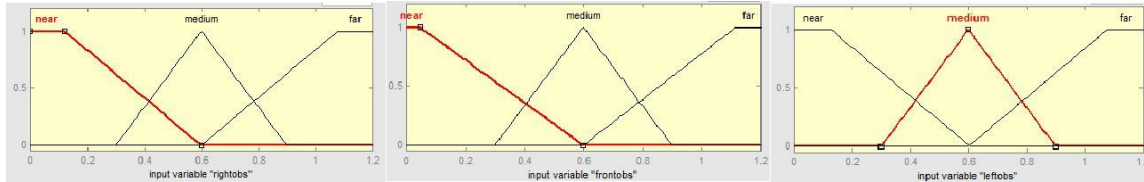
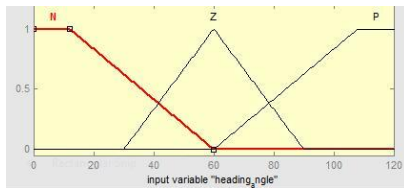


Fig-3: Input member functions

Left hindrance

Right hindrance

Front hindrance



Heading angle

Output member function

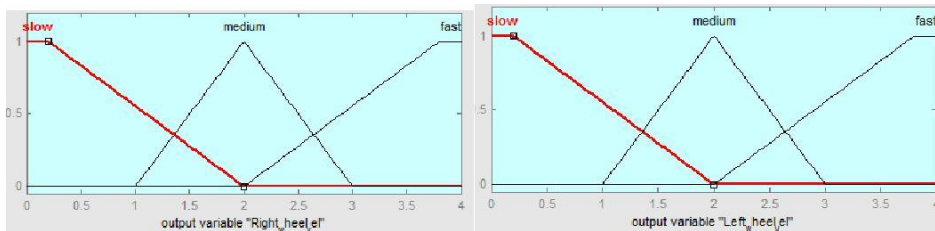


Fig-4: Output member function

Right wheel velocity

Lef wheel velocity

Now we are apprehensive about the steering of bot with hindrances. As the hindrance will come nearer to the bot say to its left, right, and front the speed of the right wheel and left wheel will vary accordingly. This can be shown by the following way

