CONTROLING OF MOBILE AGENTS USING INTELLIGENT STRATEGY

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By

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CERTIFICATE

This is to certify that the project entitled, “Controlling of an Agent using Intelligent Strategy” submitted by Sanmay Satpathy in partial fulfilment of the requirements for the award of Bachelor of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the project has not been submitted to any other University / Institute for the award of any Degree or Diploma.

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ABSTRACT

Robots are developed to carry out certain task to help the human beings. A robot carrying out a particular needed task has promising applications for the betterment of human society. So the control of their motion remains a vital part for a robot.

In this project, I have to develop the simulation of mobile agents (robots) in an arena of obstacles from a start point to a destination point without collision. So in a way this project deals with successful navigation of robots in prior known environment.

This document presents a computer vision method and related algorithms for the navigation of a robot in a static environment. Our environment is a simple white coloured area with coloured obstacles (circle with white colour, rectangles with orange colour, triangle with green colour and hexagon with pink colour which helps in identifying the obstacle) and robot is in a rectangular form. The agents starting point is in blue colour and the destination point is in red colour. This environment is input by the user with the starting point and the destination point. The data acquired from here is then used as an input for the program which controls the robot drive motion in graphic control window. Robot then tries to reach its destination avoiding obstacles in its path. The algorithm presented in this paper uses the distance transform methodology to generate paths for the robot to execute which are written in C++ compiler. These paper developments can also be applied to vehicles for collision free driving.

Chapter 1

INTRODUCTION

1.1 Objective

1.2 Navigation

1.3 Robotics

1.4 Mobile Robots

1.5 Intelligence Strategy

INTRODUCTION

We know that we can make robot working and carry out assign task successfully with a little help in programming.

1.1 OBJECTIVE: The main scientific objective of the project is to add intelligence into robot artificial by using programming software.

1.2 NAVIGATION: The term navigation means the process of planning and directing the route or course of a robot or a vehicle.

1.3 ROBOT: A robot is an electro-mechanical device that can perform autonomous or pre-programmed task. A robot may act as under the direct control of human or autonomously under the control of a programmed computer. Robots may be used to perform tasks that are dangerous or difficult for humans to implement directly (e.g. nuclear waste cleanup), or may be used to automate repetitive tasks that can be performed with more precision by a robot than the employment of a human (e.g. automobile production).

Robots may be controlled directly by a human, such as remotely controlled bomb disposal robots, robotic arms, or shuttles, or may act according to their own decision making ability, provided by Artificial Intelligence. However, the majority of robots fall between these extremes, being controlled by pre-programmed computers. Such robots may include feedback loops such that they can interact with their environment, but do not display actual intelligence.

1.4 MOBILE ROBOTS: Mobile Robotics is an emerging field of robotics that studies the behaviour of robots under dynamic and challenging conditions to achieve its goal.

Mobile Robotics successfully incorporates all the constraints that the robot experiences in its due course of operation and induces behaviour of self-thinking to the robot by harnessing the power of optimisation and intelligent techniques like Artificial intelligence, Fuzzy-Logic, etc.

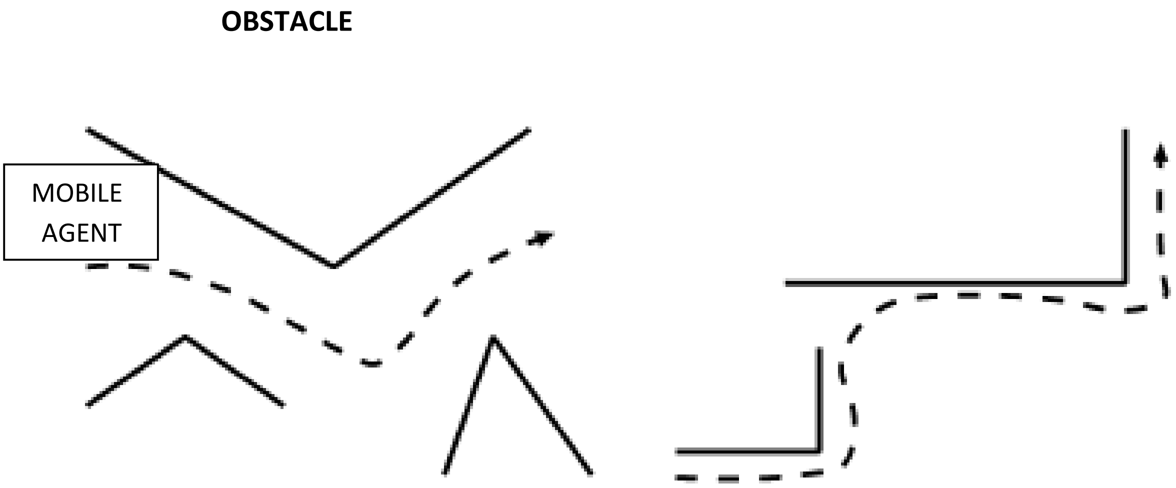
Mobile robots present special challenges. These robots can move their bodies around from place to place. Why is this capability difficult? Many more things can go wrong if your robot is free to move around rather than being bolted to one place. Being mobile multiplies the number of situations your robot needs to be able to handle.

Mobile robots actually come in two varieties: *tethered* and *autonomous.* A tethered robot "cheats" by dumping its power supply and brain overboard, possibly relying on a desktop computer and a wall outlet. Control signals and power are run through a bundle of wires (the tether) to the robot, which is free to move around, at least as far as the tether will allow.

Autonomous mobile robots are even more challenging. These robots need to bring everything along with them, including a power supply and a brain. The power supply is typically an array of batteries, which adds a lot of weight to the robot. The brain is also constrained because it has to fit on the robot, not weigh a ton, and be frugal about sucking power out of the batteries.

1.5 <u>INTELLIGENCE STRATEGY</u>: Intelligence Strategy making is a part of Artificial Intelligence (AI) technology which provides techniques for developing computer programs for carrying out a variety of tasks, simulating the intelligent way of problem solving by humans. The problems that humans solve in their day-to-day life are of a wide variety in different domains. Though the domains are different and also the method, AI technology provides a set of formalisms to represent the problems and also the techniques for solving them. In this intelligent strategy making we have to plan the path for autonomous robot by programming. Different people working in this topic for many years have proposed different definitions. According to Rich, Intelligent strategy is the study of how to make computers do things at which humans are better at. It is observed that it is equally difficult to define human intelligence.

Users can create complex virtual worlds and simulate their robots within these environments. A complete programming library is provided to allow users to program the robots C++ compiler. From the controller programs, it is possible to read input values and show the required simulation in a graphic window.



C++ Compiler

It provides an environment for programming. Due to its functions and syntaxes it more versatile and faster programming language. It is very popularly used for writing the codes for artificial intelligence. For bigger and complicated programs C++programming software provides much more quicker results than other softwares. The space consumption by this software is also quiet less. C++ compiler also provides very good hardware interfacing between computer and machine (in this case robot).

Graphics Window

It is very crucial for the display of the output on the window screen. Graphic is a tool to draw figure and set into then required colours and patterns. In graphic window we can create different obstacles set them colours also. The simulation of the navigation is seen on a graphic window.

Chapter 2

LITERATURE SURVEY

LITERATURE SURVEY

Location estimation is essential for guidance of autonomous vehicles in many indoor navigation applications. A widely adopted approach is the vision-based technique. Most existing vision-based, Wua[1] techniques deal only with frontal scenes acquired by traditional cameras and are easily interfered by unexpected objects around the vehicle. A feasible solution to this problem is to use an omni-directional camera which looks upward at certain target shapes, called landmarks usually, attached on the ceiling. This solution has the unique advantage of providing wide-angle views with fewer objects appearing in the field of view, thus reducing the guidance error coming from landmark occlusion, noise inference, etc. This is important for applications of intelligence robots such as cleaning robots, pet robots, tour guide robots, etc., which must work among humans or objects at close distances.

In order to test the effectiveness of the proposed location estimation method a study has been made which includes two parts (1)using computer simulations to test if the circular shape of the landmark in the acquired images taken with omni-directional cameras with different shapes of hyperboloidal mirrors can be detected by the proposed ellipse approximation method; (2) using real images to determine the precision of the estimated vehicle locations relative to the landmark. For measurement of the estimation precision, we define a distance error ratio and an orientation error as follows:

distance error ratio=(real distance-estimated distance)/(real distance)

orientation error = real orientation-estimated orientation

So this new approach provides a way to location estimation of an autonomous vehicle for navigation guidance in an indoor environment using a circular-shaped landmark on the ceiling by omni-directional vision techniques.

Cooperative behaviours, Parhi [2] using a colony of robots are becoming more and more significant in industrial, commercial and scientific application. Applications in the area of service robotics demand a high degree of system autonomy, which robots without learning capabilities will not be able to meet? Problems such as co-ordination of multiple robots, motion planning and co-ordination of multiple robotic systems are generally approached having a central (hierarchical) controller in mind.

Here by using Rule base technique and petri net modelling to avoid collision among robots one model of collision free path planning has been proposed. The second model incorporates rule based fuzzy-logic technique and both the models are compared. It has been found that the rule-based technique has a set of rules obtained through rule induction and subsequently with manually derived heuristics. This technique employs rules and takes into account the distances of the obstacles around the robots and the bearing of the targets in order to compute the change required in steering angle. With the use of Petri net model the robots are capable of negotiate with each other. It has been seen that, by using rule-based-neuro-fuzzy technique the robots are able to avoid any obstacles (static and moving obstacles), escape from dead ends, and find targets in a highly cluttered environments. Using these techniques as many as 1000 mobile robots can navigate successfully neither colliding with each other nor colliding with obstacles present in the environment. It was observed that the rule-based-neuro-fuzzy technique is the best compared to the rule-based technique for navigation of multiple mobile robots.

A paper by Fainekos et al.[3] provides a tractable solution to the RTL motion planning problem for dynamics models of mobile robots. Temporal logic motion planning problem for mobile robots are modelled by second order dynamics. Temporal logic specifications can capture the usual control specifications such as reach ability and invariance as well as more complex specifications like sequencing and obstacle avoidance. An automatic framework for the solution of the temporal logic motion planning problem for dynamic mobile robots has been presented here. The framework is based on hierarchical control, the notion of approximate bisimulation relations and a new definition of robustness for temporal logic formulas. In the process of building this new framework two intermediate results have been derived. First, an automatic framework for the solution of the temporal logic motion planning problem for kinematic models has been presented. Second, how to construct a more robust solution to the above problem, which can account for bounded errors in the trajectories of the systems has been shown. This paper presents the first computationally tractable approach.

