

Novel Mobile Robot Path planning Algorithm

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Abstract—In this present work we propose a novel mobile robot path planning algorithm. Autonomous robots which work without human operators are required in robotic fields. In order to achieve tasks, autonomous robots have to be intelligent and should decide their own action. When the autonomous robot decides its action, it is necessary to plan optimally depending on their tasks. More, when a robot moves from a point to a target point in its given environment, it is necessary to plan an optimal or feasible path avoiding obstacles in its way and answer to some criterion of autonomy requirements such as : thermal, energy, time, and safety for example. First, we assume that the goal position is unknown. Secondly, only obstacles in the “relevant” area (according to the logical position) are consider, i.e. the obstacles that are far, or in the direction opposite to the movement of the robot are not relevant. In this context, a full range of “main sub_position concepts” for vehicle control have been investigated by the execution of the asked mission. These feasible sub_position works demonstrate that obstacle detection and collision avoidance are improved with good results. While this model has been successful for the path planning problem, it is problematic for robots to react, act, decide, and to take a suitable action “high level reasoning”. Much of the challenge of the mobile robots requires intelligence at subconscious level. In this context, the proposed path planning algorithm provides the robot the possibility to move from the initial position to the final position (target). The results are satisfactory to see the great number of environments treated.

Keywords—Intelligent Autonomous Mobile Robots, Path planning , reaction, decision, behavior.

I. INTRODUCTION

Today, robotic occupies special place in the area interactive technologies. It combines sophisticated computation with rich sensory input in a physical embodiment that can exhibit tangible and expressive behaviour in the physical world. In this regard, a central question that occupies some research group - at -large: “what is an appropriate first role for intelligent human-robot interaction in the daily human environment? The time is ripe to address this question. Robotic technologies are now sufficiency mature to enable interactive, competent robot artefacts to be created.

The study of human-robot interaction, while fruitful in recent year, show great variation both in the duration of interaction and the roles played by human and robot participants. In care where human caregiver provides short-term, nurturing interaction to a robot, research has demonstrated the development of effective social relationships.

Anthropomorphic robot design can help prime such interaction experiment by providing immediately

comprehensible social cues for the human subjects. Technology has made this feasible by using advanced computer control systems. Also, the automotive industry has put much effort in developing perception and control systems to make the vehicle safer and easier to operate.

A robotic body is an intelligent mobile machine capable of autonomous operations in structured and unstructured environment, it must be capable of sensing (perceiving its environment), thinking (planning and reasoning), and acting (moving and manipulating). But, the current mobile robots do relatively little that is recognizable as intelligent thinking.

Autonomous robots which work without human operators are required in robotic fields. In order to achieve tasks, autonomous robots have to be intelligent and should decide their own action. When the autonomous robot decides its action, it is necessary to plan optimally depending on their tasks. More, when a robot moves from a point to a target point in its given environment, it is necessary to plan an optimal or feasible path avoiding obstacles in its way and answer to some criterion of autonomy requirements such as : thermal, energy, time, and safety for example.

When the autonomous robot decides its action, it is necessary to plan optimally depending on their tasks. More, it is necessary to plan a collision free path minimizing a cost such as time, energy and distance. When an autonomous robot moves from a point to a target point in its given environment, it is necessary to plan an optimal or feasible path avoiding obstacles in its way and answer to some criterion of autonomy requirements such as : thermal, energy, time, and safety for example [1, 2, 3].

The robots are compelling not for reasons of mobility but because of their *autonomy*, and so their ability to maintain a sense of position and to navigate without human intervention is paramount. For example, AGV (Autonomous Guided Vehicle) robots autonomously deliver parts between various assembly stations by following special electrical guide wires using a custom sensor. The Helpmate service robot transports food and medication throughout hospitals by tracking the position of ceiling lights, which are manually specified to the robot beforehand. Several companies have developed autonomous cleaning robots, mainly for large buildings. One such cleaning robot is in use at the Paris Metro. Other specialized cleaning robots take advantage of the regular geometric pattern of aisles in supermarkets to facilitate the localization and navigation tasks.

Research into high-level questions of cognition, localization, and navigation can be performed using standard

research robot platforms that are tuned to the laboratory environment. This is one of the largest current markets for mobile robots. Various mobile robot platforms are available for programming, ranging in terms of size and terrain capability. The most popular research robots are those of ActivMedia Robotics.

Although mobile robots have a broad set of applications and markets as summarized above, there is one fact that is true of virtually every successful mobile robot: its design involves the integration of many different bodies of knowledge. No mean feat, this makes mobile robotics as interdisciplinary a field as there can be. To solve locomotion problems, the mobile roboticist must understand mechanism and kinematics; dynamics and control theory.