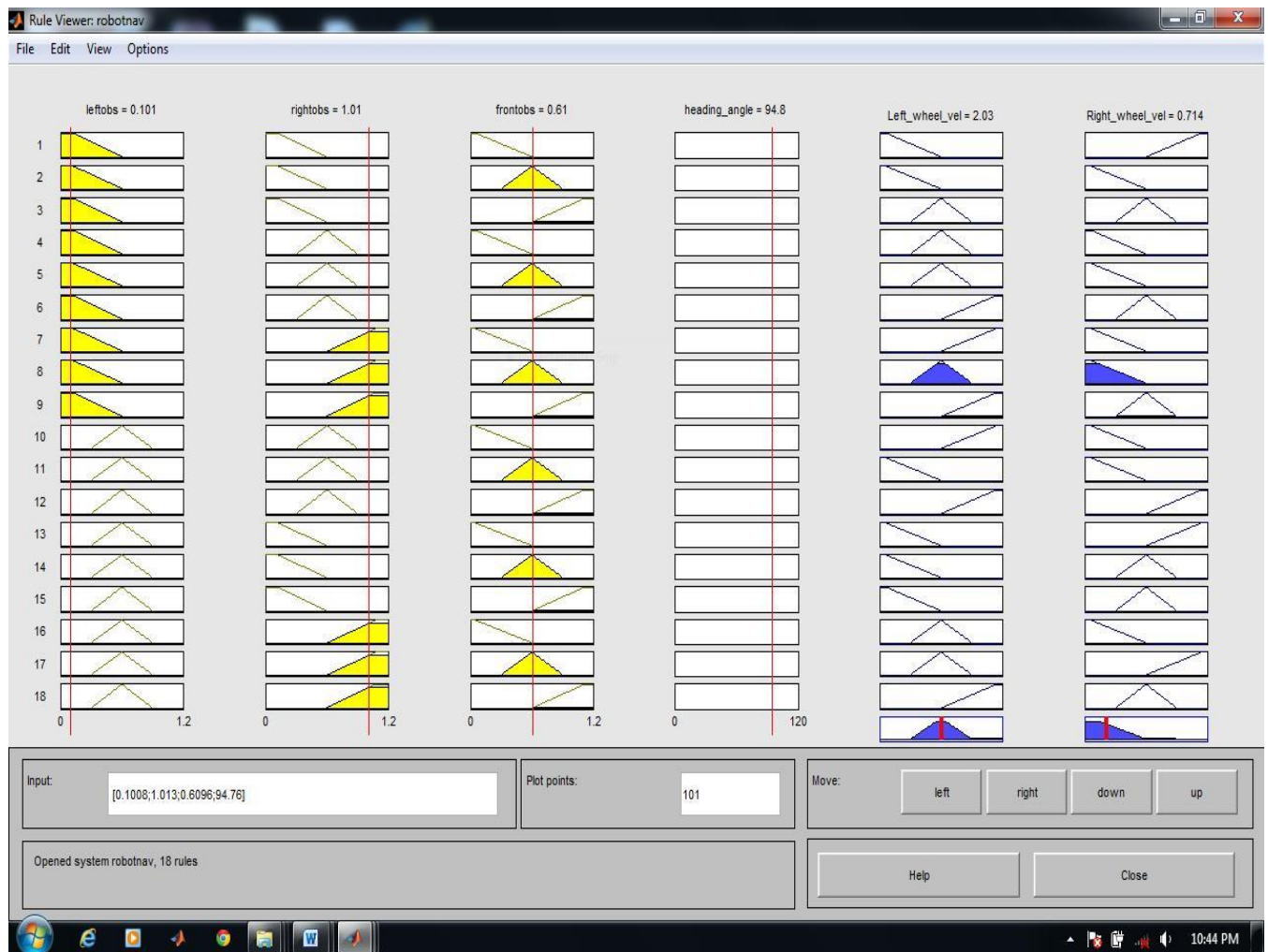


Fig 5: output in fuzzy interface

For this particular rule editor output are given below

Lefhindrance distance = 0.101 unit

Rghhindrance distance= 1.01

Front hindrance distance= 0.61

Heading angle = 94.8

Output

Lef wheel velocity= 2.03

Rgh wheel velocity= 0.714



Another output is given below

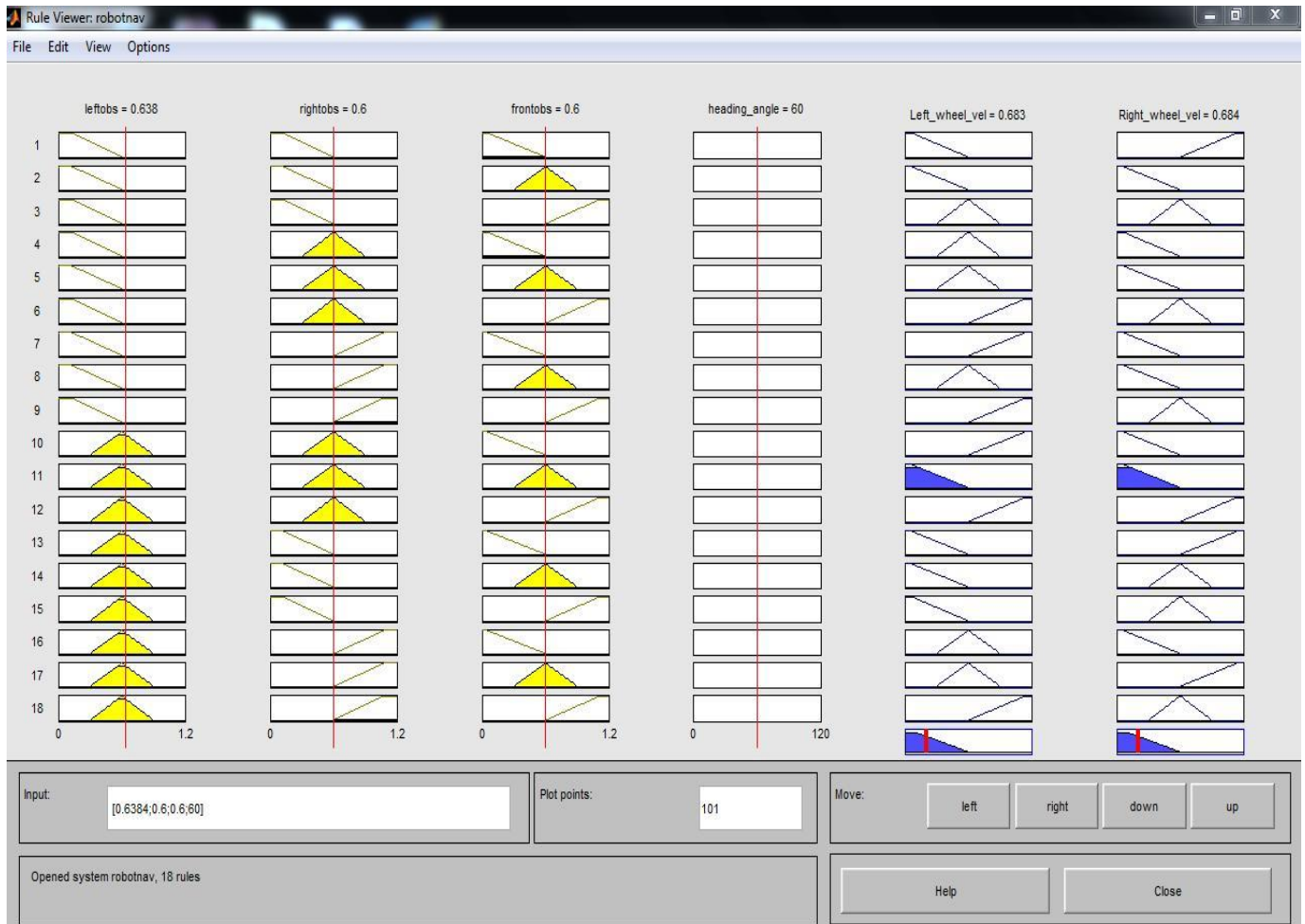


Fig 6-Schematic diagram of fuzzy logic for steering of mobile bots

Output-2

Lefhindrance distance = 0.638 unit

Rghhindrance distance= 0.6

Front hindrance distance= 0.6

Heading angle = 60

Output

Lef wheel velocity= 0.683

Rgh wheel velocity= 0.684

Rules that are used in fuzzy logic control scheme are given below in tabular form.

Table-1.

Rule no	operator	Lef_obs	operator	Rgh_obs	operator	Front_obs	operator	Head_ang	Operator	Lef_vel	Rgh_vel
1	If	Near	And	Near	And	Near	And	Any	Then	Slow	Fast
2	If	Near	And	Near	And	Med	And	Any	Then	Slow	Slow
3	If	Near	And	Near	And	Far	And	Any	Then	Med	Med
4	If	Near	And	Med	And	Near	And	Any	Then	Med	Slow
5	If	Near	And	Med	And	Med	And	Any	Then	Med	Slow
6	If	Near	And	Med	And	Far	And	Any	Then	Fast	Med
7	If	Near	And	Far	And	Near	And	Any	Then	Fast	Slow
8	If	Near	And	Far	And	Med	And	Any	Then	Med	Slow
9	If	Near	And	Far	And	Far	And	Any	Then	Fast	Med
10	If	Med	And	Med	And	Near	And	Any	Then	Fast	Slow
11	If	Med	And	Med	And	Med	And	Any	Then	Slow	Slow
12	If	Med	And	Med	And	far	And	Any	Then	Fast	Fast
13	If	Med	And	Near	And	Near	And	Any	Then	Slow	Fast
14	If	Med	And	Near	And	Med	And	Any	Then	Slow	Med
15	If	Med	And	Near	And	Far	And	Any	Then	Slow	Med
16	If	Med	And	Far	And	Near	And	Any	Then	Med	Slow
17	If	Med	And	Far	And	Med	And	Any	Then	Med	Fast
18	If	Med	And	Far	And	Far	And	Any	Then	Fast	Med
19	If	Far	And	Near	And	Near	And	Any	Then	Slow	Med
20	If	Far	And	Near	And	Med	And	Any	Then	Med	Fast
21	If	Far	And	Near	And	Far	And	Any	Then	Med	Fast
22	If	Far	And	Med	And	Near	And	Any	Then	Slow	Fast
23	If	Far	And	Med	And	Med	And	Any	Then	Slow	Med
24	If	Far	And	Med	And	Far	And	Any	Then	Med	Fast
25	If	Far	And	Far	And	Near	And	Any	Then	Fast	Slow
26	If	Far	And	Far	And	Med	And	Any	Then	Fast	Med

