World understanding and planning missions

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***Abstract*—**In this paper, we present an intelligent control of an autonomous mobile robot in unknown environments. When an autonomous robot moves from an initial 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. Therefore, the major main work for path planning for autonomous mobile robot is to search a collision free path. . A key prerequisite for a truly autonomous robot is that it can navigate safely within its environment and executing the task without doubt. The problem of achieving this mobility is one of the most active areas in mobile robotics research. When the mission is executed, it is necessary to plan an optimal or feasible path for itself avoiding obstructions in its way and minimizing a cost such as time, energy, and distance. In order to get an intelligent component, the proposed approach based on intelligent computing offers to the autonomous mobile system the ability to realize these factors: recognition, learning, decision-making, and action (the principle obstacle avoidance problems) which are the main factors to be considered in any design of navigation approach. The acquisition of these faculties constitutes the key of a certain kind of intelligence. Building this kind of intelligence is, up to now, a human ambition in the design and development of intelligent vehicles. However, the mobile robot is an appropriate tool for investing 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. In this context we discuss this ability by proposing this approach. The results are promising for next developments.

***Keywords*—** Autonomous Mobile Robot , Navigation, Obstacle avoidance, Planning missions, World understanding.

I. Introduction

Robotics has achieved its greatest success to date in the world of industrial manufacturing.

A fixed manipulator has a limited range of motion that depends on where it is bolted down. In contrast, a mobile robot would be able to travel throughout the manufacturing plant, flexibly applying its talents wherever it is most effective. Mobile robotics is a large field, From mechanism and perception to localization and navigation, this one focuses on the techniques and technologies that enable robust *mobility*.

The question of architecture is of paramount importance when one chooses to address the higher-level competences of a mobile robot: how does a mobile robot navigate robustly from place to place, interpreting data, localizing and controlling its motion all the while? For this highest level of robot competence, which we term *navigation competence*, there are numerous mobile robots that showcase particular architectural strategies.

In the artificial intelligence community planning and reacting are often viewed as contrary approaches or even opposites. In fact, when applied to physical systems such as mobile robots, planning and reacting have a strong complementarity, each being critical to the other's success.

The navigation challenge for a robot involves executing a course of action (or plan) to reach its goal position. During execution, the robot must react to unforeseen events (e.g., obstacles) in such a way as to still reach the goal. Without reacting, the planning effort will not pay off because the robot will never physically reach its goal. Without planning, the reacting effort cannot guide the overall robot behavior to reach a distant goal again, the robot will never reach its goal.

In order to reach its goal nonetheless, the robot must incorporate new information gained during plan execution. As time marches forward, the environment changes and the robot's sensors gather new information. This is precisely where reacting becomes relevant.

In the best of cases, reacting will modulate robot behavior locally in order to correct the planned upon trajectory so that the robot still reaches the goal. At times, unanticipated new information will require changes to the robot's strategic plans, and so ideally the planner also incorporates new information as that new information is received.

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.

Robot programming is the mean by which a robot is instructed to perform it task .The guiding for example, is the process of moving a robot trough a sequence of motion to "*show it*" what it must do. One guidance method is to physically drag around the end effectors of the robot, while it records joint position at frequent intervals along the trajectory. The robot then plays back the motion just as it was recorded. An alternative is a master-slave or teleoperation configuration.

Early systems of this type were first used or manipulate radioactive material remotely.

Teloperator techniques are now employed to guide the space shuttle manipulator. Guiding may also be applied using a *teach pendant*; which is a box keys that are used to command the robot. Several modes of operation are often available on the each pendant. Guiding is limited as a robot-programming technique, because it does not provide conditionality or iteration. Some systems provide called extended guiding capability that include teaching in a coordinate system that may be moved at run-time and conditional branching between motion sequence.

Robot programs must command robots to move: thus, the way in which motion is specified is important. Also, the program use information obtained from sensors. One way of using sensory information is to monitor sensor until prescribed condition occur and then perform or terminate a specified action is to use feedback from sensors to modify the robots behaviour continuously. A different approach is used to describe the behaviour of the system in terms of relationships that are to be maintained with respect to force, velocity, position, and another measured and controlled quantities.

Classical artificial intelligence systems presuppose that all knowledge is stored in a central database of logical assertions or other symbolic representation and that reasoning consist largely of searching and sequentially updating that database. While this model has been successful for disembodied reasoning system, it is problematic for robots.