To create robust perceptual systems, the mobile roboticist must leverage the fields of signal analysis and specialized bodies of knowledge such as computer vision to properly employ a multitude of sensor technologies. Localization and navigation demand knowledge of computer algorithms, information theory, artificial intelligence, and probability Theory.

It is important that algorithms for navigation control in cluttered environments not be too computationally expensive as this would result in a sluggish response. It has been acknowledged that the traditional Plan-Sense-Model-Act approaches are not effective in such environments; instead, local navigation strategies that tightly couple the sensor information to the control actions must be used for the robot to successfully achieve its mission. [4,5]

A robot is a "device" that responds to sensory input by running a program automatically without human intervention. Typically, a robot is endowed with some artificial intelligence so that it can react to different situations it may encounter. The robot is referred to be all bodies that are modeled geometrically and are controllable via a motion plan.

The theory and practice of intelligent autonomous systems are currently among the most intensively studied and promising areas in computer science and engineering which will certainly play a primary goal role in future. These theories and applications provide a source linking all fields in which intelligent control plays a dominant role. Cognition, perception, action, and learning are essential components of such-systems and their use is tending extensively towards challenging applications (service robots, micro-robots, bio-robots, guard robots, warehousing robots).

The study of human-robot interaction, while fruitful in recent year, show great variation both in the duration of interaction and the roles played by human and robot participants. In care where human caregiver provides short-term, nurturing interaction to a robot, research has demonstrated the development of effective social relationships. Anthropomorphic robot design can help prime such interaction experiment by providing immediately comprehensible social cues for the human subjects.

Technology has made this feasible by using advanced computer control systems. Also, the automotive industry has put much effort in developing perception and control systems to make the vehicle safer and easier to operate. To perform all tasks in different environments, the vehicle must be characterized by more sever limits regarding mass volume, power consumption, autonomous reactions capabilities and design complexity. Particularly, for planetary operations sever constraints arise from available energy and data transmission capacities, e.g., the vehicles are usually designed as autonomous units with: data transfer via radio modems to rely stations (satellite in orbit or fixed surface stations) and power from solar arrays, batteries or radio-isotope thermo electric generators (for larger vehicles). A common application of mobile robot is the object manipulation. Examples include pick and place operation on the factory floor, package sorting and distribution.

Some researchers are interesting in the simplest kind of object manipulation i.e. pushing. Pushing is the problem of changing the pose of an object by imparting a point contact force to it. For the simplicity, they constrain their self to the problem of changing the pose (in a horizontal plane). An early approach to robot pushing was implemented with two wheeled, cylindrical robots equipped with tactile sensors which implemented object reorientation and object translation. The strategy was to use two robots to push the object at its diagonally opposite corner. As a result of this off-center pushing a torque is applied to the box, rotating it roughly in place.

This problem is addressed to detect and push stationary objects in a planar environment by using an environment-embedded sensor network and a simple mobile robot. The stationary sensors are used to detect push able objects. This way illustrates how the robot box-pushing with environment embedded Sensors. On the other direction, the teleoperation is very important and it is the way which is always studied to propose a good navigation. Teleoperation is often employed in controlling mobile robots navigating in unknown environment and unstructured environment. This is largely because teleoperation makes use of the sophisticated cognitive capabilities of the human operator.

However, for navigation in dynamic environments or high-speeds, it is often desirable to provide a sensor-based collision avoidance scheme; it would be difficult for the (remote) operator to prevent the robot from colliding with obstacles. This is primarily due to: limited information from the robot's sensors, such as images within a restricted viewing angle without depth information, which is insufficient for the users full perception of the environment in which the robot moves, and significant delay in the communication channel between the operator and the robot.

II. MOTION PLANNING

A robot is a "device" that responds to sensory input by running a program automatically without human intervention. Typically, a robot is endowed with some artificial intelligence so that it can react to different situations it may encounter. The robot is referred to be all bodies that are modeled geometrically and are controllable via a motion plan. A robotic vehicle is an intelligent mobile machine capable of autonomous operations in structured and unstructured environments.

The main focus idea is to be capable of sensing thinking and acting. The mobile robot is an appropriate tool for investigating optional artificial intelligence problems relating to world understanding and taking a suitable action, such as , planning missions, avoiding obstacles, and fusing data from many sources.

The path planning problem is in its most general form any problem consists of four descriptions:

The first description

The first description is designed to the geometry of the robot sometimes as unit mass moving (in some research works) to take the simplified physical part. Otherwise, this designation describes the geometry of the robot (if it is possible).

The second description

This description presents the structure of the environment (workspace) in which the robot reacts, navigates and acts. It is very important to know which environments that the navigation approach deals and sometimes call to construct the map building.

The third description

A description of the degrees of freedom of the robot's motion. The simplest instance of the path planning problem is finding a path for a *point* robot in a two-dimensional static environment. In most cases, it is assumed that the geometry of the workspace obstacles is given using some models and strategies of previous work such as: a polygonal representation, a straightforward approach, the *visibility graph* method, etc.