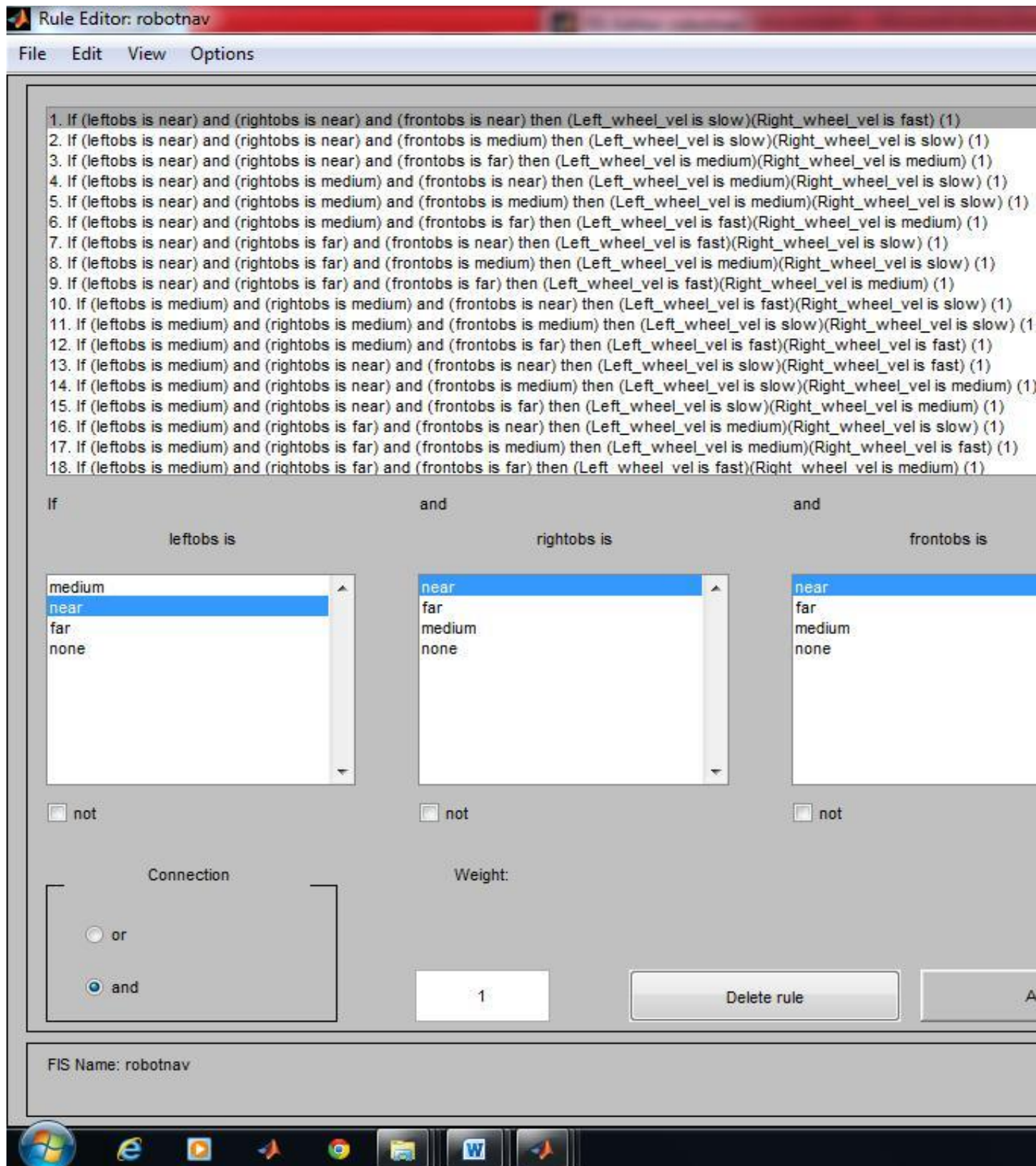


FIG 7- RULES FOR MOBILE BOTSTEERING

## **Hindrance Avoidance**

Hindrance avoidance is one of the most significant feature of mobile bot steering without which it is like good for nothing. When the bot is very much near enough to strike the hindrance, it must alter its track ,speed and heading angle in order to reach the endpoint with an impact free track that is why hindrance avoidance is of so much importance. The fuzzy rules that are combined during the hindrance evasion is given in a tabular form. Specially, when the bot is very much close to the hindrance it must slow down and change its steering angle and this particular code is used for any kind of rounded track or track. All the rules that we have used through the fuzzy logic controller design is given in a tabular form.

Few rules are shown for our better explanation

If (Lef\_obs\_dis is near and Rgh\_obs\_dis is near and Front\_obs\_dis is near and H\_angia any) then (Lef\_whe\_vel is slow and Rgh\_whe\_vel is fast).

If (Lef\_obs\_dis is far and Rgh\_obs\_dis is far and Front\_obs\_dis is near and H\_angia any) then (Lef\_whe\_vel is slow and Rgh\_whe\_vel is fast).

Here an hindrance evasion state is shown.

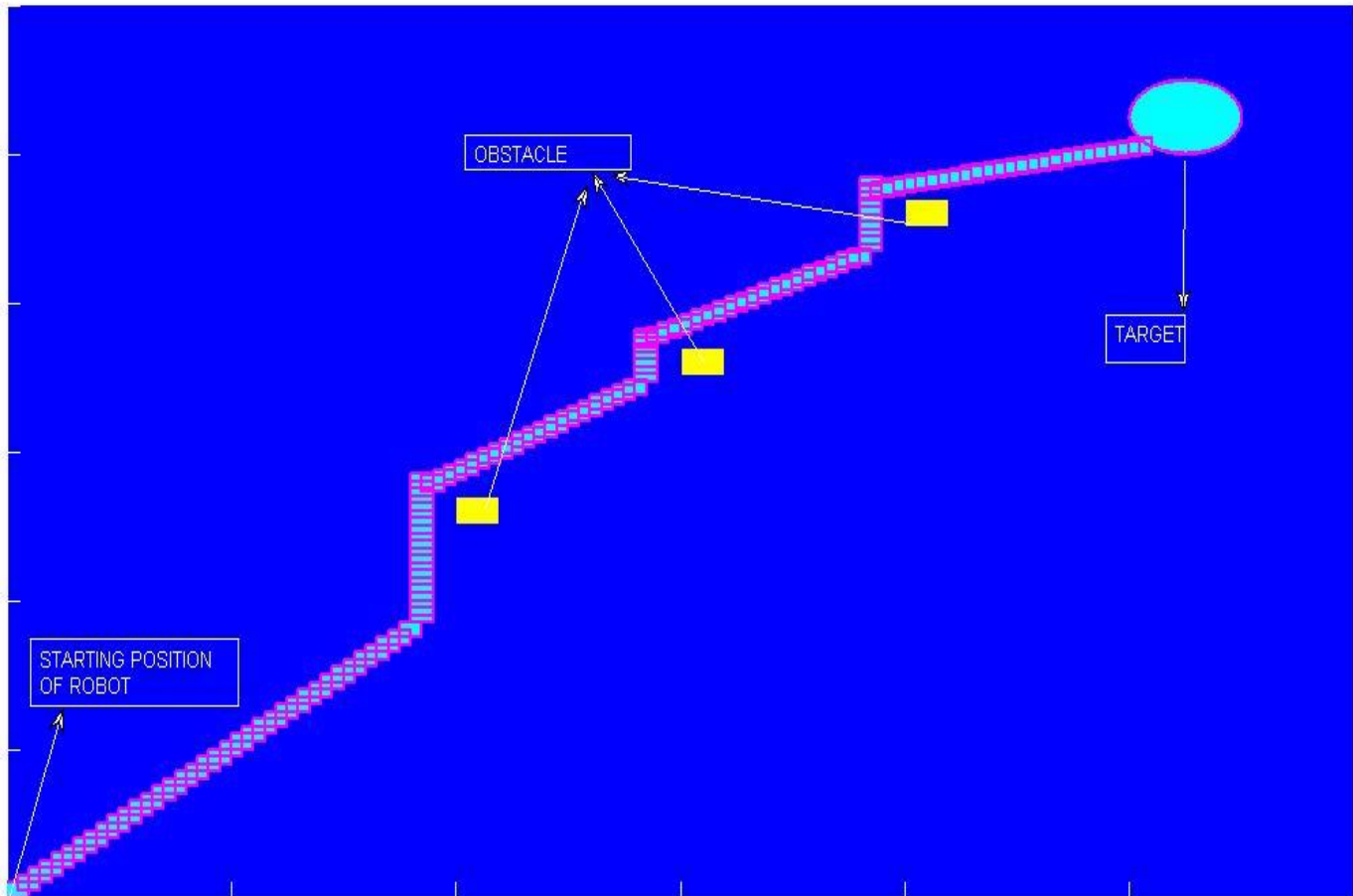


Fig 8- hindrance avoidance

This specific case is for single bot and single endpoint.

Hindrance evasion for double bot and single endpoint.