Temporal logics such as Linear Temporal Logic (LTL) (Pnueli, 1977) and its continuous time version propositional temporal logic over the reals (RTL) (Reynolds, 2001) have the expressive power to describe a conditional sequencing of goals under a well-defined formal framework.

Such a formal framework can provide us with the tools for automated controller synthesis and code generation. Beyond the provably correct synthesis of hybrid controllers for path planning from high level specifications, temporal logics have one more potential advantage when compared to other formalisms, e.g., regular languages (Koutsoukos, Antsaklis, Stiver, & Lemmon, 2000). That is to say, temporal logics were designed to bear a resemblance to natural language. Along the same lines, one can develop computational interfaces between natural language and temporal logics (Kress-Gazit, Fainekos, & Pappas, 2007). This fact alone makes temporal logics a suitable medium for our daily discourse with future autonomous agents.

Gurman has described in detail the neural network models RuleNet and its extension. RuleNet is a feed forward network model with a supervised learning algorithm, a dynamic architecture, and discrete outputs. He has achieved results in the simulation and experimental environment. Li et al. have presented neuro-fuzzy system architecture for behaviour-based control of a mobile robot in unknown environments. The simulation experiments show that the proposed neuro-fuzzy system can improve navigation performance in complex and unknown environments. Barfoot and Ibrahim have discussed a newly developed adaptive fuzzy behavioural control system. That has been designed for use with an autonomous mobile robot. They have shown their results on both experimental and industrial applications in which their new control system was applied.

Their results have shown that the robot can avoid simple obstacles only. Experiment results done on a single mobile robot confirms their technique. Jelena has considered a rule-based fuzzy controller and a learning procedure based on the stochastic approximation method. They have considered the radial basis function neural network and have shown that a modified form of this network is identical with the fuzzy controller, which they claim it as a neuro-fuzzy controller. Acosta et al. have used a neuro-fuzzy technique to steer a mobile robot. The results of the approach are satisfactory (i.e., avoiding the obstacles when the mobile robot is steered to the target).Marichal et al. have presented a neuro-fuzzy approach in order to guide a mobile robot. They have shown that such a neuro-fuzzy system is successful in the control of a single mobile robot only.

Althoefer et al. have reported a navigation system for robotic manipulators. The navigation method is a combination of fuzzy logic and neural networks. They successfully applied this technique to robot arms in different environments. Nefti et al. have applied neuro-fuzzy inference system for mobile robot navigation in partially unknown environment. The experimental results confirm the meaningfulness of the elaborated methodology when dealing with navigation of a mobile robot in partially unknown environment. Tunstel et al. have discussed operational safety and health monitoring of critical matters for autonomous field mobile robots. de Souza and Ferreira have proposed a reusable architecture for rule-based systems described through design patterns. The aim of these patterns is to constitute a design catalogue that can be used by designers to understand and create new rule-based systems. A hybrid control architecture combining behaviour-based reactive navigation and model based environment classification has been developed by Na and Oh. The effectiveness of the proposed architecture has been verified through both computer simulation and an actual robot called MORIS (mobile robot as an intelligent system). Dietrich et al. have discussed a general architecture for rule-based agents and described the method to realise the navigation control with the help of semantic web languages. McIntosh et al. have described a simple ‘proof of concept’ rule- based system. They have developed to contribute methodologically to management-oriented modelling of vegetated landscapes. They have not specifically used rule-based technique for navigation of mobile robot. Pradhan et al. have discussed about the fuzzy control technique for navigation of robots.

Fraichard and Garnier, Abdessemed et al. used manually designed fuzzy logic controller (FLC) for planning collision-free motion of a car-like robot. As the performance of an FLC depends on the selection of membership function distributions (known as database) and its rule base (RB), some investigators tried to optimize both the RB as well as database, either separately or simultaneously. In this connection, the work of Song and Sheen, Li et al. are worth mentioning. However, the effectiveness of their optimized FL-based systems was studied in a static environment. In most of the fuzzy control systems, fuzzy if–then rules were designed by human experts, who may sometimes find it difficult to express their actions or may decide on a subconscious level. Thus, some attempts were made by Marichal et al., Pratihar and Bibel and others to develop the RB of the FLC automatically, using an NN and/or a GA. Hui and Pratihar also developed a method for automatic design of FLC, inwhich the whole task of designing it, was given to a GA. The GA evolves a suitable knowledge base (KB) of that FLC through the interactions between the robot and the environment.

The main advantage of this method lies in the fact that the designer may not need to have a complete knowledge of the problem to be solved. Moreover, the entire optimization process is normally carried out off-line and once trained, the FLC might be suitable for on-line implementations.

NNs had also been used by some investigators for solving the said problem. In this connection, work of Yang and Meng, Floreano and Mondada , Pal and Kar , Gu and Hu are important to mention. However, the performance of an NN depends on its architecture and connecting synaptic weights, the optimal selection of which is a tedious job. A variety of tools, namely supervised and reinforcement learning algorithms, back propagation algorithm, simulated annealing (SA), genetic programming (GP), GA were utilized by some researchers for the said purpose.

Zielin[4] et al taking into account the utilised principle of communication two extreme classes of multi-robot (multi-agent) systems exist. The first category uses explicit communication, where the robots communicate directly between themselves (e.g., using wireless or network technology). The second category uses implicit communication, where each robot observes the actions of the others or the results of their activity in the environment (i.e., stigmergy). In the former case the problem at hand is subdivided into tasks. In the latter case, rather than decomposing the problem into tasks, investigations focus on the definition of elementary behaviours of individuals. The approach to the design of those categories of systems differs considerably. The first relies on task decomposition (this results in a top down approach) while the second relies on the definition of elementary behaviours and lets them interact freely (this produces a bottom up approach) – in this case the resultant behaviour of the system emerges as a consequence of those interactions. Between those extremes spreads the realm of hybrid systems utilising both implicit and explicit communication mechanisms.

Explicit communication usually requires problem decomposition into tasks and subsequently allocation of those tasks to robots. The task allocation problem depends on the requirements of the tasks and the capabilities of robots. Hence the tasks and robots are subdivided into categories. Tasks can either be executed by single robots, thus SR tasks, or need many robots, thus multiple-robot (MR) tasks. The robots can either execute a single task at a time (i.e., ST robots) or several tasks simultaneously (i.e., MT – multiple task robots). Moreover, all tasks to be executed can be known in advance – this produces an instantaneous assignment (IA) problem, or the tasks can appear randomly as the time passes – this results in time-extended assignment (TA). In the former case no planning for the future is necessary, while in the latter case future requirements have to be taken into account. If there are more tasks than robots or vice versa optimal allocation of tasks requires some criterion of judging the result. Usually utility is defined as a difference between quality of the obtained result and the cost of producing it. In the simplest case utility depends only on the robot and the task it has to execute. However, utility might also depend on the sequence of task execution, number of robots executing the task, other tasks that the robot has already executed, the tasks that the other robots have executed etc.

Implicit communication is used to solve a wide variety of problems, e.g., path planning, object sorting, building structures, self-assembly, cooperative transport, surveillance, prey hunting. Many of such systems are biologically inspired – frequently they rely on mimicking insect social behaviour. Social insects (i.e., insects living in colonies, e.g., ants, bees, wasps, termites) draw our attention, because each insect exhibits simple behaviour, yet the colony as a whole produces useful and complex output. Thus limited perceptual and cognitive capabilities, through mutual interactions, both between the individuals and between an individual and the environment, result in attaining a complex goal. This is termed as emergent behaviour. The attractiveness of emergent behaviour, where individual elementary behaviours are simple and the communication is limited to individual's perception, is even more underscored by the fact that explicit communication faces a scaling problem which is absent in the implicit case. In the explicit case with the increase of the number of robots the organisation of communication between them becomes ever more difficult. On the other hand, although implicit communication systems tend to be robust (immune to the failure of some individuals or changes in the environment), the emergent result is difficult to predict, hence program. The difficulty arises from the fact that the result is not only based on each individual's behaviour, but also on the interactions between them and the environment, which are hard to foresee.

In some cases, as the individuals do not have the knowledge about the global goal, this can lead to stagnation (deadlock). However, the advantages of those systems prevail over their disadvantages, if only the above disclosed drawbacks are dealt with appropriately. Although in reality it will be probably necessary to design hybrid systems, it is important to find out to what extent they can rely on autonomous behaviour of individual agents. The greater the extent of autonomy of an agent the more robust will the system as a whole be. Especially the immunity to failure of individuals will be greatly enhanced.

Thus this paper mainly focuses on the method of defining and implementing behaviours of individual agents neglecting to a large extent the benefits of explicit communication. However, the presented method of defining autonomous activity of agents is elaborated in such a way that behaviours can also utilise information communicated to them directly by the other agents.

Bio-inspired[5] vision system is a particularly good candidate for navigation of mobile robots and vehicles because of its computational advantages, e.g., low power dissipation and compact hardware. Previously, we had designed a mixed analog digital integrated vision system for collision detection inspired by a locust neuronal circuit model. The response of the system was, however, susceptible to the luminance of approaching objects and the vibratory self-motion of a car when it was installed on a miniature mobile car. In the present study, we developed a new collision detection algorithm to overcome these problems based on robust image-motion detection and applied the algorithm to control a miniature mobile car.

Visually guided real-time collision avoidance requires expensive computation of the conventional machine vision systems comprising charge-coupled device (CCD) cameras and digital processing systems operating with serial algorithms. In this regard, the bio-inspired vision systems are suitable for navigation of autonomous robots because of their highly efficient computation of visual information.
Bio-inspired algorithms for collision avoidance, mimicking the response of the lobula giant movement detector (LGMD) of locusts, have been implemented on a personal computer as well as a digital very large-scale integrated (VLSI) vision chip based on a neural circuit model proposed by Rind and Bramwell.

In this case designed a model with parallel computational architecture inspired by the LGMD neuron and implemented it with a compact hardware system comprising a resistive network and field-programmable gate array (FPGA) circuits so as to take advantage of the real-time analog computation and programmable digital processing. This system computes image expansion in real time using an analog resistive network in order to detect approaching objects. This mixed analog digital model is designed to minimize proliferated wirings between neural layers, which communicate with the duplicated connection pattern in the original model, and therefore, can achieve real-time computation with a high computational efficiency. The system responded to virtual approaching objects, which were created on a computer and presented on a liquid crystal display (LCD) monitor, only at close range. The response of the system was, however, susceptible to the luminance of approaching objects and the vibratory self-motion of a car when it was installed on a miniature mobile car in real-world situations.

