Project Plan

Autonomous Reversing Truck

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Version 1.1

TRUCKVISION

Status

Reviewed	2019-09-23	Alexander Källström
Approved	2019-09-18	Oskar Ljungkvist

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DOCUMENT HISTORY

Version	Date	Changes made	Sign	Reviewer
0.1	2019-09-18	First draft.	Oskar Lind Jonsson	Oskar Lind Jonsson
1.1	2019-09-23	Added activities for improvement of current functionality.	Alexander Källström	Alexander Källström

1 OVERVIEW OF THE PROJECT

Here we'll give a brief summary of project goals and deliveries during over the course of the project.

1.1 Definitions

- **ROS** - Robotic Operative System, an open source software library which simplifies writing modular code for robotic applications
- **Visionen** - A research arena for robotics applications at Linköping University
- **QualiSys** - Positioning system used in Visionen
- **Trailer Tracking System** - Physical model of loading bay with computing unit and tracking sensor(s).

1.2 Background and purpose

Development of advanced driver aid systems and algorithms for controlling autonomous vehicles is a hot topic in both research and in the vehicle industry. Reversing a truck with trailer is a prime example of a task that puts high demand on the drivers skill. An autonomous truck and trailer reversing system is an example of a driver aid system that would aid the work of the truck driver. To be able to conduct research in this area, the division of automated control has made a small scale LEGO truck with trailer which is equipped with a LEGO EV3 unit.

The project group from the previous year integrated a research platform in "Visionen" position system QualiSys. The group also implemented a graph search with euclidean distance heuristic based motion planner and a path following controller for the LEGO truck where all code is developed in Robot Operating System (ROS).

The purpose of this years project is to further develop this system and develop a robust and reliable parking system for the LEGO truck which autonomously should be able to reverse the vehicle into the loading bay. To make sure the system has a realistic potential to be implemented in practice, the need for the positioning system should be reduced to instead use information from an external stereo camera placed on the loading bay. To further improve the system performance, the motion planner should be expanded with an optimisation routine to calculate optimal motion patterns.

1.3 Project goals

The aims of the Autonomous Truck project is to create a platform for research and teaching on autonomous vehicles at Linköping University. Last year, the platform was integrated with the positioning system in Visionen. A graph search-based motion planner and trajectory controller was also implemented.

This year, the focus is on reversing the truck and trailer autonomously. To aid in the positioning of the trailer, different sensor-based tracking techniques should be implemented and evaluated. A state-observer should be implemented to fuse measurements from the different available sensors. The motion planning should also be improved by implementing a more efficient search heuristic and further optimization of the motion plan.

1.4 Deliveries

The deliveries that is to be delivered during the project is listed in table 1.

Table 1: Deliveries throughout the project

Date	Delivery	Version
2019-09-17	Requirement Specification	First Version
2019-09-17	Project Plan	First Version
2019-09-17	Time Plan	First Version
2019-09-24	Requirement Specification	Final Version
2019-09-24	Project Plan	Final Version
2019-09-24	Time Plan	Final Version
2019-09-24	Verbal presentation of the system	
2019-09-26	Design Specification	First Version
2019-09-26	Test Plan	First Version
2019-10-01	Design Specification	Final Version
2019-10-01	Test Plan	Final Version
2019-11-13	All individual systems tested	
2019-11-21	Test Protocol	First Version
2019-11-21	User Manual	First Version
2019-11-28	All functionality delivered	
2019-11-28	Test Protocol	Final Version
2019-11-28	User Manual	Final Version
2019-11-28	Presentation that all requirements fulfilled	
2019-12-09	Technical Documentation	First Version
2019-12-16	Technical Documentation	Final Version
2019-12-16	After Study	
2019-12-16	Poster Presentation	
2019-12-16	Website describing the project	
2019-12-16	Movie to publish	

2 PHASE PLAN

This section describes the different phases that are included in the project as well as a description of what each phase entails. The division of phases is done according to the LIPS project model (Tomas Svensson, 2011).

2.1 Before project start

During this phase the project group is formed. The group members are assigned individual roles with different responsibilities. The task is defined in the requirement specification while details in its execution is described in this project plan as well as the time plan.

2.2 During the project

The majority of the activities in the project plan is executed in this phase. A design specification is made to describe how the different parts of the project will work. The test plan defines the tests that will be used to verify the requirements. Weekly status reports are delivered to the orderer and customer.

