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A Reactive Navigation for a Mobile Robot: An Improvement for Modified Virtual Semi Circle Approach

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ABSTRACT

Background: An important task for navigation is to navigate an autonomous mobile robot. An autonomous mobile robot has to gain the information from its environments to successfully reach it predetermined goal without any collision. There are many type of mobile robots existed. One of an autonomous mobile robot is known as Unmanned Ground Vehicle (UGV). UGV can be an autonomous vehicle. An improvement for Modified Virtual Semi Circle ($MVSC_i$) is proposed to navigate a UGV that is equipped with five ultrasonic range finder sensors. **Objective:** The objective of this paper is to improve a reactive navigation for a UGV path planning. **Results:** The proposed method enhances the time processing for the UGV. It computes shortest time processing, smoothness of velocity, shortest path, and successfully navigates the UGV towards goal location without any collision. **Conclusion:** The improvement of MVSC produces simplest path planning and a cost effective UGV.

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INTRODUCTION

Surveillance issues have received an increasing amount of attention among the researcher. The application of the unmanned ground vehicle through civilian as well as military applications is increasing as well (David Anisi and Petter Ogren, 2009). There are several types of unmanned vehicles are introduced such as unmanned ground vehicle (UGV), unmanned aerial vehicle (UAV) for in the air, unmanned underwater vehicle (UUV) and unmanned sea-based vehicle (USV) for surface craft. (R. N. Farah *et. al*., 2013). However, this research is focusing on UGV types of mobile robot only.

UGV can be in an autonomous vehicle category. An autonomous mobile robot travels from the start location to the goal location without the need of human intervention (Gu. J. and G. Qixin., 2011). The path planning for navigating the UGV is divided into two; local path planning and global path planning. Local path planning gains the environment information from sensors. It directly uses the sensor's information command that control motion without constructing global map (R. N. Farah *et. al*.,2014). UGV with global path planning is necessary to build the environment model by implementing any method existed such as map model method and network grid based modeling method (Guo and Liu, 2010). The optimal path with shortest path selection, the smoothness of velocity and successfully travel toward goal location without trapped is mainly become the main attention for the researcher nowadays.

An improvement of Modified Virtual Semi Circle ($MVSC_i$) approach proposed an improvement works from MVSC approach proposed by R. N. Farah *et. al*.,2014. MVSC is a new reactive navigation approach path planning based on Virtual Semi Circle (VSC) proposed by S.H Tang *et. al*.,2013. VSC approach mainly developed based on the "situated-activity paradigm" and "divide and conquer" strategy. This strategy is a simplified techniques by applying motion law based on navigation cases (Minguez *et.al*., 2004). The $MVSC_i$ is a real-time based navigation, it is mainly used the data from the sensory information to execute it path planning, The UGV in this research is known as Mobile Guard UGV- Truck Surveillance (MG-TruckS).

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Methodology:

This paper proposed $MVSC_i$ approach to simplify the previous modules in MVSC. This approach reduces the amount of modules in MVSC from four modules to three modules. The $MVSC_i$ approach enhances the time processing of evaluating the path planning for the UGV. The proposed approach is divided into two phases which are detection phase and avoidance phase. Detection phases only keep one module of MVSC known as division. Meanwhile, avoidance phase keeps the original works of MVSC decision and motion generation's module.

A. ***Detection phase:***

Detection phase present the division modules for the $MVSC_i$ approach. The information of the workspace area of the MG-TruckS is collected by the ultrasonic range finder.

i. Division:

There are five ultrasonic range finder sensors is equipped to detect the position of the obstacles in the workspace area. Therefore, the space area of the sensors array is divided into five subspaces. Each subspaces are *BL (Bottom Left), TL (Top Left), C (Centre), TR (Top Right), and BR (Bottom Left)*. Each of the ultrasonic range finder sensor arrays has 30° radius of detection with 3 meter distance range. The sensors have been arranged to produce 158.487° total angle of the sensor arrays for forward looking motion with the existence of 1° blind zone. The sensor arrangement has been discussed in MVSC approach. Fig. 1 shows the subspace for five ultrasonic range finder sensors in MVSC.

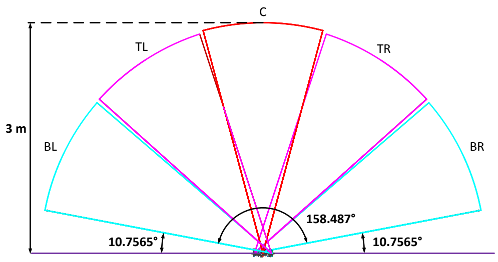

Fig. 1: The subspaces for five ultrasonic range finder sensors in MVSC (R.N Farah *et. al.*, 2014).

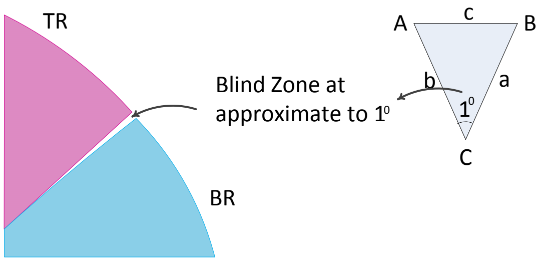

Fig. 2: The approximation length from 1° blind zone area.

