

Requirements Specification

Indoor mapping with autonomous vehicle

Version 1.0

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1 Introduction

The objective is to create an autonomous map making robot designed on a wheeled platform from Segway. This will be accomplished using different sensors. The robot will operate indoors and shall be able to be released into an unknown environment and autonomously draw a complete closed map.

The requirements are divided into three priority levels. Priority 1 indicates that the requirement is a basic requirement and has to be fulfilled. Priority 2 denotes that the requirement isn't compulsory, but that the project group believes it can fulfill it. Priority 3 denotes that the project group aim to fulfill the requirement if time allows. The requirements will be listed as follows:

Requirement No.	Change	Requirement description	Priority
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The column "Requirement no" states the requirement number, "Change" indicate whether the requirement is an original requirement or if it has been renegotiated, the column "Requirement" states the requirement and the column "Priority" states the priority of the requirement.

1.1 Parties

The orderer of the project is André Carvalho Bittencourt, PhD-student in Automatic Control, Department of Electrical Engineering at Linköping University. The advisor of the project is Michael Roth, PhD-student in Automatic Control, Department of Electrical Engineering at Linköping University. Customer of the project is Joakim Rydell att Sensor informatics, FOI. The development is performed by the project group MARCO.

1.2 Purpose and Goal

The purpose of the project is to develop a software for a robot which enables it to navigate through an unknown indoor environment and simultaneously map its surroundings. In addition the acquired information should be used to plan a new trajectory, for the robot to follow, to further explore the environment (see Intended application environment). The goal is to have a product which can navigate through different rooms and generate a complete map.

1.3 Usage

The product can be used as a platform for further research at Sensor Informatics, FOI or at Linköpings University.

1.4 Background Information

This project is a part of the CDIO-course TSRT10 at Linköping University and is performed in collaboration with the Sensor Informatics division at FOI. The group consists of seven students with expertise within automatic control and sensor fusion.

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1.5 Definitions

This section explains abbreviations and definitions used in this document.

- IMU - Inertial Measurement Unit
- GUI - Graphical User Interface

1.6 Intended application environment

The segway is designed to operate in an indoor environment without access to stairs. The floors and walls must be flat and all possible objects in the area must be able to be seen by the segway.



2 System overview

The system consists of a robot with different sensors with different uses. Figure 1 shows an overview of the system.

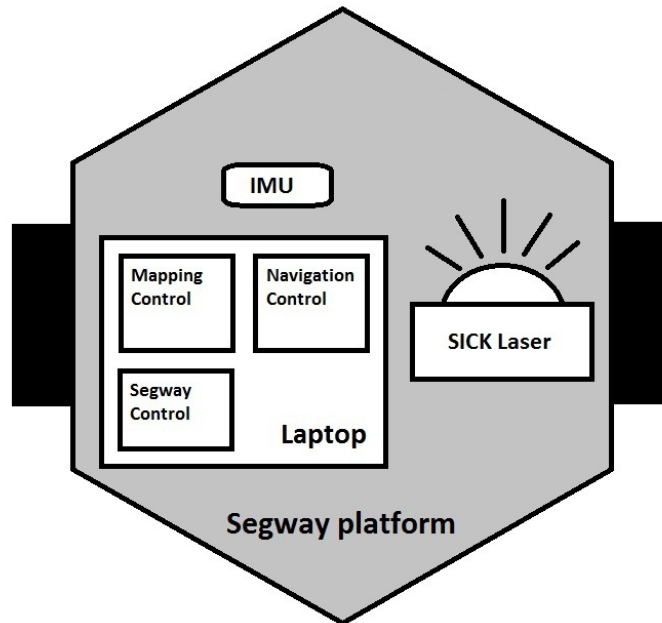


Figure 1: An overview of the system components

2.1 Subsystems

This section describes the different subsystems.

2.1.1 Segway RMP50

The Segway RMP50 is a robot platform from Segway. It is possible to control the translational and angular velocities and to measure how many turns each wheel have turned. All the other subsystems will be mounted to the platform.

2.1.2 XSens MTi-G IMU

The IMU measures the 3D orientation and acceleration. This will be used to estimate the 2D position and orientation of the robot.

2.2 Stereo camera

The stereo camera is a camera with two lenses, this allows the camera to collect images with a depth sense.



2.2.1 SICK LMS-511

The SICK LMS-511 is a one-dimensional laser ranging sensor, that sweeps back and forth with a view of 190 degrees. It provides a range profile along one line. This will be used to estimate the position and to draw the map.

2.2.2 Computer

A computer is used for all calculations based on information from the sensors. The computer will also send commands to control the segway.

2.3 Dependencies on other systems

The software is built and designed for the system and its subsystem described above. If any subsystem is replaced, software modifications will most likely be necessary.

3 Software Requirements

This section specifies the software requirements. The requirements are divided into four subsections: "Mapping", "Trajectory planning", "Path following and localization" and "User interface".

3.1 Mapping requirements

This section lists the mapping requirements.