In this work, we are particularly interested in the action selection and coordination for joint multi-robot tasks, motivated by a prototype environment of robot soccer[6]. We have successfully applied Case-Based Reasoning (CBR) techniques to model the action selection of a team of robots within the robot soccer domain. However, our previous approach did not address the dynamic intentional aspect of the environment, in particular, in robot soccer, the presence of adversaries. Many efforts aim at modelling the opponents in particular when the perception is centralized. Instead, we address here a robot soccer framework in which the robots are fully distributed, without global perception nor global control, and can communicate.

We follow a CBR approach where cases are recorded and model the state of the world at a given time and prescribe a successful action A case can be seen as a recipe that describes the state of the environment (problem description) and the actions to perform in that state (solution description). Given a new situation, the most similar past case is retrieved and its solution is reused after some adaptation process to match the current situation. We model the case solution as a set of sequences of actions, which indicate what actions each robot, should perform. Our case-based approach is novel in the sense that our cases represent a multi-robot situation where the robots are distributed in terms of perception, reasoning, and action, and can communicate. Our case-based retrieval and reuse phases are therefore based on messages exchanged among the robots about their internal states, in terms of beliefs and intentions.

Our case representation ensures that the solution description in the cases indicates the actions the robots should perform; that the retrieval process allocates robots to actions; and finally, with the coordination mechanism, that the robots share their individual intentions to act. Our approach allows for the representation of challenging rich multi-robot actions, such as passes in our robot soccer domain, which require well synchronized positioning and actions.

The results obtained both in simulation and with the real robots, confirm that the Case-Based Reasoning approach is better than the reactive approach, not only on placing a higher percentage of balls close to the opponent's goal, but also achieving a lower percentage of out balls. More precisely, the results obtained in the third scenario with the real robots confirms the simulation results. In the fourth scenario, once again the average of balls out is higher for the reactive approach, which confirms that the defence had more chances to steal the ball.

Hui[7] et al. had made a comparative study of various robot motion planning schemes has been made in the present study. Two soft computing (SC)-based approaches, namely genetic-fuzzy and genetic-neural systems and a conventional potential field method (PFM) have been developed for this purpose. Training to the SC-based approaches is given off-line and the performance of the optimal motion planner has been tested on a real robot. Results of the SC-based motion planners have been compared between themselves and with those of the conventional PFM. Both the SC-based approaches are found to perform better than the PFM in terms of travelling time taken by the robot. Moreover, the performance of fuzzy logic based motion planner is seen to be comparable with that of neural network-based motion planner.

Comparisons among all these three motion planning schemes have been made in terms of robustness, adaptability, goal reaching capability and repeatability. Both the SC-based approaches are found to be more adaptive and robust compared to the PFM. It may be due to the fact that there is no in-built learning module in the PFM and consequently, it is unable to plan the velocity of the robot properly. Building an autonomous and intelligent robot that requires minimal or no human interactions, has become a thrust area in robotic research. It should have a real-time sensing assembly, an intelligent decision maker and precise actuators. The present paper deals with design and development of adaptive motion planner of a car-like robot navigating among some moving obstacles. Both algorithmic as well as soft computing (SC)-based approaches of robot motion planning were developed by various investigators [8]. Latombe [9] provides an extensive survey on various algorithmic methods of robot motion planning. A large number of algorithmic approaches, such as tangent graph [10], path velocity decomposition method [11], accessibility graph [12], space–time concept [13], incremental planning [14], relative velocity approach [15], potential field method (PFM) [2], reactive control scheme [16], curvature-velocity method [17], dynamic window approach [18], randomized kinodynamic planning [19] are available in the literature. However, these algorithmic approaches suffer from the following drawbacks: (i) not all the approaches are computationally tractable and thus, they may not be suitable for on-line implementations, (ii) one method may be suitable for solving a particular type of problem and no versatile technique is available, (iii) most of the approaches do not have any in-built optimization module and as a result of which, the generated path may not be optimal in any sense. Out of all the algorithmic approaches, PFM is found to be the most popular one, due to its elegant mathematical analysis and simplicity. However, it has the following disadvantages [20]: (i) it may not be able to yield local minima-free path, when the robot navigates among concave obstacles, (ii) it may not find any feasible path for the robot, when it moves among closely spaced obstacles, (iii) a dead-lock situation may occur, when the attractive potential balances the repulsive potential. Several modified versions of the PFM are also available in the literature. Interested readers may refer to for the same. However, none of these methods could plan the motion of the robot in an optimal way, as there is no in-built optimization module in it.

Ahuactzin et al.[21] has formulated a genetic algorithm for motion planning of robots which shows that the path planning problem can be expressed as an optimization problem and thus solved with a genetic algorithm. We illustrate this approach by building a path planner for a planar arm with two degree of freedom, and then we demonstrate the validity of the method by planning paths for a holonomic mobile robot.

The ability to acquire a representation of the spatial environment and the ability to localize within it are essential for successful navigation in a-priori unknown environments[22] .This paper briefly reviews the relevant neurobiological and cognitive data and their relation to computational models of spatial learning and localization used in mobile robots. The resulting model allows a robot to learn a place-based, metric representation of space in a-priori unknown environments and to localize itself in a stochastically optimal manner.

Autonomous Cross-Country Navigation[23] requires planning algorithms which supports rapid traversal of challenging terrain while maintaining vehicle safety. The planning system uses a recursive trajectory generation algorithm, which generates spatial trajectories and then heuristically modifies them to achieve safe paths around obstacles. Velocities along the spatial trajectory are then set to ensure a dynamically stable traversal.

In this paper we describe a robot path planning algorithm that constructs a global skeleton of free-space[24] by incremental local methods. The curves of the skeleton are the loci of maxima of an artificial potential field that is directly proportional to [the] distance of the robot from the obstacles. Our method has the advantage of fast convergence of local methods in uncluttered environments, but it also has a deterministic and efficient method of escaping local external points of the potential function.

In a paper, Cherif [25] we address the problem of motion planning for a mobile robot moving on a hilly three dimensional terrain, and subject to dynamic and physical interaction constraints. A mixed planning method based upon a two-level approach combining a discrete search strategy operating on a subset of the configuration space of the robot, and a continuous motion generation technique considering the kinematic and dynamic constraints of the task.

Najera[26] et al. presents an approach to plan motion strategies for robotics tasks constrained by uncertainty in position, orientation and control. Our approach operates in a (x, y, theta) configuration space and it combines two local functions: a contact-based attraction function and an exploration function. Compliant motions are used to reduce the position/orientation uncertainty. An explicit geometric model for the uncertainty is defined to evaluate the reachability of the obstacle surfaces when the robot translates in free space.

The path planning problem for arbitrary devices[27] is first and foremost a geometrical problem. For the field of control theory, advanced mathematical techniques have been developed to describe and use geometry. In this paper, we use the notations of the flow of vector fields and geodesics in metric spaces to formalize and unify path planning problems. A path planning algorithm based on flow propagation is briefly discussed. Applications to the theory to motion planning for a robot arm, a maneuvring car, and Rubik's Cube are given. These very different problems (holonomic, non-holonomic and discrete, respectively) are solved by the same unified procedure.

Egbert et al.[28] present a technique for automatically providing animation and collision avoidance in a general-purpose computer graphics system. The technique, which relies on an expanded notion of vector fields, allows users to easily set up and animate objects, then prevents objects from colliding as the animation proceeds.

LaValle[29] et al. introduces a visibility-based motion planning problem in which the task is to coordinate the motions of one or more robots that have omni-directional vision sensors, to eventually "see" a target that is unpredictable, has unknown initial position, and is capable of moving arbitrarily fast. A visibility region is associated with each robot, and the goal is to guarantee that the target will ultimately lie in at least one visibility region. A complete algorithm for computing the motion strategy of the robots is also presented.

Zelinsky[30] presents an algorithm for path planning to a goal with a mobile robot in an unknown environment. The robot maps the environment only to the extent that is necessary to achieve the goal. Paths are generated by treating unknown regions in the environment as free space. As obstacles are encountered en route to a goal, the model of the environment is updated and a new path to the goal is planned and executed. The algorithm presented in this paper makes use of the quadtree data structure to model the environment and uses the distance transform methodology to generate paths for the robot to execute.

Jönsson[31] describes an algorithm for approximately finding the fastest route for a vehicle to travel between two points in a digital terrain map, avoiding obstacles along the way. The enemies are avoided by staying out of their line of sight. However, the general results of this paper should be feasible for a much wider range of applications ranging from complex GIS [Geographic Information Systems] systems to home computer games. The approach taken in this work is to translate the problem into a least cost path graph problem with an associated cost function on the graph edges.

Chapter 2

CURRENT WORK DONE

1. Algorithm of The Programme
2. My First Programme
3. Obstacles and The Arena
4. Final Programme

3.1 WORK ANALYSIS

Algorithm of Path Planning of Mobile Robots:

- User will be asked to input the type of obstacle .Depending on the type of obstacle number of sides if it is a polygon.
- Then depending on the type of obstacle it asks to enter the co-ordinate of the vertices if it is a polygon and the co-ordinate of centre and the radius if it is a circle.
- User has the flexibility to add any number of obstacles in the arena. The arena has a co-ordinate system which ranges from **0** to **700** in the horizontal axis (x-axis) and from **0** to **500** in the vertical axis(y- axis).
- After inserting the obstacles it will ask to enter the starting point and the destination point of the mobile agent.
- In the programme the starting point co-ordinates are taken as **a** and **b** and the destination point is taken as(**x1, y1**).
- For shortest distance path the robot has to travel to the destination along a straight line. So the slope of the line joining (**a, b**) and (**x1, y1**) is **mo=(y1-b)/(x1-a).** The equation of the line in which the robot has to move: $y_i=(mo)*(x_i-a)+b$.
- Now "for loop" for the programme will be start incrementing the value of x_i by**1** and getting the value of y_i from the above mentioned equation.
- According to the value of the co-ordinates given to the obstacles the equation and the range of their side or curves are obtained.
- While the "for loop" is running the values of xi and yi were continuously being checked with the equations of sides or curves (circle) of the obstacles.
- If the value of xi and yi satisfies the preset values of equation then the robot will move till the end point of that side with the same slope as that of side in order to avoid collision.

