DEVELOPMENT AND EVALUATION OF MODIFIED VIRTUAL SEMI CIRCLE PATH PLANNING OF MOBILE GUARD UNMANNED GROUND VEHICLE TRUCK FOR SURVEILLANCE

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ABSTRACT

This study aims to develop and evaluate path planning algorithm for an Unmanned Ground Vehicle (UGV). UGV in this thesis is known as Mobile Guard UGV-Truck for Surveillance (MG-TruckS). MG-TruckS is used to enhance the efficiency of the security in monitoring the residential areas. MG-truckS is able to help human in facing a high risk situations such as burglary, murder, theft and robbery. Modified Virtual Semi Circle (MVSC) algorithm is an algorithm that has been proposed to navigate the MG-TruckS. MVSC approach is implemented in this study. MVSC is divided into two phases which are obstacle detection and obstacle avoidance to compute an optimal path. MG-TruckS is equipped with five ultrasonic range finder sensors with an ideal arrangement in order for locating a minimum number of sensors. There is a blind zone in order to perform a wide forward looking motion. There are three influence zone with three conditions that are formed in each obstacle detection. The study succeeded in producing lemmas and theorem that support the algorithm proposed and has been verified through simulation by MATLAB. In conclusion, this study is managed to build, evaluate and modified Virtual Semi Circle (VSC) with new approach based on VSC to navigate the MG-TruckS. The implication is the simplest path planning proposed helps to reduce the workload by an UGV to compute it path planning.

PEMBINAAN DAN PENILAIAN PERANCANGAN PERJALANAN SEPARA BULATAN MAYA TERUBAHSUAI BAGI PENGAWAL MUDAH ALIH KENDERAAN TRUK DARAT TANPA PEMANDU UNTUK PENGAWASAN

ABSTRAK

Kajian ini bertujuan untuk membina dan menilai algoritma perancangan perjalanan bagi Kenderaan Darat Tanpa Pemandu (KDTP). KDTP di dalam tesis ini dikenali sebagai Truk Pengawal Mudah Alih untuk Pengawasan (TPMAP). TPMAP digunakan untuk meningkatkan kecekapan dari segi keselamatan dalam pemantauan kawasan perumahan. TPMAP dapat membantu manusia dalam menghadapi keadaan yang berisiko tinggi seperti pecahrumah, pembunuhan, kecurian dan rompakan. Algoritma Bulatan Separa Maya Terubahsuai (BSMT) adalah algoritma yang dicadangkan bagi mengemudi TPMAP. Pendekatan BSMT digunakan di dalam kajian ini. BSMT dibahagikan kepada dua fasa iaitu fasa mengesan halangan dan fasa mengelak halangan bagi membolehkan pengiraan perjalanan yang optimum. TPMAP telah dilengkapi dengan lima pengecam sensor julat ultrasonik dan telah disusun dengan perkiraan ideal bagi meletakkan bilangan sensor yang minimum. Terdapat zon buta dalam menghasilkan sudut pandangan hadapan yang besar. Terdapat tiga zon pengaruh dengan tiga keadaan yang terbentuk pada setiap pengesanan pada halangan. Dapatan kajian berjaya menghasilkan lemma dan teorem bagi menyokong algoritma BSMT yang dicadangkan dengan disahkan melalui simulasi menggunakan MATLAB. Kesimpulannya, kajian ini telah berjaya membina, menilai dan mengubahsuai algoritma Bulatan Separa Maya (BSM) dengan pendekatan baharu berdasarkan BSM bagi mengemudikan TPMAP. Implikasinya, perancangan perjalanan mudah yang dicadangkan membantu mengurangkan beban bagi KDTP dalam pengiraan perancangan perjalanan.