Motion planning will frequently refer to motions of a robot in a 2D or 3D world that contains obstacles. The robot could model an actual robot, or any other collection of moving bodies, such as humans or flexible molecules. A motion plan involves determining what motions are appropriate for the robot so that it reaches a goal state without colliding into obstacles. When the autonomous robot decides its action, it is necessary to plan optimally depending on their tasks especially if it is a 3D environments complexity.

To plan 3D collision free path is to find the capability to operate independently in unknown or partially known 3D environments complexity. The autonomy implies that the robot is capable of reacting to static 3D obstacles and unpredictable

dynamic 3D events that may impede the successful execution of a task. To achieve this level of robustness, methods need to be developed to provide solutions to localization, map building, planning and control.

Moreover, when a robot moves in a 3D specific space, it is necessary to select a most reasonable 3D path so as to avoid collisions with obstacles. Several approaches for path planning exist for mobile robots, whose suitability depends on a particular problem in an application.

2D, 3D or higher n -dimensional configuration spaces is can explicitly be constructed in more or less the same way as any standard configuration just to deal with the n parametric dimensional description of the environments which are necessary to define the degrees of freedom of the robot's motion.

The fourth description

The last description needs to define a source and a target configuration in the environment, between which a path is to be planned for the robot.

For the four descriptions cited before, it is clear that if the robot is not just a point, but a dimensional geometric object, the problem becomes harder, as the configuration space is no longer equal to the workspace. Let us assume that the robot can only translate in a two-dimensional workspace, then, a configuration of the robot is defined as the position of a certain *reference point* on the robot in the workspace.

Now, it may very well be possible that for some configuration the reference point is in the free workspace, yet some other point on the robot is not. Hence, the configuration is forbidden. This makes that the obstacles in the configuration space are different from the obstacles in the workspace.

The configuration space obstacles can still be constructed explicitly, by taking the *Minkowski sum* of the workspace obstacles with the robot reflected in its reference point. This takes $O(n \log n)$ time using a randomized algorithm if the robot is convex and has constant complexity . In the configuration space, the robot can then be treated as a point, and either some methods can be used.

For a translating robot in a three-dimensional workspace, the configuration space is also three-dimensional and can explicitly be constructed in more or less the same way as two – dimensional workspace methods but just introducing the 3D parameters of conception. A few advanced researches have been addressed to the problem of 3D navigation where the problem is focused how to pass from 2D to 3D concept.

A 3D efficient navigation of mobile platforms in dynamic human-centered environments is done with 3D principle. In Summary, the key is focused on 3D geometrical surfaces or in 3D map knowledge. For each one, the scientists solve the 3D problem which sometimes can be reduced to a problem of two dimensions by projecting the objects on the plan containing obstacles.

Topological path planning is useful for the creation of long – distance paths, which support the navigation for solving a task. Therefore, those nodes representing for example, free

region space are extracted from a topological map, which connect a start point with a target point. The start point is mostly the actual position of the robot. To generate the path, several sophisticated and classical algorithms exist that are based on graph theory like the algorithm; of the shortest path. To give best support for the path planning it could be helpful to use different abstraction levels for topological maps. For example, if the robot enters a particular room; of an employee for postal delivery, the robot must use a topological map that contains the doors of an office building and the room numbers.

Topological maps can be used to solve abstract tasks, for example, to go and retrieve objects whose positions are not exactly known because the locations of the objects are often changed. Topological maps are graphs whose nodes represent static objects like rooms, and doors for example. The edges between the nodes is part's relationships between the objects. For example, an abstract task formulated.

The navigation planning is one of the most vital aspect of an autonomous robot. Navigation is the science (or art) of directing the course of a mobile robot as the robot traverses the environment. Inherent in any navigation scheme is the desire to reach a destination without getting lost or crashing into any objects. The goal of the navigation system of mobile robots is to move the robot to a named place in a known, unknown, or partially known environment [6, 7, 8].

In most practical situations, the mobile robot can not take the most direct path from start to the goal point. So, path finding techniques must be used in these situations, and the simplest kinds of planning mission involve going from the start point to the goal point while minimizing some cost such as time spent, chance of detection, etc. When the robot actually starts to travel along a planned path, it may find that there are obstacles along the path, hence the robot must avoid these obstacles and plans a new path to achieve the task of navigation.

Several approaches for path planning exist for mobile robots, whose suitability depends on a particular problem in an application. For example, behavior-based reactive methods are good choice for robust collision avoidance. Path planning in spatial representation often requires the integration of several approaches. This can provide efficient, accurate, and consist navigation of a mobile robot. It is sufficient for the robot to use a topological map that represents only the areas of navigation (free areas , occupied areas of obstacles). It is essential the robot has the ability to build and uses models of its environment, that enable it to understand the environment's structure. This is necessary to understand orders, plan and execute paths. Path planning in spatial representation often requires the integration of several approaches.

