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MODIFIED VIRTUAL SEMI-CIRCLE PATH PLANNING

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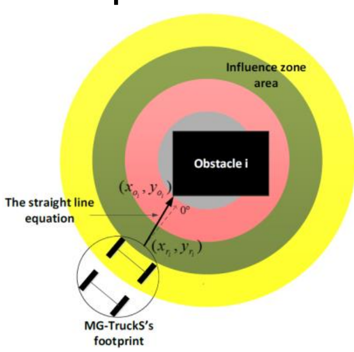
Graphical abstract



Abstract

The challenging part of path planning for an Unmanned Ground Vehicle (UGV) is to conduct a reactive navigation. Reactive navigation is implemented to the sensor based UGV. The UGV defined the environment by collecting the information to construct it path planning. The UGV in this research is known as Mobile Guard UGV-Truck for Surveillance (MG-TruckS). Modified Virtual Semi Circle (MVSC) helps the MG-TruckS to reach it predetermined goal point successfully without any collision. MVSC is divided into two phases which are obstacles detection phase and obstacles avoidance phase to compute an optimal path planning. MVSC produces shorter path length, smoothness of velocity and reach it predetermined goal point successfully.

Keywords: Unmanned Ground Vehicle, Path Planning, Reactive Navigation, Obstacles Detection, Obstacles Avoidance, Optimal Path Planning

1.0 INTRODUCTION

Unmanned Ground Vehicle (UGV) is a type of mobile robot that usually been used in military field. [1]. It is helpful to perform difficult military task where the soldier oversight is limited. The autonomous UGV must have the ability to plan it path and overcome the expected and unexpected obstacle while heading toward goal point The UGV is also able to work outdoor and indoor in any types of ground [2].

Path planning is an important task to the vehicles that capable to sense its own environment and drive by its own toward target location. It travels from the starting location toward target location without the need human intervention [3]. The path planning of a UGV is always considered about the efficiency, safety and the accuracy [4].

Local obstacle avoidance is an elementary problem in the UGV navigation. Most of the path planning for the UGV combines global navigation method in partially known environments to compute an optimal path planning for the UGV [5]. Potential Field Method (PFM) is a well-known local path planning among the researchers. It was first proposed by Khatib [6]. PFM generate the repulsive forces within the mobile robot and the obstacles. Meanwhile the attraction forces is generate between the goal point and the mobile robot. Therefore the mobile robot is always guided toward the goal point. Research paper [7] is one of the examples that enhance the PFM path planning.

This paper is focusing on the path planning a UGV known as Mobile Guard UGV-TruckS for Surveillance (MG-TruckS). The MG-TruckS is used to help safety guard to monitor the residential area. This will help to reduce the number of safety guard hired in a residential area. The MG-TruckS implement the MVSC approach to plan it path. The details of MVSC are explained in details in the next section followed with the experiment results and conclusion to summarize this paper.

2.0 MODIFIED VIRTUAL SEMI CIRCLE APPROACH

Modified Virtual Semi Circle Approach (MVSC) is simple approaches that have three modules. MVSC approach is divided into two phases which are obstacles detection phase and obstacles avoidance phase [8]. Obstacles detection phase consist of division module. Meanwhile, an obstacles avoidance phase consists of two modules which are decision and motion generation module. MVSC approaches enhance the time processing of the MG-TruckS to reach the goal point [9].

MVSC is a path planning for the Mobile Guard UGV-Truck for Surveillance (MG-TruckS) to complete it expedition. Figure 1 shows the MG-TruckS footprint.

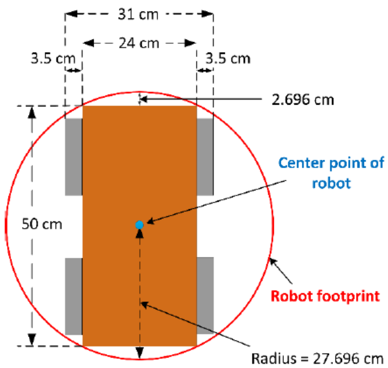


Figure 1MG-TruckS footprint as in [10]

The MG-TruckS is equipped with five ultrasonic range finder sensors with 158O sensor range for forward looking motion. In division module each of the sensors is labelled as Bottom Left (BL), Top Left (TL), Centre (C) and Top Right (TR), and Bottom Right (BR). The sensor arrays of each of the ultrasonic range finder sensors are divided into six regions as shown in Figure 2.

