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Path Planning for Mobile Robot Based On Reactive Collision Avoidance Method

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ABSTRACT
Background: The number of researchregarding local path planning of the Unmanned Ground Vehicle (UGV) is increasing widely. The Modified Virtual Semi Circle (MVSC) approach is proposed for real-time path planning. This research proposes the implementation of five ultrasonic range finder sensors with a very small blind zone existence in the sensor arrangement. The navigation of the mobile robot depends on the position of the mobile robot in the influence zone area. The formation of three layers of influence zone shows the optimized path planning without making any unnecessary obstacle avoidance presence. **Objective:** The purpose of this paper is to navigate a cost effective UGV known as MG-TruckS with optimal path planning. **Results:** The implementation of MVSC produced shortest path, smoothness of the velocity and successfully avoids collision with the obstacles to reach it predetermined target. **Conclusion:** MVSC propose a simple path planning that requires low computational cost and do not demand for a very large memory.

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INTRODUCTION

Path planning is executed by calculating a path for a mobile robot to move from one position towards target position without any collision with obstacles (Ya-Chung Chang and Yoshio Yamamoto, 2009). There are many type of mobile robot. This research is focusing on Unmanned Ground Vehicle (UGV). UGV is a type of an autonomous mobile robot. It is a vehicle that operates while in contact with the ground and without human presence on board. UGV can be autonomous vehicles which are capable to sense their environment on their own or can either be remote guided vehicles (R.N. Farah *et al*., 2013). There exist the other types of unmanned vehicle which are unmanned aerial vehicle (UAV) for in the air, unmanned underwater vehicle (UUV) and unmanned sea-based vehicle (R.N. Farah *et al*., 2014).

There are two types of path planning approach to navigate an autonomous mobile robot; local path planning and global path planning. Through years, most of the researchers are more interested to create a real-time path planning for an autonomous mobile robot in an unknown environment. Real-time path planning of a mobile robot involves static or dynamic (moving) environment. It is usually known as local path planning. Local path planning is path planning that will directly map the local sensory data to control command without building any global model (Yi Zhu *et al*., 2012). While, global path planning need to have the whole information about the environment to create it path based on map, cell, grid or etc (Buniyamin N. *et al*., 2011). In order to navigate the real-time path planning for a mobile robot, it needs to rely on the sensory information data in order to perform it path and reach it predetermined target successfully. The sensor-based motion planning method also named as reactive navigation methods. In the most reactive navigation approach, the challenge is to cope with cluttered, dense and complex environment (S. H. Tang *et al*., 2013).

This paper describes a new local path planning anda new reactive collision avoidance approachbased on Virtual Semi Circle by S. H. Tang *et al*. (2013). This new approach is known as Modified Virtual Semi Circle (MVSC). MVSC keep four modules of VSC which are division, evaluation, decision and motion generation with new methods.The purpose of this research is to navigate a UGV called Mobile Guard UGV-Truck Surveillance (MG-TruckS).

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The next section of this paper is methodology of the MVSC that included two phases of the mobile robot navigation which are detection phase and avoidance phase. Then, the experimental results will be discussed followed with conclusion to summarize this paper.

Methodology:

Real-time obstacle detection and avoidance is one of the key issues in an autonomous navigation of mobile robots (R. Lagisetty *et al*., 2013). MVSC proposed the usage of five ultrasonic range finder sensors to detect the actual position of the obstacles. Detection phase include two modules; division and evaluation. While, the obstacles avoidance phase navigate the MG-TruckS towards target with free collisions path planning. This phase involved another two modules; decision and motion generation. The footprint of the MG-TruckS is illustrated as in Figure 1.

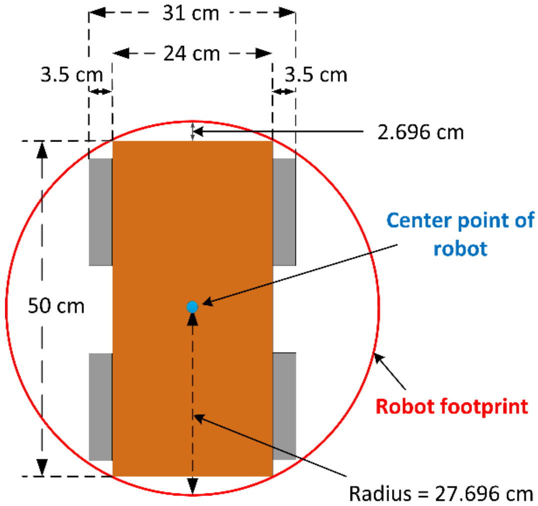

Fig. 1: MG-TruckS footprint.

