

**VISUAL SIMULTANEOUS LOCALIZATION AND MAPPING
USING DIRECT-BASED METHOD FOR UNMANNED AERIAL
VEHICLE (UAV)**

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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VEHICLE (UAV)**

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**This report is submitted in partial fulfilment of the requirements
for the degree of Bachelor of Electronic Engineering with Honours**



**Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka**
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

**BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II**

Tajuk Projek : VISUAL SIMULTANEOUS LOCALIZATION AND MAPPING USING DIRECT-BASED METHOD FOR UNMANNED AERIAL VEHICLE (UAV)

Sesi Pengajian : 2022/2023

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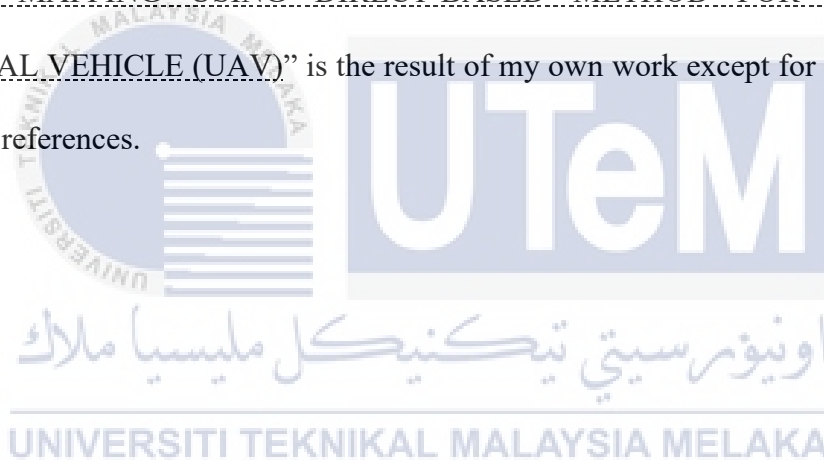
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Tarikh : 15 Januari 2023

Tarikh : 17 January 2023
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DECLARATION

I declare that this report entitled “VISUAL SIMULTANEOUS LOCALIZATION AND MAPPING USING DIRECT-BASED METHOD FOR UNMANNED AERIAL VEHICLE (UAV)” is the result of my own work except for quotes as cited in the references.



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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.



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DEDICATION

I would like to thank all those who actively or passively contributed to the completion of this project. Without their help and support, it might not be possible to fulfil all of these commitments. Besides, Dr. Norhidayah Binti Mohamad Yatim, the Supervisor of PSM, has placed her trust in me to accomplish the required thesis, for which I am very grateful. I'd also want to thank everyone who contributed diligently to the project's completion, especially my supervisor, Dr. Norhidayah Binti Mohamad Yatim, for the guidance she offered during the duration of this work. Not forget also to several individuals who helped me complete the PSM and this dissertation are also thanked. Not forgetting also to my fellow classmate, who have contributed a substantial amount of aid and cooperation in performing our job successfully.

ABSTRACT

The Direct Sparse Odometry (DSO) technique is a new form of visual odometry that makes use of a direct and sparse structure and motion formulation to achieve unprecedented precision. In this project, the objective is to apply the DSO algorithm on the Unmanned Aerial Vehicle (UAV) application. The main studies in this project are focusing on the DSO Algorithm parameter setting to achieve an optimum setting to be applied on real-time. Another objective is to evaluate the parameter and performance of DSO algorithm. The data evaluation was based on three different environments near the university campus. In this project, the Realsense D435i Camera was applied to the RDDRONE-FMUK66 with interface of the Raspberry Pi 3 B+ model to capture the data. This project managed to analyze suitable point values on the active points and gradient parameter setting. Three environments also have been experimented with the same parameter which concerns on point density, keyframe management and sparsity of the environment. Conclusion from this project is DSO on UAV can be improved in order to gain a stable data processing to apply on the algorithm.