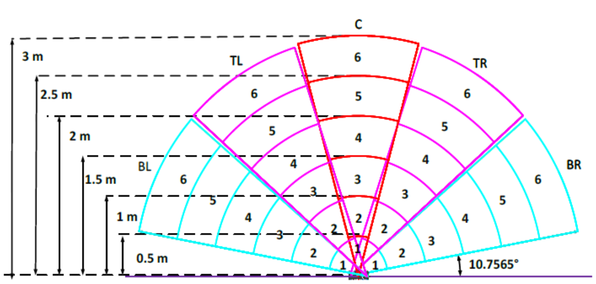


Figure 2 The MG-TruckS subspaces for five ultrasonic range finder sensor as in [9]

The MG-TruckS decided it path by referring to the sensor range and influence zone information. Figure 3 shows the formation of the three layers of influence zone in one detection. Since there are three layers of influence zone the information of the influence zone is declared as $IZ_{(1)}$,$IZ_{(2)}$ and $IZ_{(3)}$ in the algorithm given.

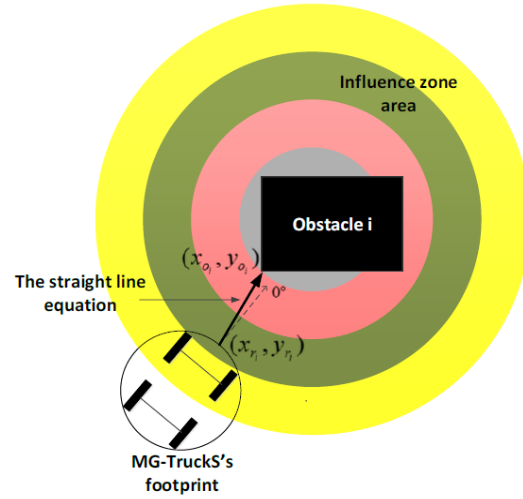


Figure 3 The formation of the Influence Zone in detection

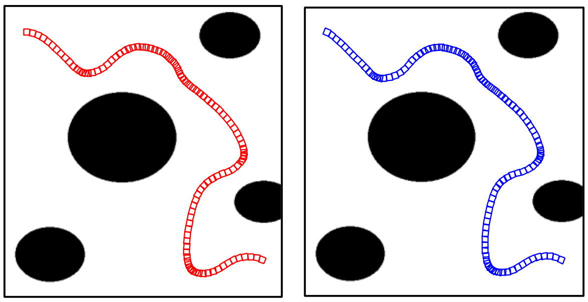
Figure 3 also shows the coordinate of the MG-TruckS and the coordinate of the obstacle detected by the obstacle. The straight line equation is used to construct the circular shape of the influence zone by using tangent concept. The algorithm of MVSC is given in this section.

Step 1: Start
Step 2: Get current position of MG-TruckS (Coordinate of the MG-TruckS)
Step 3: Move toward waypoint
Step 4: if obstacle detection then create influence zone and regions and get position of the MG-TruckS within influence zone
if IZ_1 (d≤0.027m) then MG-TruckS reverse 0.5 and get the value formotion generation in MotionGeneration Table (θ,v)
else if IZ_2 (condition) or IZ_3 (condition)then get the value for motiongeneration in Motion GenerationTable (θ,v)
else
get coordinate of the MG-TruckS =waypoint
if waypoint=goal then stop
else
go to next waypoint
end
Step 5: Return to step 3 until waypoint=goal
Step 6: Obtain the optimal path
Step 7: Robot moves along the optimization path

The next section previewed the simulation results of MVSC approach and the comparison of the MVSC approach with the conventional method which is PFM.