Robots are distributed systems; multiple sensory, reasoning, and motor control processes run in parallel, often on separate processor hate rate only loosely coupled with one another. Each of these procure necessarily maintains its own separate, limited representation of the world and task; requiring them to constantly synchronize with the central knowledge base is probably unrealistic. Automated reasoning systems are typically built on a transaction-oriented model of computation .knowledge of the world is stored in a database of assertion in some logical language, indexed perhaps by predicate name.

This paper presents a novel approach based on intelligent computing which offers to the autonomous mobile system the ability to realize these factors: recognition, learning, decision-making, and action (the principle obstacle avoidance problems). The main details of concept are clarified. The results are promising for nest development.

II. PATH PLANNING

Even before the advent of affordable mobile robots, the field of path-planning was heavily studied because of its applications in the area of industrial manipulator robotics. Interestingly, the path planning problem for a manipulator with, for instance, six degrees of freedom is far more complex than that of a differential-drive robot operating in a flat environment.

Therefore, although we can take inspiration from the techniques invented for manipulation, the path-planning algorithms used by mobile robots tend to be simpler approximations owing to the greatly reduced degrees of freedom.

Furthermore, industrial robots often operate at the fastest possible speed because of the economic impact of high throughput on a factory line. So, the dynamics and not just the kinematics of their motions are significant, further complicating path planning and execution. In contrast, a number of mobile robots operate at such low speeds that dynamics are rarely considered during path planning, further simplifying the mobile robot instantiation of the problem.

Path planning plays an important role in various fields of application and research, among which are CAD-design, computer games and virtual environments, molecular biology, and robotics. However, the environment complexity is a specific problem to solve since this environment can be imprecise, vast, dynamical and partially or not structured. Robots must then be able to understand the structure of this environment. To reach the goal without collisions, these robots must be endowed with perception, data processing, recognition, learning, reasoning, interpreting, decision-making, and actions capacities.

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. For path planning areas, it is sufficient for the robot to use a topological map that represents only the different areas without details such as office rooms.

The possibility to use topological maps with different abstraction levels helps to save processing time. The static aspect of topological maps enables rather the creation of paths without information that is relevant at runtime. The created schedule, which is based on a topological map, holds nothing about objects which occupy the path. In that case it is not possible to perform the schedule. To get further actual information, the schedule should be enriched by the use of more up-to date plans like egocentric maps.

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.

Often, a path is planned off-line for the robot to follow, which can lead the robot to its destination assuming that the environment is perfectly known and stationary and the robot can rack perfectly. Early path planners were such off-line planners or were only suitable for such off-line planning.

However, the limitations of off-line planning led researchers to study on-line planning, which relies on knowledge acquired from sensing the local environment to handle unknown obstacles as the robot traverses the environment.

One of the key issues in the design of an autonomous robot is navigation, for which, the navigation planning is one of the most vital aspect of an autonomous robot. Therefore, the space and how it is represented play a primary role in any problem solution in the domain of mobile robots because it is essential that the mobile robot has the ability to build and use models of its environment that enable it to understand the scene navigation's structure. This is necessary to understand orders, plan and execute paths.

Moreover, when a robot moves in a specific space, it is necessary to select a most reasonable 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. 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 consistent navigation of a mobile robot.

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. 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.

Systems that control the navigation of a mobile robot are based on several paradigms. Biologically motivated applications, for example, adopt the assumed behavior of animals. Geometric representations use geometrical elements like rectangles, polygons, and cylinders for the modeling of an environment. Also, systems for mobile robot exist that do not use a representation of their environment. The behavior of the robot is determined by the sensor data actually taken. Further approaches were introduced which use icons to represent the environment.

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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.

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In mobile robot applications where the robot operates in a completely static environment using a route-based navigation system, it is conceivable that the number of discrete goal positions is so small that the environmental representation can directly contain paths to all desired goal points. For example, in factory or warehouse settings, a robot may travel a single looping route by following a buried guidewire. In such industrial applications, path-planning systems are sometimes altogether unnecessary when a precompiled set of route-based solutions can be easily generated by the robot programmers.

The fundamental information-theoretic disadvantage of planning off-line is that, during run-time, the robot is sure to encounter perceptual inputs that provide information, and it would be rational to take this additional information into account during subsequent execution. Episodic planning is the most popular method in mobile robot navigation today because it solves this problem in a computationally tractable manner.