ABSTRAK

Teknik Lurus Jarang Odometri adalah bentuk baharu visual odometri yang menggunakan struktur dan rumusan gerakan langsung untuk mencapai ketepatan yang jitu. Untuk projek ini, objektif utama adalah mengaplikasikan algoritma kepada Pesawat Udara tanpa Pemandu atau dron. Pembelajaran utama pada projek ini ialah kepada kepada tetapan pada algoritma untuk mencapai tetapan yang optima diaplikasikan pada masa sebenar. Antara objektif lain adalah untuk menilai tetapan dan kecekapan algoritma Teknik Lurus Jarang Odometri. Penilaian data adalah berdasarkan tiga situasi berbeza berhampiran kampus university. Dalam projek ini, kamera "Realsense D435i" digunakan bersama dron "RDDRONE-FMUK66 diimplementasi bersama model "Raspberry Pi 3 B+" untuk merekod data. Projek ini menilai tetapan pada algoritma iaitu titik aktif dan titik kecerunan. Selain itu, tiga situasi Berjaya diperhalusi untuk kesan kepada tetapan yang sama untuk menilai titik ketumpatan, pengurusan rangkacunci dan titik jarangan. Kesimpulan projek ini adalah algoritma pada dron boleh diperbaiki untuk mencapai proses data yang lebih stabil untuk diaplikasikan kepada algoritma.

ACKNOWLEDGEMENTS

Dr. Norhidayah Binti Mohamed Yatim, my supervisor, whose genuineness and support I will never forget, deserve my heartfelt appreciation. Dr. Norhidayah has been an inspiration as I have navigated this degree route. She is the epitome of leadership and the ideal role model. Dr. Norhidayah's supervision from the beginning of the study process helped me get a thorough knowledge of the subject matter, particularly the project topic on the Visual Simultaneous Localization and Mapping using direct based method for Unmanned Aerial Vehicle (UAV). I owe her a debt of gratitude for the incredible experiences she provided for me as well as the chances she gave me to further my career.

I am adored by my parents, Badzli Bin Said and Salina Binti Ahmad, because of their steadfast affection and self-assurance-boosting support. Their confidence in me has led to my victories and successes. My heartfelt appreciation goes to my brothers and sisters, Hamizah, Hazim, Hanif, Hazman, and Hanani, who keep me grounded, remind me of what is crucial in life, and continually encourage my endeavours. I shall be eternally grateful to my friends for their unconditional love and support during the full thesis writing process and every day.

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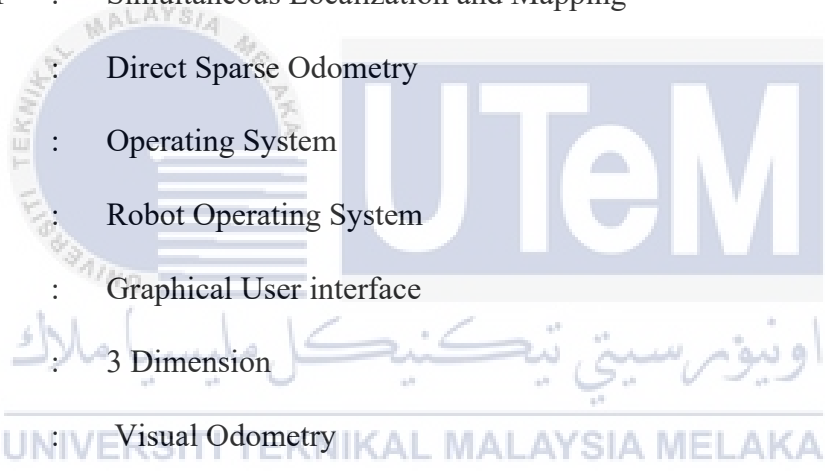
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LIST OF SYMBOLS AND ABBREVIATIONS



