# TIME CALCULATION OF ALTERNATE PATHS

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***Abstract***— To determine the time of the alternate paths traced-out by the robots from their respective origins to their respective targets based on the work place layout.. The Alternate Paths (APs) are determined which trace the shortest path(SP) to the virtual path. At the first stage, the possible alternate paths are designed to overtake the obstacles. A detailed Methodology to trace-out the Alternate Paths (APS) by each robot is discussed with the Layout considering the distances between each obstacle. The distance between each obstacle is shown in detail. Further, specific situation is studied considering the working environment of ten Robots with ten target positions.

***Keywords—Time of Alternate Path, Virtual Path, Shortest Path, Layout.***

## I. INTRODUCTION

Robot path control is to program the robot to move on the designed path without any deviation so as to reach the target position. Thus the motion planning system has to be able to cope with the dynamic or static situations. To take advantage of high performance robots and respond quickly to external changes in the domain, the system has to run at real time rates during the motion with high speed. It means the respecting dynamics constraints in the robot motion to avoid collisions while staying within the operational bounds of the robot, in multiple robots working environment. Thus in such situation, the system must find solutions such that the robots do not collide to reach their respective destinations. Otherwise, the robot path control becomes more complex and unpredictable in the multiple working environment. The main goal of any designer is to develop a simple strategy for modifying the individual robot path by the shortest distance possible, to reach the target positions. In many situations multiple mobile robots operate in the same environment. When the robots stay far enough apart they can plan their motions more or less independently, but when they get within close range of each other, their motions must be co-ordinated in order to avoid mutual collisions leading to deadlock situations.

Any approach proposed by a designer has to suggest a suitable feasible motions for a robot and network in multiple robots systems. Once a path is available, path planning queries are solved easily by finding alternative path or paths, in case of the possibility of the robots facing obstacles.. First, a simple path is designed for just one robot. Then number of such paths can be combined to identify number of shortest paths and alternate paths. Such approach is a flexible one, in the sense that it is easily applicable to various robots, provided that one is able to design simple path for one such robot. Proper design of the simple paths guarantees probabilistic completeness and then find the solution for planning problem and their time complexity, for which a solution exists and their time complexity. Therefore, a model is necessary to over come such issues.

## II. TIME DURATION OF ALTERNATE PATHS

An Alternate Path (AP) consists of number segments depending on the number of obstacles. The Methodology of calculation of the total distances is presented in the following topics. Amongst the available alternate paths, the shortest path is calculated and then the efficiency of that path is found.

## III. GENERATION OF TIME FOR ALTERNATE PATHS

The Layout of paths for the smooth motion of each Robot is described in the following.

**Time consideration of Path Layout without any Obstacle**

The layout of the path for Robot – 1 is shown in Fig.1. The layout shows the initial position of the Robot -1 with its initial and target coordinates. The path generated is taken as straight paths since the DDA is used to find the path.

**Time consideration of Path Layout with one Obstacle**

During the Robot's travel after starting from its Original Position, if an obstacle is intervened, the Robot has to over take and reach the destination. In such case, the possible alternate paths, ie., $1ap_1$ and $1ap_2$ with their slopes are shown in Fig. – 2.

**Time consideration of Path Layout with two Obstacles**

During the travel of the same Robot-1, when two obstacles are intervened and the robot has to overcome the robot has to overtake the two obstacles. In such case, the possible four alternate paths (APs) $2ap_1$, $2ap_2$, $2ap_3$ and $2ap_4$ with their slopes are shown in Fig. – 3.

**Time consideration of Path Layout with three Obstacles**

Similarly, the same Robot-1 when it has to move across three obstacles and the robot has to overtake the three obstacles. In such situation, the possible eight APs - $3ap_1$, $3ap_2$ , $3ap_3$ $3ap_4$, $3ap_5$, $3ap_6$, $3ap_7$ and $3ap_8$ to overtake three obstacles and reach its target with their slopes are shown in Fig. – 4.

Likewise all such alternate paths are calculated for every robot with one, two and three obstacles.

## V. TIME CALCULATION CONSIDERING THE OBSTACLES

The calculation of the total distance of the paths is explained in the following. **Time Taken : 10 Sec (Every pixel movement is assumed to take ¼ sec)**

**(i) Path without Obstacle , Minimum time**

The shortest distance for the Robot – 1 without any obstacle is shown Figure – 1.

