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

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VISUAL SIMULTANEOUS LOCALIZATION AND MAPPING USING DIRECT-BASED METHOD FOR UNMANNED AERIAL 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

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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.

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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.

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ABSTRAK

Teknik Lurus Jarang Odometri adalah bentuk baharu visual odometri yang menggunakan struktur dan rumusan gerakan lansung 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 rangkakunci dan titik jarangan. Kesimpulan projek ini adalah algoritma pada dron boleh diperbaiki untuk mencapai proses data yang lebih stabil untuk diaplikasikan kepada algoritma.

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TABLE OF CONTENTS

Declaration

Approval **i**

Dedication **i**

Abstract **i**

Abstrak **ii**

ACKNOWLEDGEMENTS **iii**

Table of Contents **iv**

List of Figures **viii**

List of Tables **xii**

List of Symbols and Abbreviations **xiii**

List of Appendices **xv**

CHAPTER 1 INTRODUCTION **1**

1.1 Background of the project 1

1.2 Problem Statement 2

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

1.3 Aim & Objectives 3

1.4 Scope of Project 4

1.5 Project Significant 4

CHAPTER 2 BACKGROUND STUDY 5

2.1 Visual SLAM Overview 5

2.2 Methods in VSLAM 6

2.3 Direct-Based Method 7

2.4 Photometric error in SLAM 9

2.5 Bundle Adjustment 9

2.6 Photometric Calibration Model 10

2.7 Direct Sparse Model 11

2.7.1 Frame Management 12

2.7.2 Parameter studies 13

2.8 Algorithm Analysis 14

2.8.1 Direct Sparse Odometry (DSO) 14

2.8.2 Visual-Inertial Direct Sparse Odometry (ViDSO) 15

2.8.3 Monocular visual SLAM system with loop closure detection (LDSO) 16

2.9 Algorithm summary 17

CHAPTER 3 METHODOLOGY 18

3.1 Method Design 19

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

3.1.1 Project Implementation 21

3.2 Software Required 22

3.2.1 Linux Ubuntu Software 22

3.2.2 Oracle VM VirtualBox 24

3.2.3 GitHub 24

3.2.4 QGroundControl Application 25

3.2.5 Robot Operating System (ROS) 26

3.2.6 Installation DSO 27

3.3 Hardware Components 28

3.3.1 NXP HoverGames drone kit including RDDRONE-FMUK66 28

3.3.1.1 Flight Management Unit (FMU) - RDDRONE-FMUK66 29

3.3.1.2 Specification of Drones 30

3.3.1.3 Assembly component 30

3.3.1.4 PX4 configuration using QgroundControl 32

3.3.2 Raspberry Pi 3 B+ Model 35

3.3.2.1 Installing the Operating System 36

3.3.3 Stereo Camera-Intel RealSense Depth Camera D435i 38

3.3.3.1 Installation packages on Ubuntu 39

3.3.4 Laptop IdeaPad Gaming 3 15ARH05 40

3.4 Interface Component 41

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

3.4.1 Interfacing Stereo Camera with DSO 41

3.4.1.1 Rqt_graph for the interfaces 43

3.4.2 Interface Raspberry Pi with PC via ROS 46

3.4.3 Interfacing the camera with Raspberry Pi 47

3.4.3.1 Rqt_graph 48

3.4.4 Interfacing the camera with Raspberry Pi on Drone 49

3.4.4.1 Block diagram of components 50

CHAPTER 4 RESULTS AND DISCUSSION 52

4.1 Mapping DSO Algorithm by using Drone 53

4.1.1 Point Parameter testing on the DSO algorithm 57

4.2 Mapping DSO Algorithm at Outdoor Environment 61

4.3 Mapping DSO Algorithm at Indoor Environment 64

4.4 DISCUSSION 66

4.5 ENVIRONMENT AND SUSTAINABILITY 74

CHAPTER 5 CONCLUSION AND FUTURE WORKS 76

5.1 Conclusion 77

5.2 Future works 78

REFERENCES 80

LIST OF PUBLICATIONS AND PAPERS PRESENTED 85

APPENDICES 86

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF FIGURES

Figure 2.1: Flowchart of the photometric image formation.....11

Figure 2.2 Initial Frame tracking.....12

Figure 2.3: Block diagram of DSO algorithm.....15

Figure 2.4: DSO-related distinctions.....15

Figure 2.5: SLAM system's flowchart.....16

Figure 3.1: Flowchart design.....19

Figure 3.2: Communication link of the project.....22

Figure 3.3: Structure of Ubuntu.....22

Figure 3.4: Installation complete.....23

Figure 3.5: Oracle box logo.....24

Figure 3.6: GitHub main page.....24

Figure 3.7: QgroundControl Apps.....25

Figure 3.8 Instructions code installation.....25

Figure 3.9: QgroundControl display.....26

Figure 3.10: Steps install ROS.....26

Figure 3.11: Command window after running ROS.....27

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 3.12: Codes run the datasets. 28