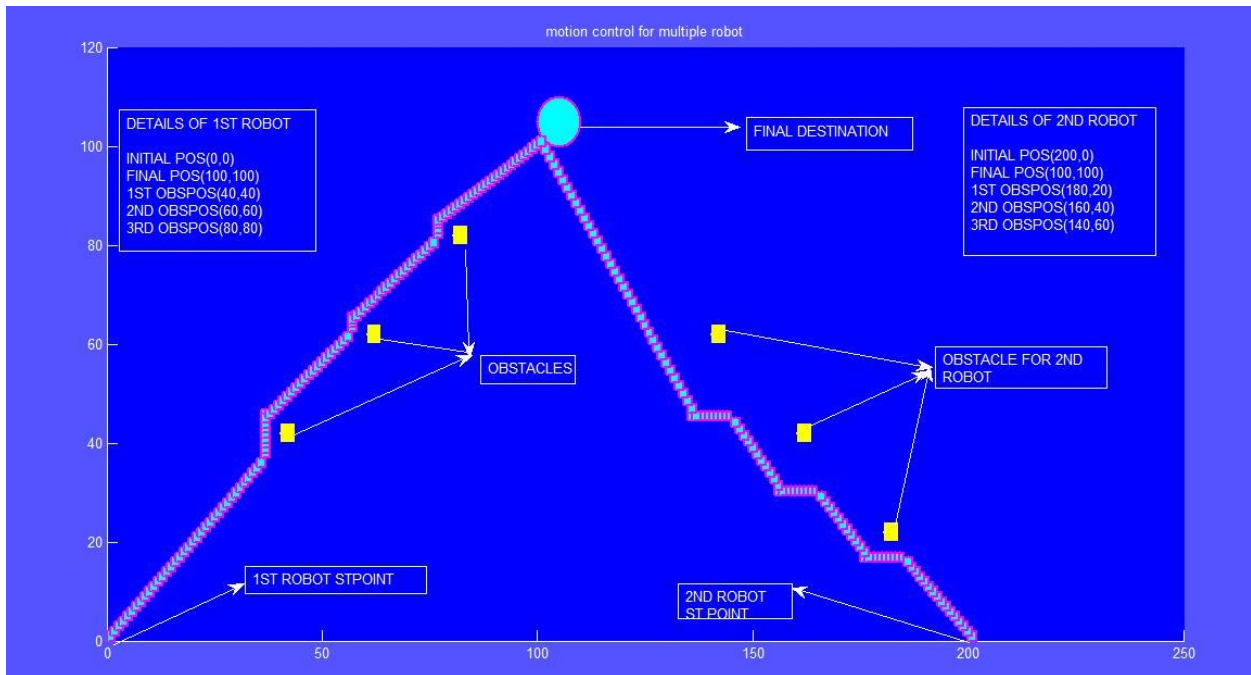


Fig 9- Hindrance avoidance for double bot and single endpoint

Hindrance avoidance for double bot and double endpoint

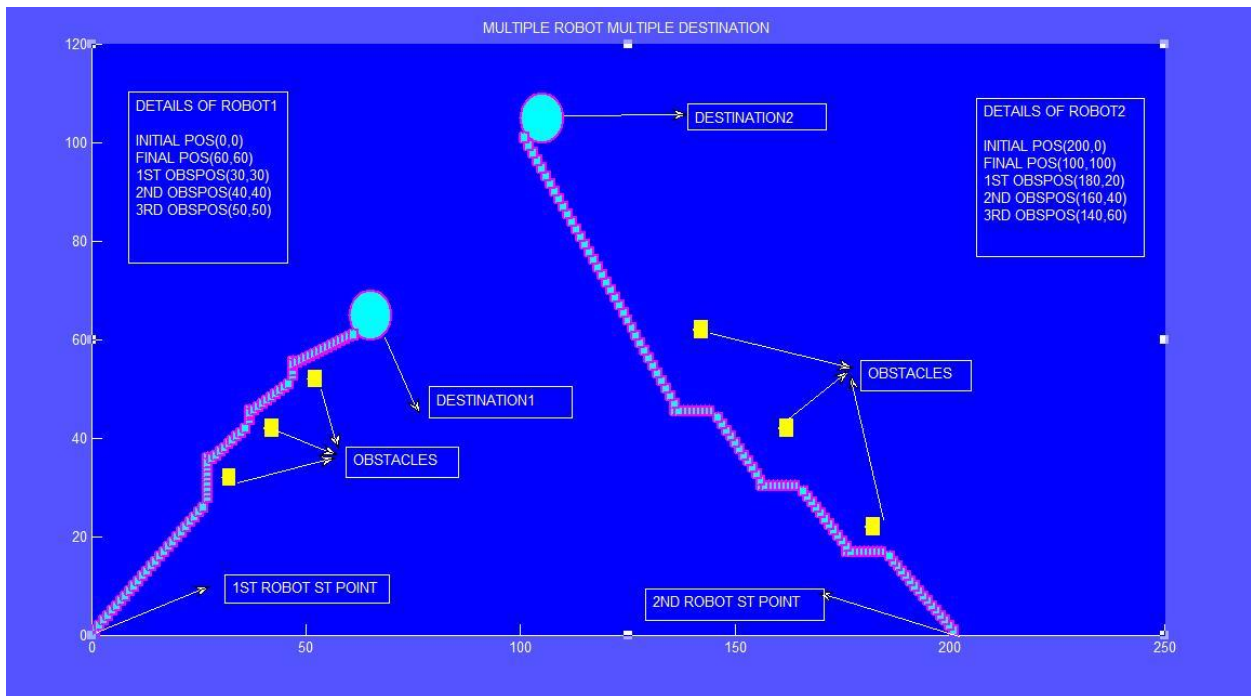


Fig 10- Hindrance avoidance for double bot and double endpoint

## ANALYSIS AND RESULT:

Here we are doing two type of analysis

- 1.velocity analysis
2. hindrance avoidance analysis.

### 1. Velocity analysis:

In this case we are examining whether the lef wheel speed and rgh wheel speed is changing or not according to our desire or it fails somewhere. For this here we are giving a set of data that shows that the speed change of lef wheel and rgh wheel is in agreement with our requirements.

### Result of velocity control

Table-2

Lef hindrance(mt)	Rgh hindrance (mt)	Front hindrance (mt)	Heading Angle (degree)	Lef wheel vel (m/sec)	Rgh wheel vel (m/sec)
0.12	0.84	0.418	Any	2.55	0.826
0.302	0.715	0.418	Any	2.42	0.876
0.456	0.715	0.418	Any	1.92	3.74
0.926	0.715	0.418	Any	2	2
0.13	0.293	0.187	Any	0.74	3.26
0.13	0.466	0.187	Any	1.58	1.64
0.13	0.907	0.187	Any	3.26	0.74

### 2.Hindrance avoidance analysis:

In this case we are placing the hindrance in dissimilar places and checking whether the bot is accomplishing the endpoint without collision or not. Here we are seeing four CRITICAL POSITION through which bot has to pass and reach the endpoint.

Below are the four critical situations.