3.2 My First Program:

```
#include <graphics.h>
#include <stdlib.h>
#include <stdio.h>
#include<iostream.h>
#include <conio.h>
#include<dos.h>
#include<math.h>
void main()
{

int x1,y1,a=30,b=450;
int
ans=1,a1=0,b1=0,a2=0,b2=0,a4=0,b4=0,a5=0,b5=0,a6=0,b6=0;
line4: if(ans==2)
{
int
k,a11=152,b11=330,a12=120,b12=110,a14=317,b14=87,a15=5
20,b15=205,a16=490,b16=470;
int cas1;
line1: cout<<"if you want to change triangle 1 enter1 , to change
rectangle 1 enter 2, to change the circle enter3, to change
triangle2 enter 4, to change rectangle2 enter 5, to change
rectangle3 enter 6\n";
cin>>k;
a=30;
b=450;
switch(k)
{
case 1:
{
cout<<"Enter the new centriod in x,y currently(152,330)\n";
cin>>a11>>b11;
a1=a11-152; b1=b11-330;
break;
}
```

```
case 2:
{
cout<<"Enter the new centriod in x,y currently(120,110)\n";
cin>>a12>>b12;
a2=a12-120;  b2=b12-110;
break;
}
case 3:
{
cout<<"Enter the new centriod in x,y currently(280,210)\n";
//  cin>>a13>>b13;
//  a3=a13-280; b3=b13-210;
break;
}
case 4:
{
cout<<"Enter the new centriod in x,y currently(317,87)\n";
cin>>a14>>b14;
a4=a14-317; b4=b14-87;
break;
}
case 5:
{
cout<<"Enter the new centriod in x,y currently(520,205)\n";
cin>>a15>>b15;
a5=a15-520; b5=b15-205;
break;
}
case 6:
{
cout<<"Enter the new centriod in x,y currently(490,470)\n";
cin>>a16>>b16;
a6=a16-490; b6=b16-470;
break;
}
}
```

```
cout<<"Do you want to make subsequent changes if yes enter 1 otherwise enter 2";
cin>>cas1;
if(cas1==1)
{
goto line1;
}
if(cas1==2)
{
goto line3;
}
}


line3: cout<<"Set the target point";
cin>>x1>>y1;
clrscr();
/* request auto detection */
int gdriver = DETECT, gmode, errorcode;

/* initialize graphics mode */
initgraph(&gdriver, &gmode, "c:\\tc\\bgi");
/* read result of initialization */
errorcode = graphresult();

if (errorcode != grOk)  /* an error occurred */
{
printf("Graphics error: %s\n", grapherrormsg(errorcode));
printf("Press any key to halt:");
line(5, 5, 30, 30);
getch();
exit(1);             /* return with error code */
}

//instruction for drawing a hexagon//
int poly[14],tr1[7],tr2[7],r1[9],r2[9],r3[9];
poly[0]=480;
```

```
poly[1]=300;
poly[2]=532;
poly[3]=330;
poly[4]=532;
poly[5]=390;
poly[6]=480;
poly[7]=420;
poly[8]=428;
poly[9]=390;
poly[10]=428;
poly[11]=330;
poly[12]=poly[0];
poly[13]=poly[1];
drawpoly(7,poly);
// instruction for drawing a triangle 1//
tr1[0]=170+a1;
tr1[1]=230+b1;
tr1[2]=240+a1; tr1[3]=380+b1; tr1[4]=45+a1; tr1[5]=380+b1;
tr1[6]=tr1[0];
tr1[7]=tr1[1];
drawpoly(4,tr1);
//instruction for drawing rectangle 1 //
r1[0]=50+a2; r1[1]=40+b2; r1[2]=190+a2; r1[3]=40+b2;
r1[4]=190+a2; r1[5]=180+b2; r1[6]=50+a2; r1[7]=180+b2;
r1[8]=r1[0];
r1[9]=r1[1];
drawpoly(5,r1);
//instruction for drawing a circle//
//  circle(280+a3, 210+b3, 60);
// instruction for drawing a triangle 2//
tr2[0]=300+a4;
tr2[1]=20+b4;
tr2[2]=400+a4, tr2[3]=120+b4, tr2[4]=250+a4, tr2[5]=120+b4;
tr2[6]=tr2[0];
tr2[7]=tr2[1];
drawpoly(4,tr2);
```

```
//instruction for drawing rectangle 2 //
r2[0]=440+a5, r2[1]=150+b5, r2[2]=600+a5, r2[3]=150+b5,
r2[4]=600+a5,r2[5]=260+b5, r2[6]=440+a5, r2[7]=260+b5;
r2[8]=r2[0];
r2[9]=r2[1];
drawpoly(5,r2);
//instruction for drawing rectangle 3 //
r3[0]=400+a6, r3[1]=450+b6, r3[2]=580+a6, r3[3]=450+b6,
r3[4]=580+a6,r3[5]=490+b6, r3[6]=400+a6, r3[7]=490+b6;
r3[8]=r3[0];
r3[9]=r3[1];
drawpoly(5,r3);

// line3: cout<<"Set the target point";
//    cin>>x1>>y1;
// start of main program//
int i,y=0,p1;
for(i=30;i<=x1;i++)                                    //
equation of line of travel//
{
line5:   y=(((y1-b)*(i-a))/(x1-a))+b;
int w=0,m=0,s=0;
m=(y1-b)/(x1-a);
if(m>7)
{
s=10;
}
else
{
s=0;
}
if(i>40+a1 && i<171+a1)                                    //for
triangle1
{
if(y>=(220+b1) && y<=(385+b1))
{
p1=y+(1.2*(i+7))-434-b1-(1.2*a1);
```

```
if(p1>=-15&&p1<=15)
{
if(y1>y)
{
outtextxy(i,y,"*");
}
else
{
if(y<=385+b1 && y>=225+b1)
{
y=434-(1.2*(i+7-a1))+b1;
{
outtextxy(i,y,"*");
w=1;
}
}
}
}
}
}
int p2;
if(i<=250+a1 && i>=170+a1)
{
if(y<=381+b1 && y>=220+b1)
{
p2=y-2.15*(i-240-a1)-380-b1;
if(p2<=20 && p2>=-20)
{
y=2.15*(i-240-a1)+380+b1;
outtextxy(i,y,"*");
w=1;
}
}
}
if(i>=40+a1 && i<=250+a1)
{
if(y>387+b1 && y<392+b1)
```

```
{
if(x1<120 && y1>250)
{
for(i=a;i>=25;i--)
{
outtextxy(i,y,"*");
w=1;
delay(40);
}
}
else
{
for(i=a;i<=250+a1;i++)
{
outtextxy(i,390+b1,"*");
w=1;
y=390+b1;
delay(40);
}
}
}
}
if(i>=39+a2 && i<=200+a2)                // for rectangle1//
{
if(y>=30+b2 && y<=190+b2)
{
if(i==40+a2)
{
if(y<=189+b2)
{
for(y=b;y>=30+b2;y--)
{
w=1;
outtextxy(40+a2,y,"*");
delay(40);
}
// break;//
```

```
}
}
}
}
if(i>40+a2)
{
if(y<192+b2+s && y>175+b2-s)
{
for(i=a;i<=195+a2;i++)
{
outtextxy(i,190+b2,"*");
y=190+b2;
w=1;
delay(40);
}
}
}
if(i>=39+a2 && i<=200+a2)
{
if(y>=32+b2-s && y<40+b2+s)
{
for(i=a;i<=200+a2;i++)
{
outtextxy(i,y,"*");
w=1;
delay(40);
}
}
}
if(y>30+b2 && y<190+b2)
{
if(i==195+a2)
{
for(y=b;y>=30+b2;y--)
{
outtextxy(i,y,"*");
w=1;
```

```
delay(40);
}
}
}


if(i>240+a4 && i<310+a4)                    //for triangle 4//
{
if(y<125+b4 && y>15+b4)
{
y=-(11/7)*(i-240-a4)+125+b4;
outtextxy(i,y,"*");
w=1;
}
}
if(i>=245+a4 && i<=410+a4)
{
if(y>125+b4-s && y<132+b4+s)
{
for(i=a;i<=410+a4;i++)
{
outtextxy(i,130+b4,"*");
w=1;
y=130+b4;
delay(40);
}
}
}
if(i==430+a5)                    // for rectangle 2//
{
if(y<270+b5 && y>=140+b5)
{
for(y=b;y>140+b5;y--)
{
outtextxy(430+a5,y,"*");
w=1;
delay(40);
```

```
}
}
}
if(i>435+a5 && i<605+a5)
{
if(y>260+b5 && y<270+b5)
{
if(x1<=605+a5)
{
outtextxy(i,y,"*");
w=1;
}
else
{
y=270+b5;
for(i=a;i<610+a5;i++)
{
outtextxy(i,y,"*");
w=1;
delay(40);
}
}
}
if(y>140+b5 && y<150+b5)
{
y=140+b5;
for(i=a;i<610+a5;i++)
{
outtextxy(i,y,"*");
w=1;
delay(40);
}

}
}
if(i==608+a5)
{
```

```
if(y<270+b5 && y>140+b5)
{
for(y=b;y>140+b5;y--)
{
outtextxy(i,y,"*");
w=1;
delay(40);
}
}
}
if(i==390+a6)                    //for rectangle3//
{
if(y<500+b6 && y>=440+b6)
{
for(y=b;y>440+b6;y--)
{
outtextxy(390+a6,y,"*");
w=1;
delay(40);
}
}
}
if(i>395+a6 && i<585+a6)
{
if(y>490+b6 && y<500+b6)
{
y=500+b6;
for(i=a;i<585+a6;i++)
{
outtextxy(i,y,"*");
w=1;
delay(40);
}
}
if(y>=440+b6 && y<450+b6)
{
if(x1<585+a6)
```

```
{
outtextxy(i,y,"*");
w=1;
}
else
{
y=440+b6;
for(i=a;i<585+a6;i++)
{
outtextxy(i,y,"*");
w=1;
delay(40);
}
}
}
}
if(i==584+a6)
{
if(y<495+b6 && y>455+b6)
{
for(y=b;y>455+b5;y--)
{
outtextxy(i,y,"*");
w=1;
delay(40);
}
}
}
if(i>=423 && i<480)          //hexagon//
{
if(y<=290 && y>=360)
{
if(y<=360 && y>330)
{
i=423;
for(y=b;y>=330;y--)
{
```

```
outtextxy(423,y,"*");
w=1;
delay(40);
}
}
if(y<=330 && y>=295)
{
int q3;
q3=y-330+.614*(i-423);
if(q3>=0)
{
y=-.614*(i-423)+330;
outtextxy(i,y,"*");
w=1;
}
}
}
//hexagon 2nd //
if(y<=360 && y>=420)
{
if(y<=390 && y>360)
{
i=423;
for(y=b;y<=390;y++)
{
outtextxy(423,y,"*");
w=1;
delay(40);
}
}
if(y<=425 && y>=390)
{
int q4;
q4=y-425-(.614*(i-480));
if(q4<=0)
{
y=.614*(i-480)+425;
```

```
outtextxy(i,y,"*");
w=1;
}
}
}
}
//hexagon 3rd//
if(i>=480 && i<538)
{
if(y<=290 && y>=360)
{
if(y<=360 && y>330)
{
i=537;
for(y=b;y>=330;y--)
{
outtextxy(537,y,"*");
w=1;
delay(40);
}
}
if(y<=330 && y>=295)
{
int q5;
q5=y-295-.614*(i-480);
if(q5>=0)
{
y=.614*(i-480)+295;
outtextxy(i,y,"*");
w=1;
}
}
}
// hexagon 4th//
if(y<=360 && y>=420)
{
if(y<=390 && y>360)
```

```
{
i=537;
for(y=b;y<=390;y++)
{
outtextxy(537,y,"*");
w=1;
delay(40);
}
}
if(y<=425 && y>=390)
{
int q6;
q6=y-425+(.614*(i-480));
if(q6<=0)
{
y=-.614*(i-480)+425;
outtextxy(i,y,"*");
w=1;
}
}
}
}
if(w==0)
{ outtextxy(i,y,"*");

}
a=i;
b=y;
delay(40);
if(a>x1)
{
i=i-1;
goto line5;
}

}
ans=2;
```

```
int z1;
cout<<" do you want to continue then press 1 ";
cin>>z1;
if(z1==1)
{
goto line4;
}
else
{
exit;
}
getch();
}
```