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LIST OF ABBREVIATIONS

APF	Artificial Potential Energy
AUV	Autonomous Underwater Vehicle
BL	Bottom Left
BR	Bottom Right
C	Centre
CCTV	Closed-Circuit Television
F	Far
FL	Front-Left
FR	Front Right
GNRON	Goals Non-Reachable with Obstacles Nearby
GPS	Global Positioning System
HSGR	High Safety Goal in Region
HSNR	High Safety Narrow Region
HSWR	High Safety Wide Region
HVFF	Hybrid Virtual Force Field
L	Left
LGSR	Low Safety Goal Region
LS1	Low Safety 1 Side
LS2	Low Safety 2 Side
M	Middle
MG-TruckS	Mobile-Guard UGV Truck Surveillance

MVSC	Modified Virtual Semi Circle
N	Near
ND+	Nearness Diagram
PDRM	Royal Malaysia Police
PFM	Potential Field Method
R	Right
RELA	The People's Volunteer Corps
RF	Right-Front
RS	Regression Search
SND	Smoothness Nearness Diagram
TL	Top Left
TR	Top Right
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
USV	Unmanned Surface Vehicle
VFF	Virtual Force Field
VGC	Virtual Goal Concept
VOC	Virtual Obstacle Concept
VSC	Virtual Semi Circle
2D	Two dimensional

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The 10th Malaysia Plan (2011-2015) government put an effort to enhance public confidence in public safety since it is a critical concern for all Malaysians. It showed the government's efforts and strategies to improve public safety in order to decrease in overall index crime. Police patrol, The People's Volunteer Corps (RELA), Civil Defend Department and other public department will be increased, especially in 50 hot spots areas to curb criminal activities. In addition, 496 closed-circuit televisions (CCTV) are currently being installed in hot spot areas cross Malaysia that linked to Royal Malaysia Police (PDRM)'s control centre to increase monitoring capacity (10th Malaysia Plan, 2010). This shows that the government spend a large amount of money on surveillance issues and the seriousness of the problems need to be overcome.

This research is focusing on creating a safer and more secure environment in the residential areas. The efficiency of the security in monitoring the residential areas is important. Their actions will enhance the environment for citizens and visitors and is also expected to reduce crime and improve the sense of security.

The application of unmanned vehicle toward surveillance issue has received an increasing amount of attention through decades. Unmanned system describes a machines or device that is equipped with necessary data processing units, sensors, automatic control and communication systems that capable to execute missions autonomously without human intervention (Caska & Gayretli, 2015). The presents of the unmanned vehicle is to enhance the ability of the CCTV which recorded at static placed. Unmanned vehicle can be used for many applications where it may be inconvenient and dangerous to be handled by human. Due to this significant, unmanned vehicle is able to help the security guard facing with high risk situation to be handled by human such as burglary, murder, theft and robbery. There are many types of unmanned vehicle existence that will be discussed in the next section.

1.1.1 Unmanned System Type of Vehicle

All types of unmanned vehicles have different speciality with different usage in several situations. Unmanned vehicle has the ability of sensing their environment or can either be a remote control vehicle. The types of unmanned vehicle that will be discussed in this sections are Unmanned Ground Vehicle (UGV), Unmanned Aerial Vehicle (UAV), Unmanned Surface Vehicle (USV) and Autonomous Underwater Vehicle (AUV).

1.1.1.1 Unmanned Ground Vehicle (UGV)

Unmanned Ground Vehicle (UGV) is a vehicle that is able to operate while in contact with the ground without human presence on board. Generally, UGV operates with the existence of the sensors. The sensory information helps to observe the environment and automatically makes decision or send the information to a human operator that operate the UGV in a different location (Xin & Bin, 2013).

Figure 1.1. The Surveillance UGV test bed. Adapted from "Minimum time multi-UGV surveillance" by Anisi and Ogren, 2011

Figure 1.1 is adapted from Anisi and Ogren (2011) research worked. It shows a small scale UGV used in surveillance and security application that was used in their experiment. This research will also focusing on surveillance issues. The UGV is equipped with cameras to patrol residential areas. In this research, the UGV is known as Mobile Guard UGV-Truck for Surveillance (MG-TruckS).

1.1.1.2 Unmanned Aerial Vehicle (UAV)

Unmanned Aerial Vehicle (UAV) is commonly known as drone, it is an aircraft without human pilot aboard. It uses aerodynamic forces to provide vehicle lift, can fly autonomously or piloted remotely. It is usually used to get aerial photos and videos at traffic collisions, crime scenes and in search and rescue operations (Caska & Gayretli, 2015).

