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AN EFFECTIVE APPROACH FOR PATH PLANNING OF AUTOMATED ROBOT WITH A STAR ALGORITHM & ARTIFICIAL INTELLIGENCE

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ABSTRACT: Path planning in mobile robots must ensure optimality of the path. The optimality achieved may be in path, time, energy consumed etc. Path planning in robots also depends on the environment in which it operates like, static or dynamic, known or unknown etc. Global path planning using A* algorithm and genetic algorithm is investigated in this paper. A known dynamic environment, in which a control station will compute the shortest path and communicate to the mobile robot and the mobile robot, will traverse through this path to reach the goal. The control station will keep track of the path traversed by the robot. The mobile robot navigates through the shortest path and if the robot detects any obstacle in the destined path, the mobile robot will update the information about the environment and this information together with the current location will be communicated to the control station. Then the control station, with the updated map of the environment and new starting location and destination recalculates the new shortest path, if any, and will communicate to the mobile robot so that it can reach the destination. The technique has been implemented and tested extensively in real-world experiments and simulation runs. The results demonstrate that the technique effectively calculates the shortest path in known dynamic environment and allows the robot to quickly accomplish the mission.
Keyword: A* Algorithm, Artificial Intelligence, Path Planning, Robotic Motion, MATLAB

I. INTRODUCTION

A Robot is reprogrammable, multi purposeful manipulator premeditated to be in motion material, parts, tools or specific plans through unpredictable programmed motions for the presentation of a variety of tasks." According to application of mobile robot, capability to navigate in the environment is essential. Navigation defined as the process of directing the movement of a vehicle from one point to another with the help of types of sensors to the different environment like indoor, outdoor and cluttered by using the various navigation techniques such as artificial intelligence. A Robot is in general a programmable, multi purposeful, manipulator premeditated, continue function device which is to be in specific plans through unpredictable programmed motions for the presentation of a many application. Robot navigation and path planning for it motion is nothing but the mobile robot's capability to decide its own location and then to map a path towards target location. Path planning is efficiently the addition of localization and it wants the resolving the robot present condition and a target place and together within the identical coordinates. Path planning during and mapping of arena during movement of robots is describing the position of robot with the reference to its destination position.

Fig 1.1: Mobile robot with arm manipulator

Robots are used in almost every application related to industry where repetitive and complex task are involved and task which is very dangerous or cannot do the manually such as

- Painting the car, Welding the different specimen or machine and surface finishing in the aerospace and automobile industries
- submarine and space application
- Destructive fritter away remediation in administration labs, nuclear services and medicinal labs
- Examination of parts Electronic and consumer products assembly
- Inspection and dispatching parts in various industries

Robots are very efficient working machine , continuous a very long period without any wrong decision making even it can work in very dangerous areas and play very crucial role in industry as well save human effort and life.it has various application as below.

1) Maintain the aerospace craft and maintain its outer peripheral side.
2) submarine and space application
3) Destructive fritter away remediation in administration labs, nuclear station and its maintain services and medicinal laboratories
4) Examination of parts Electronic and consumer products assembly
5) Searching a parts and send to specific person at assembly line in various industries with due care.
6) Painting the car welding the different specimen machine.

1.1 Path planning of robot

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 self decisive and very practical approach.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. Therefore, the major main work for path planning for autonomous mobile robot is to search a collision free path. Many works on this topic have been carried out for the path planning of autonomous mobile robot. Motion planning is one of the important tasks in intelligent control of an autonomous mobile robot. It is often decomposed into path planning and trajectory planning. Path planning is to generate a collision free path in an environment with obstacles and optimize it with respect to some criterion. Trajectory planning is to schedule the movement of a mobile robot along the planned path. Several approaches have been proposed to address the problem of motion planning of a mobile robot

1.2 How Autonomous robot moves

The robot moves within the unknown environment by sensing and avoiding the obstacles coming across its way towards the target. 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.