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structure. This is necessary to understand orders, plan and execute paths [9, 10, 11,12, 13, 14].

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A robotic vehicle is an intelligent mobile machine capable of autonomous operations in structured and unstructured environment, it must be capable of sensing (perceiving its environment), thinking (planning and reasoning), and acting (moving and manipulating). But, the current mobile robots do relatively little that is recognizable as intelligent thinking, this is because: Perception does not meet the necessary standards, much of the intelligence is tied up in task specific behavior and has more to do with particular devices and missions than with the mobile robots in general.

This paper deals with the intelligent path planning of autonomous mobile robot in an unknown environment. The aim of this paper is to develop an algorithm for the stationary obstacle avoidance to provide them more autonomy and intelligence. A robotic vehicle is an intelligent mobile machine capable of autonomous operation in structured and unstructured environment, it must be able of sensing (perceiving its environment) thinking (planning, reasoning) and acting (moving and manipulating).

III. THE PROPOSED PATH PLANNING

Assume that path planning is considered in a rectangular terrain and a path between two locations is approximated with a sequence of adjacent cells in the grid corresponding to the terrain. We denote that the configuration grid is a representation of the configuration space. In the configuration grid starting from any location to attend another one, cells are thus belonging to reachable or unreachable path.

Note that the set of reachable sub_positions is a subset of the set of free configuration cells, the set of unreachable cell is a subset of the set of occupied configuration cells. By selecting a goal that lies within reachable space, we ensure that it will not be in collision and it exists some "feasible path" such that the goal is reached in the environment. Having determined the reachability space, the algorithm works and operates on the reachability grid. This one specifies at the end the target area.

A hidden grid of (x,y) dimension of free path is denoted by "X," an occupy hidden grid of (x',y') is denoted by "Y" . A hidden grid concept is very useful to check all the neighbor positions. This is as a center program data from which we test and valid the building map. An obstacle is collection of hazardous cells in the "Y" *hidden grid* .A path from start cell "C" to destination cell "D" that the detected color of "X" does not interest any detected color "Y". The path is said to be

monotone of free cells "X" with respect to x-coordinates if no lines parallel to y'-axis cross the y-axis (see figure 1).

The proposed algorithm here relies on number of cells and iterates, as follows :

Algorithm Path Planning

Begin

- * "x" by "y" grid, start cell a in the grid.
- * Select and Detect free destination in the grid (free Cells.
- * Five the dangerous area of walking (hazardous occupied cells area) this is denoted by "obstacle positions".
- * A path from "C" to "D" such that the total of neighboring cells is detected free.

- * If the collection of free cells is continuous, detect all neighboring on the same destination until the target is reached.
- * If the collection of free cells is discontinuous, change the direction and continue on another free continuous collection of cells.
- * Stop when the target cell position is detected.

END.

To maintain the idea ; we have created several environments which contain many obstacles. The search area (environment) is divided into square grids. Each item in the array represents one of the squares on the grid, and its status is recorded as walkable or unwalkable area (obstacle)

The robot starts from any position then it must move by sensing and avoiding the obstacles. The trajectory is designed in form of a grid-map, when it moves it must verify the adjacent case by avoiding the obstacle that can meet to reach the target. We use an algorithm containing the information about the target position, and the robot will move accordingly.

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To determine the nature of space of navigation, and as we have illustrated before, cells are marked as either free or occupied; otherwise unknown. We can therefore divide our search area into free and occupied area. note that all free space cells represent the walkable space and unwalkable in occupied space. Each free cell is able of lying all the neighbor free cell within a certain distance "d". This distance "d" is usually set to a value greater than or equal to the size of cell. Note that the set of free cells is a subset of the of free cells, which is in turn a subset of the set of free occupancy cells (see the figure2).

The basic path planning problem deals with *static* environments, that is, workspaces solely containing stationary

obstacles . The simplest instance of the path planning problem is finding a path for a *point* robot in a two-dimensional static environment. In most cases, it is assumed that the geometry of the workspace obstacles. Let us assume that the robot can only translate in a two-dimensional workspace, then, a configuration of the robot is defined as the position of a certain *reference point* on the robot in the workspace.

Now, it may very well be possible that for some configuration the reference point is in the free workspace, yet some other point on the robot is not. Translation a robot, A Region is translated by using two parameters, xt, yt belonging to R. the delta_moving is given by $\Delta = (xt, yt)$, and F is defined as the total of visited cells and given by :

$$F(x, y) = (x + xt, y + yt) \tag{1}$$

The translated robot is denoted as A(xt, yt). Translation by (0, 0) is the identity transformation, which results in A(0, 0) = A. Suppose that A is defined directly in $W_{orld\ translation}$ with translation. Each cell point (xi, yi), in the sequence is replaced by (xi + xt, yi + yt).