A. Detection phase:

The main objective of this research is to prove the effectiveness of thenew MVSC approach. The MVSC implemented only five numbers of sensors which lead to the cost effective mobile robot. Detection phase include division and evaluation.

i. Division:

Figure 2 shows the sensor array of six sonar sensor in VSC with 35°radius of detection. It produces 180° total angle for the forward looking motion of the mobile robot. Corresponding to the six sensors arrangement, the robot workspace is divided to six subspaces. The subspaces are *R (Right), RF (Right-front), FR (Front-right), FL (Front-left), LF (Left-Front) and L (Left)*. VSC divided each of it subspaces into three regions named as *Near (1 m radius from the robot), Middle (with radius 1m to 2m middle semi-circle) and Far (with radius from 2m to 3m.).* Hence, the total region in VSC is 18 regions ($6 \times 3 = 18$).

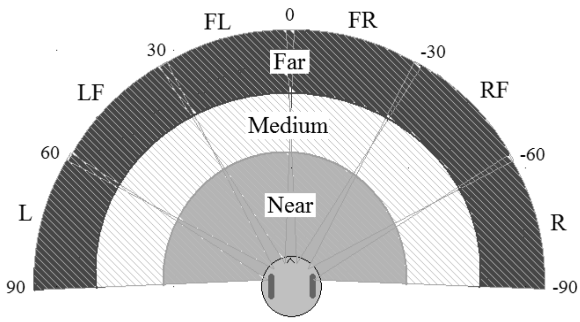

Fig. 2: The robot's subspaces for six sonar sensors in VSC (H. Tang *et al*., 2013).

Meanwhile, the MG-TruckS in new MVSC is equipped with five ultrasonic range finder sensor with 30° radius of detection as shown in figure 3 with maximum range detection is set to 3m. The total angle produced by MVSC is 158.487°. Even though there are less number of sensors being implemented to the MG-TruckS in MVSC but it still able to create wide angle of view for forward looking motion. This proved that the arrangement of the ultrasonic range finder sensor plays an important role to create wider angle. The subspaces for MVSC are *BL (Bottom Left), TL (Top Left), C (Centre), TR (Top Right), and BR (Bottom Left)*.

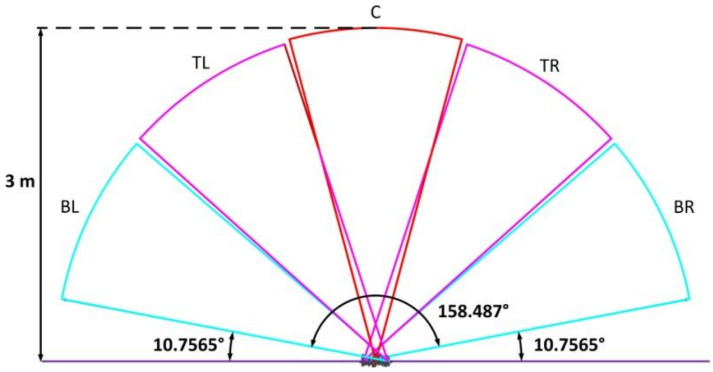

Fig. 3: The MG-TruckS subspaces for five sonar sensors in MVSC.

The arrangement of five ultrasonic range finder sensors for the MG-TruckS is shown in figure 4. In order to generate wide angle of the forward looking motion, the arrangement of the sensor produce overlap area (figure 4) and blind zone area (figure 5).Figure 5 presents the sensor array (S0, S1, S2, S3 and S4) of the MVSC with the existence of approximate to1° blind zone. The existence of the blind zone helps to increase the total angle of the sensor array and reduce overlapping issue of the obstacle detections since the overlapping area exist in some of the region in the sensor arrays.