1.3 How robot works with AI

Autonomous robots have the ability to gain information about their environments, and work for an extended period of time without human intervention. Examples of these robots range from autonomous helicopters to robot vacuum cleaners. These self-reliant robots can move themselves throughout the operation without human assistance, and are able to avoid situations that are harmful to themselves or people and property. Autonomous robots are also likely to adapt to changing surroundings.

1.4 How AI Enhance the robotic motion:

When we deal with hybrid AI (artificial intelligence) technique in which Cesar Munoz recommended an adaptive behavior of mobile robot swarms with the help of neural network and genetic algorithm. When the environment in which navigation is occur and if it is unknown to mobile robot then it is considered as unsupervised learning and if the environment is known then it is considered as supervised learning stage. In this, navigation is considered in unsupervised learning stage.

1.5 Relation between Artificial intelligence and robots

(AI) is the human-like intelligence exhibited by machines or software. The AI field is interdisciplinary, in which a number of sciences and professions converge, including computer science, psychology, linguistics, philosophy and neuroscience, as well as other specialized fields such as artificial psychology. Major AI researchers and textbooks define the field as "the study and design of intelligent agents", where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success. John McCarthy, who coined the term in 1955, defines it as "the science and engineering of making intelligent machines".

1.6 Nine point laplacian for Robotic motion

There are other difference schemes that are based on nine-point formulas as opposed to five-point formulas. Two of these schemes can be obtained by combining the standard (Figure 1(a)) and the skewed (Figure 1(b)) stencils. Both approximations are second order accurate. Other schemes are based on nine-point stencils (Figure 1(c) and 1(d)).

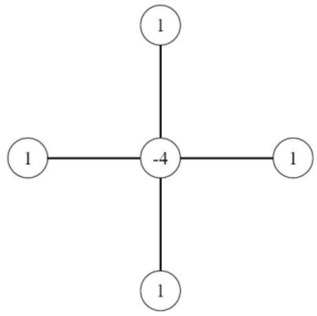

Fig 1(a): Standard 5-point stencil

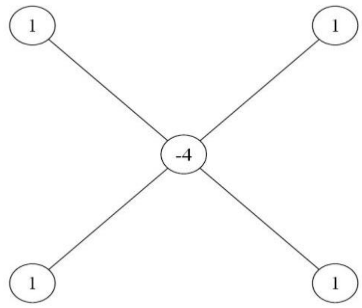

Fig 1 (b) Skewed 5-point stencil

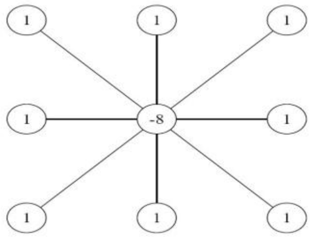

Fig 1 (c) Standard 9-point stencil

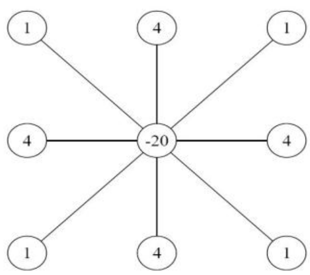

Fig1 (d) Skewed 9-point stencil

1.7 Mathematical Formule for Nine Point Laplacian

The finite difference approximation for 9- point formula uses 9-point stencil as illustrated in Figure 1.1. By having more points (9 points instead of 5 points) in the formulation, each calculation would give greater accuracy thus lead to faster convergence.

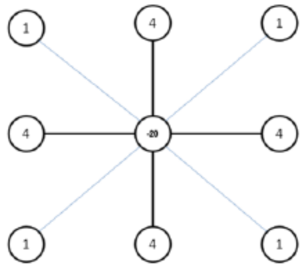

Figure 1.1 : The stencil for 9-point formula.

Laplace's equationare examined with Dirichlet boundary conditions.

Now, let us consider the two-dimensional Laplace's equation in Eq. (1) defined as

$$\frac{\partial^2 U}{\partial^2 x}+\frac{\partial^2 U}{\partial^2 y}=0 \qquad \text{……………………(1)}$$

In the implementation of nine point laplacian block iterative method, the values of four points will be obtained in each calculation. This can be achieved by having a block of four points calculated simultaneously as illustrated in Figure 1.2.