A. Path and trajectory considerations

In mobile robotics, we care not only about the robot's ability to reach the required final configurations but also about how it gets there. Consider the issue of a robot's ability to follow paths: in the best case, a robot should be able to trace any path through its workspace of poses.

Clearly, any omnidirectional robot can do this because it is holonomic in a three dimensional workspace. Unfortunately, omnidirectional robots must use unconstrained wheels, limiting the choice of wheels to Swedish wheels, castor wheels, and spherical wheels. These wheels have not yet been incorporated into designs allowing far larger amounts of ground clearance and suspensions.

Although powerful from a path space point of view, they are thus much less common than fixed and steerable standard wheels, mainly because their design and fabrication are somewhat complex and expensive.

Additionally, nonholonomic constraints might drastically improve stability of movements. Consider an omnidirectional vehicle driving at high speed on a curve with constant diameter.

During such a movement the vehicle will be exposed to a non-negligible centripetal force. This lateral force pushing the vehicle out of the curve has to be counteracted by the motor torque of the omnidirectional wheels. In case of motor or control failure, the vehicle will be thrown out of the curve. However, for a car-like robot with kinematic constraints, the lateral forces are passively counteracted through the sliding constraints, mitigating the demands on motor torque.

But recall an earlier example of high maneuverability using standard wheels: the bicycle on which both wheels are steerable, often called the *two-steer.*

Furthermore, mobile roboticists will often plan under the further assumption that the robot is simply a *point*. Thus we can further reduce the configuration space for mobile robot path planning to a 2D representation with just - and -axes. The result of all this simplification is that the configuration space looks essentially identical to a 2D (i.e., flat) version of the physical space, with one important difference. Because we have reduced the robot to a point, we must inflate each obstacle by the size of the robot's radius to compensate. With this new, simplified configuration space in mind, we can now introduce common techniques for mobile robot path planning.

B. Navigation

Navigation is the ability to move and on being self-sufficient. The autonomous mobile ,robots must be able to achieve these tasks: to avoid obstacles, and to make one way towards their target. In fact, recognition, learning, decision-making, and action constitute principal problem of the navigation.

One of the specific characteristic of mobile robot is the complexity of their environment. Therefore, one of the critical problems for the mobile robots is path planning, which is still an open one to be studying extensively. Accordingly, one of the key issues in the design of an autonomous robot is navigation, for which, the navigation planning is one of the most vital aspect of an autonomous robot.

In mobile robotics, we often assume the independence of random variables even when this assumption is not strictly true. The simplification that results makes a number of the existing mobile robot-mapping and navigation algorithms tenable.

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.

Several models have been applied for environment where the principle of navigation is applied to do path planning. For example, a grid model has been adopted by many researchers, where the robot environment is dividing into many line squares and indicated to the presence of an object or not in each square.

On line encountered unknown obstacle are modeled by piece of "wall", where each piece of "wall" is a straight-line and represented by the list of its two end points. This representation is consistent with the representation of known objects, while it also accommodates the fact the only partial information about an unknown obstacle can be obtained from sensing at a particular location.

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.

For any starting point within the environment representing the initial position of the mobile robot, the shortest path to the goal is traced. The algorithm described here therefore is to develop a method for path planning by using simple and computationally efficient-way to solve path planning problem in an unknown environment without consuming time, lose energy, un-safety of the robot architecture.

The use of autonomous robots can provide significant benefits in the surveillance field. Robots can be used to reduce the risk involved with human physical intervention, especially in hazardous environments. They can approach the locations of interest to report sensory data and to show more detailed views of a suspicious area. Moreover they can perform long-time tedious tasks that require reliable execution, without lowering their level of efficiency. In recent years there has been a number of projects dealing with the problems involved in the use of autonomous robot to enhance a surveillance system.

Some works focus on surveillance algorithms and path planning during the patrolling task. Others deal with navigation and localization problems. An important challenge in robotics is path planning in dynamic environments. That is, planning a path for a robot from a start location to a goal location that avoids collisions with the moving obstacles. In many cases the motions of the moving obstacles are not known beforehand, so often their future trajectories are estimated by extrapolating current velocities (acquired by sensors) in order to plan a path .

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. In the figure 1 we present one example of navigation approach using a square cellule grid for the movement.