Figure 3.13: Command for DSO-ROS. 28

Figure 3.14: Drone overview 29

Figure 3.15: Block diagram FMU 29

Figure 3.16: Motor numbering and position PWM wires 31

Figure 3.17: Completed drone installation 31

Figure 3.18: QgroundControl firmware updates 32

Figure 3.19: Quadrotor uses S500 airframe. 33

Figure 3.20: Completed calibration on sensor 33

Figure 3.21: Flight mode setup 34

Figure 3.22: Safety and ESC calibrate 34

Figure 3.23: Raspberry pi 3 B+ circuit module 35

Figure 3.24: Raspberry Pi imager front display 36

Figure 3.25: Format of the Raspi IP address 37

Figure 3.26: Raspberry pi success SSH 37

Figure 3.27: ROS on raspberry pi 38

Figure 3.28: Intel RealSense Depth Camera D435i 39

Figure 3.29: Instruction installation. 39

Figure 3.30: Connection establishes with RealSense camera 40

Figure 3.31: RealSense camera with ROS 40

Figure 3.32: IdeaPad Gaming 3 15ARH05 41

Figure 3.33: Overview system 42

Figure 3.34: RealSense camera with ROS 43

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 3.35: RealSense camera with DSO algorithm 43

Figure 3.36: All nodes of Rqt graph 44

Figure 3.37: Rqt graph of node only 44

Figure 3.38: Calibration information. 45

Figure 3.39: Geometric calibration files 45

Figure 3.40: Camera.txt file details 45

Figure 3.41: Configurations of IP address of PC. 46

Figure 3.42: Bash files instructions 46

Figure 3.43: .bashrc files for window and Raspberry Pi 47

Figure 3.44: Successfully establish connection on ROS 47

Figure 3.45: Rapberry Pi with Realsense camera 48

Figure 3.46: Rqt graph for all topic involves 48

Figure 3.47: Rqt graph for all topic involves includes DSO 49

Figure 3.48: Drone and camera placement 50

Figure 3.49: Block diagram of interconnection 51

Figure 4.1: 3D Mapping using DSO algorithm on Drone. 53

Figure 4.2: DSO algorithm result on DSO. 54

Figure 4.3: Zoomed DSO mapping. 55

Figure 4.4: Camera movement on DSO. 55

Figure 4.5: Keyframe management of data captured by drone. 56

Figure 4.6: Point Density on Drone mapping 56

Figure 4.7: Different view of the DSO algorithm with another parameter. 57

Figure 4.8: 3D Mapping DSO on another parameter. 58

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Figure 4.9: Key management of the parameter 58

Figure 4.10: Point density image on different parameter. 59

Figure 4.11: DSO results on new parameter. 60

Figure 4.12: Point density on next parameter changes.....61

Figure 4.13: Outdoor environment DSO mapping. 62

Figure 4.14: Different views on the straight-line outdoor 3D mapping. 63

Figure 4.15: Point density of the outdoor environment.....63

Figure 4.16: Example of 3D mapping in Lab research 3.....65

Figure 4.17: Value of track fps and KF fps. 65

Figure 4.18: Point density on DSO algorithm in lab testing. 66

Figure 4.19: Drone armed which video becomes lag. 67

Figure 4.20: Video captured when drones switch off. 67

Figure 4.21: Bad coverage network led to lost track trajectory. 68

Figure 4.22: Graph analysis on number of trajectories. 69

Figure 4.23: Graph minimum gradient on 10 trials 70

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF TABLES

Table 2.1: Differentiate between algorithms **8**

Table 3.1: Specification of drones **30**

Table 3.2: Specification of Raspberry Pi. **36**

Table 4.1: Parameter DSO on Drone Testing. **53**

Table 4.2: Different parameter tested on algorithm. **57**

Table 4.3: Parameter testing with the algorithm on drone. **59**

Table 4.4: Parameter test on outdoor environment. **62**

Table 4.5: Parameter used in lab environment. **64**

Table 4.6: Drone parameter setting on fps values **71**

Table 4.7: Three different environment on values obtained **73**

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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

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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

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LIST OF APPENDICES

Appendix A: Data of trajectory analysis. **86**

Appendix B: Command used for the project **87**

Appendix C: cameratry.txt file **87**

Appendix D: Gantt Chart project **88**

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CHAPTER 1

INTRODUCTION

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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.

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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.

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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.