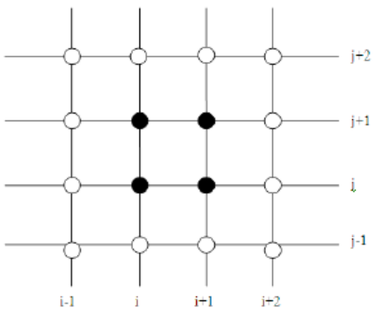

Figure 1. 2: Illustration of a block of four node points to be computed iteratively.

II. LITERATURE SURVEY

The use of potential functions for robot path planning, as introduced by Khatib [1], views every obstacle to be exerting a repelling force on an end effector, while the goal exerts an attractive force. Koditschek [2], using geometrical arguments, showed that, at least in certain types of domains, there exists potential functions which can guide the effector from almost any point to a given point. These potential fields approach to path planning, however, suffer from the spontaneous creation of local minima.Connolly *et al.* [3] and Akishita *et al.* [4] independently developed a global method using solutions to Laplace's equations for path planning to generate a smooth, collisionfree path. The potential field is computed in a global manner, i.e. over the entire region, and the harmonic solutions to Laplace's equation are used to find the path lines for a robot to move from the start point to the goal point. Connolly & Gruppen [5] reported that harmonic functions have a numberof properties useful in robotic applications. Several other methods are also proposed for solving path planning problem. The work by Sasaki [6] demonstrated the practical of using numerical technique for solving path planning problem. Then, Waydo & Murray [7] utilized stream functions that are similar to harmonic functions to generate motion planning for a vehicle. Daily & Bevly [8] used vehicles. Meanwhile, Garrido *et al.* [9] had applied finite elements to obtain harmonic functions for robotic motion. More recently, harmonic functions were used for real-time obstacles avoidance in Szulczyński *et al.* [10]. In the previous works by Saudi and Sulaiman [11, 12, 13, 14], the Laplace's equation was solved numerically via block iterative method, in which the computation speed of the potential field was improved tremendously. This global method, however, suffer from the occurrence of flat region in complex environment which caused the path generation algorithm to fail.

III. EARLIER WORK

Path Planning for Mobile Robot using 4EGSOR via Nine-Point Laplacian (4EGSOR9L) Iterative Method

9- point laplacian for path planning indoor environment model using iterative numerical technique. It is based on the use of Laplace's Equation to compute the potential functions in the environment grid model of the robot. The proposed block iterative method, better known as Four Point-Explicit Group via Nine-Point Laplacian (4EGSOR9L), employs a finite-difference scheme to compute the potential functions to be used in generating smooth path between start and goal points. The simulation results demonstrate that the proposed 4EGSOR9L method performs faster than the previous methods in computing the potential functions of the environment model.

IV. PROPOSED WORK

Integration of 9 point laplacian for A-Star algorithm (Grid Value algo)

Grid algorithmFor example, if you have this grid, where a * = obstacle and you can move up, down, left and right, and you start from S and must go to D, and 0 = free position:

```
S 0 0 0
* * 0 *
* 0 0 *
0 0 * *
* 0 0 D
```

You put S in your queue, then "expand" it:

```
S 1 0 0
* * 0 *
* 0 0 *
0 0 * *
* 0 0 D
```

Then expand all of its neighbours:

```
S 1 2 0
* * 0 *
* 0 0 *
0 0 * *
```


* 0 0 D
And all of those neighbours' neighbours:
S 1 2 3
* * 3 *
* 0 0 *
0 0 * *
* 0 0 D
And so on, in the end you'll get:
S 1 2 3
* * 3 *
* 5 4 *
7 6 * *
* 7 8 9

So the distance from S to D is 9. The running time is O(NM), where N = number of lines and M = number of columns. I think this is the easiest algorithm to implement on grids, and it's also very efficient in practice. It should be faster than a classical dijkstra, although dijkstra might win if you implement it using heaps.