Figure 1.2. The Micro drones MD4-200 UAV with Tetracam ADC Lite. Adapted from "Multi-temporal imaging using an unmanned aerial vehicle for monitoring a sunflower crop" by Vega, Ramirez, Saiz and Rosua, 2015

Figure 1.2 shows one type of UAV which is the Micro drones MD4-200 UAV with Tetracam ADC Lite that was used for image acquisition in agricultural research. Vega et. al (2015) discovered the capability of an unmanned aerial vehicle system carrying a multispectral sensor to acquire multi-temporal images during the growing season of a sunflower crop.

1.1.1.3 Unmanned Surface Vehicle (USV)

Unmanned Surface Vehicle (USV) is also known as Autonomous Surface Vehicle (ASV). It is a vehicle that operate at the surface of the water without a crew (Xiaowie, Guang, Jin & Aiping, 2011). The development of remote sensing and radar technology lead to the long distances observations for the ocean. Therefore, USV is commonly known as a kind of observation platform (Sheng, Yan, Jiu & Zhao, 2014).

Figure 1.3. USV called Edredon. Adapted from "Using neural-evolutionary-fuzzy algorithm for anti-collision system of Unmanned Surface Vehicle" by Szymak and Praczyk, 2012

Presented in Figure 1.3 is a USV called Edredon. It is the first Polish Unmanned Surface Vehicle. Edredon was used by the naval forces to protect the seas and coastal waters, bay and harbors. USV is also an important vehicle in marine's sciences and oceanography. It helps to collect weather and ocean data within the world's oceans. The vehicle can be autonomously or remotely operated from Mobile Command Centre or controlled by a steersman from its board (Szymak, 2010).

1.1.1.4 Autonomous Aerial Vehicle (UAV)

Autonomous Underwater Vehicle (AUV) is a vehicle that has the ability to travel underwater, it accomplishes underwater exploration, detection, and even offensive and defensive military missions. AUV is a vehicle that can drift, glide through the ocean and collect data deep in the ocean. The AUV communicate through satellite signal or underwater acoustic beacon to permit some level of control (Ji & Jiang, 2014).

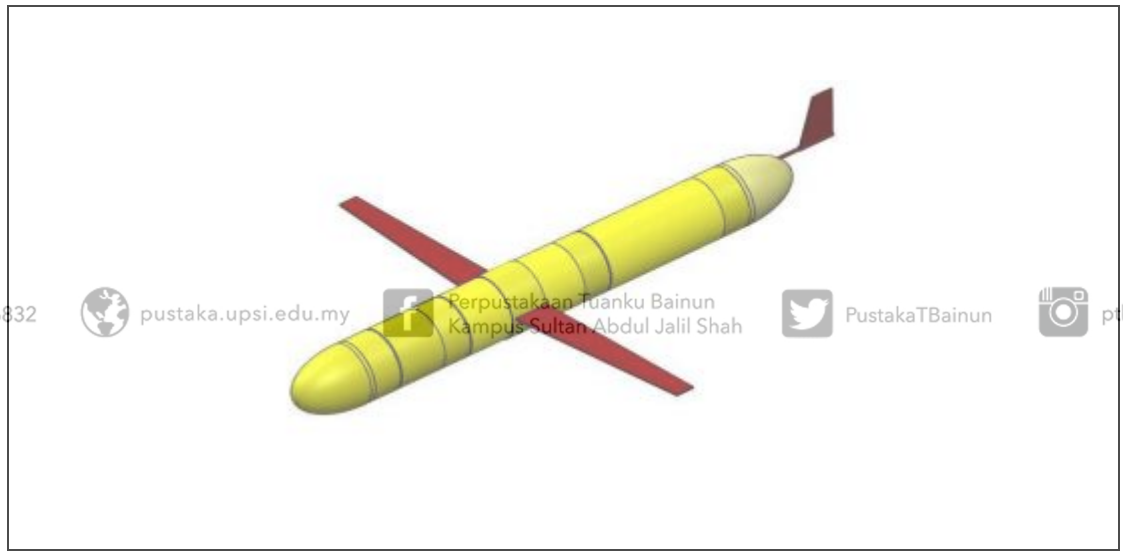

Figure 1.4. Glider modular underwater vehicle. Adapted from "Design of a reconfigurable modular underwater vehicle" by Wang, Zhang, Zhang and Su, 2011

Figure 1.4 shows the design of an AUV that glide through the ocean. Wang et al. (2011) improve the adaptability of a small AUV for different requirements in various work by analysing the current structure of modern modular underwater vehicles. Since the different mechanical interface for each AUV affect the overall performance of AUV hence, a strong adaptability of the AUV is required. The reconfigurable structure validated the modular design method and the module interfaces are feasible and effective.