Shortest Path (SP) Distance = 1154. **Shortest time – 10.5 sec**

**(ii) Alternate Path of time with one Obstacle:**

The time of Alternate Paths (AP) for the Robot – 1 with one obstacle is shown Figure – 4.3 and distances are shown in thefollowing.

Alternate Paths:

1AP1=1d01 +1d11 = 180 + 1007 = 1187, 1T1=11.5 Sec

AP2 = 1d01 +1d12 = 180 + 1112 = 1292, 1T2=12.5 Sec

Shortest Path = 1187, Shortest Time =11.5 Sec

**(iii) Alternate Paths of time with two Obstacles**

The time of APs for the Robot – 1 with two obstacles are shown Figure – 4.4 and the distances are shown in the following.

2AP1 = 2d01 + 2d11 + 2d21=180 + 480 + 579 = 1239,2T1-12.25 sec

2AP2 = 2d01 + 2d11 + 2d22 = 180 + 480 + 989 = 1649,2T2-15.5 s

2AP3 = 2d01 + 2d12 + 2d21 = 180 + 480 + 787 = 1447,2T3- 13.5 s

2AP4 = 2d01 + 2d12 + 2d22 = 180 + 472 + 744 = 1396,2T4- 13 s

Shortest Path = 1239, shortest time – 12.25 s

**(iv) Alternate Paths of time with three Obstacles**

The time of APs for the Robot – 1 with three obstacles are shown Figure – 4.5 and the distances are shown in the following.

3AP1 = 3d01 + 3d11 + 3d21 + 3d31 = 1240,3T1- 12.25 s

3AP2 = 3d01 + 3d11 + 3d21 + 3d32= 1457,3T2- 13.55s

3AP3 = 3d01 + 3d11 + 3d22 + 3d31 = 1917,3T3- 18.55 s

3AP4 = 3d01+ 3d11 + 3d22 + 3d32 = 1647,3T4- 15.5 s

3AP5 = 3d01+ 3d12 + 3d21 + 3d31 = 1492,3T5- 14 s

3AP6 = 3d01+ 3d12 + 3d21 + 3d32 = 1706,3T6- 16.75 s

3AP7 = 3d01+ 3d12 + 3d22 + 3d31 = 1658,3T7- 15.5 s

3AP8 = 3d01+ 3d12 + 3d22 + 3d32 = 1388,3T8- 12.75 s

Shortest Path = 1240, shortest time – 12.25 s

## IV. CALCULATION OF THE TIME EFFICIENCY

The calculation of efficiency of Alternate Path is calculated using the formula. Distance of the path as per the Design

$$\eta\ T_i = \frac{Time\ of\ the\ path\ as\ per\ the\ Design}{Shortest\ Time\ of\ each\ alternate\ path}$$

Considering the Figure – 2, For the **first** robot the total distance as per the design without any obstacle is 1154 units. The total distance of $AP_1$ = 1187, and time with one obstacle.

$$\eta\ 1T_1 = \frac{10.5}{11.5} = 97.21\ \%\ \text{(With 1 obstacle)}$$

$$\eta\ 3T_4 = \frac{10.5}{15.5} = 93.06\ \%\ \text{(With 3 Obstacles)}$$

Likewise all the efficiencies are calculated as shown in the following Tables. All the alternate paths of only first robot and only second robot are shown in figure 1 to 8.

| Time Alternative Path | Slope (Deg) | Time (sec) | Efficiency η(%) | Best Efficiency η (%) |
|---|---|---|---|---|
| **With No Obstacle (Figure – 1)** | | | | |
| T | $34^0$ | 10.5 | 100 | 100 |
| **With One Obstacle (Figure – 2)** | | | | |
| $^1T_1$ | $40^0$ | 11.5 | 91.3 | 91.3 |
| $^1T_2$ | $24^0$ | 12.5 | 84 | |
| **With Two Obstacle (Figure – 3)** | | | | |
| $^2T_1$ | $55^0$ | 12.25 | 85.71 | 85.71 |
| $^2T_2$ | $12^0$ | 15.5 | 67.74 | |
| $^2T_3$ | $55^0$ | 13.5 | 77.77 | |
| $^2T_4$ | $12^0$ | 13 | 80.76 | |

| With Three Obstacles (Figure – 4) | | | | |
|---|---|---|---|---|
| $^3T_1$ | $60^0$ | 12.25 | 85.71 | 85.71 |
| $^3T_2$ | $6^0$ | 13.75 | 79.20 | |
| $^3T_3$ | $60^0$ | 18.75 | 59.82 | |
| $^3T_4$ | $6^0$ | 15.5 | 56 | |
| $^3T_5$ | $60^0$ | 14 | 75 | |
| $^3T_6$ | $6^0$ | 16.75 | 62.68 | |
| $^3T_7$ | $60^0$ | 15.75 | 66.66 | |
| $^3T_8$ | $6^0$ | 12.75 | 82.35 | |