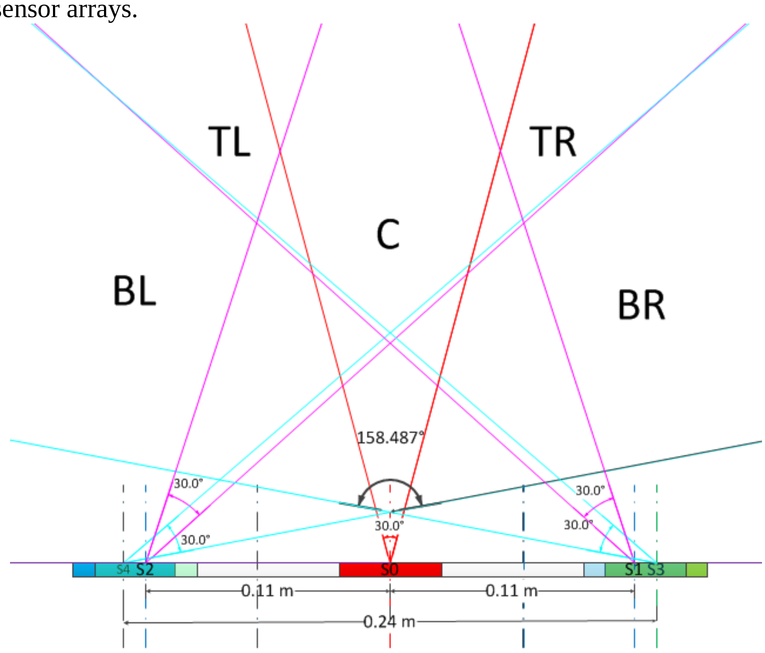

Fig. 4: The arrangement of five ultrasonic range finder sensors and overlap area of the sensor.

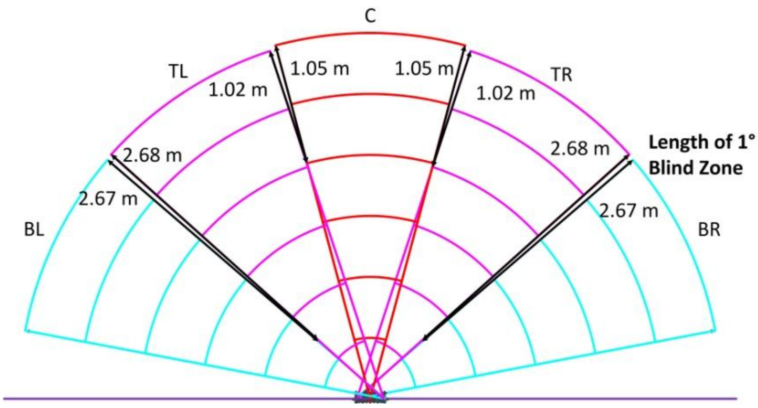

Fig. 5: The length of the blind zone area.

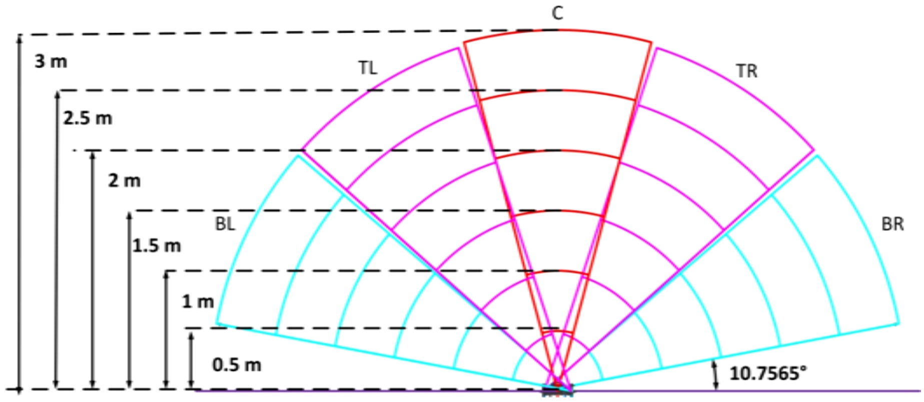

Fig. 6: The MG-TruckS subspaces for five sonar sensors in MVSC.