4.1 PROCESS

Starting with the initial node, it maintains a priority queue of nodes to be traversed, known as the open set or fringe. The lower f(x) for a given node x, the higher its priority. At each step of the algorithm, the node with the lowest f(x) value is removed from the queue, the f and g values of its neighbors are updated accordingly, and these neighbors are added to the queue. The algorithm continues until a goal node has a lower f value than any node in the queue (or until the queue is empty). (Goal nodes may be passed over multiple times if there remain other nodes with lower f values, as they may lead to a shorter path to a goal.) The f value of the goal is then the length of the shortest path, since hat the goal is zero in an admissible heuristic.

The algorithm described so far gives us only the length of the shortest path. To find the actual sequence of steps, the algorithm can be easily revised so that each node on the path keeps track of its predecessor. After this algorithm is run, the ending node will point to its predecessor, and so on, until some node's predecessor is the start node.

After the path selection this is introduced by 9 point laplacian which provide very huge power of decision capability for iteration and very very fast calculation for next desion making.

4.2 MATLAB Program to Find A Function Minimum using a Grid Search Method

The following program calculates the minimum point of a multi-variable function using the grid search method. This method performs a multi-dimensional grid search. The grid is defined by a multiple dimensions. Each dimension has a range of values. Each range is divided into a set of equal-value intervals. The multi-dimensional grid has a centroid which locates the optimum point. The search involves multiple passes. In each pass, the method local a node (point of intersection) with the least function value. This node becomes the new centroid and builds a smaller grid around it. Successive passes end up shrinking the multidimensional grid around the optimum.

