Requirement Specification

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DOCUMENT HISTORY

Version	Date	Changes made	Sign	Reviewed
0.1	2020-09-18	First Draft	All	Jesper Johansson
0.2	2020-09-22	Second Draft	All	Jesper Johansson
0.3	2020-09-24	Third Draft	All	Axel Malmberg
1.0	2020-09-24	First Version	All	Axel Malmberg
1.1	2020-11-16	First Revision, removed: 32, 33; revised: 27	A.Malmberg	Jesper Johansson

NOTATIONS

ROV	–	Remotely Operated Underwater Vehicle
ROS	–	Robot Operating System
RPi	–	Raspberry Pi 3
LiU	–	Linköping University
ISY	–	Linköping University department of electrical engineering
GUI	–	Graphical User Interface
CoG	–	Center of gravity
CoB	–	Center of buoyancy
DP	–	Decision Point

1 INTRODUCTION

Manned underwater missions can be both resource-intensive and dangerous. The possibility to have a system able to perform simple underwater tasks without human presence can be useful in many industrial applications, for example in search & rescue and research missions.

The project described in this specification is aimed towards the continued development of a realistic simulation model able to accurately simulate the behaviour and mission progression of a remotely operated underwater vehicle. The model will be built to be easily expandable in the future.

1.1 Task overview / Aims and goals

The main goal of this project is to create a simulation environment and model for the vehicle to aid the continued development of the vehicle's controls and features. The vehicle is a Remotely Operated Underwater Vehicle and will be referred to as ROV. The necessity for a real time simulation model of the ROV has become apparent. Existing models of the vehicle are crude which makes future progress limited by the simulation possibilities. One of the main goals of this project is therefore to design and implement a robust vehicle model together with a simulation environment. The model should include the physical properties of the ROV and the ROV's sensors. The simulation should be able to accurately represent the ROV's actual movements and behaviour in real time. Additional tasks involves making the graphic user interface more user-friendly, together with automating the magnetometer calibration sequence.

The long term goals of the project is to enable the vehicle to complete tasks fully autonomously by itself and to remove the need for a cable between the vehicle and the workstation. Performed tasks could be such as mapping or item search and retrieval. Another long term goal with the project is to use the ROV as a test platform for development of different underwater control systems.

1.2 Background

This project is a collaboration between the department of Electrical Engineering (ISY) at Linköping University and Combine Control Systems AB. The underwater vehicle used in this project is a BlueROV supplied by Combine Control Systems AB, a product manufactured by Blue Robotics Inc.

1.3 Priority

The priority of the requirements of this document is set by a number 1 or 2 where 1 is high priority and 2 are requirements completed if time allows.

2 SYSTEM OVERVIEW

The system referred to in this document is a BlueROV, a ROV kit supplied by Bluerobotics. The ROV kit, a chassis with attached hardware such as camera, flight controller and single-board-computer, is connected to and controlled by an external workstation through an Ethernet cable. The components used to control the system are listed in section 2.1. All components listed together with the ROV kit and external workstation are provided by Combine Control System AB.

2.1 ROV components & Workstation

The ROV has the following components:

- 1x single-board-computer, Raspberry Pi 3 B+
- 1x Camera, Raspberry Pi V2
- 1x Flight controller, HKPilot Mega 3.7 including:
  - 1x Internal Measurement Unit
  - 1x Barometer
  - 1x Magnetometer
- 3x Ultrasonic sensors
- 1x Pressure transducer

All components above are used to control the ROV. To manually operate the ROV via the external workstation, the following components are needed:

- 1x Computer with a GUI
- 1x Xbox controller

2.2 Communication

The ROV and the workstation communicates via an Ethernet cable.

2.3 System modules

The ROV is built with various modules. These modules are shortly described below.

2.3.1 *Hardware*

The hardware of the system is the ROV with all attached parts described in section 2.1.

2.3.2 *GUI*

The GUI module provides the user with information about the current mission and allows the user to interact with the system.

2.3.3 *Sensor fusion*

The sensor fusion module calculates the current position and orientation of the ROV from the data of the different sensors.

2.3.4 *Pathfinder*

The pathfinder module take it's input from the sensor fusion module such as current position and orientation and creates a reference path for the control module.

2.3.5 *Control*

The control module takes inputs from the Pathfinder module and Sensor fusion module to steer the ROV's thrusters.

2.3.6 *Simulation*

The Simulation module is run from the external workstation to test the system without having hardware in the loop. The simulation module can individually test the other modules such as the control module to see if control strategies perform as wanted.

2.3.7 *Decisions*

The decision making module dictates how the ROV will act in certain events. This module is intended to work as the system's brain when in autonomous operation.

3 MODEL

It is important to have a good enough model, to make certain that the simulations of the ROV will be useful. To ensure that the model upholds a certain quality, requirements are placed upon the modeling aspect of the project. These requirements are listed below.