### CRITICAL POS-1

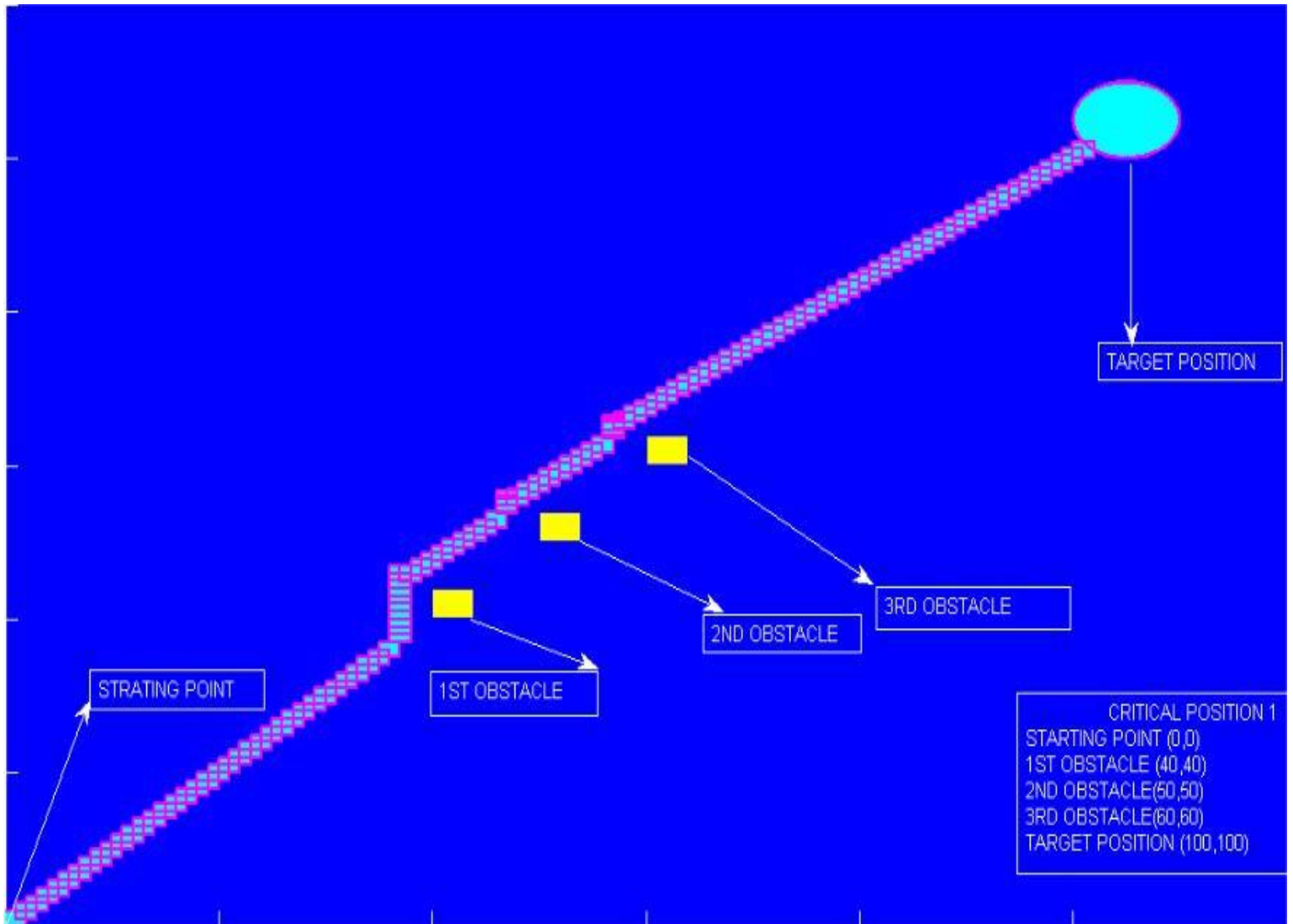


Fig 11- Hindrance avoidance for single bot and single endpoint case1

#### Input data

enter the target coordinate in x-axis =100  
 enter the target co-ordinate in y-axis =100  
 enter the hindrance in x-axis =40  
 enter the hindrance in y-axis =40

enter the hindrance in x-axis =50  
 enter the hindrance in y-axis =50  
 enter the hindrance in x-axis =60  
 enter the hindrance in y-axis =60