V. ROBOT RESULT SIMULATION

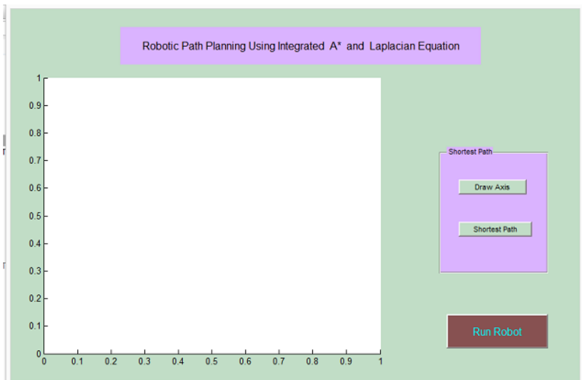

Fig 5.1 : Simulation Main Window

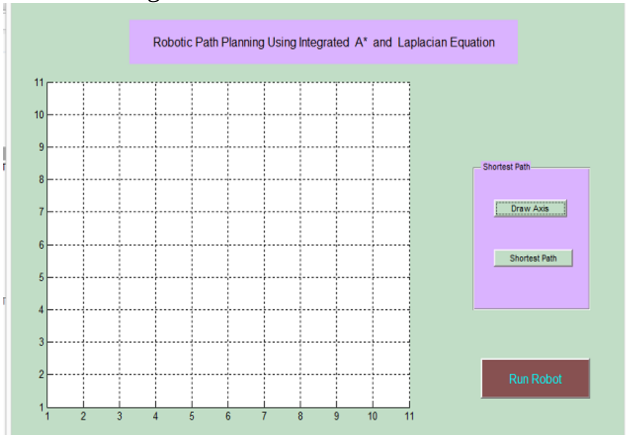

Fig 5.2: Draw axis

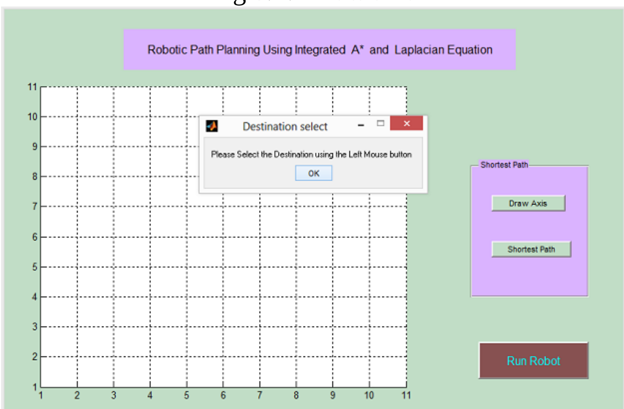

Fig 5.3: Select Destination

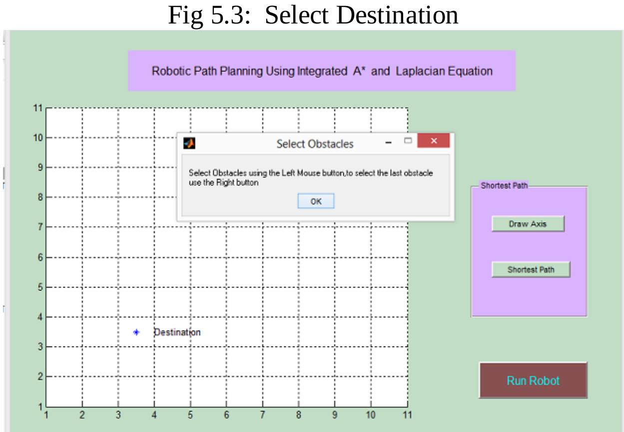

Fig 5.4 : Destination Selected & Select Obstacles

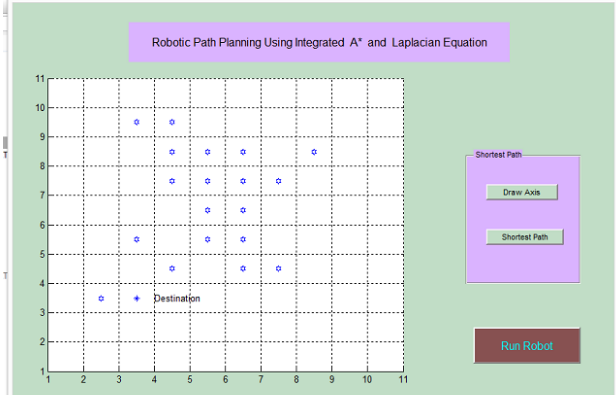

Fig 5.5: Destination Selected & Selected Obstacles

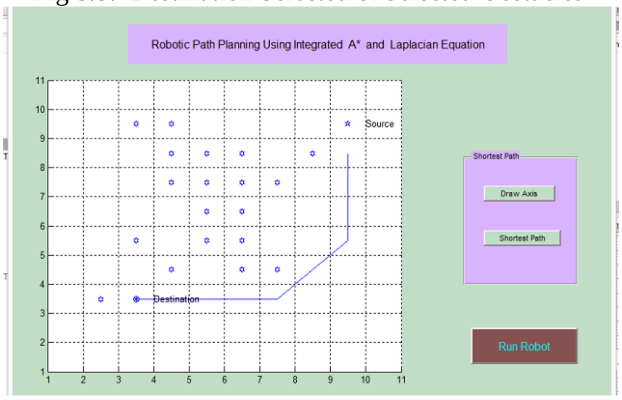

Fig5.6 : Selected Shortest Path

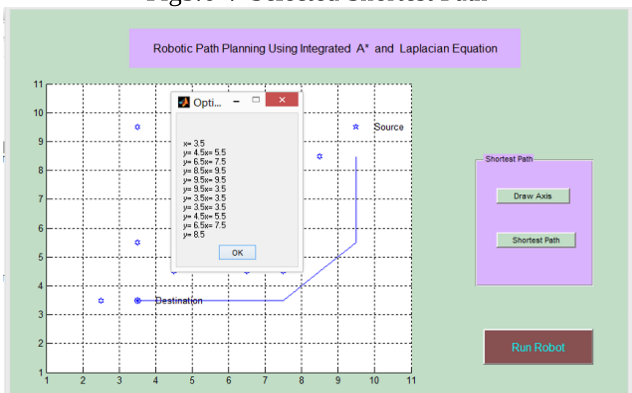

Fig 5.7: Optimal Distance

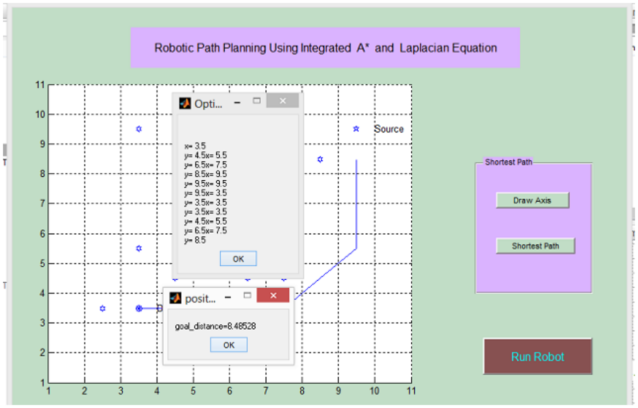

Fig 5.8: Goal Distance

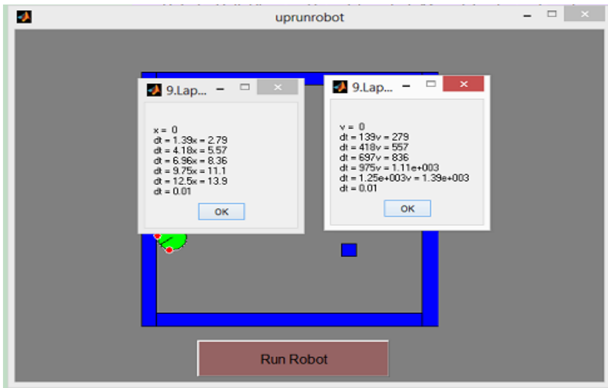

Fig 5.9: Nine-point-laplacian Value

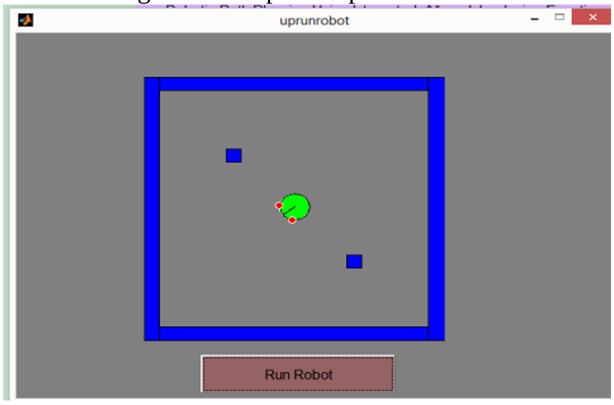

Fig5.10 : Moving Robot

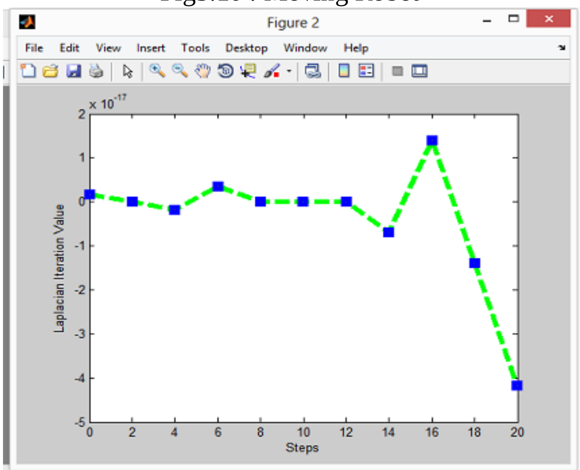

Fig 5.11: Steps Vs Laplacian iteration value

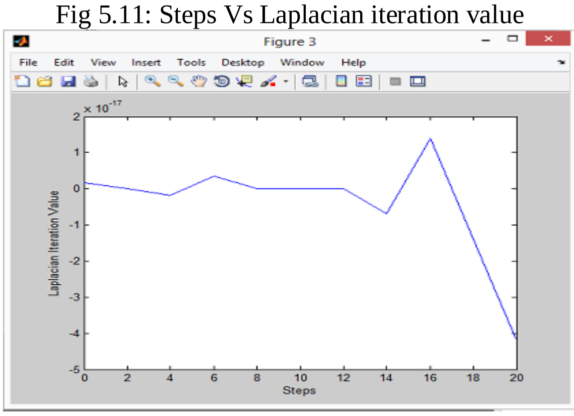

Fig 5.12 : Steps Vs Laplacian iteration value