For unwalkable space, we compute the total size of free cells around danger (obstacle) area. This total may be at least 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±SE (S is size of security). In principle, we generate a plan for reaching safety area for every neighboring danger area. The safety distance is generated to construct the safety area building to the navigation process, to be near without collision within this one

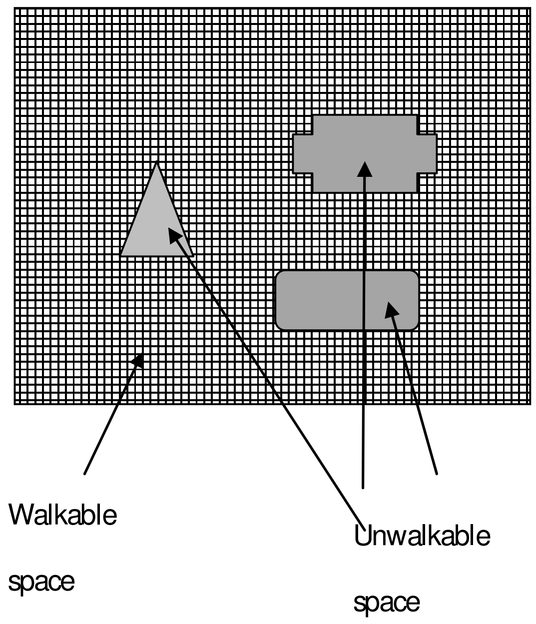

Fig. 1 an example of walkable space and walkable space

Another example is presented in the figure 2 to find an optimal path to navigate intelligibly avoiding the obstacles. This example shows the way on which the scene of navigation is decomposed.

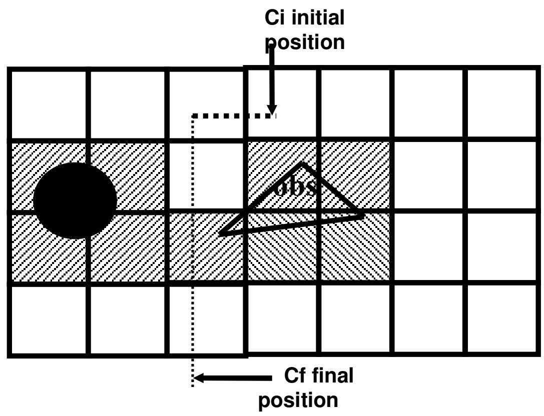

Fig. 2: example of the navigation finding an optimal path.

III. THE PROPOSED NAVIGATION APPROACH

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.\q robotic vehicle is an intelligent ;mobile machine capable of autonomous operations in structured and unstructured environment. It ;must 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.

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However, the limitations of off-line planning led researchers to study on-line planning, which relies on knowledge acquired from sensing the local environment to handle unknown obstacles as the robot traverses the environment.

One of the key issues in the design of an autonomous robot is navigation, for which, the navigation planning is one of the most vital aspect of an autonomous robot. Therefore, the space and how it is represented play a primary role in any problem solution in the domain of the ;mobile robots because it is essential that the ;mobile robots have the ability to build and use ;models of its environment that enable it to understand the scene navigation's structure. this is necessary to understand orders, plan and execute paths.

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.

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. Thus, by selecting a goal that lies within free space , we ensure that the free sub-path will not be in collision with the environment, and that there exists some sub-paths to get the target.

Our general flowchart is presented in the figure 3, where the main work is described in order to get the target. To reflect the vehicle behaviors acquired by learning and to demonstrate generalization and adaptation abilities of our approach, the robot is simulated in different static environments.

In this context, we have created N unknown environments containing static obstacles; (complexity order of theses creations is limited at the last environment one, until now we have tested 68 environments), we start with no obstacle until the complexity order is done