## CRITICAL POS-2

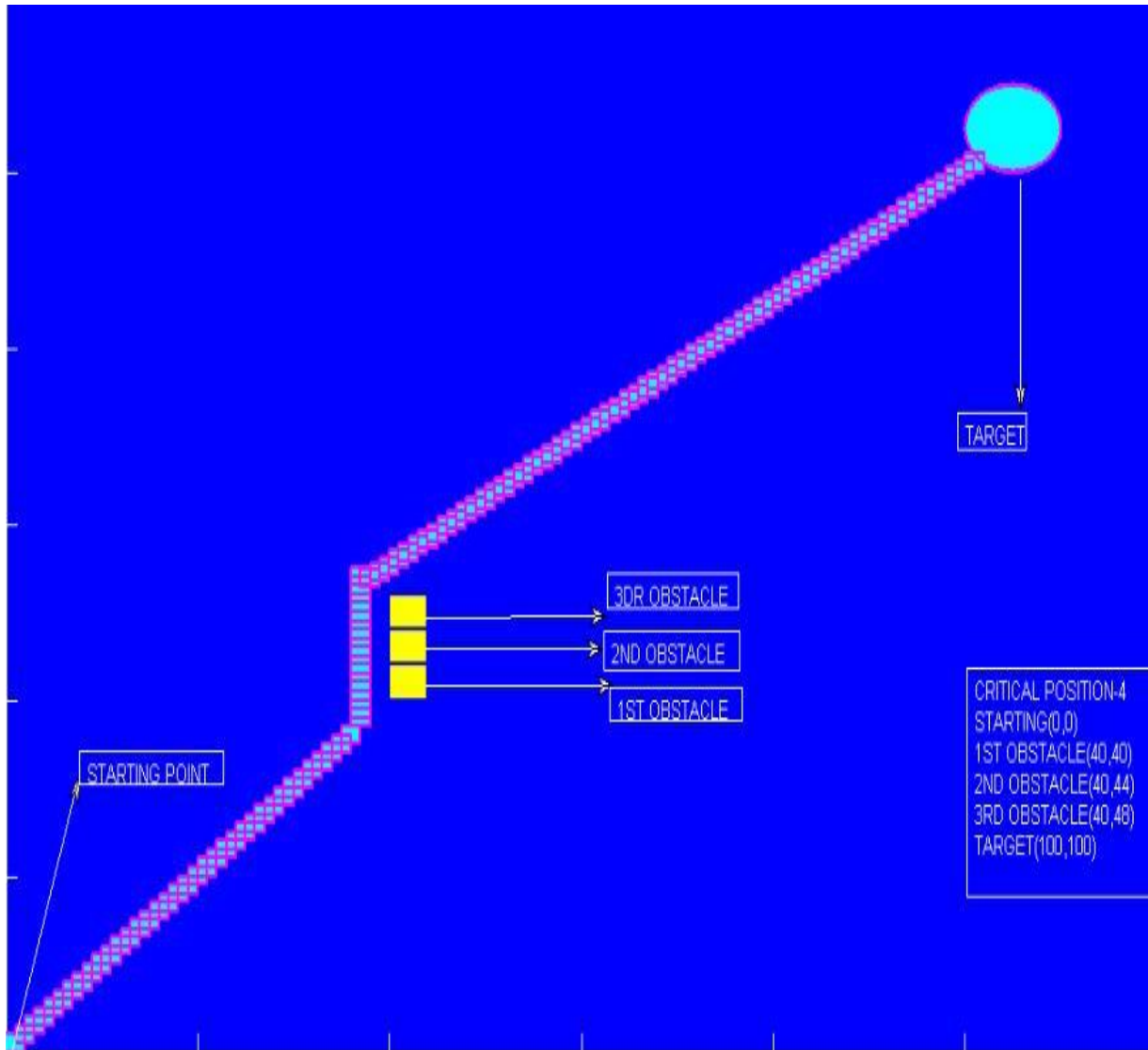


Fig 12- Hindrance avoidance for single bot and single endpoint case2

enter the target coordinate x-axis =100

enter the target co-ordinate in y-axis

=100 enter the hindrance in x-axis =40

enter the hindrance in y-axis

=40 enter the hindrance in x-

axis =40 enter the hindrance in

y-axis =44 enter the hindrance

in x-axis =40 enter the

hindrance in y-axis =48

## CRITICAL POS-3

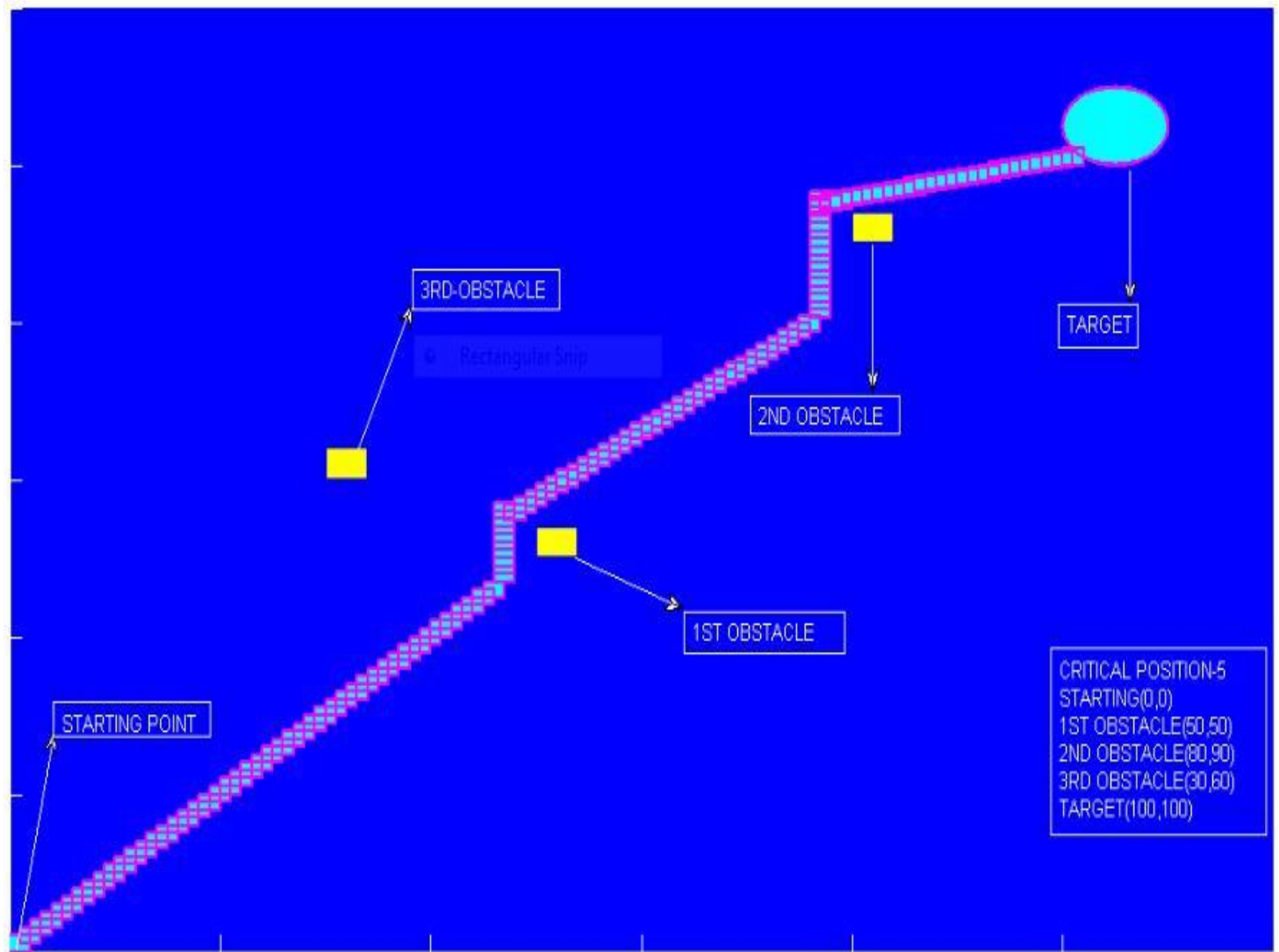


Fig 13- Hindrance avoidance for single bot and single endpoint case3

enter the target co-rdinate in x-axis =100

enter the target co-ordinate in y-axis  
 =100 enter the hindrance in x-axis =50

enter the hindrance in y-axis  
 =50 enter the hindrance in x-  
 axis =80 enter the hindrance in  
 y-axis =90 enter the hindrance  
 in x-axis =30 enter the  
 hindrance in y-axis =60

## CRITICALPOS-4

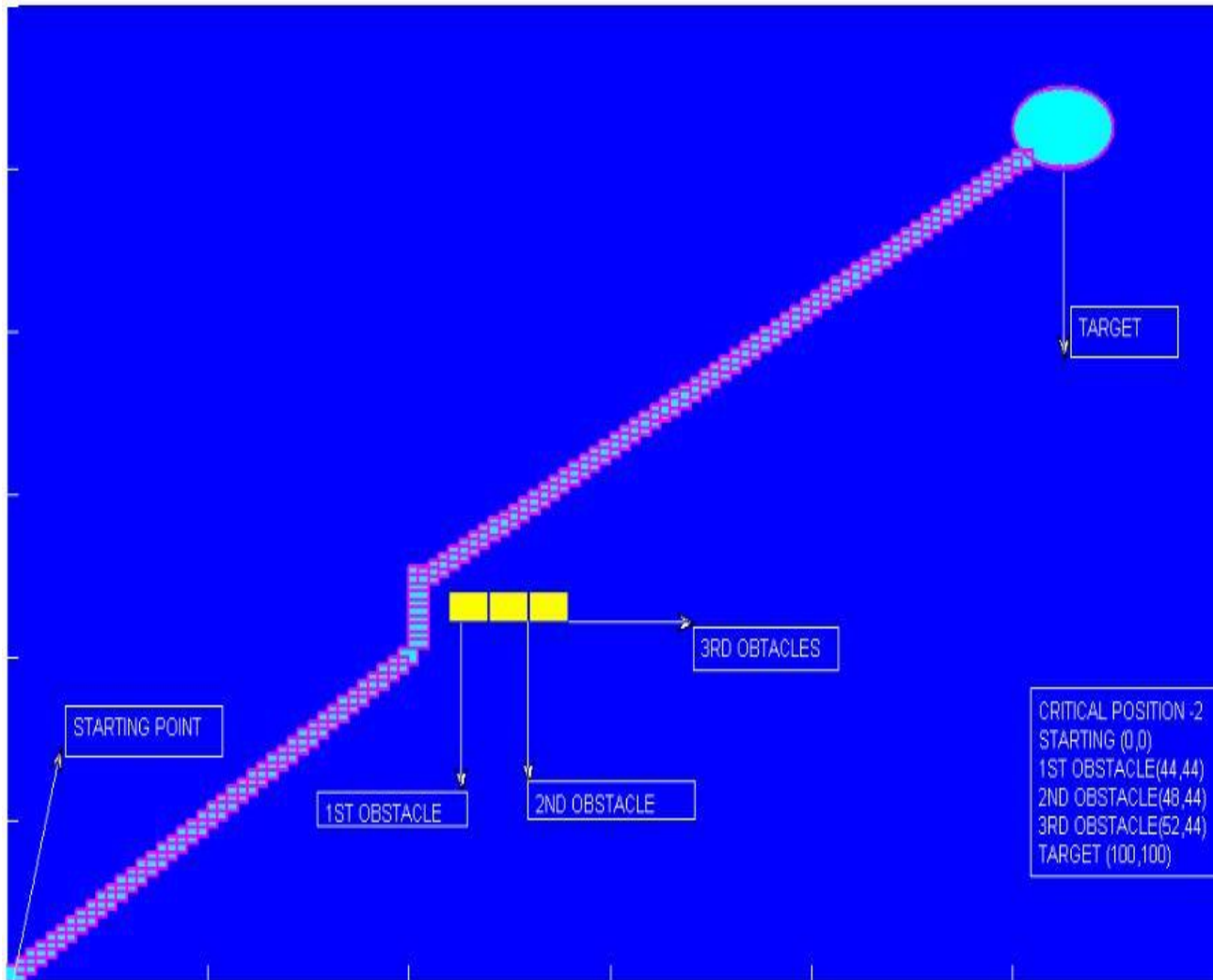


Fig 14- Hindrance avoidance for single bot and single endpoint case4

enter the target coordinate in x-axis =100

enter the target co-ordinate in y-axis

=100 enter the hindrance in x-axis =44

enter the hindrance in y-axis

=44 enter the hindrance in x-

axis =48 enter the hindrance in

y-axis =44 enter the hindrance

in x-axis =52 enter the

hindrance in y-axis =44

Now for double bot single endpoint.