3.3 OBSTACLES AND THE ARENA

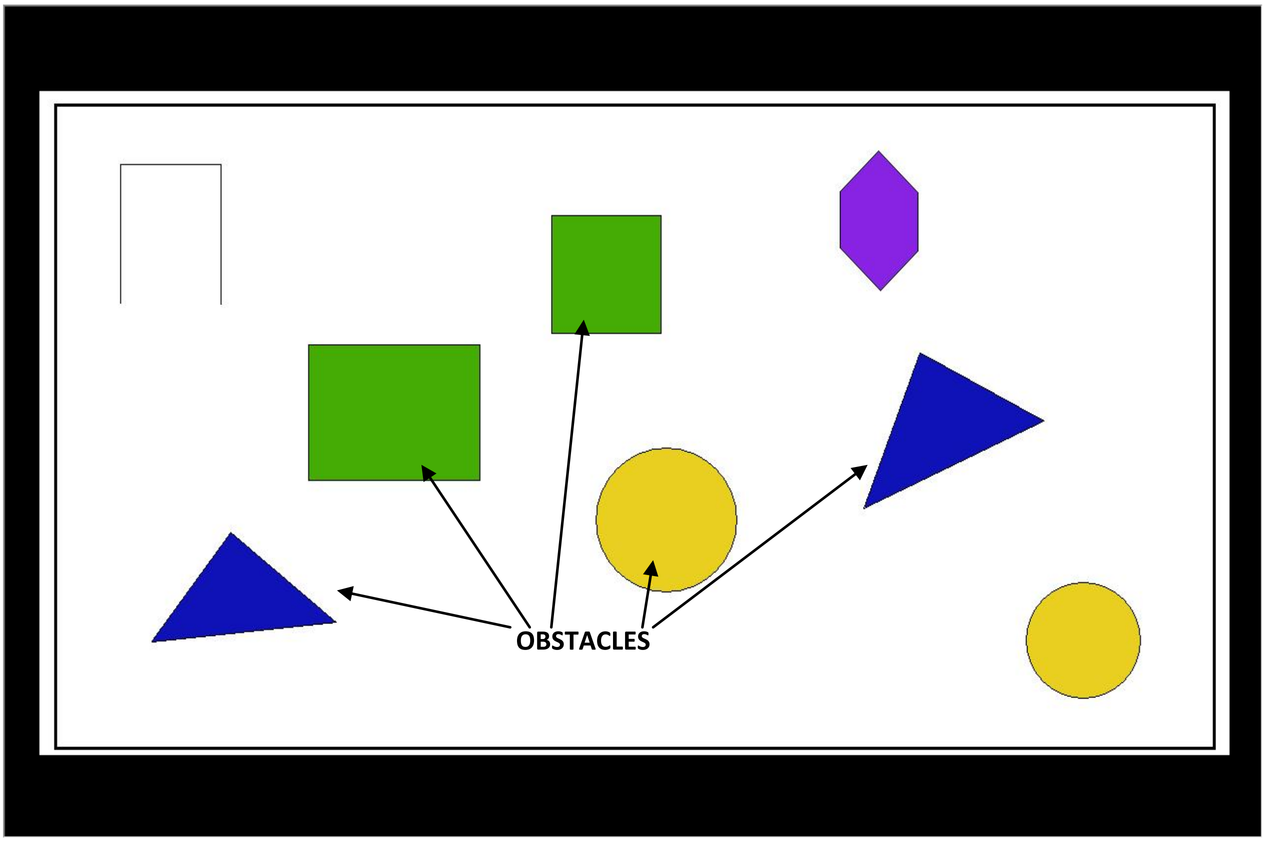


Figure shows Obstacles and the Arena enclosing them

OUTPUT AND RESULTS

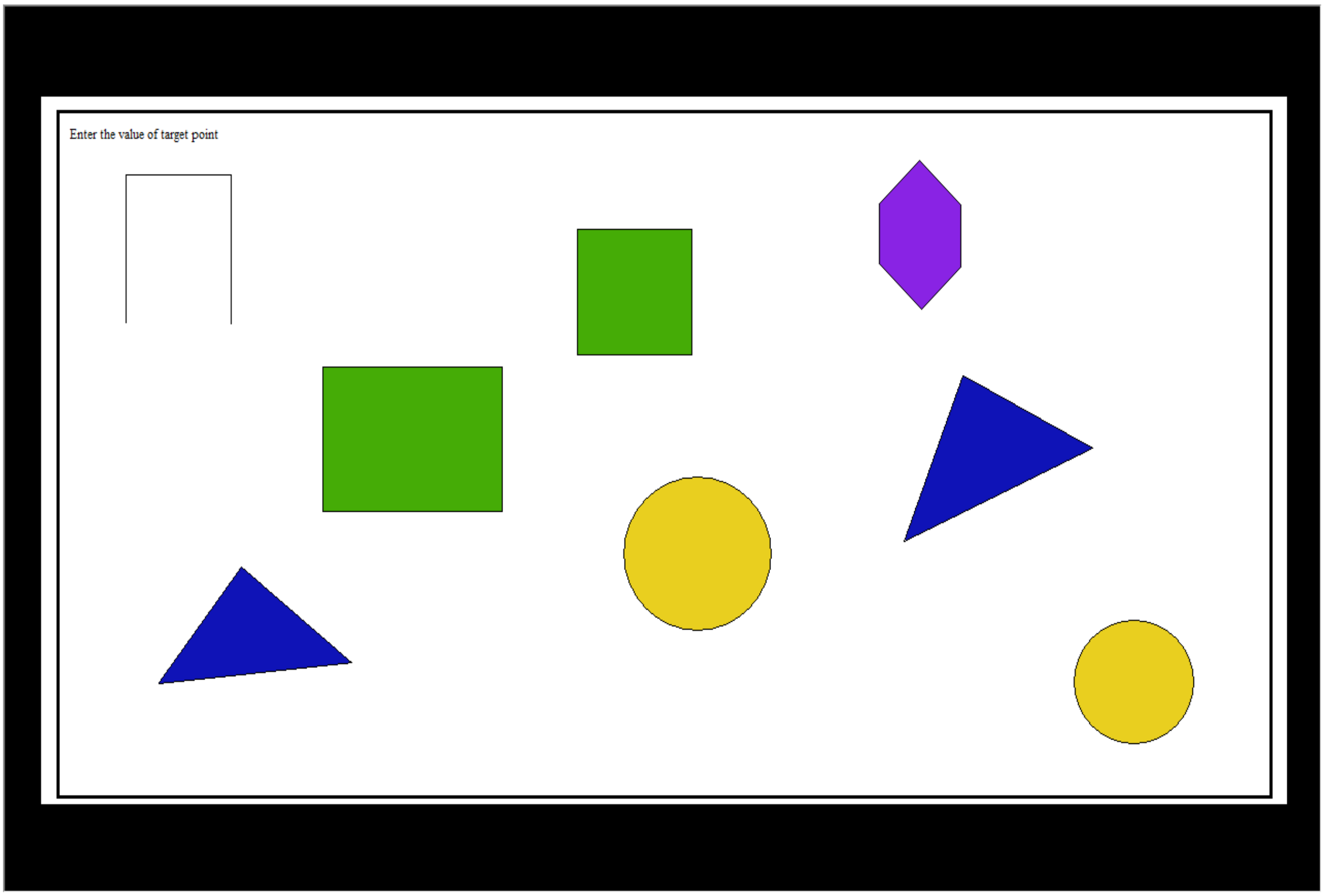


Figure shows the Programme asking for Input for the Target Point after Completing the Obstacles