2.3 After the project

After all work on the task is done a technical documentation is written to describe how the system works while a user manual describes how to use the system. The project is presented in an oral presentation as well a project conference. For advertising puroses a web page presenting the project and a movie demonstrating the results i done. Lastly an after study is written to evaluate project.

3 ORGANIZATION PLAN

This section describes the organization of the project with respect to the different roles, both internal and external, in the project.

3.1 Overview

Figure 1 shows an overview of the organization for the project.

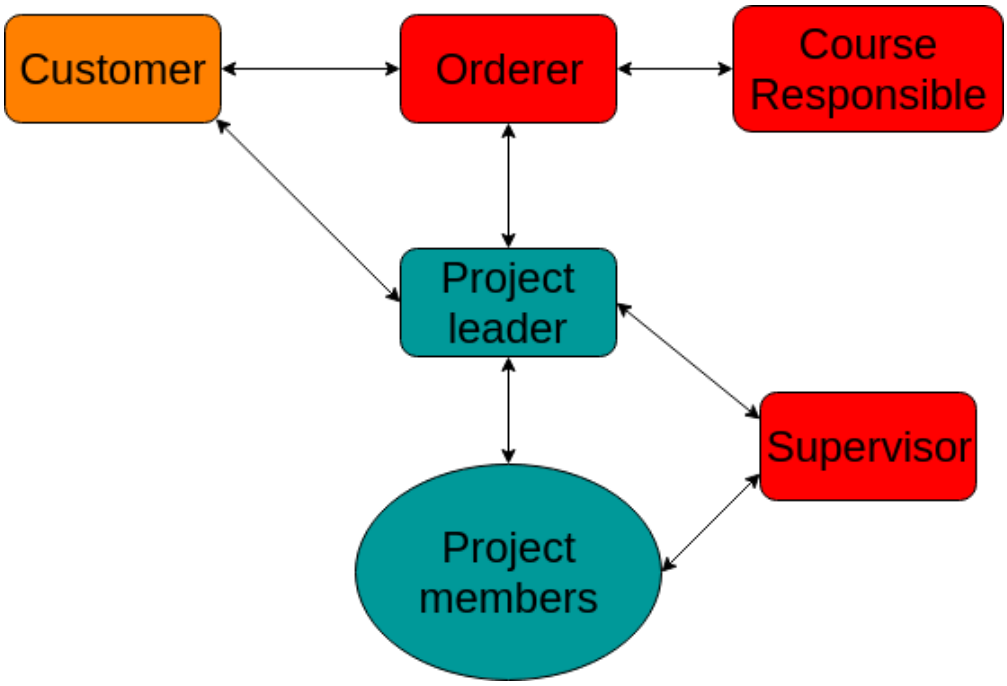

Figure 1: Visual representation of the project organization

3.2 Project group

The different responsibilities that the members of the group has is described in this section.

3.2.1 *Project Leader*

The project leader leads the group and is responsible for achieving the goals. This person is responsible for communication towards the orderers and makes sure the project is aligned with the project plan. Furthermore, this person makes sure all project members have all required resources needed and is in charge of managing and arranging group meetings.

3.2.2 *Software Architect*

The software architect is responsible for the overall architecture of all implemented software components. It is also responsible that new code follows the defined guidelines, and that the version control is used in an efficient manner.

3.2.3 *Visionen Responsible*

The person assigned to this role is responsible to learn all systems that is used in Visionen, including the QualiSys system.

3.2.4 *Document Manager*

The document manager is responsible that all documents are available to everyone in the project group and that they contain the correct information.

3.2.5 *Information Manager*

The information manager is responsible that the website, the movie and poster is done correctly and in time.

3.2.6 *Test Responsible*

The test responsible is responsible for that the system is thoroughly tested throughout the whole project. A test plan and a test protocol is set up to ensure that all things are tested.

4 DOCUMENTATION PLAN

The documentation will be written following the LIPS model and will be done in LaTeX. All documentation will be written in English except the meeting protocol that will be written in Swedish. The documents in table 2 show all documents that will be written during the project. Different target groups is Project Group (PG), Orderer (O), Customer (C) and Course Responsible (CR).

