

INDOOR POSITIONING SYSTEM USING MARKER TAG

By

Mikael Kevin  
11501019

BACHELOR'S DEGREE  
in

MECHANICAL ENGINEERING – MECHATRONICS CONCENTRATION  
FACULTY OF ENGINEERING AND INFORMATION TECHNOLOGY



SWISS GERMAN UNIVERSITY  
The Prominence Tower  
Jalan Jalur Sutera Barat No. 15, Alam Sutera  
Tangerang, Banten 15143 - Indonesia

July 2019

**Revision after the Thesis Defense on 18 July 2019**

### STATEMENT BY THE AUTHOR

I hereby declare that this submission is my own work and to the best of my knowledge, it contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at any educational institution, except where due acknowledgement is made in the thesis.

Mikael Kevin

\_\_\_\_\_  
Student

\_\_\_\_\_  
Date

Approved by:



Dr. Eka Budiarto, S.T., M.Sc.

\_\_\_\_\_  
Thesis Advisor

\_\_\_\_\_  
Date

Dr. Rusman Rusyadi, B.Eng., M.Sc.

\_\_\_\_\_  
Thesis Co-Advisor

\_\_\_\_\_  
Date

Dr. Maulahikmah Gaulinium, S.Kom., M.Sc.

\_\_\_\_\_  
Dean

\_\_\_\_\_  
Date

---

Mikael Kevin

## ABSTRACT

### INDOOR POSITIONING SYSTEM USING MARKER TAG

By

Mikael Kevin

Dr. Eka Budiarto, S.T., M.Sc., Advisor

Dr. Rusman Rusyadi, B.Eng., M.Sc., Co-Advisor

SWISS GERMAN UNIVERSITY

Indoor navigation has been a challenge for a system to move from a location to another location. A good navigation requires a good positioning as the system moves along the way. This thesis presents about an indoor positioning system that uses vision system to detect an artificial marker called ArUco. By using ROS as the main control platform, a node has been created to control the positioning based on the message sent by reading the marker. The system is integrated with a moving camera system that will always update the position data as it finds marker on its movement, even when the object is not moving. By combining the system with odometry, the robot position is always updated and corrected when it finds a marker on its way. The result proves the system is usable and gives a good accuracy that is still in tolerable range for indoor navigation.

*Keywords: Indoor Positioning System, Visual System, ArUco, ROS*

© Copyright 2019  
by Mikael Kevin  
All rights reserved



## DEDICATION

I dedicate this works to God  
My Family  
And for the future of the country I loved: Indonesia



## ACKNOWLEDGEMENTS

First, I thank God for giving me the chance to do and learn many things especially in this thesis.

I thank my family that supports me until the end.

To my advisor, Mr. Eka, and my co-advisor, Mr. Rusman, and Mr. Benny that has advised me.

To Mr. Freddy and Mr. Kris that have guided me in specific technical knowledge and advice.

To Yosh that has helped me when I asked about some advices.

To Jason, Leonard, Marchellino, Deo, Dinar, Raira, and Darin that were doing thesis in SGU's workshop because we are doing our best to graduate together.

To Richard Christo, my fullko friend, that has been working together with me since 1<sup>st</sup> semester and was having a concert together with the theme "Sobat Ikhlas" in our working space, SGU workshop, while doing our thesis.

To Dean, Aldo, and Felicia as a fellow Lab Assistant that were teaching 2<sup>nd</sup> semester while giving our best to our thesis with our limited time.

To Daniel that was studying for OFSE in SGU Workshop and encouraging me.

To Kelvin, my weeaboo friend, with the same signal when we were talking about something that makes my day fun as ever.

To Lolo and Chosua that pushed thesis together although we were doing our thesis in different continent.