Requirement 1	Original	The product should be able to generate a 2D map of an unknown environment with a small amount of objects	1
Requirement 2	Original	The system should be able to detect when the reachable environment has been completely mapped and stopped thereafter	1
Requirement 3	Original	The distance between opposite walls in the generated map must not differ more than 20 percent compared to the real world	1
Requirement 4	Original	The distance between opposite walls in the generated map must not differ more than 10 percent compared to the real world	2
Requirement 5	Original	The distance between opposite walls in the generated map must not differ more than 5 percent compared to the real world	3
Requirement 6	Original	The product should be able to generate a 3D map of the environment	2
Requirement 7	Original	The map should be generated on an external computer	2



3.2 Trajectory planning requirements

This section lists the trajectory planning requirements.

Requirement 8	Original	The product should be able to plan a trajectory in order to gather more information to fulfill the mapping requirements	1
Requirement 9	Original	If the product can't follow a planned trajectory, a new trajectory should be calculated	1
Requirement 10	Original	The requirements 8 and 9 should be done on-line	1
Requirement 11	Original	The requirements 8 and 9 should be done in real time or such that they can be carried out during a short halt	2
Requirement 12	Original	The segway's planned trajectory should be drawn for visualization on top of the map on an external computer	2

3.3 Path following and localization requirements

This section lists the path following and localization requirements.

Requirement 13	Original	The product should be able to orient itself when navigating through the area with a maximum error of ten degrees	1
Requirement 14	Original	The product should be able to estimate its position when navigating through the area with a maximum error of 5 percent of traveled distance	1
Requirement 15	Original	The product should be able to follow a planned trajectory with a maximum error of 5 percent of traveled distance	1
Requirement 16	Original	When the mapping is done the product should be able to navigate back to the starting position	2
Requirement 17	Original	The position of the segway should be drawn on an external computer	2
Requirement 18	Original	The segway's driven path should be drawn on an external computer	2



3.4 User interface requirements

This section lists the user interface requirements.

Requirement 19	Original	The user should be able to start the product in a GUI	1
Requirement 20	Original	When the entire area is searched a complete map should be available on the laptop	1
Requirement 21	Original	The user should be able to start and stop the product from an external computer	2
Requirement 22	Original	The user should be able to control the segway via an external computer	2
Requirement 23	Original	The user should be able to control the segway via an android device	3
Requirement 24	Original	The user should be able to control the segway via an iOS device	3

4 Requirements regarding further development

This section lists requirements regarding further development.

Requirement 25	Original	All code shall be commented	1
Requirement 26	Original	The product shall have a demo	1

5 Economy requirements

In this section all requirements regarding economic limitations are listed.

Requirement 27	Original	The project has a maximum of 40 hours of guidance by advisors	1
Requirement 28	Original	The project must not take more than 1680 man hours. This includes time for lectures, education, meetings, document writing, media work and development of the product	1
Requirement 29	Original	Every member of the group shall spend equally much time on the project	1

6 Security Requirements

Since the equipment isn't indestructible we need to have some safety requirements listed below.

Requirement 30	Original	The product should have a system which prevents the segway from hitting walls and obstacles, e.g. staircases	1
Requirement 31	Original	The product shall not run into moving objects	2



7 Delivery and subdelivery requirements

In this section all deliveries and subdeliveries will be listed. More information about decision point (DP) delivery times will be in the Time Plan.

Requirement 32	Original	At DP2 the following shall be delivered: Requirements Specification, Project Plan including Time Plan and System Description.	1
Requirement 33	Original	At DP3 the following shall be delivered: Design Specification and Test Plan.	1
Requirement 34	Original	At DP5 the following shall be delivered: All functionality, Test Protocol, User Manual and a presentation showing that the requirements stated in the Requirements Specification are fulfilled.	1
Requirement 35	Original	At DP6 the following shall be delivered: Technical Documentation, Project Evaluation, Poster Presentaion, a homepage describing the project and a YouTube-video which demonstrates the final product.	1

8 Documentation and media

This section lists the documents and the media which shall be delivered during the realization of the project. The documents are based on the LIPS project model developed by Tomas Svensson and Christian Krysander at Linköping University. The language used for all documents and media will be in English.

Document	Purpose	Format
Requirement Specifications	Specifies the requirements of the project	PDF
System Description	Interprets the Requirements Specification. Includes ideas of how specific problems can be solved	PDF
Project Plan	Describes how the project will be realized	PDF
Time Plan	Describes how the time is divided between the different activities	PDF
Design Specification	Describes in more detail how the specific parts of the system shall be constructed	PDF
Test Plan	Describes what and how testing will be done	PDF
Test Protocol	Protocol of all tests	PDF
Technical Documentation	Describes in detail what is implemented in the final product. It also describes how this was done	PDF
User Manual	Describes how to use the product	PDF
Poster	A poster which briefly describes the product.	PDF
Webpage	A webpage of the product	HTML
Video	A video which demonstrates the products functionality	YouTube
Project Evaluation	An evaluation of the projects result and its execution	PDF