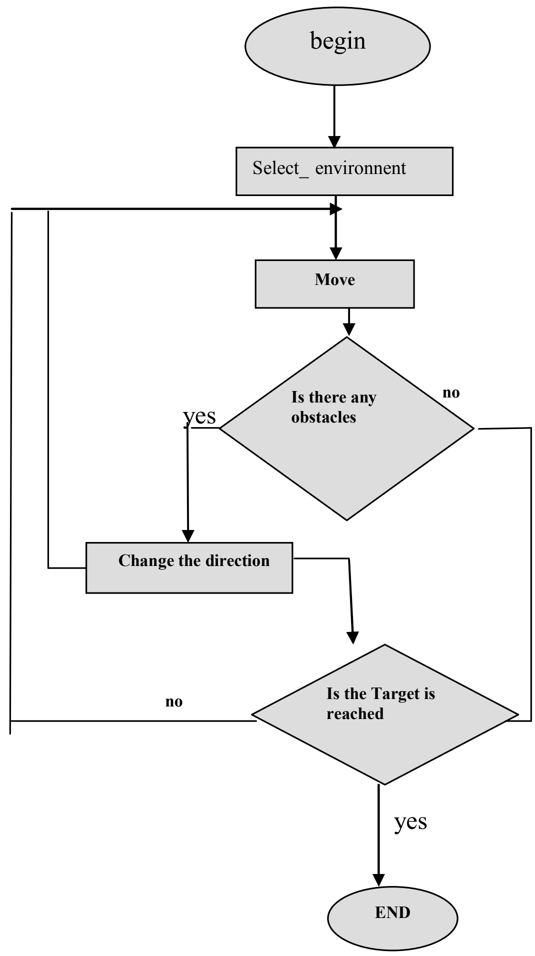

Fig. 3: general flowchart.

As there is no information at advance, this creation can give another configurations of environments, that means that, the user of this concept can change the positions of all objects as he want in the scene and can change the shapes of obstacle(big, small, different sizes,…), this have no effect since the environment is unknown, the robot success, in satisfactory manner, to avoid suitably the static obstacles while it makes one's way toward its target, we can give different infinite environment complexity, in order to achieve the desired task.

The environment set up is shown in the figure 4.The squares are small enough to permit the robot land in the next square horizontal at just one step of robot. The path is found by figuring all the squares. Once the path is found, the robot moves from one square to the next until the target is reached, once we have simplified our search area into a convenient number of nodes, as we have done with the grid design, the next step is to conduct a search to find the path.

We do this by starting at point A, checking the adjacent squares, and generally searching outward until we find our target. We start the search by the following steps: we have fixed the starting position, it moves forward horizontally as shown above in figure 5.The robot meets an obstacle, it moves a step down then back until it meets another obstacle. The robot keeps navigation in this manner until the target is found.

The input parameters Map contain the ground information In order to evaluate, the performance of navigation algorithm of autonomous mobile robots over various environments, we observed simulation of the navigation in different environments.

We can change the position of obstacles so we get other different environments. These environments were randomly generated. To find a new path after insertion of deletion of an obstacle. Hence, a mobile robot detects unknown hazardous obstacle on the path and find its free path without collision.

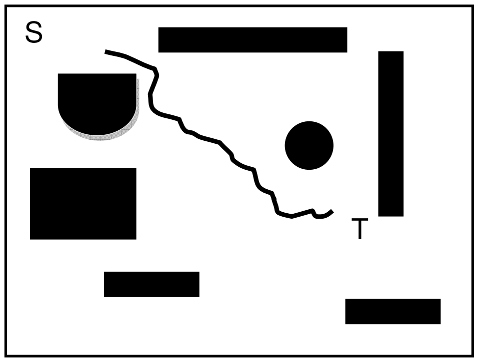

Fig.4 the reached best path environment set-up 1

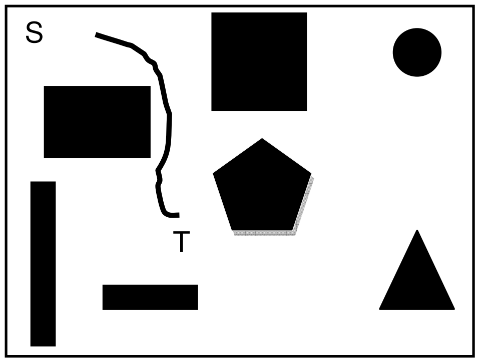

Fig. 5 the reached best path environment set-up 2

V. Conclusion

The theory and practice of IAS 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).

In this paper, we have presented a software implementation of navigation approach of an autonomous mobile robot in an unknown environment. The proposed approach can deal a wide number of environments.

This system based on intelligent reactions constitutes the knowledge bases of our *approach* allowing recognizing situation of the target localization and obstacle avoidance, respectively. Also, the aim work has demonstrated the basic features of navigation of an autonomous mobile robot simulation .

The proposed approach can deal a wide number of environments. This navigation approach has an advantage of adaptivity such that the AMR 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, 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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