## TABLE OF CONTENTS

	Page
INDOOR POSITIONING SYSTEM USING MARKER TAG .....	1
<b>STATEMENT BY THE AUTHOR</b> .....	2
<b>ABSTRACT</b> .....	3
<b>DEDICATION</b> .....	5
<b>ACKNOWLEDGEMENTS</b> .....	6
<b>TABLE OF CONTENTS</b> .....	7
<b>LIST OF FIGURES</b> .....	11
<b>LIST OF TABLES</b> .....	15
<b>CHAPTER 1 - INTRODUCTION</b> .....	16
1.1. Background .....	16
1.2. Research Problems.....	17
1.3. Research Objectives.....	18
1.4. Significance of Study.....	18
1.5. Research Questions.....	18
1.6. Hypothesis.....	19
1.7. Thesis Scope .....	19
1.8. Thesis Limitation .....	19
1.9. Thesis Outline .....	20
<b>CHAPTER 2 - LITERATURE REVIEW</b> .....	21
2.1. Positioning System.....	21
2.1.1. Odometry .....	22
2.1.2. Inertia Navigation System .....	23
2.1.3. Global Positioning System .....	24
2.1.4. Wifi-Based Systems.....	24
2.1.5. Ultra Wide-band (UWB) Systems .....	25
2.1.6. Simultaneous Localization and Mapping .....	25

2.1.7.	Marker-based Localization .....	26
2.1.8.	Data comparison .....	27
2.2.	Fiducial Marker.....	28
2.2.1.	QR Code .....	29
2.2.2.	ArUco .....	30
2.3.	Robot Operating System .....	35
CHAPTER 3 - RESEARCH METHODS .....		36
3.1.	Design Justification.....	36
3.1.1.	System Overview .....	36
3.1.2.	Mechanical Design .....	38
3.1.3.	Electrical Design.....	42
3.1.4.	Mathematical Algorithm.....	44
3.1.5.	Flowchart .....	50
3.2.	Component of Design .....	55
3.2.1.	Mechanical Components .....	55
3.2.2.	Electrical Components.....	57
3.2.3.	Software.....	62
3.3.	ROS Package .....	63
3.3.1.	usb_cam .....	63
3.3.2.	Image_calibration .....	64
3.3.3.	aruco_ros.....	65
3.3.4.	rosserial.....	65
3.3.5.	localization node.....	66
3.3.6.	localization Rviz .....	67
3.3.7.	Final Connection.....	69
3.4.	Performance Testing .....	71
3.4.1.	Aruco Library Parameter .....	71
3.4.2.	Panning Movement.....	72
3.4.3.	Panning and ArUco Reading Integration.....	72
3.4.4.	Odometry .....	72



3.4.5.	Final Integration.....	72
<b>CHAPTER 4 - RESULTS AND DISCUSSIONS .....</b>		<b>73</b>
4.1.	Mechanical Assembly .....	73
4.2.	Performance Testing .....	74
4.2.1.	ArUco Static Reading Consistency Test.....	75
4.2.2.	Camera Center Point Finding .....	80
4.2.3.	ArUco Node Message Speed .....	82
4.2.4.	Limitation Parameter .....	83
4.2.5.	ArUco Reading Accuracy .....	86
4.2.6.	Encoder Calibration Result.....	89
4.2.7.	Encoder Rotation Speed .....	90
4.2.8.	Odometry Result .....	91
4.2.9.	Fake Odometry Result .....	92
4.2.10.	Comparison between Ps3 Eye Camera and Logitech C270 .....	93
4.2.11.	CPU Load Testing .....	95
4.3.	Integrated Panning and Camera Test .....	98
4.3.1.	First Integrated Test.....	98
4.3.2.	Corrected Integrated Test .....	102
4.3.3.	Static vs Rotating Movement Data .....	110
4.3.4.	Auto-locking algorithm in static position .....	111
4.3.5.	Marker dynamic test .....	113
4.4.	Error Analysis and Solution.....	118
4.4.1.	Distortion Orientation.....	119
4.4.2.	Angle Accuracy .....	123
4.4.3.	Offset Error Analysis .....	125
<b>CHAPTER 5 - CONCLUSIONS AND RECOMMENDATIONS .....</b>		<b>126</b>
5.1.	Conclusions.....	126
5.2.	Recommendations.....	127
<b>GLOSSARY.....</b>		<b>128</b>
<b>REFERENCES.....</b>		<b>129</b>

---

<b>APPENDICES</b> .....	131
APPENDIX A. Solidworks Part Drawing .....	131
APPENDIX B. Programming Code .....	134
APPENDIX C. Bill of Material .....	136
<b>CURRICULUM VITAE</b> .....	137