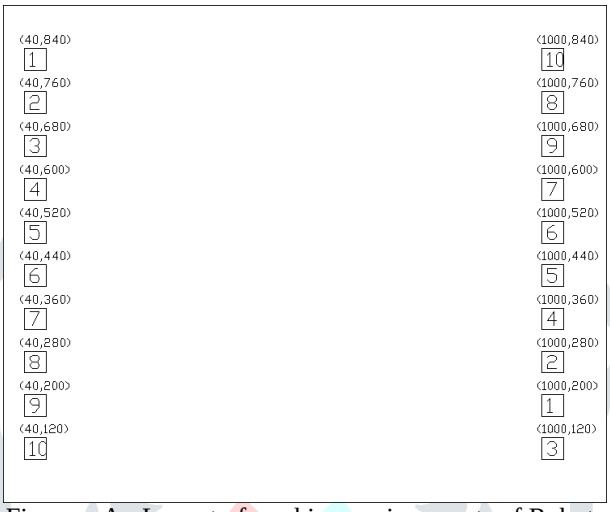


Figure – A : Layout of working environments of Robots

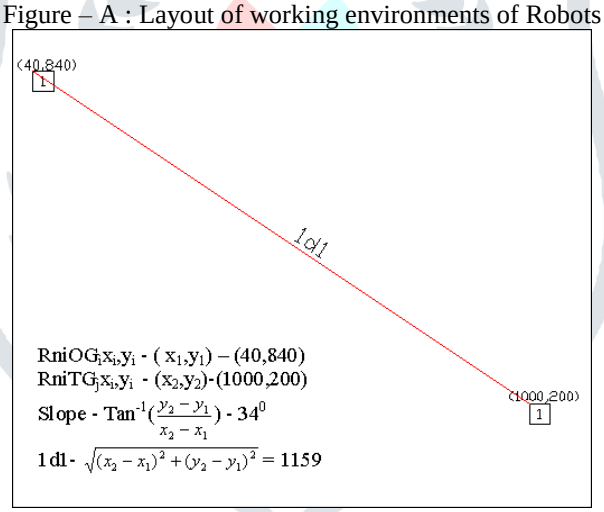


Fig. 1 - Path of Robot 1 with no obstacle

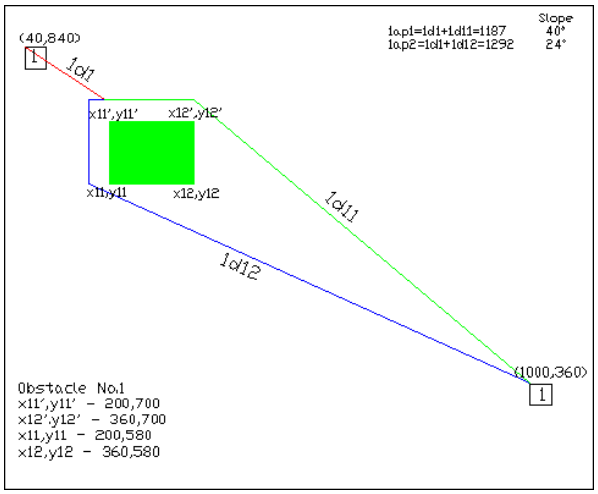


Fig. 2 - Robot1 with one obstacle, its dimensions

and alternative path

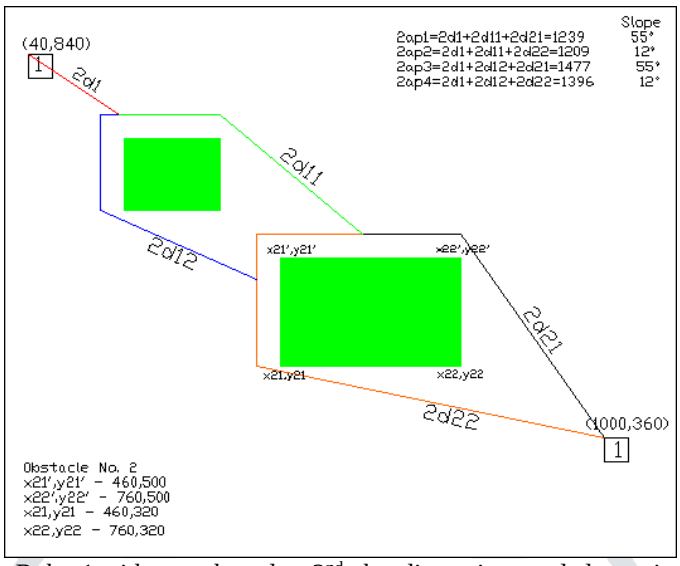


Fig. 3 - Robot1 with two obstacles, 2nd obs dimensions and alternative paths

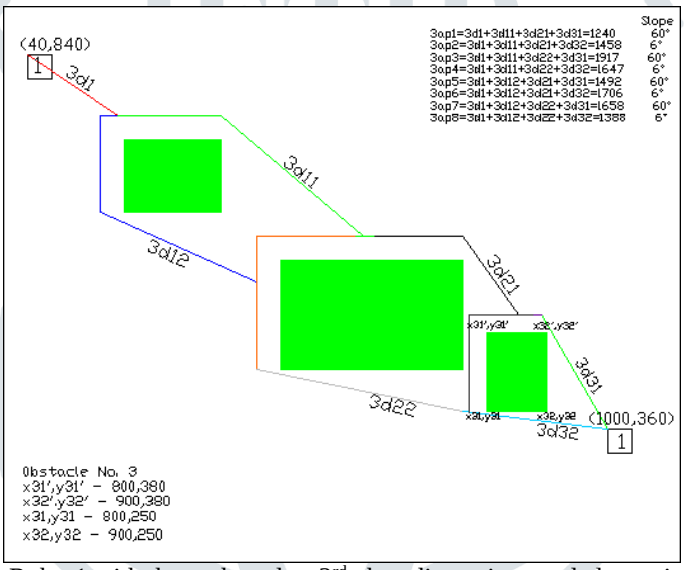


Fig. 4 - Robot1 with three obstacles, 3rd obs dimensions and alternative paths

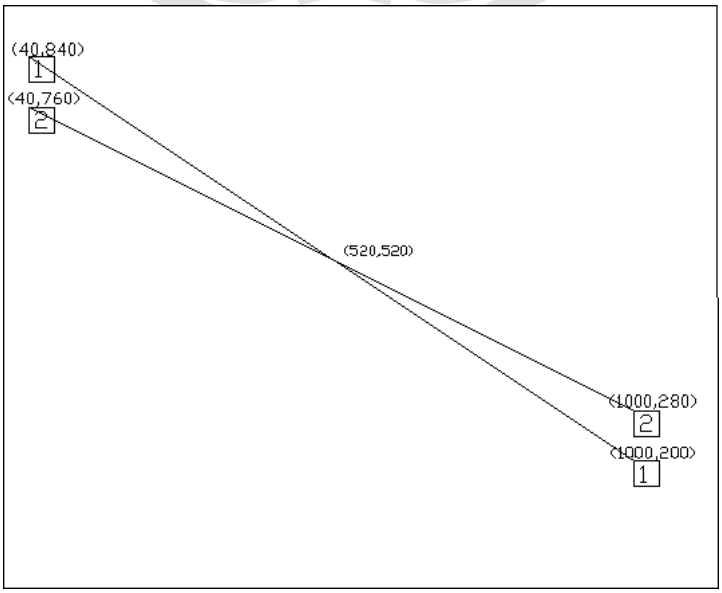


Figure – 5 : Robot1 and Robot2 with no obstacle and an intersection coordinate

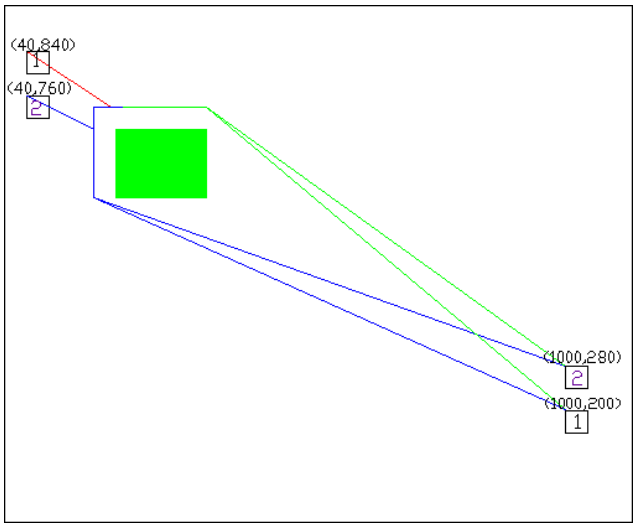


Figure – 6 : Robot1 and Robot2 with one obstacle and alternative paths

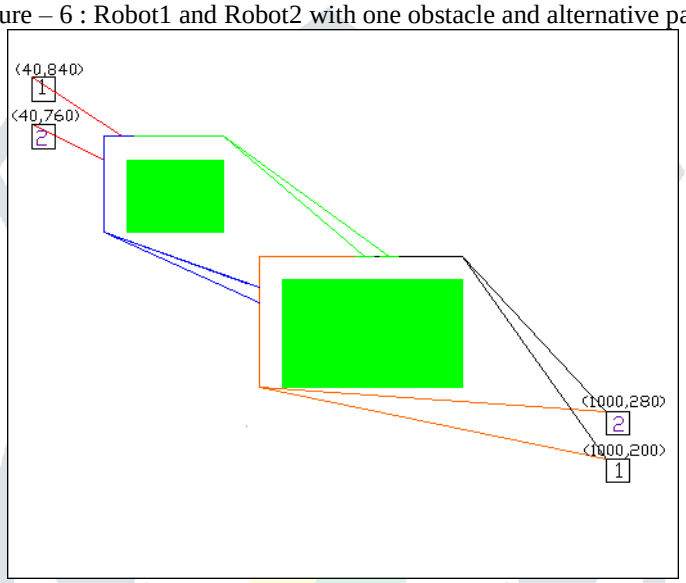