### CRITICAL POS-1

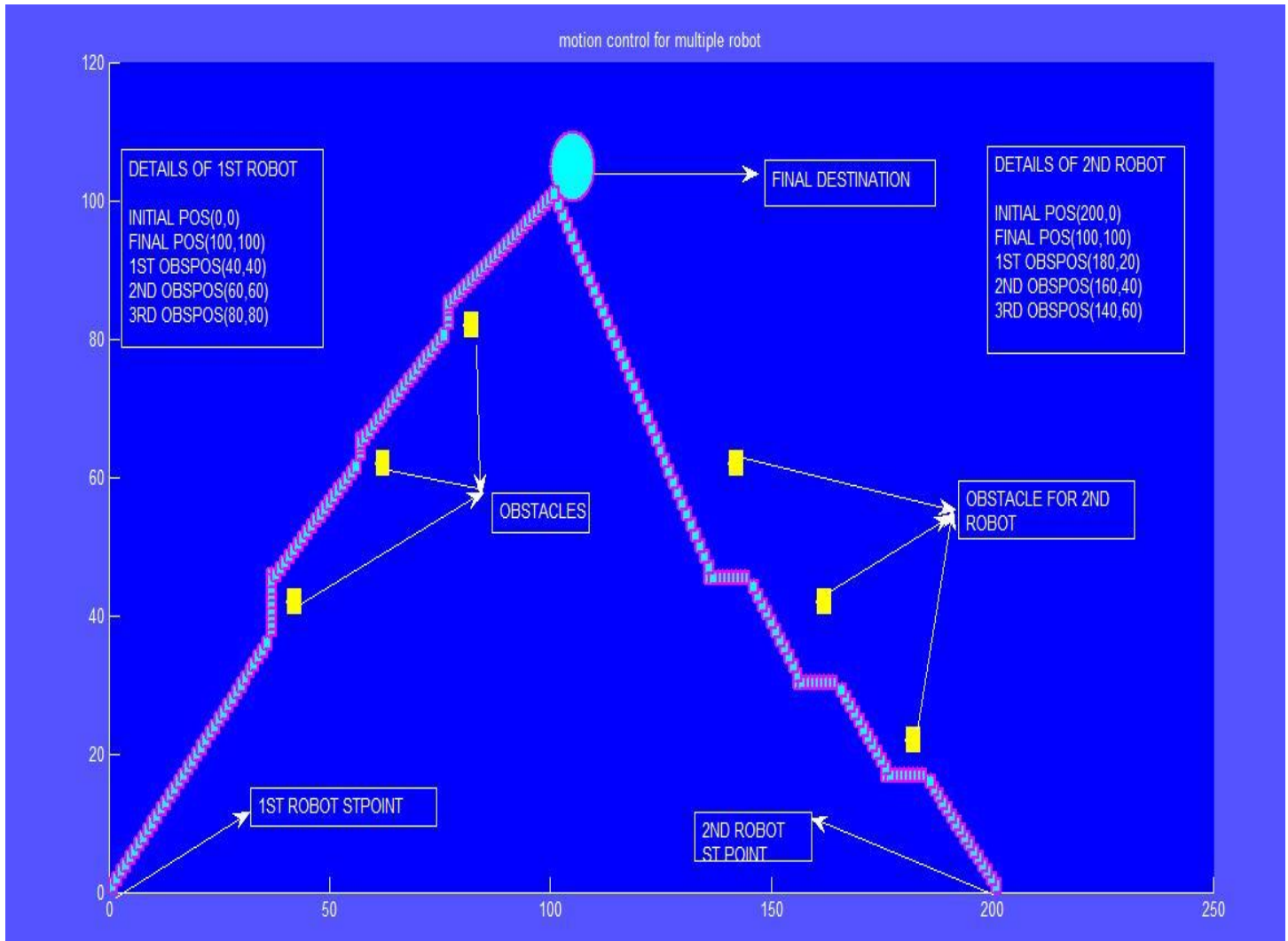


Fig 15- Hindrance avoidance for double bot and single endpoint case1  
hindrance in y-axis =80

enter the target coordinate in x-axis =100

enter the target co-ordinate in y-axis

=100 enter the hindrance in x-axis =40

enter the hindrance in y-axis

=40 enter the hindrance in x-

axis =60 enter the hindrance in

y-axis =60 enter the hindrance

in x-axis =80 enter the

enter the target co-ordinate in x-axis =100

enter the target co-ordinate in y-axis =100

enter the hindrance in x-axis =180

enter the hindrance in y-axis =20

enter the hindrance in x-axis =160

enter the hindrance in y-axis =40

enter the hindrance in x-axis =140

enter the hindrance in y-axis =60

## CRITICAL POS-2

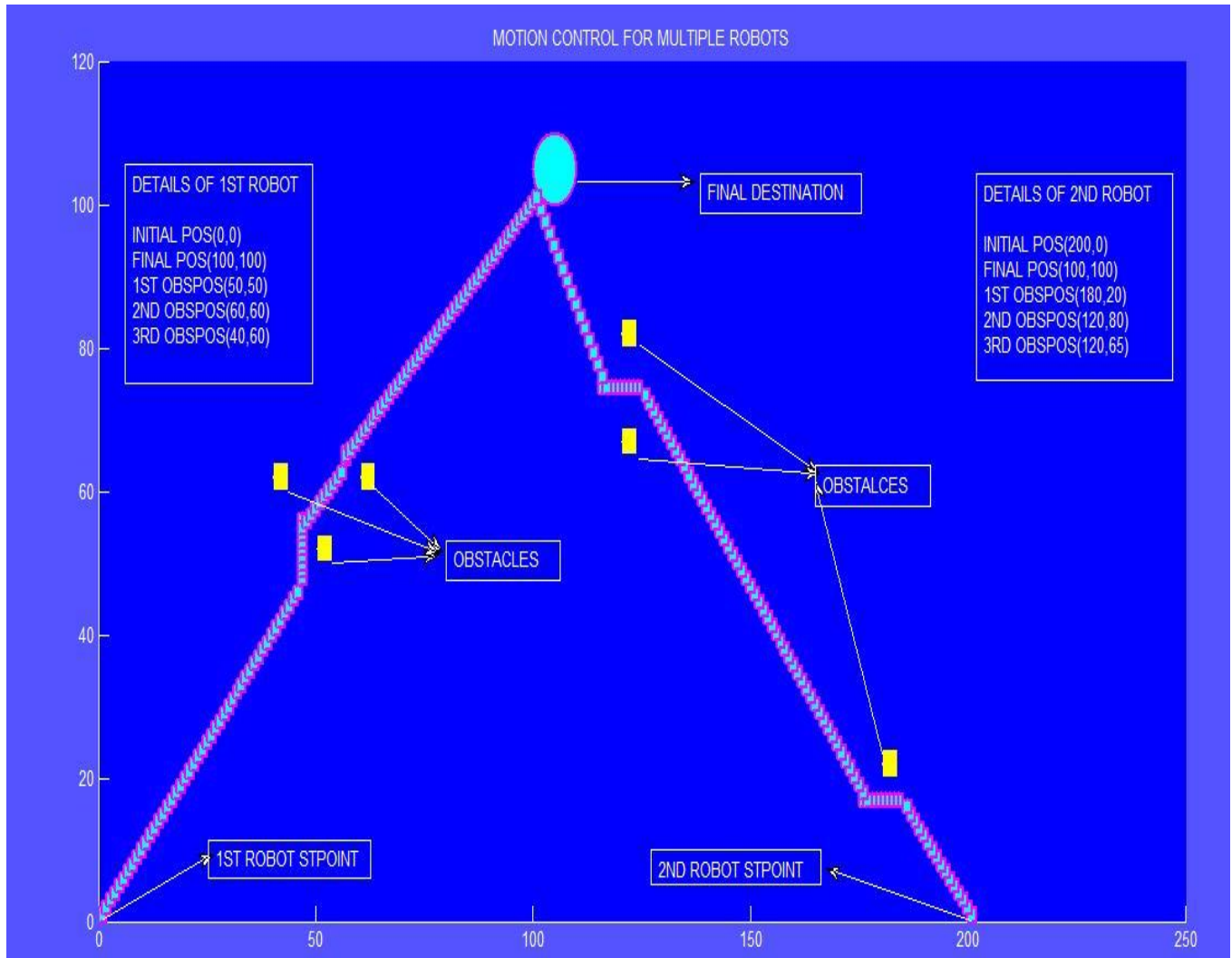


Fig 16- Hindrance avoidance for double bot and single endpoint case2  
 in x-axis =40 enter the  
 hindrance in y-axis =60

