

SELF-BALANCING SPHERICAL WHEEL ROBOT

By

William Lieberty

11401052

BACHELOR'S DEGREE

in

MECHANICAL ENGINEERING – MECHATRONICS CONCENTRATION
FACULTY OF ENGINEERING AND INFORMATION TECHNOLOGY

SGU[®]
SWISS GERMAN UNIVERSITY

SWISS GERMAN UNIVERSITY

The Prominence Tower

Jalan Jalur Sutera Barat No. 15, Alam Sutera

Tangerang, Banten 15143 - Indonesia

July 2018

Revision after the Thesis Defense on 19th July 2018

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.

William Lieberty

Student

Date

Approved by:

Benny Widjaja, S.T., M.T.

Thesis Advisor

Date

Dr. Irvan Setiadi Kartawiria, ST.,MSc

Dean

Date

William Lieberty

ABSTRACT

SELF-BALANCING SPHERICAL WHEEL ROBOT

By

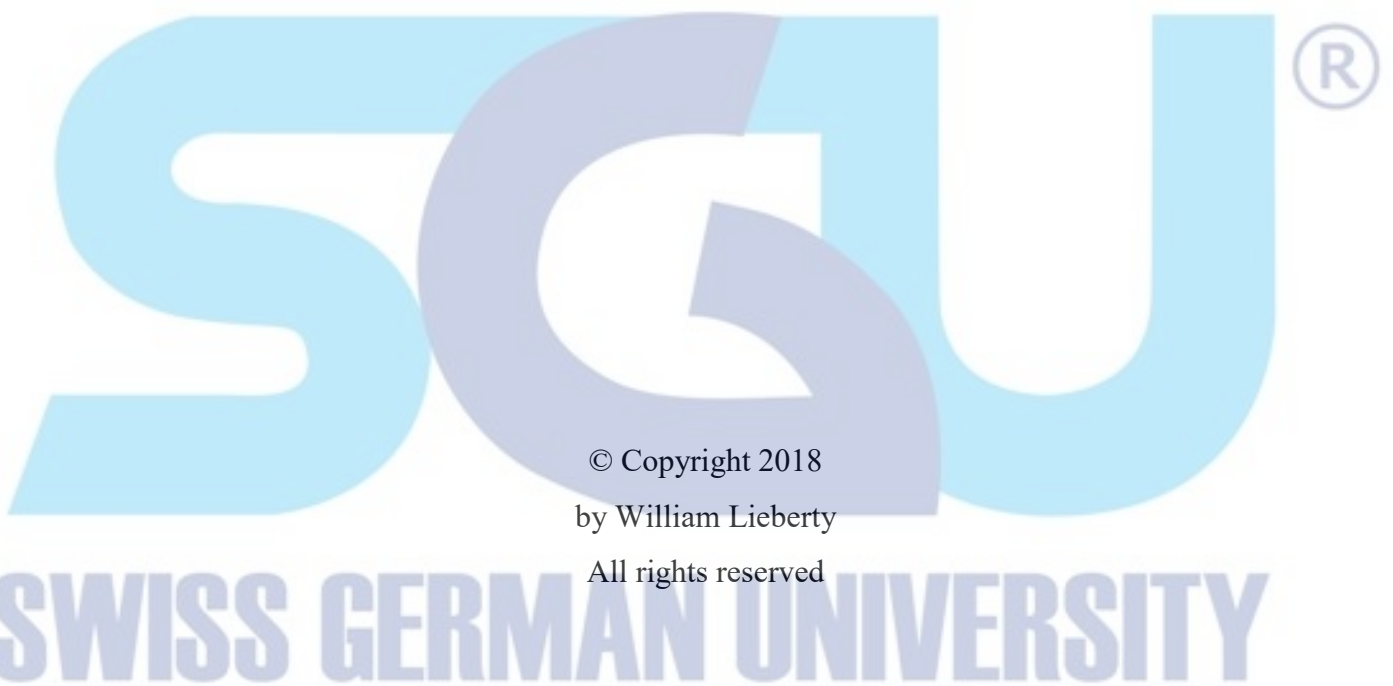
William Lieberty

Benny Widjaja, S.T., M.T., Advisor

SWISS GERMAN UNIVERSITY

The self-balancing system is used to control the system to its set point. In this thesis the set point will be 0 degree, which means the body of the robot will stand up straight. A spherical wheel is used as the wheel in this thesis. A spherical wheel will give more agile movement and shorter movement path. The control of the spherical wheel, had been done by the previous thesis by Calvin Thelma and Kevin Chandra. This thesis will try to develop the spherical wheel by creating self-balancing system to the spherical wheel. The self-balancing system is using gyroscope and accelerometer as the sensor to detect tilting of the system. To balance the system, three brushless DC motors are used to control the movement of the spherical wheel. The design will be done with SolidWorks and the code will be done in Arduino.