Each subspace of sensor is divided into 6 regions. The divisions of the region will helps to identify the actual position of the obstacles and avoid creating the unnecessary obstacles avoidance path. The radius of detection for the sensor arrays is 3m then be divided into 0.5m, 1m, 1.5m, 2m, 2.5m and 3m. The total region in MVSC are 30 regions ($5 \times 6 = 30$) which is more regions compared to the VSC approach.

ii. Evaluation:

This module describes the mobile robot and obstacles relation within the evaluation region. Each region of the sensor arrays will be label by numbering.

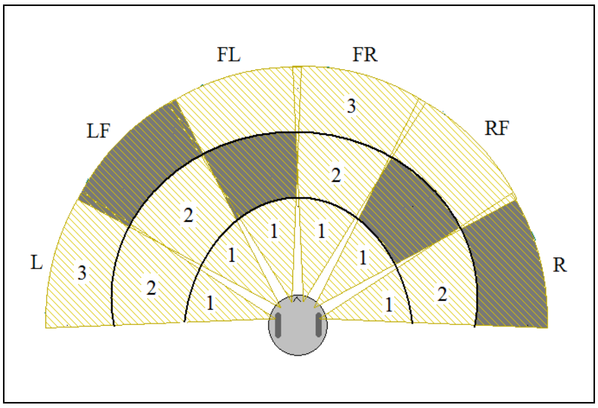

Fig. 7: Evaluation of the robot's workspace in VSC (H. Tang *et al*., 2013).

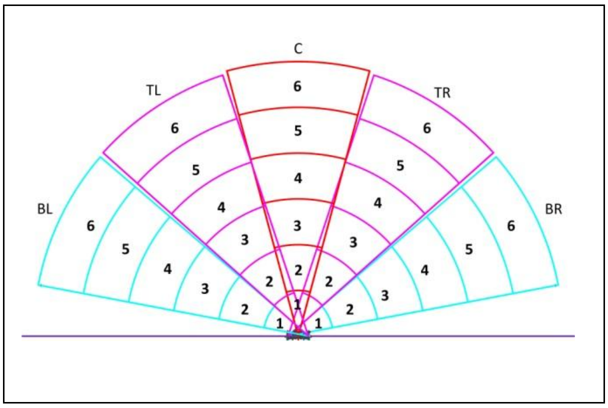

Fig. 8: Evaluation of the MG-TruckS region in MVSC.

Figure 7is the evaluation from the original work of VSC. It defines the regions by numbering it from region 1 until region 3 in each subspace with the obstacles detection in grey regions. MVSC proposed 6 regions and labeling it as shown in Figure 8. The region with high value represents the higher distance from the UGV to the obstacle detection. If UGV detect the obstacles position in region 3 inTR's sensor, region 3-6 will be defined as not navigable region. The next step is to decide the navigable path for the UGV to compute its new trajectory for the path planning of the MG-TruckS.

B. Avoidance phase:

Obstacle avoidance is the process of directing a robot's path to overcome expected and unexpected obstacles (J. A. Oroko and G. N. Nyakoe, 2102). Therefore, in order to navigate the MG-TruckS toward free collision avoidance path, the mobile robot must have the ability to avoid detected obstacles.

iii. Decision:

The MG-TruckS will create it path planning toward target by fulfill all the cases as shown below:

Case 1: Influence Zone 3:

When distance of the obstacles is longer, the angle for new trajectory direction of motion will be smaller.

Case 2:Influence Zone 2:

When distance of the obstacles is shorter, the angle for new trajectory direction of motion will be larger.

Case 3: Influence Zone 1:

The angle for steering motion of the MG-TruckS will be the smallest one which will navigate the MG-TruckS to be nearer to the obstacles.

The influence zone will be generated after the ultrasonic range finder sensors detect the obstacles. It consists of three layer of influence zone.Each layer is created from the obstacles. The first layer known as first influence zone with 1 m distance from the obstacle detection, followed by second influence zone within 2 m from the obstacle, and 3 m from the obstacle as for the third influence zone as shown in Figure 9. The MG-TruckS will navigate from influence zone three towards influence zone one in order to reach the target position.