Note that here we determine the free resultant cells within free space to get a feasible path during navigation. For unwalkable space (occupied space) we just develop a procedure of avoiding danger.

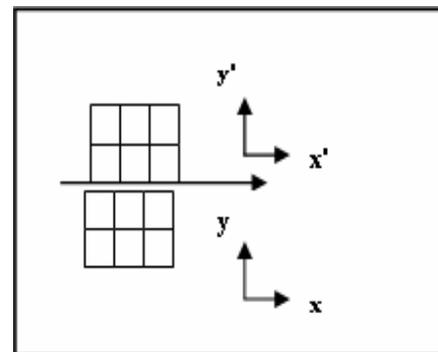


Fig. 1 an example of no intersecting in unknown environment

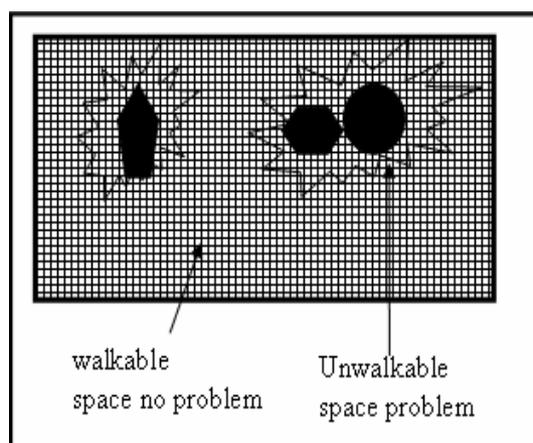


Fig. 2 an example of walkable space and walkable space of

IV. SIMULATION RESULTS

To design a software program, two elements must be taken into consideration: the first one is the structure of the program i.e. the flowchart, and the second is the language in which the program will be written.

The goal of the navigation process of mobile robots is to move the robot to a named place in a known, unknown or partially known environment. In most practical situations, the mobile robot can not take the most direct path from the start to the goal point. So, path planning techniques must be used in this situation, and the simplified kinds of planning mission involve going from the start point to the goal point while minimizing some cost such as time spent, chance of detection, or fuel consumption.

The major task for path-planning for single mobile robot is to search a collision-free path. The work in path planning has led into issues of map representation for a real world. Therefore, this problem considered as one of challenges in the field of mobile robots because of its direct effect for having a simple and computationally efficient path planning strategy.

The navigation planning is one of the most vital aspects of an autonomous robot. When the robot actually starts to travel along a planned path, it may find that there are obstacles along the path, hence the robot must avoid these obstacles and plans a new path to achieve the task of navigation.

In order to evaluate, the average performance of our approach over various environments, we observed simulation of the proposed algorithm for great number of environments. We can change the position of obstacles so we get other different environments. These environments were randomly generated.

To maintain the idea; we have created several environments which contain many obstacles. The search area (environment) is divided into reachable (free area) and unreachable area (containing hazardous obstacles); this one specifies at the end the target. Note that here; as it is mentioned before, that the grid model used here is hidden and the robot navigates through the sub_positions which are belonging to the hidden cells.

The robot starts from any position then using our algorithm learning must move and attends its target. Note that the set of reachable sub_positions is a subset of the set of free configuration sub_positions, the set of unreachable cell is a subset of the set of occupied configuration cells. By selecting a goal that lies within reachable space, we ensure that it will not be in collision.

For unwalkable space, we compute the total size of free cells around danger (obstacle) area. This total may be at least greater or equal than to the length of architecture of robot. This is ensure the safety to our robot to not be in collision with the obstacle, and that the path P has enough security SE to attend it target where it is given by $P \pm SE$ (S is size of security). For walkable space the robot reaches its target carefully.

By selecting a goal that lies within reachable space. we ensure that it will not be in collision and it exists some "feasible path" such that the goal is reached in the environment. Having determined the reachability space, the algorithm works and operates on the reachability workspace. This one specifies at the end the target area.

As an example: the environment set up is shown in the figure 3. The path is found by figuring all the suppositions of the feasible path.

Once the path is found, the robot moves from one sub_position to the next until the target is reached, once we have simplified our search area into a convenient number of sub_positions. The next step is to conduct a search to find the path. We do this by starting point, checking the adjacent sub_position, and training until we find our target. We start the search by the following steps: we have selected the starting position; it moves forward as shown above in figure 4.

The robot meets an obstacle, it moves a step down then back until it meets an obstacle. The robot keeps navigation in this manner until the target is found, as shown in figure 5.