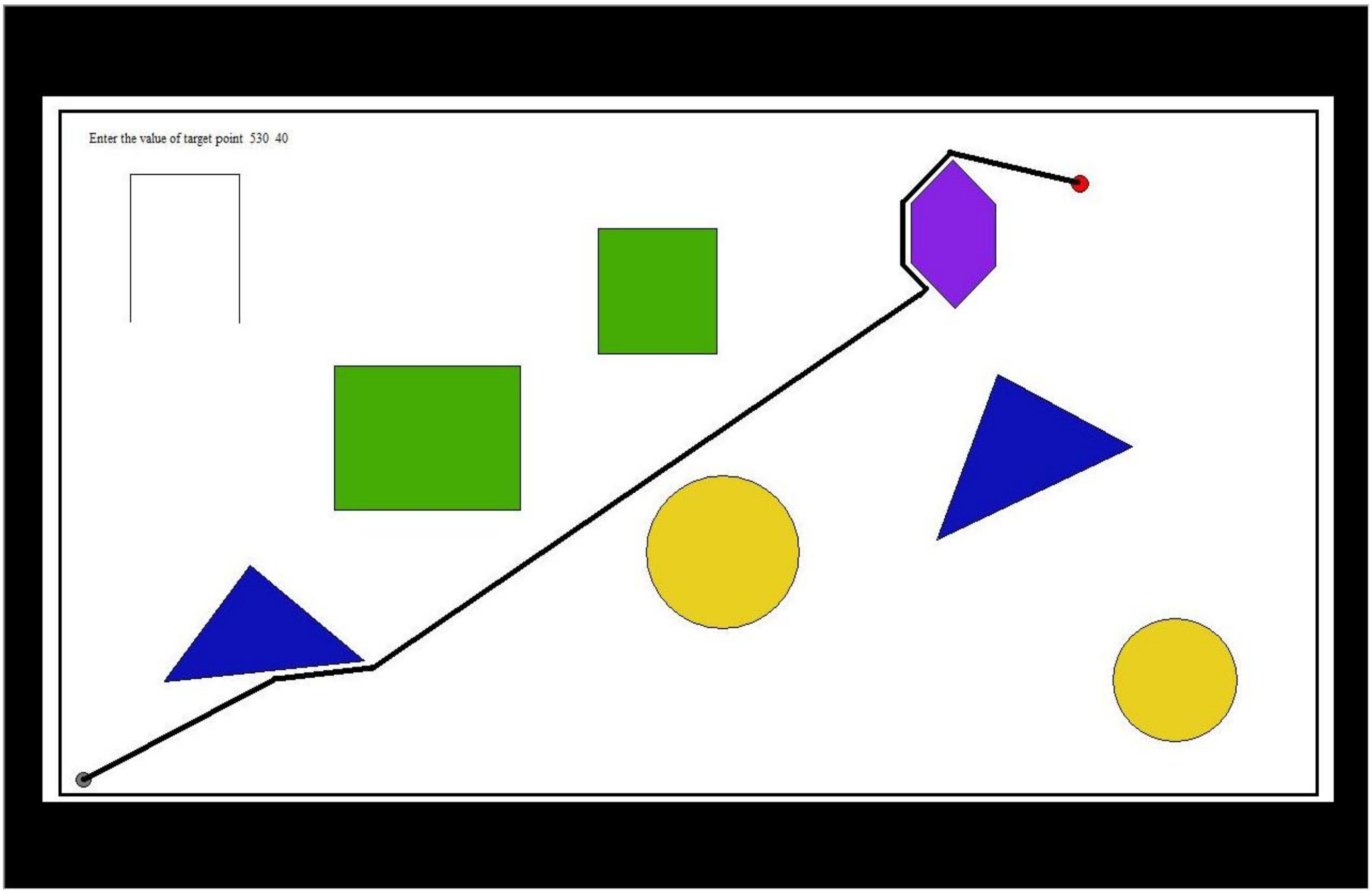


Figure shows the Path Traced by the Mobile Agent for Destination
(**530**, **40**)

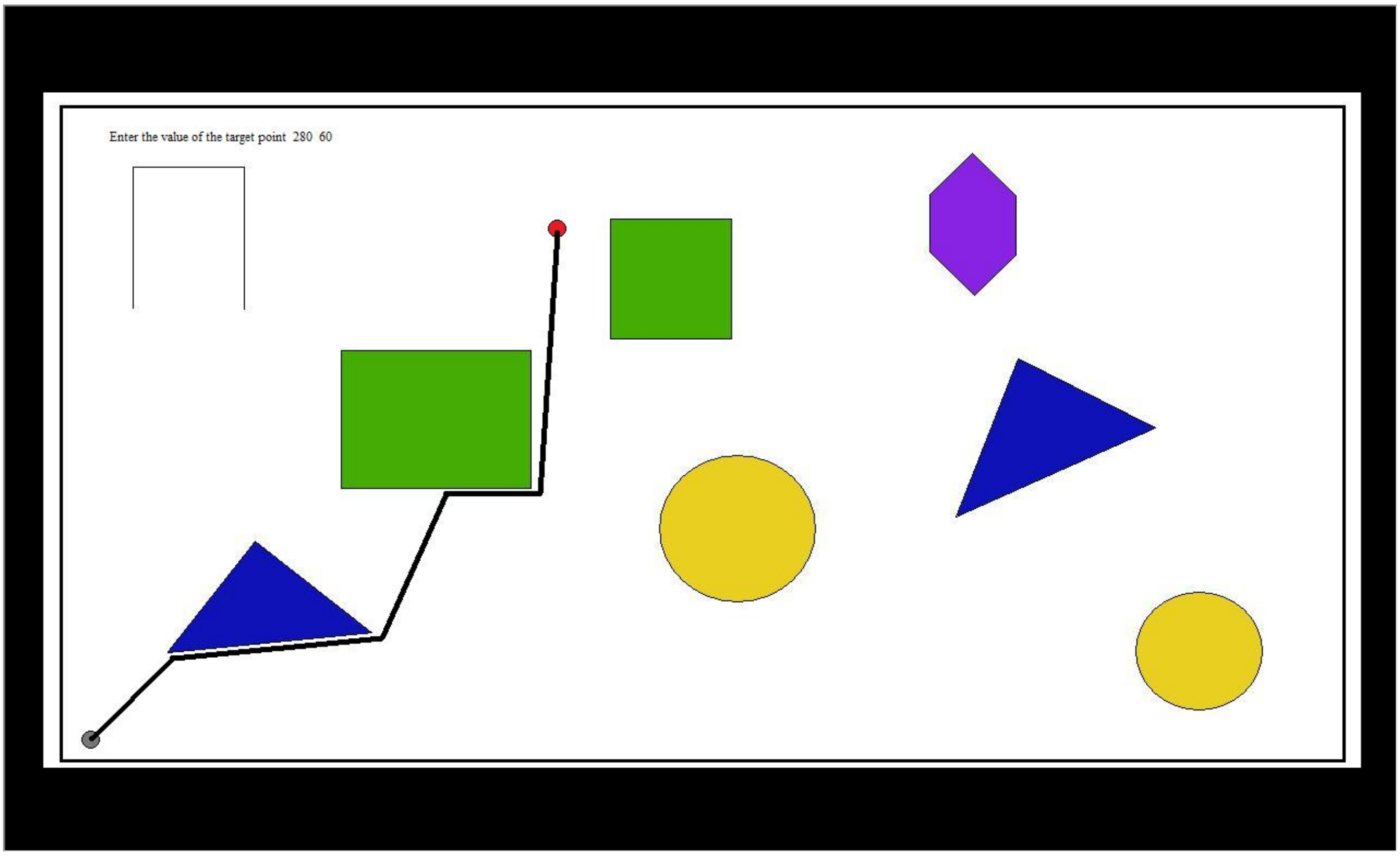


Figure shows the Path Traced by the Mobile Agent for Destination
(**280**, **60**)

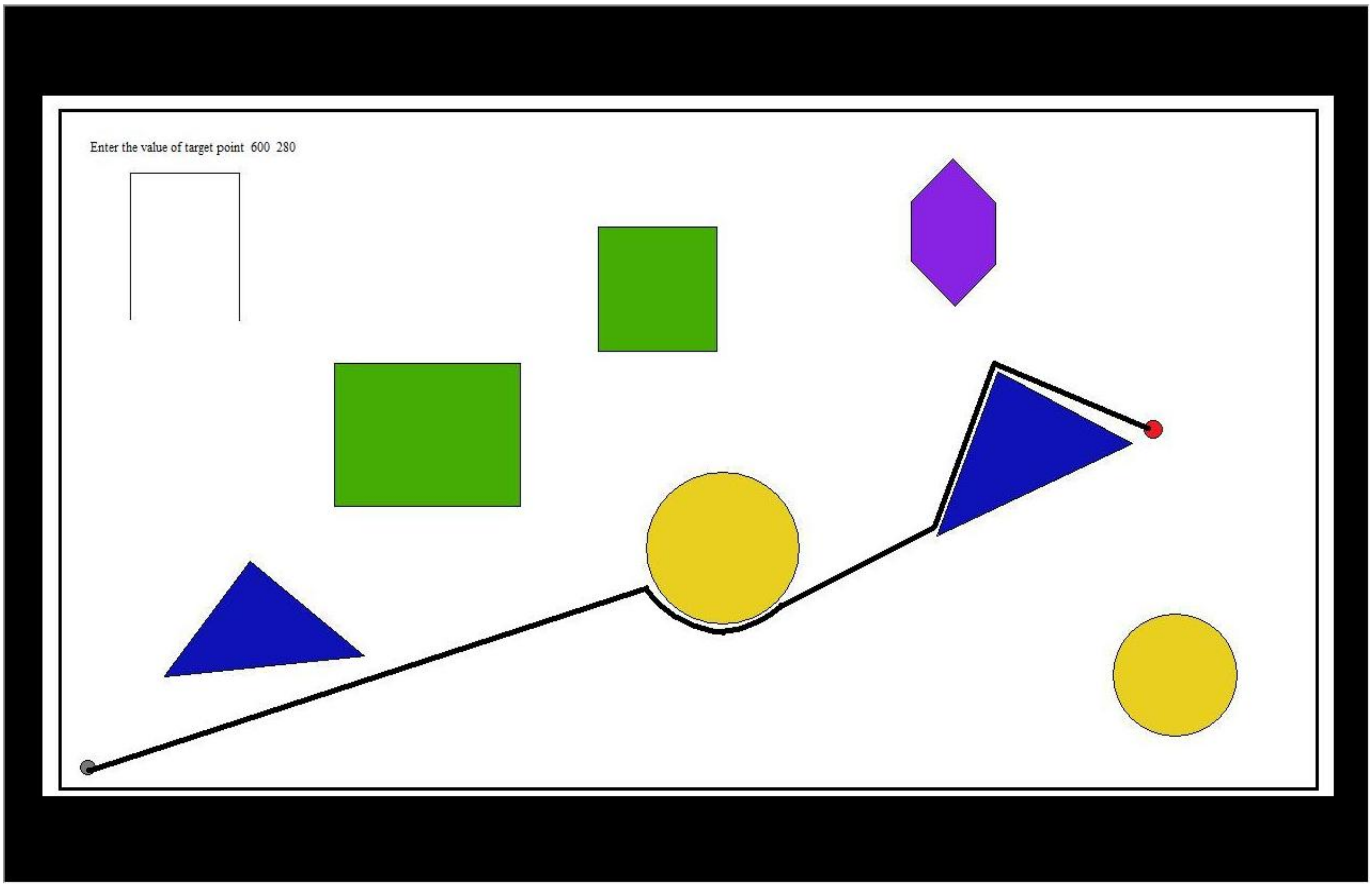


Figure shows the Path Traced by the Mobile Agent for Destination
(**600**, **280**)