Table 2: Documents throughout the project

Document	Description	Target group	Date
Requirement Specification	Specifies all requirements that shall be fulfilled at the final delivery.	PG, C, O	2019-09-24
Project Plan	Defines the organization, milestones and deliveries for the project.	PG, O	2019-09-24
Time Plan	Specifies how the time shall be distributed between the activities.	PG, O	2019-09-24
Design Specification	Specifies the design of the project. How the different parts of the project will work.	PG, O	2019-10-01
Test Plan	Defines the tests that will verify that all requirements are fulfilled.	PG, O	2019-10-01
Test Protocol	A collection of the test results that verifies that all requirements are fulfilled.	O	2019-11-28
User Manual	Describes how the system shall be used by.	C	2019-11-28
Technical Documentation	A complete description how the system works and is designed.	O	2019-12-16
After Study	A document that follows up the result and how the time was used. Describes what went well and what could've gone better in the project.	O, CR	2019-12-16
Poster	Summary of the project on a poster, done in advertising purpose.	C	2019-12-16
Web page	A webpage that presents the whole project, with documents, movie and the result.	C	2019-12-16
Movie	A movie that demonstrates the project and the results.	C	2019-12-16
Meeting protocol	A protocol from project meetings.	PG	Every week
Time Report	A report of the time spent each week and on what activities the time was spent on.	PG, O	Every week
Status Report	Status of the project. Shall be reported every week	PG, C, O	Every week

5 DEVELOPMENT METHODOLOGY

The group will use an agile methodology while working on the project. This will be done by setting up weekly goals, so called *sprints*. There should be room for flexibility, making it easy for project members to switch tasks. This could be the case if there, for example, is need for finishing another task with higher priority or if some other project member is in need of assistance.

6 REPORT PLAN

The group shall hand in time report and status report weekly to the orderer. The time report will contain a report of how much time each member has spent during the week. In the time report each member also specifies on what activity the time has been spent. The status report will contain a status update, what has been done during the week, if any problems has occurred and what work will be done next week.

7 MEETING PLAN

Group meetings will be held every Monday at 13.15-15.00. The project leader will make the meeting agenda and publish it on Google Drive the day before the meeting. All group members are responsible to read the agenda and prepare for the meeting. The secretary role of the meeting will rotate between the group members in alphabetical order. The meeting protocol will be stored in Google Drive. If additional meetings is needed the project leader invites to a meeting through the group communication channel Slack. In addition to the weekly meetings a daily standup will be held. In the standup each member present what has been done yesterday and what the member is going to do that day and if there is any problems.

8 RESOURCE PLAN

The resources in the project is everything that is needed for the project in a practical point of view. The resources is divided in different areas and is described in the following sections.

8.1 Personnel

The project group consist of six members, who are expected to put in 240 hours of work during the project. The group is also entitled to 40 hours of guidance from the supervisor.

8.2 Material

The hardware included in the project is the following:

- LEGO EV3 Truck
- Linux computer running ROS
- Windows computer running QualiSys
- Projector for map visualization
- Raspberry Pi (for Trailer Tracking System)
- Astra Camera (for Trailer Tracking System)
- RPLidar (for Trailer Tracking System)
- Physical model of loading bay

8.3 Work areas

The group is entitled to a project room that only the project group has access to. The group will also have limited access to Visionen.

9 MILESTONES

The following milestones have been defined by the project group.

ID	Description	Date
1	IMU, Odometer and QualiSys data published on ROS	2019-10-09
2	All tracking sensors up and running	2019-10-10
3	Trailer position estimate calculated and published	2019-11-06
4	Truck driving to suitable reversing position	2019-11-06
5	State observer working with QualiSys measurements	2019-11-06
6	State observer working with trailer tracking measurements	2019-11-11
7	Truck able to reverse to loading bay	2019-11-26

10 ACTIVITIES

The activities is divided into different categories, general, trailer tracking system, state observer and motion planning.

10.1 General activities

In this section all general activities, including documents, are described.

Number	Activity	Description	Time (hours)
1	Requirement Specification	Establish a requirement specification	48
2	Project Plan	Establish a project plan	30
3	Time Plan	Establish a time plan for the project	30
4	Design Specification	Establish a design specification	30
5	Test Plan	Establish a test plan	16
6	Test Protocol	Establish a test protocol	4
7	User Manual	Produce a user manual	30
8	Technical Documentation	Establish a technical documentation of the project	70
9	After Study	Conduct an after study	12
10	Poster	Create a poster	8
11	Web page	Create a website	16
12	Movie	Production of a movie showing the project	10
13	Deliveries	Time for deliveries during the project	30
14	Meetings	Weekly group meetings during the project	144
15	Truck structure	Improve the truck structure, reduce the camber angle of the front wheels	4
16	Testing	Testing to make sure all requirements are fulfilled	100
17	Project management	Time for project management	16
18	ROS refurbish	Edit existing code to fully utilize ROS functionality and make startup more smooth	8
19	Improve visualisation	Investigate implementation of current visualisation and integrate better usage with ROS	16

10.2 Trailer tracking system

This section describes all activities related to the trailer tracking system.