Checking and searching the adjacent supposition is in another term, the key of building a feasible path. Generally searching outward until we find our target. As shown in the figure 6 another environment set up, the robot meets two obstacles; it moves and avoids the first obstacle, repeating with the same way to the second obstacle. The robot keeps navigation in this manner until the target is found, as shown in figure 7, figure 8, figure 9, figure 10 and figure 11 where the robot closes to the target.

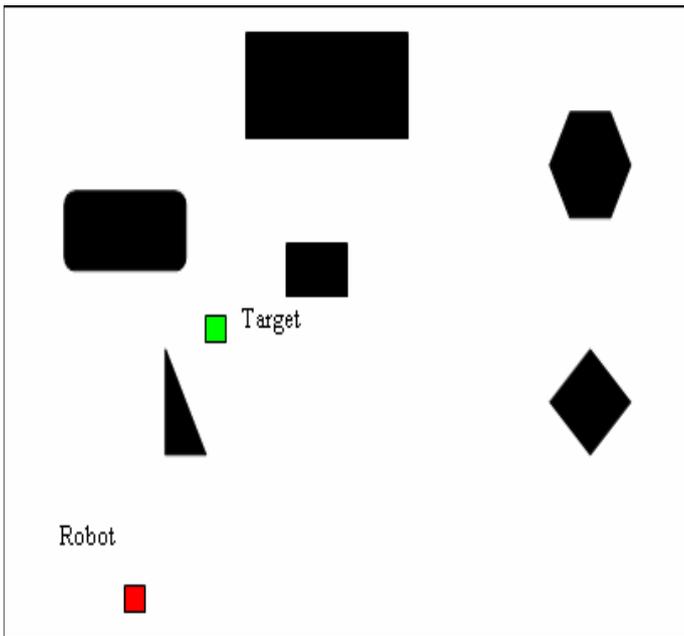


Fig. 3 assumed initial environment set up1.

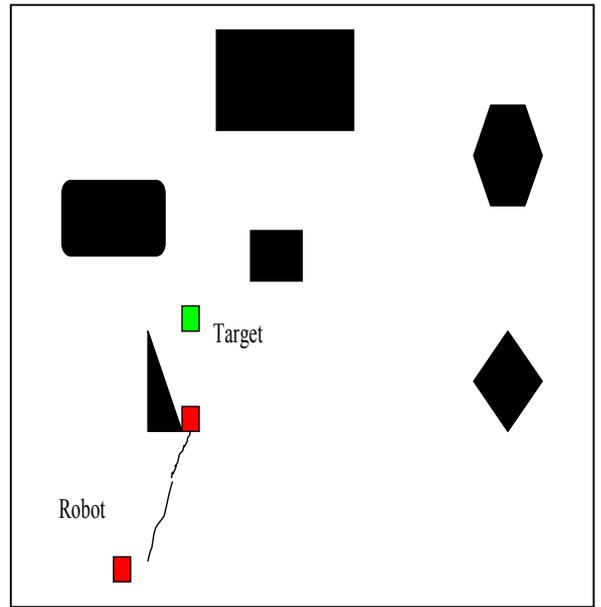


Fig. 5 assumed intermediate condition and avoiding the first obstacle environment set up1.

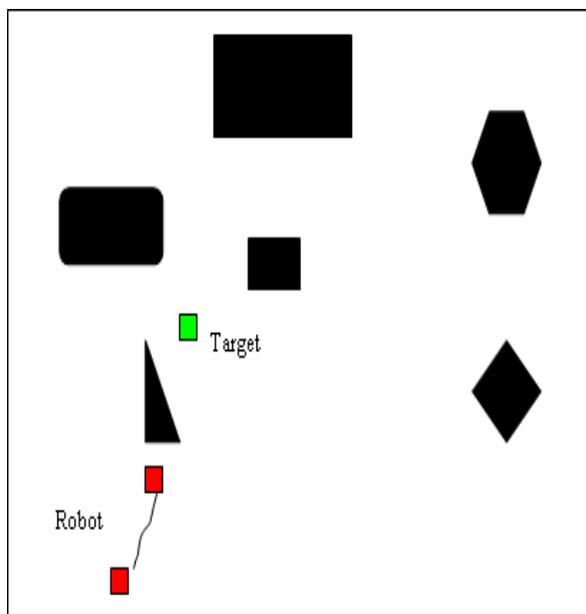


Fig. 4 assumed middle way environment set up1.

