

RÉPUBLIQUE ALGÉRIENNE DÉMOCRATIQUE ET POPULAIRE
MINISTÈRE DE L'ÉDUCATION SUPÉRIEURE ET DE LA RECHERCHE
SCIENTIFIQUE

ÉCOLE NATIONALE POLYTECHNIQUE -ENP-
CENTRE DE RECHERCHE EN TECHNOLOGIES INDUSTRIELLES -CRTI-



Département d'Automatique

End of Studies Project

For the attainment of the State Engineer Degree in Automation Engineering

Design and Control of a Quadrotor for SLAM Applications

BENAISSA Tayeb

Under the supervision of **Mr. BOUDANA Djamel** (ENP) and **Mr. ZABEL Abdelghani** (CRTI)

Publicly presented and defended on (23/06/2025)

Jury composition:

President: Mr. CHAKIR Messaoud ENP
Promoter: Mr. BOUDANA Djamel ENP
Promoter: Mr. ZABEL Abdelghani CRTI
Examiner: Mr. TADJINE Mohamed ENP

ENP 2025

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Conception et Commande d'un Quadrirotor pour des Applications de SLAM

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Sous la supervision de M. BOUDANA Djamel (ENP) et de M. ZABEL
Abdelghani (CRTI)

Présenté et soutenu publiquement le (23/06/2025)

Composition du jury:

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ملخص

يقدم هذا المشروع تصميم وتطوير طائرة رباعية المحركات ذاتية القيادة تعتمد على تقنية التوضع ورسم الخرائط البصري المتزامن (V-SLAM). تم استخدام نموذج ديناميكي يعتمد على الكواتيرنيون مع تحكم متسلسل من نوع P-PID، مطبق على وحدات التحكم في الطيران Mini 4 Pixhawk (بهيكل QAV250) و Pixhawk 2.4.8 (بهيكل X500). تم تشغيل خوارزمية ORB-SLAM3 على جهاز Jetson Orin Nano باستخدام كاميرا Intel RealSense D435، حيث تدعم أوضاع التصوير Stereo و RGB-D، مع تقييم للأداء في الزمن الحقيقي باستخدام ROS. يتم في هذا العمل استعراض الأسس النظرية للنظام، وتحديات التنفيذ العملي، والتحقق التجريبي من فعاليته.

الكلمات المفتاحية: طائرة رباعية المحركات ذاتية التحكم، PID، الطيار الآلي PX4، Pixhawk، V-SLAM، ORB-SLAM3، ROS، Jetson Orin Nano، RealSense D435.

Résumé

Ce projet présente la conception et l'implémentation d'un système de quadrirotor autonome pour la Localisation et cartographie simultanées visuelles (V-SLAM). Nous utilisons un modèle dynamique basé sur les quaternions avec contrôle P-PID en cascade, implémenté sur les contrôleurs de vol Pixhawk 4 Mini (configuration QAV250) et Pixhawk 2.4.8 (configuration X500). L'algorithme ORB-SLAM3 est déployé sur un Jetson Orin Nano utilisant une caméra Intel RealSense D435, supportant à la fois les modes stéréo et RGB-D, avec évaluation des performances en temps réel sous ROS. Les fondements théoriques, les défis pratiques de mise en œuvre et la validation expérimentale sont examinés en détail.

Mots-clés: Quadrirotor Autonome, Contrôle PID, PX4 Autopilot, Pixhawk, ORB-SLAM3, ROS, Jetson Orin Nano, RealSense D435.

Abstract

This project presents the design and implementation of an autonomous quadrotor system for Visual Simultaneous Localization and Mapping (V-SLAM). We use a quaternion-based dynamic model with cascaded P-PID control implemented on both Pixhawk 4 Mini (QAV250 configuration) and Pixhawk 2.4.8 (X500 configuration) flight controllers. The ORB-SLAM3 algorithm is deployed on a Jetson Orin Nano using an Intel RealSense D435 camera, supporting both stereo and RGB-D modes, with real-time performance evaluation in ROS. The system's theoretical foundations, practical implementation challenges, and experimental validation are thoroughly examined.

Keywords: Autonomous Quadrotor, PID Control, PX4 Autopilot, Pixhawk, ORB-SLAM3, ROS, Jetson Orin Nano, RealSense D435.

Dedication

This journey has never been just about reaching a destination—it was about growth, transformation, and the people who walked beside me. Over these five years, I've not only pursued knowledge but also discovered strength I didn't know I had, held up by those whose love and belief never wavered. To those who stood with me through every doubt and every triumph—this work is, above all, a tribute to you.

No individual is complete without the unwavering support of family—so it is only fitting that I begin there.

To my dear mother—thank you for your unconditional love, for every word of comfort, and for the silent strength that carried me through my darkest moments. Your sacrifices, patience, and prayers have shaped who I am. I only hope to make you proud and someday return even a fraction of what you've given me.

To my beloved father—thank you for showing me what it truly means to be a man — to be strong, humble, and steadfast. Your wisdom, quiet courage, and unwavering belief in me have given me the strength to chase this dream. You've always been my protector, my compass, and a living example of true resilience.