Number	Activity	Description	Time (hours)
20	RPi Setup	Install and setup Raspberry Pi with OS and ROS	8
21	Camera Setup	Install and setup Camera	2
22	RPlidar Setup	Install and setup RPlidar	2
23	Data generation	Develop software for data extraction of camera and RPlidar	20
24	Publish data on ROS	All data publishes over ROS framework	20
25	Distance estimation, lidar	The RPlidar can estimate the distance to an arbitrary object	4
26	Orientation estimation, lidar	The RPlidar can estimate the orientation of an arbitrary object	16
27	Object detection	The camera can detect a simple geometric object	40
28	Trailer detection	The camera can detect the trailer	10
29	Distance estimation, camera	The camera can estimate the distance to the trailer	20
30	Orientation estimation, camera	The camera can estimate the orientation of the trailer	40

10.3 State observer

This section describes all activities related to the state observer.

Number	Activity	Description	Time (hours)
31	ROS message	Create a ROS message for sensor data	8
32	Sensor data	Collect sensor data from the gyroscope and odometer. Publish the data on ROS	32
33	QualiSys data	Collect data from QualiSys and publish on ROS	16
34	ROS record	Record sensor data using ROS bag for observer model improvement in simulation	32
35	Pre study	Study different types of state observers and decide which one to use in the project	8
36	Sensor errors	Determine the bias and measurement noise of the inertial sensors by experimenting	32
37	Dead-reckoning	Implement a model that can estimate states using the kinematic model and internal sensors (Odometer, IMU)	32
38	Publish states	Publish estimated states on ROS	4
39	Implement observer	Implement a state observer that can estimate states using Dead-reckoning and QualiSys, where the data can be out of sync	40
40	Improve observer	Extend the state observer so it also can use data from the trailer tracking system	20
41	Starting angles	Implement a way of estimating the starting angles of the system (yaw angles of truck, dolly and trailer)	40

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Number	Activity	Description	Time (hours)
42	Remove QualiSys	Remove the the dependency of QualiSys for trailer position estimation	40

10.4 Motion planning

This section describes all activities related to the motion planning module.

Number	Activity	Description	Time (hours)
43	Heuristic look-up table	Implement an effective heuristic look-up table for use with the graph search	80
44	Estimated state usage	Implement usage of estimated state from the state observer module	30
45	Improve lattice planner	Improve the current path planner so that planning time is minimized	20
46	Receding horizon	Implement optimal path planning in receding horizon fashion	60

10.5 Buffer time

This section describes the remaining buffer time.

Number	Activity	Description	Time (hours)
-	Buffer time	Buffer time	154

11 TIME PLAN

A time plan for the project will has been done and can be found in a seperate document. In the time plan each group member will register the time spent during the week and the time plan will then be updated.

12 RISK ANALYSIS

There are no risks for physical injury connected to the project. However, there are some risks that could cause a delay in the working process. For example, if some of the hardware described in 8.2 gets damaged the project members working on the specific part will have to work on something different while the hardware is repaired/replaced. There is also a risk that some of the activities described in 10 takes more time to finish than was initially planned, which might eventually lead to the project running out of time before all activities are executed. In this case, the requirements may need to be renegotiated with the orderer.

13 QUALITY PLAN

This section describes how the group will work in order to create a high quality product.

13.1 Code

All code written shall comply to the Google code standard (https://google.github.io/styleguide/cppguide.html). The code will be version controlled with Git. Any new feature should be implemented on a separate branch and reviewed by a different group member before merged with the master branch.

13.2 Testing

A test plan will be done to ensure every module is tested independently. The test plan will include all tests that are necessary to guarantee that all requirements are fulfilled. All tests will be documented in the test protocol. After each module has been tested independently the modules will be put together and the whole system will be tested.

14 PROJECT'S ENDING

The project will end when all deliveries are fulfilled, at BP6. All documentation, the poster and the movie will be published on the website. All group members will conduct an after study where the project will be evaluated.

REFERENCES

Christian Kryssander Tomas Svensson. *Projektmodellen LIPS*. Studentlitteratur AB, Lund, 1:2 edition, 2011. ISBN 978-91-44-07525-9.