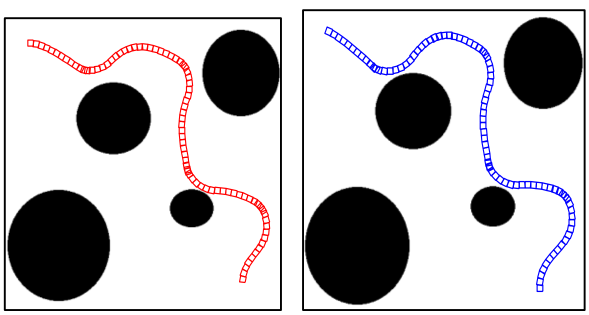
3.0 RESULTS AND DISCUSSION

The simulation result shows the comparison of the MVSC Approach with PFM. The simulation has been computed by MATLAB. The solid black shape presents the obstacles existence in the environment. The coordinate of the starting point is at (50, 50) and the goal point is (450,450). The maximum acceleration is set to 10 m-2. Figure 4 to Figure 9 shows the path planning of MVSC in different types of obstacles.



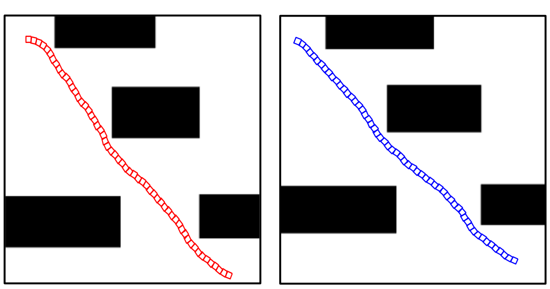
(a) (b)

Figure 4 (a) The MVSC path planning in environment 1 (b) The Potential Field Method path planning inenvironment 1



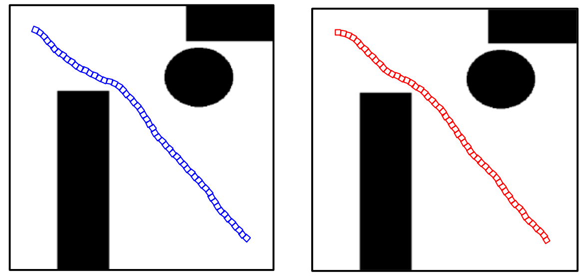
(a) (b)

Figure 5 (a) The MVSC path planning in environment 2 (b) The Potential Field Method paths planning in environment 2



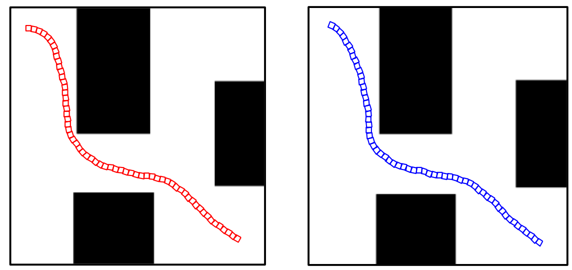
(a) (b)

Figure 6 (a) The MVSC path planning in environment 3(b) The Potential Field Method path planning in environment 3



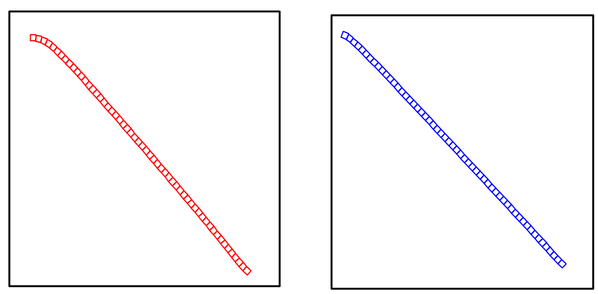
(a) (b)

Figure 7 (a) The MVSC path planning in environment 4 (b) The Potential Field Method path planning in environment 4



(a) (b)

Figure 8 (a) The MVSC path planning in environment 5 (b) The Potential Field Method path planning in environment 5



(a) (b

Figure 9 (a) The MVSC path planning in environment 6 (b) The Potential Field Method path planning in environment 6

The path planning of MVSC shows the MG-TruckS reach the goal point in each of the environment. Figure 4(a), 5(a), 6(a), 7(a), 8(a) and 9(a) shows the MVSC path planning and Figure 4(b), 5(b), 6(b), 7(b), 8(b) and 9(b) shows the PFM path planning.