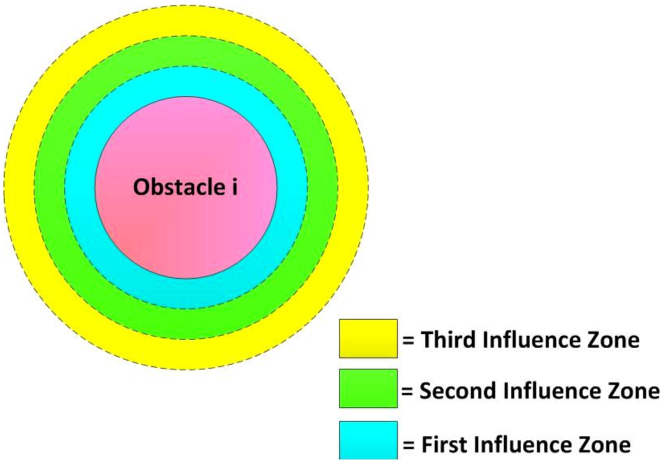

Fig. 9: Formation of the influence zone.

iv. Motion generation:

A new trajectory will be generate after the MG-TruckS decide the position of the MG-TruckS in the influence zone. Direction of motion (θ) is equal to the angle between *y-axis* of the MG-TruckS position with the safe navigable region. The value of the direction of the motion is changes based on distance of the obstacles detection and the position of the MG-TruckS in the influence zone.

Experimental Results:

The effectiveness of the proposed MVSC is demonstrated by simulations. The optimal path planning is created from start position toward thegoal position. The mobile robot gains the distance information from five ultrasonic range finder sensors that been equipped to the mobile robot. The start and the target position is known while the environment is completely unknown. The same translational velocity and environment with the VSC approach is set. Maximum velocity is set to $V_{max} = 0.4\ ms^{-1}$ and normal velocity is set to $V_n = 0.2\ ms^{-1}$.

In Example 1 (Figure 10 and Figure 11),the start point is at (6m, 11m) and the goal point is at(17m, 10m) and the robot's steering control. While in example 2 (Figure 12 and Figure 13), the start point is at (5m, 12m) and the goal point is at (14m, 15m) and the steering robot's direction was presented as well.

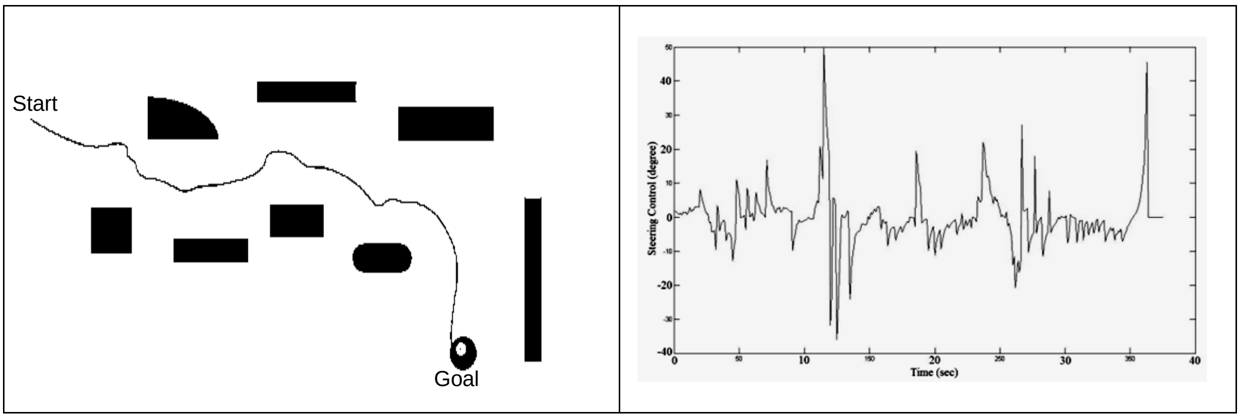

Fig. 10: Trajectory executed and steering control profile in VSC approach (H. Tang *et al*.,2013).