3.4 FINAL PROGRAM

Till of now the programme is only limit to show only one mobile robot at a time and the obstacles were also predefined. So the following program shows the path traced by any number of mobile robots having different starting point and searching for different target points. For this the study of artificial intelligence is very much required because I have to incorporate decision taking power in robot to choose between different target points basing on some principles. The program shown below related to adding flexibility for user defined obstacles and collision free navigation of mobile robot i.e., an unknown environment.

```
#include<iostream.h>
#include<stdio.h>
#include<math.h>
#include<conio.h>
#include<dos.h>
#include<stdlib.h>
#include<graphics.h>
void main()
{
clrscr();
int po=0,io=0,k,poi=0;
line1: cout<<"Enter the type of obstacle you want to insert accod. to the following:\n";
cout<<"for line enter '1', for triangle enter'2', for rectangle enter '3',for hexagon enter'4', for circle enter'5', for an U shape enter'6'\n";
cin>>k;
int n=0,cx[6],cy[6],cr[6],c[20];
switch(k)
{
case 1:
{
```

```
poi++;
n=4;
c[poi]=0;
po++;
break;
}
case 2:
{
poi++;
n=6;
c[poi]=1;
po++;
break;
}
case 3:
{
poi++;
n=8;
c[poi]=1;
po++;
break;
}
case 4:
{
poi++;
n=12;
c[poi]=1;
po++;
break;
}
case 5:
{
io++;
n=0;
cout<<"enter the (x,y) coordinate of the circle center and its radius for
circle"<<io;
cin>>cx[io]>>cy[io]>>cr[io];
```

```
// c[poi]=0;
break;
}
case 6:
{
poi++;
n=8;
c[poi]=0;
po++;
break;
}
}
cout<<"Enter the co-ordinates of the figure interms of (x,y)";
int i,fi[10][20],ni[10];
for(i=0;i<n;i++)
{
cin>>fi[po][i];
if(c[poi]==1)
{
if(i==n-1)
{
fi[po][i+1]=fi[po][0];
fi[po][i+2]=fi[po][1];
ni[po]=(n/2)+1;
}
}
if(c[poi]==0)
{
ni[po]=n/2;
}
}
int ki;
cout<<"Do you want to add one more figure if yes enter 1 \n";
cin>>ki;
if(ki==1)
{
goto line1;
```

```
}
int no, mo, a[10],b[10],e[10],d[10], nt, x1[10], y1[10], x2, y2;
cout<<"Enter the no. of mobile agent";
cin>>no;
cout<<"Enter the starting points of "<<no<<"target points in the form
of (x,y)\n";
for(i=0;i<no;i++)
{
cin>>a[i]>>b[i];
}
cout<<"Enter the number of target points";
cin>>nt;
cout<<"Enter the target point co-ordinates in (x,y) form";
int j, di[10], ds=0, dk,ko,mp, si, ap, bp;
for(j=0;j<nt;j++)
{
cin>>x1[j]>>y1[j];
}
clrscr();

/* request auto detection */
int gdriver = DETECT, gmode, errorcode;

/* initialize graphics mode */
initgraph(&gdriver, &gmode, "c:\\tc\\bgi");
/* read result of initialization */
errorcode = graphresult();

if (errorcode != grOk)  /* an error occurred */
{
printf("Graphics error: %s\n", grapherrormsg(errorcode));
printf("Press any key to halt:");
// line(5, 5, 30, 30);
// getch();
// exit(1);             /* return with error code */
}
```

```
int pu;
for(pu=1;pu<=po;pu++)
{
switch(ni[pu])
{
case 4:
{
setcolor(1);
setfillstyle(2,1);
break;
}
case 5:
{
setcolor(2);
setfillstyle(1,2);
break;
}
case 7:
{
setcolor(3);
setfillstyle(1,3);
break;
}
}
drawpoly(ni[pu],fi[pu]);
}
int ic;
for(ic=1;ic<=io;ic++)
{
setcolor(4);
setfillstyle(1,4);
circle(cx[ic],cy[ic],cr[ic]);
}
getch();
for(j=0;j<nt;j++)
{
for(i=0;i<no;i++)
```

```
{
ds=ds+sqrt(pow((x1[j]-a[i]),2)+pow((y1[j]-b[i]),2));
}
di[j]=ds;
}
dk=di[0];
for(j=0;j<nt;j++)
{
if(dk>=di[j])
{
dk=di[j];
ko=j;
}
}
x2=x1[ko];
y2=y1[ko];
int x[12],y[12],ku[12]={ 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1}, ks1[12]={ 1,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1}, tj, tjn,mk[20],ksx[15];
line14:  int k2c=0,klc=0,tpy,tny,p,ky1,kx1,ky2,kx2,yp,yn,lac,yrp,yrn;
for(j=0;j<no; j++)
{
x[j]=a[j];
y[j]=b[j];
if(x[j]!=x2 || y[j]!=y2)
{
if (ku[j]==4)
{
switch(ksx[j])
{
case 1:
{
goto line8;
}
case 2:
{
goto line9;
}
```

```
case 3:
{
goto line10;
}
case 4:
{
goto line11;
}
}
}
if(x2<a[j])
{
goto line8;
}
else
{
goto line9;
}

//if(x[j]>x2)
line8:x[j]--;
tj=0;
if(ks1[j]==1)
{
mk[j]=((y2-b[j])/(x2-a[j]))*10;
y[j]=(mk[j]*(x[j]-a[j])+b[j])/10;
}

for(si=1;si<=po;si++)
{
for(i=0;i<(2*ni[si]);i++)
{
if(i%2==0)
{
if(fi[si][i+3]>fi[si][i+1])
{
ky1=fi[si][i+3];
```

```
ky2=fi[si][i+1];
}
else
{
ky1=fi[si][i+1];
ky2=fi[si][i+3];
}
if(fi[si][i]>fi[si][i+2])
{
kx1=fi[si][i];
kx2=fi[si][i+2];
}
else
{
kx1=fi[si][i+2];
kx2=fi[si][i];
}
int mxy;
if(x[j]>(kx2-10) && x[j]<(kx1+10))
{
if(y[j]>(ky2-10) && y[j]<(ky1+10))
{
bp=fi[si][i+3]-fi[si][i+1];
ap=fi[si][i+2]-fi[si][i];
if(bp==0)
{
int ku[10];
y[j]=b[j];
outtextxy(x[j],y[j],"*");
delay(10);
//getch();
tj=1;
klc++;
ku[j]=4; ks1[j]=2;
goto line6;
}
if(ap==0)
```

```
{
if(b[j]<d[j])
{
p=-1;
}
if(b[j]>d[j])
{
p=1;
}
x[j]=a[j];
y[j]=b[j]+p;
outtextxy(x[j],y[j],"*");
delay(10);
//getch();
ku[j]=4;
klc++;
ks1[j]=2;
tj=1;
goto line6;
}
mxy= ((fi[si][i+3]-fi[si][i+1])/(fi[si][i+2]-fi[si][i]))*100;
p=(y[j]-(mxy*(x[j]-fi[si][i])/100)-
fi[si][i+1])/(sqrt(1+(pow((mxy/100),2))));
if(p<10)
{

lac=100*(sqrt(1+(pow((mxy/100),2))));
yrp=(lac/10)+(mxy/100)*(x[j]-fi[si][i])+fi[si][i+1];
yrn=((mxy/100)*(x[j]-fi[si][i]))+fi[si][i+1]-(lac/10);
yp=b[j]-yrp;
yn=b[j]-yrn;
if(yp<0)
{
yp=(-1)*yp;
}
if(yn<0)
{
```

```
yn=(-1)*yn;
}
if(yp>yn)
{
y[j]=yrn;
}
else
{
y[j]=yrp;
}
outtextxy( x[j], y[j], "*");
delay(10);
ku[j]=4;ks1[j]=2;
tj=1;
}
}
}
}
line6:
e[j]=a[j];
d[j]=b[j];
a[j]=x[j];
b[j]=y[j];
if(tj==0)
{
ku[j]=1;
ks1[j]=1;
}
else
{
ksx[j]=1;
}
}
}
if(tj==0)
{
outtextxy( x[j], y[j],"*");
```

```
delay(5);
}
goto line7;
//if(x[j]<x2)
//{
line9: x[j]++;
tjn=0;
if(ks1[j]==1)
{
mk[j]=((y2-b[j])/(x2-a[j]))*100;
y[j]=(mk[j]/100)*(x[j]-a[j])+b[j];
}
//tsi=tsi++;
for(si=1;si<=po;si++)
{
for(i=0;i<(2*ni[si]);i++)
{
if(i%2==0)
{
int ky1,kx1, ky2, kx2;
if(fi[si][i+3]>fi[si][i+1])
{
ky1=fi[si][i+3];
ky2=fi[si][i+1];
}
else
{
ky1=fi[si][i+1];
ky2=fi[si][i+3];
}
if(fi[si][i]>fi[si][i+2])
{
kx1=fi[si][i];
kx2=fi[si][i+2];
}
else
{
```

```
kx1=fi[si][i+2];
kx2=fi[si][i];
}
if(x[j]>=(kx2-10) && x[j]<=(kx1+10))
{
if(y[j]>=(ky2-10) && y[j]<=(ky1+10))
{
bp=fi[si][i+3]-fi[si][i+1];
ap=fi[si][i+2]-fi[si][i];
//mp=(bp/ap)*100;
if(bp==0)
{
int pqs;
pqs=(y[i]-fi[si][i+1]);

if(pqs<0)
{
pqs=pqs*(-1);
}
if(pqs<10)
{
int p;
y[j]=b[j];
outtextxy(x[i],y[j],"*");
delay(5);
klc++;
ku[j]=4; ks1[j]=2;
tjn=1;
goto line12;
}
}
if(ap==0)
{
int pqs;
pqs=x[i]-fi[si][i];
if(pqs<0)
{
```

```
pqs=pqs*(-1);
}
if(pqs<10)
{
if(b[j]<d[j])
{
p=-1;
}
if(b[j]>d[j])
{
p=1;
}
x[j]=a[j];
y[j]=b[j]+p;
outtextxy(x[j],y[j],"*");
delay(5);
//getch();
ku[j]=4; ks1[j]=2;
klc++;
tjn=1;
goto line12;
}
}
int mxy,pl;
mxy=((fi[si][i+3]-fi[si][i+1])/(fi[si][i+2]-fi[si][i]))*100;
pl=(y[j]-(mxy*(x[j]-fi[si][i])/100)-
fi[si][i+1])/(sqrt(1+(pow((mxy/100),2))));
if(pl<10)
{
//int mt;
//mt=((y[j]-ky1)/(x[j]-kx2-18))*100;
lac=100*(sqrt(1+(pow((mxy/100),2))));
yrp=(lac/10)+(mxy/100)*(x[j]-fi[si][i])+fi[si][i+1];
yrn=((mxy/100)*(x[j]-fi[si][i]))+fi[si][i+1]-(lac/10);
yp=b[j]-yrp;
yn=b[j]-yrn;
if(yp<0)
```

```
{
yp=(-1)*yp;
}
if(yn<0)
{
yn=(-1)*yn;
}
if(yp>yn)
{
y[j]=yrn;
}
else
{
y[j]=yrp;
}
outtextxy( x[j], y[j],"*");
delay(10);
//getch();
ku[j]=4; ks1[j]=2;
tjn=1;
}
}
}
}
line12:
e[j]=a[j];
d[j]=b[j];
a[j]=x[j];
b[j]=y[j];
if(tjn==0)
{
ku[j]=1;
ks1[j]=1;
}
else
{
ksx[j]=2;
```

```
}
}
}
if(tjn==0)
{
outtextxy( x[j], y[j],"*");
delay(10);
}
goto line7;
if(x[j]==x2)
{
if(y[j]>(y2+5) || y[j]<(y2-5))
{
if(y[j]>y2)
{
line10:
int tny=0;
y[j]--;
if(ks1[j]==1)
{
mk[j]=((y2-b[j])/(x2-a[j]))*100;
x[j]=a[j]+((y[j]-b[j])/(mk[j]/100));
}
for(si=1;si<=po;si++)
{
for(i=0;i<(2*ni[si]);i++)
{
if(i%2==0)
{
int ky1,kx1,ky2,kx2;
if(fi[si][i+3]>fi[si][i+1])
{
ky1=fi[si][i+3];
ky2=fi[si][i+1];
}
else
{
```

```
ky1=fi[si][i+1];
ky2=fi[si][i+3];
}
if(fi[si][i]>fi[si][i+2])
{
kx1=fi[si][i];
kx2=fi[si][i+2];
}
else
{
kx1=fi[si][i+2];
kx2=fi[si][i];
}
int mxy;
if(x[j]>(kx2-10) && x[j]<(kx1+10))
{
if(y[j]>(ky2-10) && y[j]<(ky1+10))
{
bp=fi[si][i+3]-fi[si][i+1];
ap=fi[si][i+2]-fi[si][i];
if(bp==0)
{
int ku[10];
y[j]=b[j];
if(a[j]<e[j])
{
p=-1;
}
if(a[j]>e[j])
{
p=1;
}
x[j]=a[j]+p;
outtextxy(x[j],y[j],"*");
tny=1;
klc++;
ku[j]=4; ks1[j]=2;
```

```
goto line13;
}
if(ap==0)
{
x[j]=a[j];
y[j]=b[j];
outtextxy(x[j],y[j],"*");
ku[j]=4;
klc++;
ks1[j]=2;
tny=1;
goto line13;
}
mxy= ((fi[si][i+3]-fi[si][i+1])/(fi[si][i+2]-fi[si][i]))*100;
int p;
p=(y[j]-(mxy*(x[j]-fi[si][i])/100)-
fi[si][i+1])/(sqrt(1+(pow((mxy/100),2))));
if(p<10)
{
lac=100*(sqrt(1+pow(mxy,2)));
yrp=(y[j]+((mxy/100)*fi[si][i])-fi[si][i+1]-(lac/10))/(mxy/100);
yrn=(y[j]+((mxy/100)*fi[si][i])-fi[si][i+1]+(lac/10))/(mxy/100);
yp=a[j]-yrp;
yn=a[j]-yrn;
if(yp<0)
{
yp=(-1)*yp;
}
if(yn<0)
{
yn=(-1)*yn;
}
if(yp>yn)
{
x[j]=yrn;
}
else
```

```
{
x[j]=yrp;
}
outtextxy( x[j], y[j],"*");
ku[j]=4;
ks1[j]=2;
tny=1;
}
}
}
}
line13:
e[j]=a[j];
d[j]=b[j];
a[j]=x[j];
b[j]=y[j];
if(tny==0)
{
ku[j]=1;
ks1[j]=1;
}
else
{
ksx[j]=3;
}
}
}
if(tny==0)
{
outtextxy( x[j], y[j],"*");
}
}
if(y[j]<y2)
{
line11:
int tpy=0;
y[j]++;
```

```
if(ks1[j]==1)
{
mk[j]=((y2-b[j])/(x2-a[j]))*100;
x[j]=a[j]+((y[j]-b[j])/(mk[j]/100));
}
for(si=1;si<=po;si++)
{
for(i=0;i<(2*ni[si]);i++)
{
if(i%2==0)
{
int ky1,kx1,ky2,kx2;
if(fi[si][i+3]>fi[si][i+1])
{
ky1=fi[si][i+3];
ky2=fi[si][i+1];
}
else
{
ky1=fi[si][i+1];
ky2=fi[si][i+3];
}
if(fi[si][i]>fi[si][i+2])
{
kx1=fi[si][i];
kx2=fi[si][i+2];
}
else
{
kx1=fi[si][i+2];
kx2=fi[si][i];
}
int mxy;
if(x[j]>(kx2-10) && x[j]<(kx1+10))
{
if(y[j]>(ky2-10) && y[j]<(ky1+10))
{
```