You are both the pillars of my life. Without your love and support, I would not be standing here today.

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To my brothers Bilel, Younes, and Mohamed—you are not only my brothers, but my first friends and lifelong companions. I hope you chase your dreams with courage and heart, and I believe with all my soul that your future holds great success.

To all my family—Your love, presence, and support, in both small and big ways, have helped shape my journey. I carry your strength with me every step of the way.

To my teachers and mentors—each lesson you offered was more than knowledge; it was encouragement to think, to question, and to reach further. You sparked the flame of curiosity that led me here and helped shape the scientist and thinker I strive to become.

To every friend who stood beside me—thank you for your laughter, for your late-night support, and for reminding me that no success is worth anything if it isn't shared. Your presence turned pressure into motivation and isolation into camaraderie.

And to every student, every dreamer—this is for those who build, fail, learn, and rise again. To those who dare to make drones fly, and ideas soar, even when the skies seem unreachable. May you never stop reaching higher.

Tayeb

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Contents

List of Figures

List of Tables

List of Acronyms

General Introduction	19
1 Quadcopter Modeling and Control	22
1.1 Introduction	22
1.2 Overview about Modeling and Control	23
1.2.1 Modeling of Quadrotors	23
1.2.2 Challenges in Quadrotor Control	23
1.2.3 Modern Control Techniques	23
1.2.4 Hardware-Driven Design Considerations	24
1.3 Modeling of the Quadrotor	24
1.3.1 General Description	24
1.3.2 Motion Modes	25
1.3.3 Reference Frames	26
1.3.4 Physical Effects Acting on the Quadrotor	27
1.3.4.1 Forces	27
1.3.4.2 Moments	28
1.3.5 Euler Angles Representation	29
1.3.6 Quaternion Representation	30
1.3.6.1 Quaternion	30
1.3.6.2 Angular Velocities	31

1.3.6.3	Linear Velocities	31
1.3.6.4	Development of the Mathematical Model	31
1.3.6.4.1	Equations of Translational Motion	33
1.3.6.4.2	Rotation Dynamics Equations	33
1.4	Control of the Quadrotor	35
1.4.1	State Space Representation	35
1.4.2	Control Strategie	36
1.4.2.1	Why Use P and PID Controllers?	36
1.4.2.2	Inner-Loop Control	37
1.4.2.3	Outer-Loop Control	40
1.5	Simulation	42
1.5.1	Discussion of Simulation Results	46
1.6	Conclusion	47
2	Control System Implementation	48
2.1	Introduction	48
2.2	Hardware Selection: Control Platform	48
2.2.1	QAV250 Propulsion system Architecture	49
2.2.1.1	QAV250 Airframe	49
2.2.1.2	X1806 2300KV Brushless Motor	49
2.2.1.3	Flycolor 30A ESC	49
2.2.1.4	5045 Propeller Aerodynamics	49
2.2.2	PX4 Pixhawk 4 Mini Flight Controller and Sensors	50
2.2.3	Radio Control System	51
2.2.3.1	Flysky FS-i6X 6CH Transmitter	52
2.2.3.2	Flysky FS-iA6B Receiver	52
2.2.3.3	433MHz 500mW Telemetry Module	53
2.2.4	Power System	53
2.2.4.1	Hjpower 4200mAh 3S LiPo Battery	54
2.2.4.2	Xcluma PDB XT60 Power Distribution Board	55
2.2.4.3	REC Power Module for Pixhawk/APM	55

2.3	Implementation	55
2.3.1	System Identification	55
2.3.1.1	Methodology Overview	56
2.3.1.2	Inertial Parameter	56
2.3.1.2.1	Mass and Geometry	56
2.3.1.2.2	Moments of Inertia	56
2.3.1.3	Propulsion System Identification	56
2.3.1.3.1	Thrust Identification Procedure	57
2.3.1.3.2	Drag Moment Identification	57
2.3.1.4	Identified Parameters Summary	57
2.3.2	Control System Architecture	58
2.3.2.1	Flight Controller (Standalone Configuration)	58
2.3.2.2	Architectural Overview	59
2.3.2.3	Flight Stack Components	59
2.3.3	Verification and Validation Framework	60
2.3.3.1	Software-in-the-Loop (SIL) Simulation	60
2.3.3.2	Hardware-in-the-Loop (HIL) Testing	61
2.3.4	Ground Control Station Configuration	62
2.3.4.1	Airframe, Sensor, and Actuator Configuration	62
2.3.4.2	Radio Control Calibration and Flight mode Setup	64
2.3.4.3	Flight Controller PID Tuning and Performance Optimization	64
2.3.4.4	Autonomous Mission Planning and Monitoring	65
2.3.5	Realtime Control Testing	66
2.3.5.1	Test Environment	66
2.3.5.2	Test Scenario: Altitude and Position Filing Mode Performance	66
2.3.5.3	PID Tuning and Performance Optimization	67
2.3.5.4	Control Performance Visualization	68
2.3.5.5	Actuator and Motor Response	71
2.3.5.6	Power Consumption	72
2.3.5.7	Discussion	73
2.4	Conclusion	73