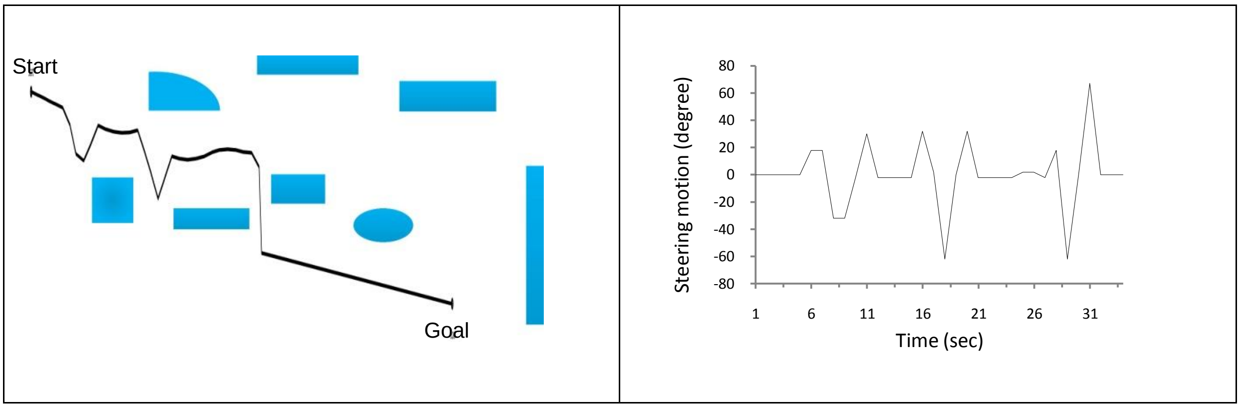

Fig. 11: Trajectory executed and steering control profile in MVSC.

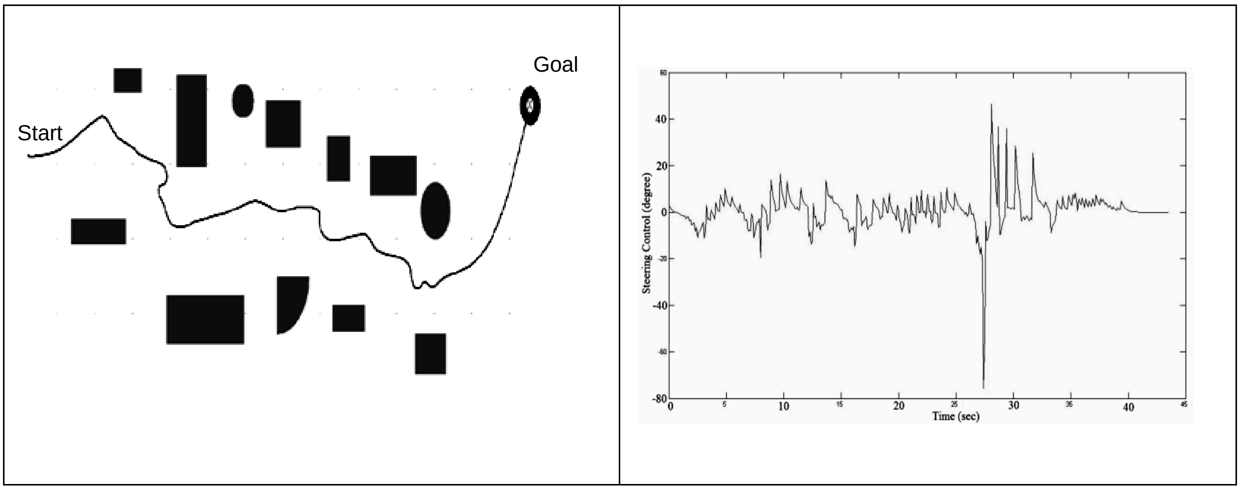

Fig. 12: Trajectory executed and steering control profile in VSC approach (H. Tang *et al*.,2013).