Fig 2. above shows the implementation of the Isosceles Triangle Theorem (equation i) to find the maximum length for the blind zone. Since the maximum length of AB is approaching 1.75 cm and it is a small value, hence the existence of the blind zone is significantly ideal.

$$\frac{a}{\sin A} = \frac{b}{\sin B} \quad \text{(i)}$$

$$\frac{100\,cm}{\sin 89.5} = \frac{b}{\sin 1} \quad \text{(ii)}$$

$$b \sin 89.5 = 100 \sin 1 \quad \text{(iii)}$$

$$\approx 1.75\ cm \quad \text{(iv)}$$

The division of the sensor arrays and the region of the subspaces array helps to identify the actual position if the obstacles inside the workspace area. Each of the subspace arrays are divided into six regions with 0.5 m difference of range. Each region ends at 0.5m, 1 m, 1.5 m, 2 m, 2.5 m, and 3 m. The number of each region labeled as shown in Fig. 3.

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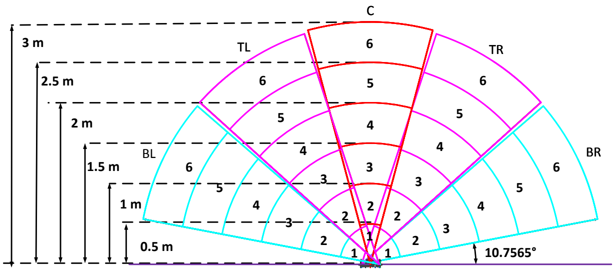

Fig. 3: The region for each subspace of ultrasonic range finder sensors

Once the obstacle has been detected by the ultrasonic range finder sensors, the influence zones will be generated from the obstacle position. There will be three layers of influence zone known as first influence zone, second influence zone and third influence zone. The first influence zone is generated within 0.00 m and 1.00 m distance from the obstacle position, while second influence zone is generated between 1.01 m and 2.00 m from the obstacle position. Meanwhile, the third influence zone is generated between 2.01 m and 3.00 m distance from the obstacle. Therefore, once the obstacle has been detected, the sensory information will define the region and the influence zone area for the position of the obstacle. The construction of the influence zone is shown in Fig. 4.

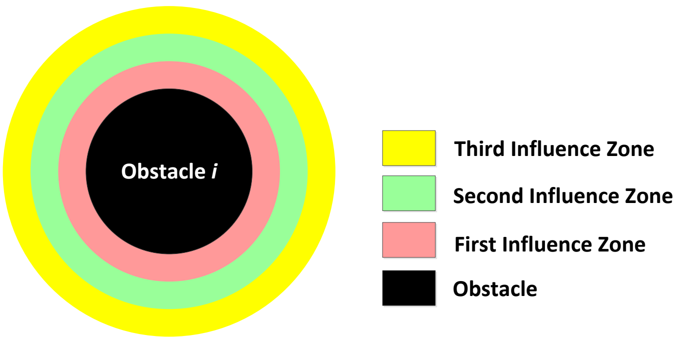

Fig. 4: The formation of the influence zone.

B. ***Avoidance phase:***

The mobile robot must have the ability to create a free collision path planning especially in an unknown environment. It requires the mobile robot to plan it motion to reach it predetermined goal when there is no prior knowledge of them (Y. Zhu *et. al.*, 2012). Avoidance action takes place if there is a detection of the obstacle from the ultrasonic range finder sensors.

ii. Decision:

The UGV will then decide it path planning towards goal based on the position of the obstacles within the region of obstacle position and the area of the influence zone. The path planning fulfills the conditions below:
Condition 1: If the UGV is in the first influence zone, then the UGV will navigate as near as it can be toward the obstacles.
Condition 2: If the UGV is in the second influence zone, then the UGV will navigate away from the obstacles.
Condition 3: If the UGV is in the third influence zone, then the UGV will navigate closer the obstacles.

iii. Motion generation:

The direction of motion of the UGV (θ_{r_i}) is decided on the decision step. The velocity value will depends on the θ_{r_i} where $v_r = v_{max}$ if the UGV navigation has no obstacles detection otherwise, the UGV will reduces the velocity.

Experimental results:

The proposed $MVSC_i$ is demonstrated by simulations result. A reactive UGV path planning gain the information based on the sensory information. The position of the obstacle is defined in the region and the influence zone area. The UGV path planning started from coordinate (5m, 12m) and the target coordinate is (14m, 15m).

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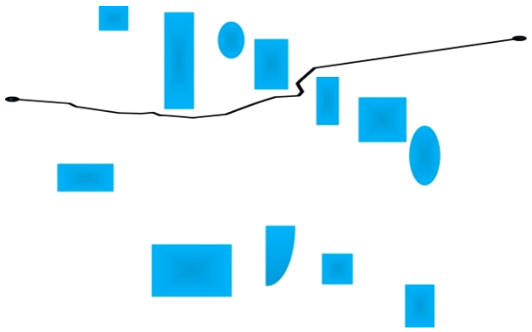

Fig. 5: Trajectory executed in the $MVSC_i$.

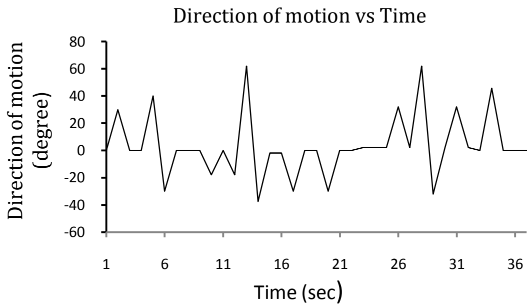

Fig. 6: The direction of motion for the UGV.

Conclusions:

A reactive navigation of UGV has been proposed. The direction of motion will totally depend on the situation of the environments of the UGV. The simple algorithm will directly produce a simple path planning and reduce the computational time. Hence, a large memory is not necessary. Since the $MVSC_i$ reduced the number of modules from it original works, it helps to reduce the processing time for the UGV to generate it new trajectory. The path planning shows it is not makes any unnecessary obstacles avoidance. Therefore the improvement of MVSC will help to reduce the computational burden and optimized with shortest path taken.

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