Table 1 The percentage of the improvement

Environment	Path length (m)		Improvement in %	Processing time (s)		Improvement in %
	MVSC	PFM		MVSC	PFM	
1	8.25	8.39	1.67	7.59	8.34	8.99
2	7.71	7.76	0.64	5.02	8.96	43.97
3	7.76	7.82	0.77	3.97	4.14	4.11
4	7.76	7.78	0.26	3.36	4.05	17.04
5	7.81	7.85	0.51	3.74	3.96	5.56
6	7.73	7.77	0.51	5.19	5.27	1.52

Table 1 compared the results of the proposed algorithm for the entire environment given. The algorithm achieves a maximum 1.67% improvement in path length and 43.97% in processing time. MVSC shows the improvement in path length and processing time for all of the experiment.

4.0 CONCLUSION

This paper proposed a reactive collision avoidance method with new approach. MVSC simplified the previous path planning of Virtual Semi Circle approach (VSC) in a new approach [11]. Presented results demonstrate the improvement of MVSC approach in various types of environment in terms of path length. MVSC always lead the MG-TruckS to reach it predetermined goal point. The proposed work produces optimal path planning. The proposed work can be further analyzed to produce shorter processing time.

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References

[1] Oroko, J., and Ikua, B. 2012. Obstacle Avoidance and Path Planning Schemes for Autonomous Navigation of a Mobile Robot: A Review. *Sustainable Research and Innovation Proceedings*. 4: 314-377.

[2] Farah, R. N., Zuraida R. L., Umairah, S., Irwan, N., Hafiz, M. H. 2014. Challenging of Path Planning Algorithms for Autonomous Robot in Unknown Environment in Unknown Environment. *Lecture Notes on Information Theory.* 2: 198-202.

[3] Gu. J., and Qixin, C. 2011. Path Planning for Mobile Robot in a 2.5-Dimensional Grid Map. *Industrial Robot: An International Journal.* 315-321.

[4] Farah, R. N., Irwan, N., Zuraida R. L., Umairah, S., Hafiz, M. H. 2013. Challenging of Path Planning Algorithms for Autonomous Robot in Known Environment. *Proceedings of the 3rd International Conference on Mathematical Sciences.* 1602: 29-35.

[5] Shi, C., Wang, Y., Yang, J. 2010. A Local Obstacle Avoidance Method for Mobile Robot in Partially Known Environment. *Robotic and Autonomous Systems.* 425-434.

[6] Khatib, O. 1985. Real-time Obstacle Avoidance for Manipulators and Mobile Robots. *IEEE International Conference on Robotics and Automation.* 500-505.

[7] Zhang, T., Zhu Y., Song J. 2010. Real-time Motion Planning for Mobile Robot by Means of Artificial Potential Field Method in Unknown Environment. *Industrial Robot: An International Journal.* 384-400.

[8] Farah, R. N., Irwan, N., Zuraida, R. L., Amira, S., and Hafiz, M. H. 2014. Modified Virtual Semi-Circle Approach for a Reactive Collision Avoidance of a Mobile Robot in an Outdoor Environment. *Applied Mechanics and Materials.* 679: 171-175.

[9] Amira, S., Farah, R. N., Irwan, N., Zuraida, R. L., and Hafiz, M. H., 2014. A Reactive Navigation for a Mobile Robot: An Improvement for Modified Virtual Semi Circle Approach. *Australian Journal of Basic and Applied Sciences.* 8(22): 35-39.

[10] Farah, R. N., Irwan, N., Zuraida, R. L., Amira, S., and Hafiz, M. H. 2014. Path Planning for Mobile Robot Based on Reactive Collision Avoidance Method. *Australian Journal of Basic and Applied Sciences.* 8(11): 1-7.

[11] Tang, S. H., Ang, C. K., Nakhaeinia, D., Karasfi, B., and Motlagh O. 2013. A Reactive Collision Avoidance Approach for Mobile Robot in Dynamic Environments. *Journal of Automation Control Engineering.* 1(1): 16-20.