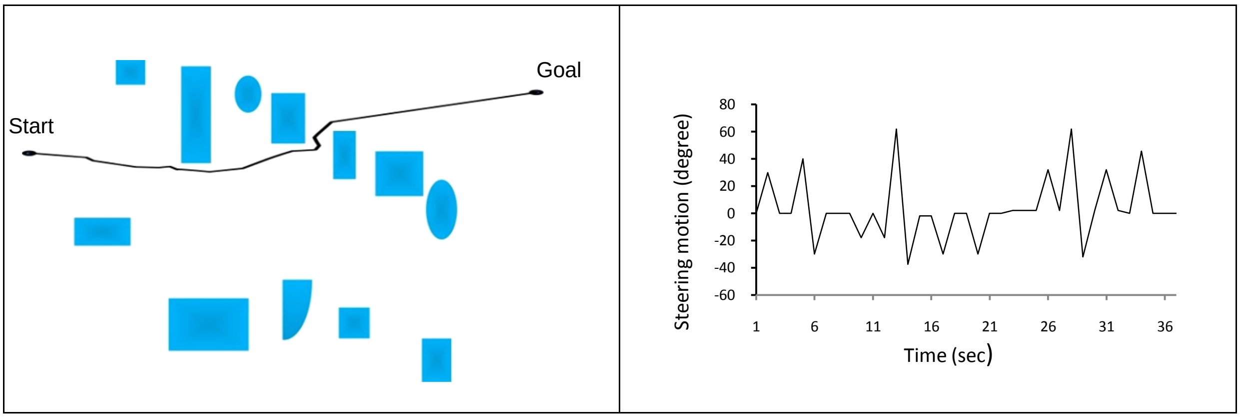

Fig. 13: Trajectory executed and steering control profile in MVSC.

Conclusion:

This paper presents a reactive collision avoidance method that describes each of the situations and simplifies the difficulty of the path planning by divide and conquers strategy with *situated-activity paradigm*. The Modified Virtual Semi Circle is a new approach. The mobile robot is equipped with new arrangement of sensor to create wider angle. The different layers of influence zone for each obstacle detection produced different steering motion in order to create the optimize path planning. The approach is simple, it requires low computational cost and do not demand for very large memory. The path planning for the mobile robot shows that it does not makes unnecessary obstacles avoidance. Hence, the path planning of the MG-TruckS is optimizing with shortest path taken.

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REFERENCES

Buniyamin, N., W.A.J. Wan Ngah, N. Sariff, Z. Mohamad, 2011. A Simple Local Path Planning for Autonomous Mobile Robots. International Journal Of Systems Application, Engineering & Development, 2(5): 151-159.

Farah, R.N., N. Irwan, R.L. Zuraida, M.H. Hafiz and Umairah, 2013. Challenging of Path Planning Algorithms for Autonomous Robot in Known Environment, presented at the Proceedings of the 3rd International Conference on Mathematical Sciences, Kuala Lumpur, Malaysia.

Farah, R.N., N. Irwan, R.L. Zuraida, M.H. Hafiz and Umairah, 2014. Challenging of Path Planning Algorithms for Autonomous Robot in Unknown Environment.Lect. Notes Inf. Theory, 2(1): 121-125.

Lagisetty, R., N.K. Philip, R. Padhi and M.S. Bhat, 2013. Detection and Obstacle Avoidance for Mobile Robot using Stereo Camera. IEEE International Conference and Control Application, 605-610.

Minguez, J. and L. Montano, 2004. Nearness Diagram (ND) Navigation: Collision Avoidance in Troublesome Scenarios. IEEE Transactions on Robotics and Automation, 20: 45-59.

Oroko, J.A. and G.N. Nyakoe, 2012. Obstacle Avoidance and Path Planning Schemes for Autonomous Navigation of a Mobile Robot: A Review. Proceedings of the 2012 Mechanical Engineering Conference on Sustainable Research and Innovation, 4: 314-318.

Tang, S.H., C.K. Ang, D. Nakhaeinia, B. Karasfi and O. Motlagh, 2013. A Reactive Collision Avoidance Approach for Mobile Robot in Dynamic Environments.*J. Autom. Control Eng.*, 1(1): 16-20.

Yi Zhu, Tao Zhang, Jingyan Song and Xiaqin Li, 2012. A New Bug-Type Navigation Algorithm For Mobile Robot In Unknown Environment Containing Moving Obstacles.Industrial Robot: An International Journal, 39(1): 27-39.