UAV	:	Unmanned aerial vehicle
SLAM	:	Simultaneous Localization and Mapping
DSO	:	Direct Sparse Odometry
OS	:	Operating System
ROS	:	Robot Operating System
GUI	:	Graphical User interface
3D	:	3 Dimension
VO	:	Visual Odometry
DTAM	:	Dense Tracking and Mapping
LSD	:	Large-Scale Direct Monocular SLAM
SVO	:	Semi-Direct Visual Odometry
PC	:	Personal Computer
Wi-Fi	:	Wireless Fidelity
SSH	:	Secure Shell
USB	:	Universal Serial Bus
FMU	:	Flight Management Unit
PBD	:	Power Distribution Board

GPS	:	Global Positioning System
ESC	:	Electronic Speed Controller
LAN	:	Local Area Network
FKEKK	:	Faculty of Electronic and Computer Engineering
FPS	:	Frame rate Per Second
RAM	:	Random Access Memory



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CHAPTER 1

INTRODUCTION



This chapter describes the basic knowledge related to the Visual Simultaneous Localization and Mapping using Direct-Based method for Unmanned Aerial Vehicle (UAV) which involves few elements such as background studies, problem statements, objective, and scope of the project.

1.1 Background of the project

Unmanned aerial vehicle (UAV) navigation and visual simultaneous localization and mapping (v-SLAM) are attracting more attention in both research and teaching. Multi-rotor unmanned aerial vehicles (UAVs) have evolved into clever agents that can navigate in unfamiliar surroundings thanks to sophisticated artificial intelligence systems. However, the application of a lot of algorithms on SLAM produced

different results that need to be enhanced, for example featured based method or indirect method. Basically, there is a lot of technology nowadays that uses VSLAM either in robotics appliances or unmanned aerial vehicle applications which cause lack of quality on locating, mapping, and tracking specifically. For that purpose, the primary goal of this initiative is to analyze the SLAM algorithm for UAVs uses. Therefore, applying VSLAM by using the direct based method for Unmanned Aerial Vehicle (UAV) could generate a better result of visual, localization and mapping of the environment. This project is expected to investigate parameters in VSLAM algorithm applied to UAV which will lead to improvement in the performance of the VSLAM algorithm.

1.2 Problem Statement

Visual simultaneous localization and mapping (v-SLAM) and unmanned aerial vehicle (UAV) navigation are gaining popularity in both education and research [1]. However, in featured based method, feature extraction and matching impose additional computational burden on the system, severely limiting the number of characteristics that can be retained and easily lost on tracking due to low texture environment is not sufficient to be extracted which is also lead on image blurring [2]. They are made up of three-dimensional coordinates that describe the environment, and one of the most successful monocular SLAM systems is Oriented FAST and Rotated BRIEF (ORB)-SLAM, developed by Mur-Artal et al. in 2015. However this method is extremely difficult to deal with robot navigation [3]. To enhance all the specification involved, direct based method on SLAM was used in this project by applying on UAVs.

Indirect approaches consist of high reliance on the amount of feature points results in low positioning precision and poor durability in situations with sparse texture. Besides, extraction and matching of features are both time-consuming processes although indirect approaches have been widely used for a long period of time [4].

Apart from those statements, as a technique for visual odometry or SLAM, DSO has several weaknesses which is mentioned that the performance of direct approaches such as DSO degrades significantly. Besides, DSO is always unable to estimate the camera motion units or magnitude of the rebuilt scene. Next, even manually specifying the best scale does not fix the problem because the predicted trajectory suffers from significant scale drift. Next, geometric distortions, such as those caused by quick motion and rolling shutter cameras, are very sensitive to DSO[5]. It is stated that DSO are not suitable for large-scale scenarios because of their accumulated drift [6].

Moreover, the implementation of direct based method on UAVs will be evaluated with the specific algorithm used to achieve a higher performance and robustness especially in localization, mapping, and tracking. One of the advantages of the direct method it does not rely on key point detectors, which may naturally pick pixels from any picture areas with intensity gradients, such as borders or smooth intensity.

1.3 Aim & Objectives

- To implement direct method of the VSLAM algorithm on unmanned aerial vehicle (UAV) platform.
- To investigate the parameter (e.g., point density, minimum gradient) and performance of direct method VSLAM algorithm.