Requirement	Description	Priority
1	The ROV's simulated movement from a point A straight to a point B, under water in the horizontal plane, should differ no more than $\pm 20\%$ of the distance travelled when compared with the position estimated by the sensor fusion module.	1
2	Differences in orientetion between state estimates obtained using collected sensor measurements and the simulation model while stationary, i.e. with constant input signals, should not deviate more than 45 deg after 5 seconds.	1
3	Simulated sensor data should include noise/uncertainty.	1
4	When traveling in straight line the simulated vehicle velocity should not differ by more than 20% from the sensor fusion model's measurement.	1
5	During constant input signals, the simulated angular velocity should not differ from the sensor fusion model's measurements by more than 20 % on average.	1

3.1 Hardware in the loop

Requirement	Description	Priority
6	The ROV should be able to send its control inputs to the simulator.	1
7	The simulator should be able to estimate the states of the ROV utilizing the control inputs from the ROV.	1

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Requirement	Description	Priority
8	The simulator should be able to, based on the ROV's estimated state, simulate realistic sensor inputs.	1
9	The simulator should be able to send the simulated sensor inputs to the ROV.	1

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4 ENVIRONMENT

This section describes the requirements for the simulation environment.

Requirement	Description	Priority
10	The simulation environment should be able to show a visualization of the ROV in a 3D space in the shape of a cuboid.	1
11	The dimensions of the environment should be changeable.	1
12	The simulation environment should contain walls that the vehicle can sense. The ROV should not be able to pass through the walls.	1
13	The ROV in the simulation environment should be able to mimic the movement of the real ROV in real time.	1
14	The simulation environment should support placing objects in the environment for the ROV to detect.	1
15	It should be possible to generate a point that follows a set path that is detectable by the simulated camera signal.	1
16	The ROV should be able to detect obstacles with the simulated sonars.	1
17	The simulation environment should be modular so that it can be easily expanded upon.	1
18	The ROV should be able to preform simultaneous localization and mapping in the simulation environment.	2

5 GUI

For a user to have a pleasant experience while operating the ROV it is imperative to have an interface that is easy to understand and navigate. To achieve this the GUI should fulfill the following criteria:

Requirement	Description	Priority
19	The user should be able to view the simulated movement in the simulation environment.	1
20	The user should be able to specify the dimensions of the environment via the GUI.	1
21	The user should be able to set start and goal points for the mission from the GUI.	1
22	The user should be able to control mission selection and mission simulation from the GUI.	1
23	The user should be able to select a manual mode to steer the simulation model in real-time through controller inputs.	1
24	The user should be able to control the movement of the inserted objects via the GUI.	2
25	There should be a visual representation of the ROV and its surroundings in the GUI.	1
26	The user should be able to activate/deactivate integration of hardware-in-the-loop (HIL).	1
27	The user should be able to initiate a manual calibration of the magnetometer with guidance from the GUI.	1, revised

6 SOFTWARE

This section covers the software requirements of the project.

Requirement	Description	Priority
28	New code written for ROS must be written according to ROS's code standard. See: `http://wiki.ros.org/CppStyleGuide`.	1
29	Code not written for ROS must be written according to Google's code standard. See: `https://google.github.io/styleguide/cppguide.html`.	1

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Requirement	Description	Priority
30	New code must be well commented.	1
31	Comments in code must be written in English.	1

7 MAGNETOMETER

This section covers the requirements for the magnetometer.

Requirement	Description	Priority
32	A script for automatically calibrating the magnetometer should be developed.	Removed
33	After the magnetometer has been calibrated with the script it should yield results of the same accuracy as it would with manual calibrating.	Removed

8 DOCUMENTATION

This section covers the documents that will be written and presented during the project.

Table 7: Documents

Document	Language	Purpose	Target	Format
Requirement Specification	English	List of requirements for the project.	Project Group, Orderer and Customer	PDF
Project Plan	English	Plan for the projects execution and milestones.	Project Group and Orderer	PDF
Design Specification	English	Detailed plan for how the model, simulator and GUI should work.	Project Group, Orderer and Customer	PDF
Test Plan	English	Plan for when a test should take place and which test.	Project Group, Orderer and Customer	PDF
Test Protocol	English	Detailed plan for how the tests will be conducted and documented.	Project Group	PDF
Technical Documentation	English	Document that describes the systems technical construction.	Project Group, Orderer and Customer	PDF
Poster	English	Graphical presentation of the project.	Project Group and Customer	Printed Poster
User Manual	English	Manual for using the ROV, Simulator and GUI.	Project Group, Orderer and Customer	PDF
Project video	English	Promotional video of the project.	Project Group, Orderer and Customer	YouTube
Website	English	Promotional website for the project.	Project Group, Orderer and Customer	Website
Post study	English	Evaluation of the project work, result and group dynamic.	Project Group, Orderer and Customer	PDF

9 DELIVERY

This section covers the delivery requirements for the projects delivery's.

Requirement	Description	Priority
34	A Time report describing every group members activity should be delivered every week.	1
35	A Requirement Specification should be delivered at DP2.	1
36	A Project Plan should be delivered at DP2.	1
37	A Time Plan should be delivered at DP2.	1
38	A Design Specification should be delivered at DP3.	1
39	A test plan should be delivered at DP3.	1
40	The product should be delivered at DP5.	1
41	Testing protocols should be delivered at DP5.	1
42	A User manual should be delivered at DP5.	1
43	A Technical Documentation should be delivered at DP6.	1
44	A Website should be uploaded at DP6.	1
45	A Poster should be presented at DP6.	1

10 POSSIBILITY TO UPGRADE

As this is an ongoing project a new group will continue the work next year and that means that the project has to be upgradeable. This section covers the requirements of the projects upgradeability.

Requirement	Description	Priority
46	The simulator code should be able to be migrated to another ubuntu desktop.	1
47	The structure of the new model should be made expandable to enable further development of the ROV	1