Keywords: Self-Balancing, Spherical Wheel, Gyroscope and Accelerometer, Brushless DC motor, SolidWorks, Arduino



DEDICATION

I dedicate this works for my university, family, friends and the future of the country I
loved: Indonesia



ACKNOWLEDGEMENTS

I would like to express my gratefulness to God for His blessing to me to complete this thesis work.

I would like to express my thank my family, who is always support me doing this project.

I would especially like to thank to my advisor, Benny Widjaja, S.T., M.T. for the advice and guidance throughout this thesis project.

I would like to thank Yohannes Fredhi Sangadi P., A.Md for the help in mechanical workshop.

I would like to thank Saiful Afrijal, A.Md for the help in electrical and programming issues.

I personally thank Albertus Rumawas for the help and advice in mechanical, electrical, and programming part.

I would like to thank Frisca Irene for support me doing this project and always prayed to me.

Thanks also to other lecturers who have given advices to help me complete my thesis work.

Thank you to Global Metal Technology, which have contributed to manufacture part with special price for student.

Last thanks go to all of my mechatronics friends for helping and supporting each other.

TABLE OF CONTENTS

STATEMENT BY THE AUTHOR.....	2
ABSTRACT.....	3
DEDICATION.....	5
ACKNOWLEDGEMENTS.....	6
TABLE OF CONTENTS.....	7
LIST OF FIGURES.....	10
LIST OF TABLES.....	12
CHAPTER 1 - INTRODUCTION.....	13
1.1 Background.....	13
1.2 Objectives.....	13
1.3 Thesis Problem.....	14
1.4 Thesis Scope.....	14
1.5 Thesis Limitation.....	14
1.6 Thesis Outline.....	15
CHAPTER 2 - LITERATURE REVIEW.....	16
2.1 Theoretical Perspectives.....	16
2.1.1 Carnegie Mellon University Ballbot.....	16
2.1.2 Tohoku Gakuin University Ballbot.....	17
2.1.3 SOLIDWORKS.....	18
2.1.4 ARDUINO MEGA 2560.....	19
2.1.5 Gyro and Accelerometer (MPU-6050).....	19
2.1.6 BLDC Motor.....	21
2.2 Previous Studies.....	24
CHAPTER 3 – RESEARCH METHODS.....	25

3.1	Materials and Equipment.....	25
3.1.1	BLDC Motor	25
3.1.2	Motor Driver	26
3.1.3	Gyro and Accelerometer	28
3.1.4	Flange Mounting	28
3.1.5	Connecting Shaft (Rod).....	29
3.1.6	Top Plate	31
3.1.7	Bottom Plate	32
3.2	Analytical Method.....	33
3.2.1	Dynamic movement modelling.....	33
3.2.2	Inverted Pendulum Modelling.....	35
3.2.3	Motor Position and Speed Equation.....	37
CHAPTER 4 – RESULTS AND DISCUSSIONS.....		38
4.1	Initial Evaluation	38
4.1.1	Motor Torque and Rpm.....	38
4.1.2	Motor Connection Port.....	39
4.1.3	Gyro and Accelerometer	39
4.2	Data Analysis.....	43
4.2.1	Gyro and Accelerometer Pitch and Roll.....	43
4.2.2	Motor PWM Output	46
4.2.3	PID Controller	49
4.2.4	Motor Driver Test.....	50
4.2.5	Motor Acceleration Test.....	52
CHAPTER 5 – CONCLUSIONS AND RECCOMENDATIONS.....		56
5.1	Conclusions	56
5.2	Recommendations	56
GLOSSARY		57
REFERENCES		58

APPENDIX 1 – BRUSHLESS DC MOTOR DATA SHEET.....	59
APPENDIX 2 – GYROSCOPE AND ACCELEROMETER DATA SHEET	61
APPENDIX 3 – TECHNICAL DRAWING.....	63
APPENDIX 4 – PROGRAMMING	65
CURRICULUM VITAE.....	71