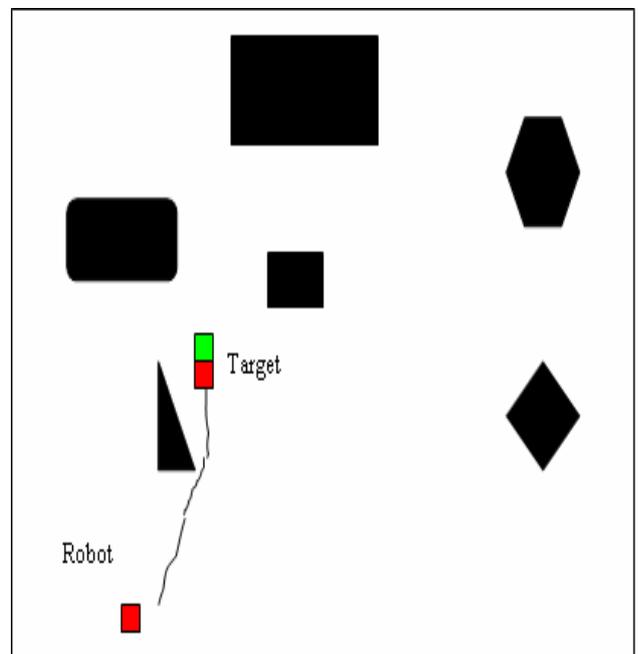


Fig. 6 The robot approaches the target

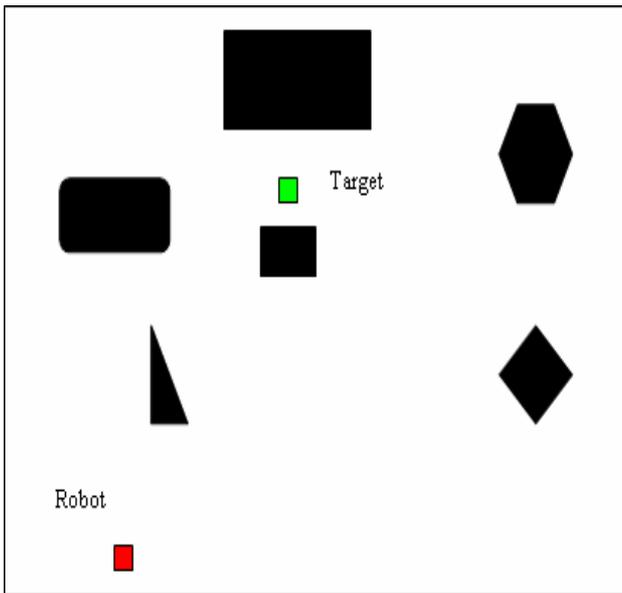


Fig. 7 assumed initial environment set up2.

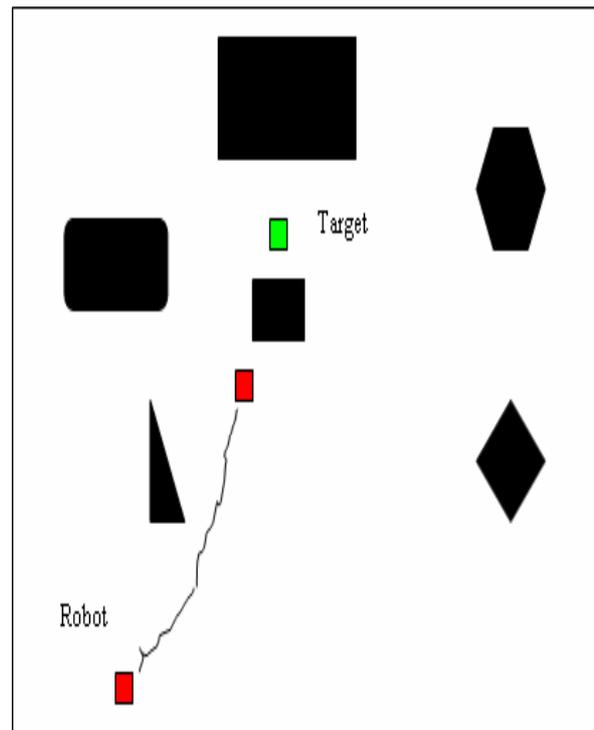


Fig. 9 assumed middle way "avoiding the first obstacle" environment set up2.

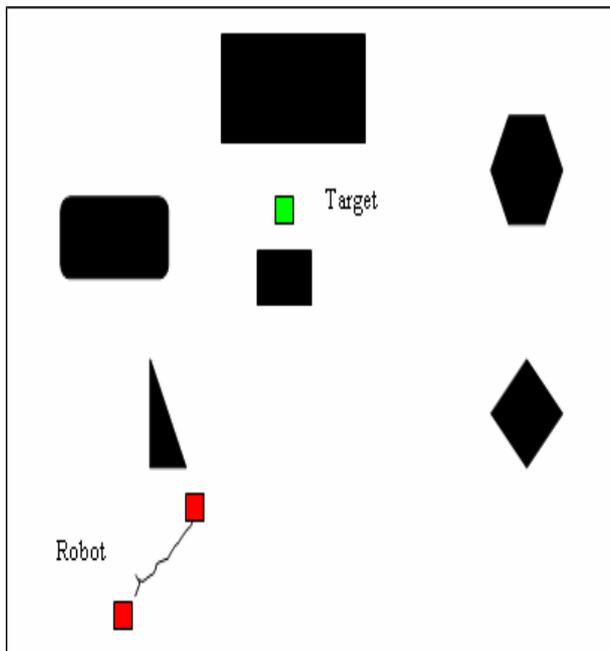


Fig. 8 assumed intermediate condition environment set up2.