enter the target co-ordinate in x-axis  
 =100 enter the target co-ordinate in y-  
 axis =100 enter the hindrance in x-axis  
 =50

enter the hindrance in y-axis  
 =50 enter the hindrance in x-  
 axis =60 enter the hindrance in  
 y-axis =60 enter the hindrance

enter the target co-ordinate in x-axis =100

enter the target co-ordinate in y-axis =100

enter the hindrance in x-axis =180

enter the hindrance in y-axis =20

enter the hindrance in x-axis =120

enter the hindrance in y-axis =80

enter the hindrance in x-axis =120

enter the hindrance in y-axis =65





enter the target co-ordinate in x-axis =100  
enter the target co-ordinate in y-axis =100  
enter the hindrance in x-axis =180  
enter the hindrance in y-axis =20  
enter the hindrance in x-axis =160  
enter the hindrance in y-axis =40  
enter the hindrance in x-axis =140  
enter the hindrance in y-axis =60

## CRITICAL POS-2

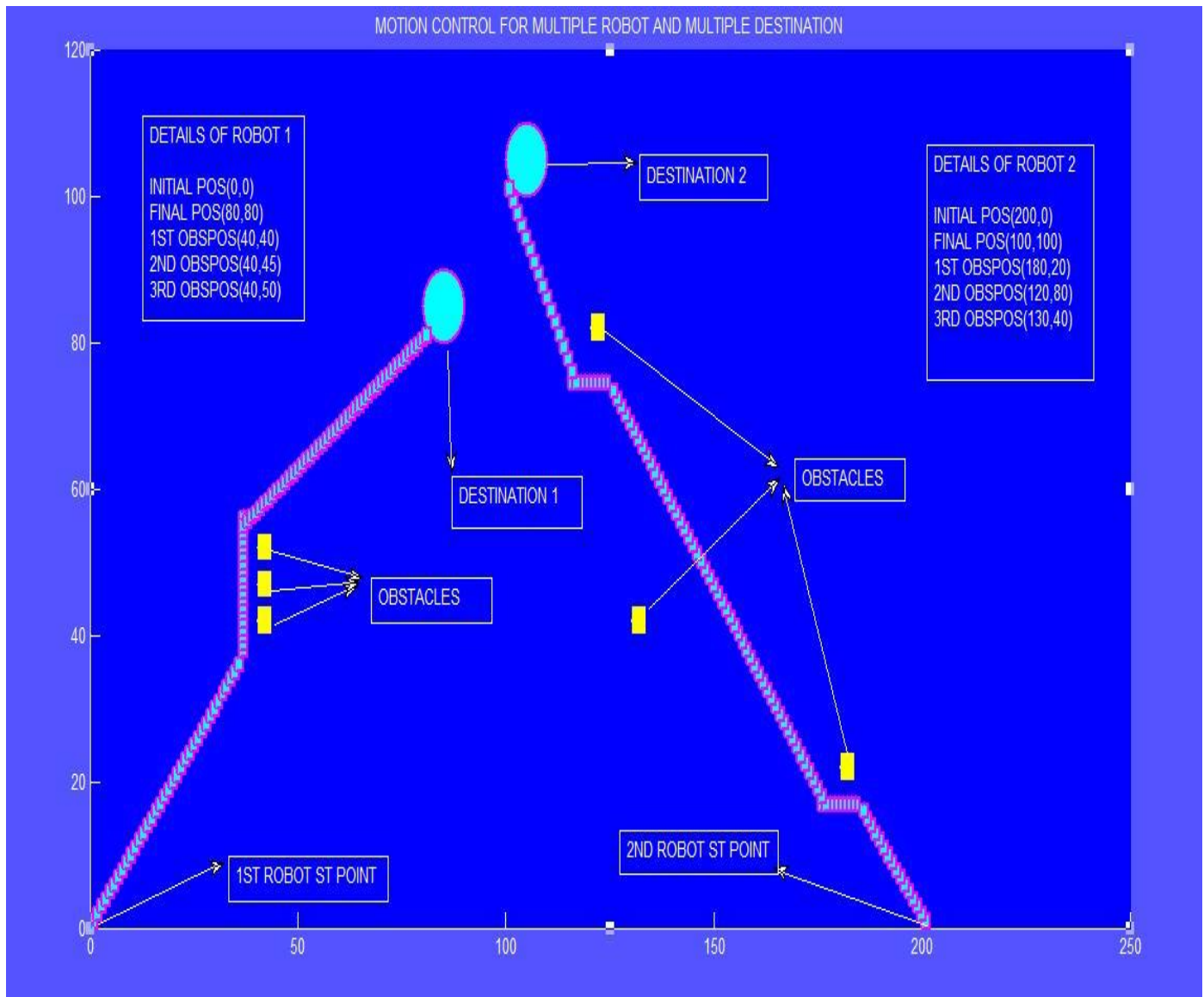


Fig 18 - Hindrance avoidance for double bot and double endpoint case2.

enter the target co-ordinate in x-axis =80  
 enter the target co-ordinate in y-axis =80  
 enter the hindrance in x-axis =40  
 enter the hindrance in y-axis =45  
 enter the hindrance in x-axis =40  
 enter the hindrance in y-axis =40  
 enter the hindrance in x-axis =50  
 enter the hindrance in y-axis =80

enter the target co-ordinate in x-axis =100  
 enter the target co-ordinate in y-axis =100  
 enter the hindrance in x-axis =180  
 enter the hindrance in y-axis =20  
 enter the hindrance in x-axis =120  
 enter the hindrance in y-axis =80  
 enter the hindrance in x-axis =130  
 enter the hindrance in y-axis =40

## **DISCUSSION**

The steering of the mobile is completed with at most care. The steering algorithm which is design for mobile bot steering is found to be most efficient , dependable and real, it is working well for both the planned and unplanned circumstances, so it is of great significant to the botics. Further to show the effectiveness and reliability, simulation results are shown for dissimilar situations.

The hindrance avoidance activated when we encounter an hindrance that is less than the minimum threshold value set for hindrance avoidance. And when it detect any hindrance it change its trajectory, which is shown very vividly in hindrance avoidance section. There was not a single point where the bot becomes failed because of some malfunctioning in the algorithm. All the results are in accordance with our expectations this further proves there is not any single iota of mistake in algorithm part.

## **SCOPE FOR FURTHER WORK**

There are lot of scope for future work in botics, till now we have worked on the algorithm part, we have develop an fuzzy logic control scheme in fuzzy interface and algorithm for steering and hindrance avoidance, which are two major contribution in the paper. But the major part become remain untouched, which is designing a physical model and checking the simulation result of the programmed one with the physical model. And lot of work can be done for steering for multiple bot and multiple endpoint with a collision free track.

## CONCLUSIONS:

From the above experimented reflection, the following conclusions can be drawn.

1. With the help of an efficient fuzzy logic control scheme the bot can easily classify both organized and formless atmosphere and can reach the goal with no struggle this is shown in the result section.
2. A efficient software is develop for many purposes like steering of single bot single endpoint, double bot double endpoint.
3. Dissimilar kind of features like hindrance avoidance, speed control can be attained using fuzzy logic control scheme. These are shown in dissimilar place in the report.
4. The fuzzy control scheme can be accepted in hazardous atmospheres.

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