3	Visual SLAM Overview	74
3.1	Introduction	74
3.2	State of the art	75
3.3	Problem Statement	76
3.4	Visual SLAM Fundamentals	77
3.4.1	Mathematical Formulation of the SLAM Problem	77
3.4.1.1	General Applicability to SLAM Paradigms	78
3.4.1.2	Chosen Formulation in This Work	79
3.4.2	Visual Sensor Modalities	81
3.4.2.1	Monocular Camera	81
3.4.2.2	Stereo Camera	81
3.4.2.3	RGB-D Camera	81
3.4.3	Data Acquisition	82
3.4.3.1	Coordinate Systems	82
3.4.3.2	Extrinsic Transformation	83
3.4.3.3	Intrinsic Transformation and the Pinhole Camera Model	84
3.4.3.4	Complete Transformation Pipeline	85
3.4.4	Visual Odometry	86
3.4.4.1	Feature Detection	86
3.4.4.1.1	Harris Corner Detection	87
3.4.4.1.2	FAST Corner Detection	89
3.4.4.2	Matching Descriptors	92
3.4.4.2.1	Scale-Invariant Feature Transform (SIFT)	92
3.4.4.2.2	Binary Robust Independent Elementary Features (BRIEF)	93
3.4.4.3	Motion Estimation	95
3.4.4.4	Pose Estimation	100
3.4.4.4.1	Triangulation (Monocular and Stereo Setups)	100
3.4.4.4.2	Back-Projection (RGB-D Setup)	101
3.4.5	Back-End Optimization	101
3.4.5.1	Bundle Adjustment for Local Mapping	101
3.4.5.2	Pose Graph Optimization and Loop Closure	103

3.4.6	Mapping	105
3.4.6.1	Sparse Mapping	105
3.4.6.2	Semi-Dense Mapping	105
3.4.6.3	Dense Mapping	105
3.5	ORB-SLAM: System Overview	106
3.5.1	Introduction to ORB-SLAM3	106
3.5.2	System Overview of ORB-SLAM3 (Visual-Only, Stereo/RGB-D)	106
3.5.2.1	Tracking and Visual Odometry	107
3.5.2.2	Mapping, and Global Optimization	108
3.5.3	Summary of Our Chosen Configuration	109
3.6	Conclusion	110
4	Visual SLAM Integration and Deployment	111
4.1	Introduction	111
4.2	Hardware of V-SLAM Platform	112
4.2.1	X500 Propulsion system Architecture	112
4.2.1.1	X500 Airframe	113
4.2.1.2	A2212 1000KV Brushless Motor	113
4.2.1.3	Flycolor 30A ESC	114
4.2.1.4	1045 Propeller Aerodynamics	114
4.2.2	Pixhawk 2.4.8 Flight Controller and Sensors	114
4.2.3	Jetson Orin Nano: Onboard Computer	115
4.2.4	Intel RealSense D435 : Perception System	117
4.2.5	Power System	118
4.2.5.1	Nanotech 6000mAh 3S LiPo Battery	119
4.2.5.2	XL6009 DC-DC Step-Up Converter	119
4.3	Software Stack	120
4.3.1	Robot Operating System (ROS)	120
4.3.1.1	Custom ROS2 Package for ORB-SLAM3 Integration	120
4.3.1.1.1	Key Features:	120
4.3.2	Essential Dependencies	120

4.4	System Architecture Overview	121
4.4.1	Visual SLAM Framework Components	121
4.4.2	Nodes Configuration and Launch	121
4.5	Embedded Platform	122
4.5.1	Jetson Orin Nano: Onboard Compute Unit	122
4.5.2	Intel RealSense D435: RGB-D Sensor	123
4.6	Real-Time Evaluation	123
4.6.1	Indoor Testing Using RGB-D Mode	123
4.6.1.1	Test Environment Configuration	124
4.6.1.2	RGB-D Sensor Configuration and Optimization	124
4.6.1.3	Real-Time SLAM Processing Pipeline	125
4.6.1.4	Trajectory Mapping and Loop Closure Analysis	126
4.6.1.5	Performance Analysis and Discussion	127
4.6.2	Outdoor Testing Using Stereo Mode	128
4.6.2.1	Stereo Sensor Configuration and Optimization	128
4.6.2.2	Multi-Loop Trajectory Execution and Performance Analysis . .	130
4.6.2.3	Outdoor SLAM Performance Assessment	132
4.6.3	Real-Time Visual SLAM Using the X500 Quadcopter Platform	133
4.6.3.1	SLAM Initialization and System Startup	133
4.6.3.2	Live Mapping During Navigation	134
4.6.3.3	Final Map Generation and Trajectory Output	135
4.7	Conclusion	136

Conclusion and Future Work	137
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Bibliography	139
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Appendix A: Business Model Canvas	144
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