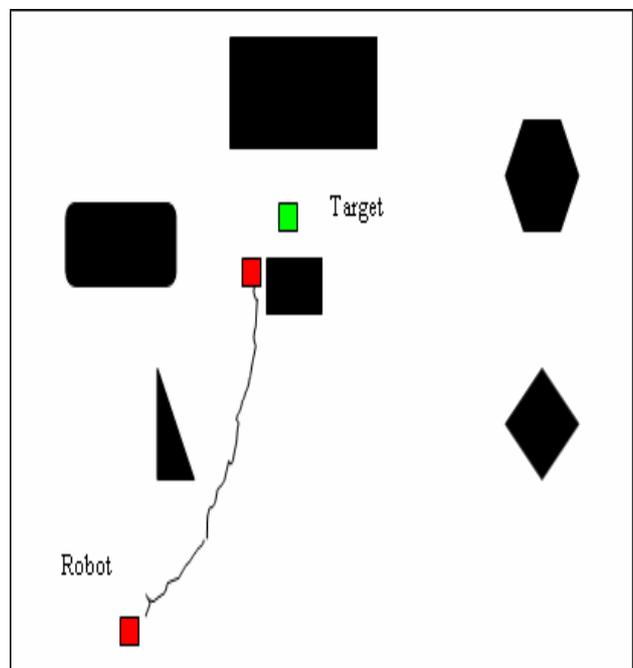


Fig. 10 assumed "avoiding the second obstacle" environment set up2.

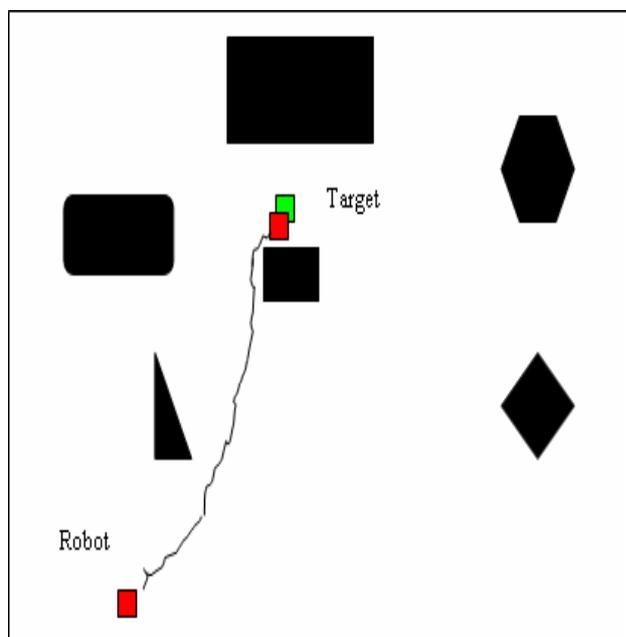


Fig. 11 The robot approaches and closes to the target..

V. CONCLUSION

This aim work has demonstrated the basic features of navigation of an autonomous mobile robot simulation. The major task for path-planning for single mobile robot is to search a collision-free path. The work in path planning has led into issues of map representation for a real world. Therefore, this problem considered as one of challenges in the field of mobile robots because of its direct effect for having a simple and computationally efficient path planning strategy. obstacles, and finding the path in order to reach a specified target.

The navigation planning is one of the most vital aspect of an autonomous robot. In most practical situations, the mobile robot can not take the most direct path from start to the goal point. So, path finding techniques must be used in these situations, and the simplest kinds of planning mission involve going from the start point to the goal point while minimizing some cost such as time spent, chance of detection, etc

In this context, we propose an algorithm that provides the robot a trajectory to be followed to move from the initial position to the specified target. The robot trajectory is designed in an unknown environment set up with static obstacles. The robot moves within the unknown environments by sensing and avoiding the obstacles coming across its way towards the target.

First, we assume that the goal position is unknown. Secondly, only obstacles in the “relevant” area (according to the logical position) are consider, i.e. the obstacles that are far, or in the direction opposite to the movement of the robot are not relevant. In this context, a full range of “main sub_position concepts “for vehicle control have been investigated by the execution of the asked mission.

This path planning approach has an advantage of adaptivity such that the robot approach works perfectly even if an environment is unknown. This proposed approach has made the robot able to achieve these tasks: avoid obstacles, deciding, perception, and recognition and to attend the target which are the main factors to be realized of autonomy requirements. Hence; the results are promising for next future work of this domain

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