1.1.2 Path Planning of the UGV

Path planning is a task for navigating the UGV with a free collision avoidance towards its goal position. There are two types of path planning; local path planning and global path planning. Local path planning can be used when the UGV has no information about the environment. The UGV directly use the sensors' information in the commands that control the robot's motion in every control cycle, without constructing a global map. Therefore, the algorithm are employed to guide the robot in one straight path from the starting point to the unknown target location or dynamic environments. While the robot navigates, it avoids obstacles that are in its path and keeps updating the significant information, such as the distance between its current location and the target position. Typically, the local navigation algorithms are easy to construct and optimal for real-time applications.

Global path planning is usually implemented to the UGV with a known environment. The information is gained offline before the UGV started. Path planning for the UGV's starts position to the target position is constructed by searching a graph that represents a map of a global environment. The graph can be constructed either off-line or on-line. The global path planning is necessary to build the environment model such as grid based modelling method (Guo & Liu, 2010). Usually, the map is initially loaded into the robot and then the optimize path will be calculated depending on the navigation algorithm (Khusheef, 2013).

There are many existed approaches to navigate an autonomous mobile robot. The approaches to be implemented to the mobile robot are different according to the environment, type of sensor, robot capabilities and many more. The numbers of new approaches increase gradually toward better performance in term of time, distance, cost and complexity (Buniyamin & Ngah, 2011).

1.1.3 Surveillance Issues

Starting from the twentieth century, crime rate in Malaysia has increased exceedingly. Tang (2011) shows the statistics compiled by Royal Malaysia Police (RMP) shows that crime rate in Malaysia surged from 66,000 cases in 1990 to approximately 182,000 cases in 2000. For a decade, the crime rate in Malaysia has increased about 165 per cent (on average 16.5 per cent a year). Furthermore, this criminal statistics continues to increase and created a new record in the Malaysia's history with approximately 250,000 cases in 2008. Meanwhile, Mohit and Hassan (2010) works preview the statistics of the crime index in Malaysia from 2006 until 2007 was increased by 13.4% and the crime rate has increased by 8.7%. There are about 90% crimes in Malaysia that is occurred in the housing area involving property crimes. Property crimes including stealing, stealing of car, stealing of truck or van, stealing of bikes, snatch thefts, daytime burglary and night time burglary.

Generally, there are two categories of crimes which is violent crime and property crime (Amin, Rahim & Ayu, 2014). Amin et al. (2014) is further discussed about the trend of violent crimes in Malaysia. There are seven types of violent crime; murder,

rape, robbery with firearm, robbery without firearm, gang robbery with firearm, gang robbery without firearm and voluntarily causing grievous hurt.

Table 1.1 shows the trend of the violent crimes by Amin et al. (2014). In 2004 until 2009 there was an increasing numbers of incidents recorded for violent incidents. The most number of incidents are occurred in 2009 which is 42,365 incidents recorded but it is steadily decreased cases reported between the year 2010 until 2013.

Table 1.1

The trend of violent crimes. Adapted from "A trend analysis of violent crimes in Malaysia" by Amin et al., 2014

Violent crimes/ Year	2007	2008	2009	2010	2011	2012	2013
Murder	590	654	601	568	530	602	627
Rape	3176	3494	3840	3693	3270	2964	2718
Robbery with firearm	197	76	155	309	52	17	21
Robbery without firearm	17235	4959	4862	3834	3871	3257	3565
Gang robbery with firearm	75	182	815	1809	318	110	98
Gang robbery without firearm	7093	21804	23722	15809	16084	16738	16647
Voluntarily causing grievous hurt	6793	6648	8370	8111	6537	6244	5699
TOTAL	35159	37817	42365	34133	30662	29950	29375