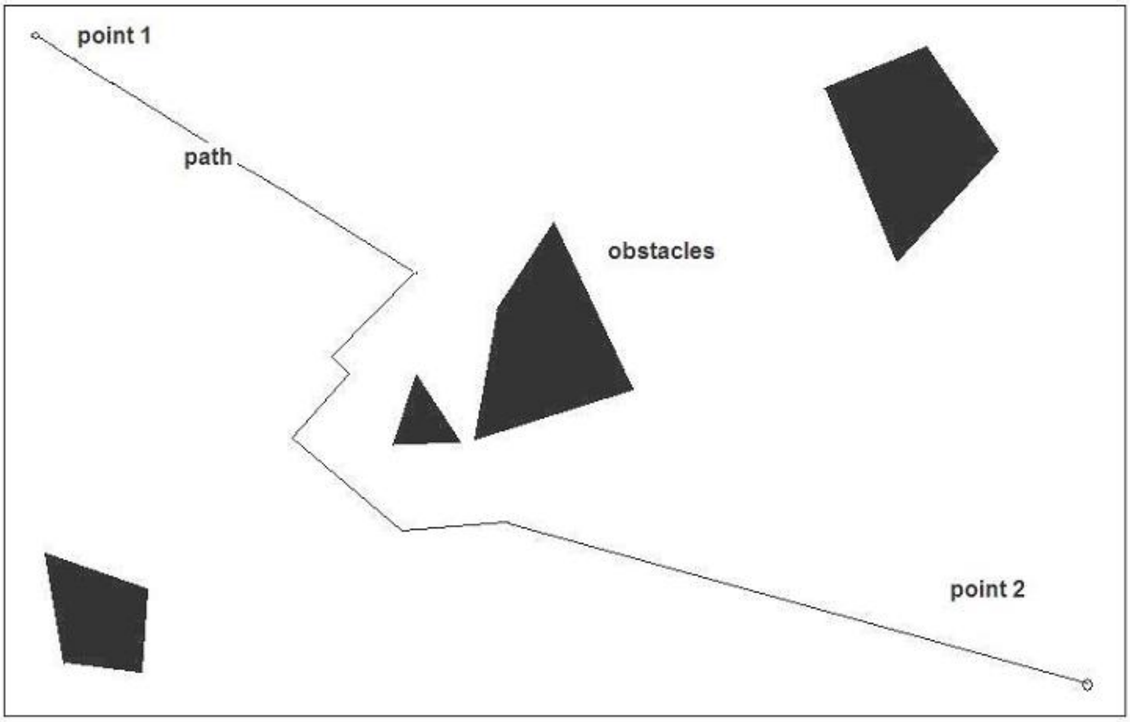
```
bp=fi[si][i+3]-fi[si][i+1];
ap=fi[si][i+2]-fi[si][i];
if(bp==0)
{
int ku[10];
y[j]=b[j];
if(a[j]<e[j])
{
p=-1;
}
if(a[j]>e[j])
{
p=1;
}
x[j]=a[j]+p;
outtextxy(x[j],y[j],"*");
tpy=1;
klc++;
ku[j]=4; ks1[j]=2;
goto line17;
}
if(ap==0)
{
x[j]=a[j];
y[j]=b[j];
outtextxy(x[j],y[j],"*");
ku[j]=4;
klc++;
ks1[j]=2;
tpy=1;
goto line17;
}
mxy= ((fi[si][i+3]-fi[si][i+1])/(fi[si][i+2]-fi[si][i]))*100;
int p;
p=(y[j]-(mxy*(x[j]-fi[si][i])/100)-
fi[si][i+1])/(sqrt(1+(pow((mxy/100),2))));
if(p<10)
```

```
{
lac=100*(sqrt(1+pow(mxy,2)));
yrp=(y[j]+((mxy/100)*fi[si][i])-fi[si][i+1]-(lac/10))/(mxy/100);
yrn=(y[j]+((mxy/100)*fi[si][i])-fi[si][i+1]+(lac/10))/(mxy/100);
yp=a[j]-yrp;
yn=a[j]-yrn;
if(yp<0)
{
yp=(-1)*yp;
}
if(yn<0)
{
yn=(-1)*yn;
}
if(yp>yn)
{
x[j]=yrn;
}
else
{
x[j]=yrp;
}
outtextxy( x[j], y[j],"*");
ku[j]=4;
ks1[j]=2;
tpy=1;
}
}
}
}
line17:
e[j]=a[j];
d[j]=b[j];
a[j]=x[j];
b[j]=y[j];
if(tpy==0)
{
```

```
ku[j]=1;
ks1[j]=1;
}
else
{
ksx[j]=4;
}
}
}
if(tpy==0)
{
outtextxy( x[j], y[j],"*");
}
}
line7:
if(x[j]!=x2 || y[j]!=y2)
{
k2c=1;
}
}
getch();
}
if(k2c==1)
{
goto line14;
}
else
{
goto line15;
}
}
}
line15:
getch();
}
```

3.5 RESULTS

It is found that the robots are successfully avoiding the obstacles and the other robots and follows an optimal path to reach the target point. "point 1" is the starting point and "point 2" is the target point



Chapter 3

CONCLUSION

CONCLUSION:

The program written in C++ for the simulation of path traced by mobile robots works successfully. The diagram shown in the previous pages is the arena where the robot is placed. The robot moves from start point and goes along the path shown in the figure avoiding obstacles to red colour point which is the destination point. When the robot was moving along its path it had some problems to navigate when there exist obstacles more than one. The C++ compiler was a very effective mode because of its fastness and good hardware interfacing.

Applications:

1. This type of system can be used in automobiles for collision free driving.
2. It can also be used handling waste material in nuclear reactions where mobile robots have to perform the work accurately.
3. It can be used in transportation in industries.

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