Figure – 7 : Robot1 and Robot2 with two obstacles and altenative paths

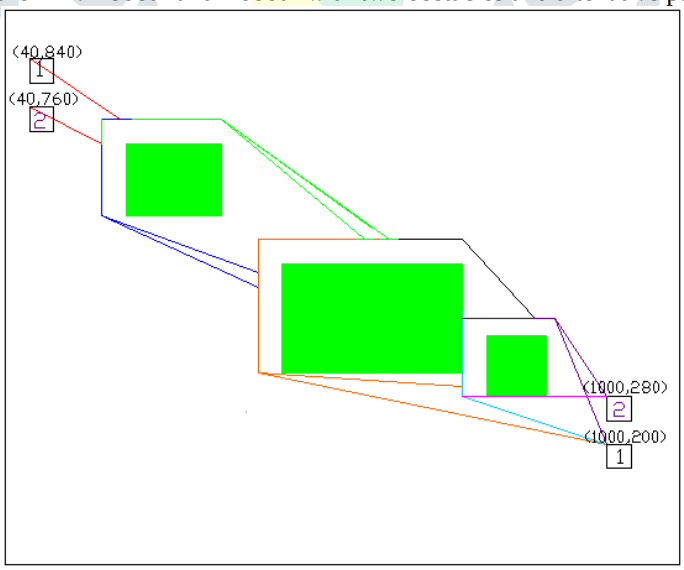


Figure – 8 : Robot1 and Robot2 with three obstacles and altenative paths

## V. RESULTS AND CONCLUSION

All the distances of the alternate paths are calculated and amongst them, the shortest path is determined. The efficiency of all the robots are calculated considering the shortest path out of the alternates paths and the path taken when no obstacles is existing. Like wise for all the robots the path having highest efficiency is decided and accordingly the program is written so that the robot follows the shortest path with highest efficiency. Only two of the possibilities are discussed here, which fetches the following results.

*1)First Robot with One Obstacle – 1T1 – 1187 Path is preferred whose efficiency is 91.3% as shown in Fig 2.*
*2)First Robot with Two Obstacles – 2T1 – 1239, Path is preferred whose efficiency is 85.71% as shown in Fig 3.*
*3)First Robot with Three Obstacles – 3T1 – 1240, Path is preferred whose efficiency is 85.71% as shown in Fig 4.*
*4)Second Robot with One Obstacle – 1T1 – 1146 Path is preferred whose efficiency is 97.61% as shown in Fig 6.*
*5)Second Robot with Two Obstacles – 2T1 – 1193 Path is preferred whose efficiency is 89.13% as shown in Fig 7.*
*6)Second Robot with Three Obstacles – 3T1 – 1255 Path is preferred whose efficiency is 82% as shown in Fig 8.*

The future scope of the calculation of the alternate paths and its efficiency can be extended to irregular shape of the obstacle instead of the regular polygonal shape.

### *References*


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