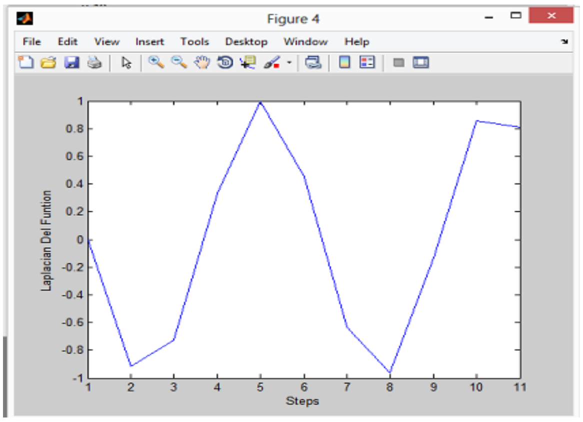

Fig 5.13: Steps Vs Laplacian Del Funtion

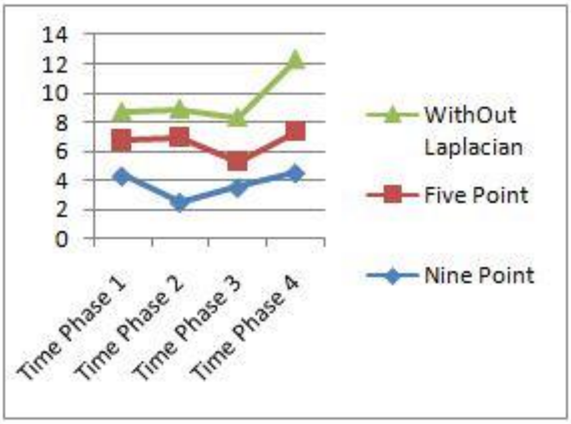

Fig 5.14: It belongs to time phase for decision time taken from different techniques

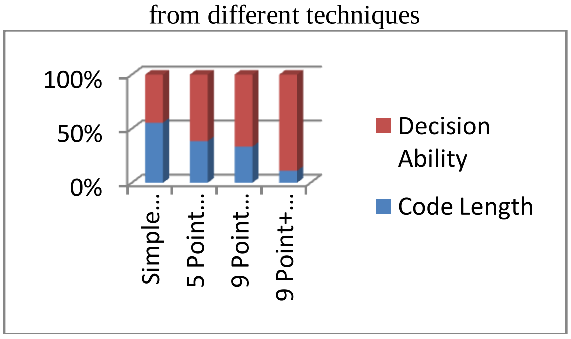

Fig: 5.15- It shows Decision Ability vs. Code length of different technique.

We find best result of proposed model as compared to old one in term of complexity, time, performance, and timing. In every aspect we have very good results.

Comparison Table

Table 5.1: Comparison table of proposed parameters

Techniques	AI	Time/ Decision	Ways	Iteration	Steps
A* Algorithm	N	2 Units	3	Single	Unit
5 Point Laplacian	Y	3+	4	Multi	Derivatives
9 Point Laplacian+ A* Algorithm(Proposed Method)	Y	3-	8	Multi	Derivatives

VI. CONCLUSION AND FUTURE WORK

This inclusion give us more dynamic model and these real time situation provides it a best model for future. This enhancement brings us more closer to real situations. So real life implication of this model give us more real parameter to the world and real time scenario for path travelling. This save time for travelers. In Real time we can save time by choosing best path rather than shortest path. All the developed path planning algorithms considered only static obstacles and size of obstacle is same as the size of the cell. In future we have plans to consider a dynamic obstacle which varies in both size and shape. The issues such as transmission range of sensor, receiving range of robot, non predictable size of arena and space considered in future because robots are going to be deployed in hostile forest environments. Furthermore the spreading effect of fires is not considered .That is how much area is burnt before the robot moves to the target to extinguish fires must be considered for efficient extinguishing purposes and the same can be incorporated in the path planning algoritm.

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