After Study

Editor: Erik Bodin

Version 1.0

Status

Reviewed	Erik Bodin	
Approved	Martin Lindfors	

PROJECT IDENTITY

2016/HT, TIGER
Linköping University, Dept. of Electrical Engineering (ISY)

Group members

Name	Responsibility	Phone	Email
Alfred Patriksson	Head of Software	076 210 94 30	alfpa324@student.liu.se
Axel Reizenstein	Head of Hardware	070 279 29 00	axere475@student.liu.se
Erik Bodin	Head of Documentation	076 241 11 32	eribo629@student.liu.se
Gustav Ling	Head of Testing	073 525 72 76	gusli621@student.liu.se
Henric Watz	Head of Information	076 817 57 75	henwa871@student.liu.se
Ingrid Sjöberg	Project Manager	070 652 14 01	ingsj090@student.liu.se
Joakim Mörhed	Head of Design	073 520 84 59	joamo950@student.liu.se

Group e-mail: tsrt10-balrog@googlegroups.com

Customer: Saab Dynamics
Contact at customer: Torbjörn Crona, torbjorn.crona@saabgroup.com
Technical expert at customer: Erik Ekelund, erik.ekelund@saabgroup.com

Examiner: Daniel Axehill, daniel@isy.liu.se
Client: Martin Lindfors, martin.lindfors@liu.se
Supervisor: Per Boström, per.bostrom@liu.se

Contents

Document history **III**

1 Use of Time **1**

1.1 Division of Work 1

1.2 Use of Time Compared to Plan 1

2 Analysis of the Work and Problems **2**

3 Goals **4**

3.1 Achievements 4

3.2 Delivery 4

3.3 Influence of/on Other Courses 4

4 Summary **5**

4.1 Important Experiences and Advice for Future Developers 5

Document history

Version	Date	Changes	Changed by	Reviewed
0.1	2016-12-04	Creation of document	IS	
1.0	2016-12-05	Finished product	-	IS

1 Use of Time

In this project we have had no problem reaching the required amount of hours, $240 \pm 10\%$. When writing this document, with two weeks of project work left, all members have reached $>$ 200h.

1.1 Division of Work

During the project, the members of the group have been able to adapt the work load from week to week, depending on their personal situation. This have led to some people working more in the beginning of the project, and some people catching up on time later on.

1.2 Use of Time Compared to Plan

Making the time plan in the beginning was not very easy. Time estimations had to be made regarding implementation of functionality we had never encountered before, which led to some guessing. The most prominent example in this project was the case of SLAM and AprilTags, where the SLAM functionality ended up taking so much time, an becoming so difficult with the hardware provided, that it had to be abandoned in favour for more convenient solutions.

Implementation and testing of AprilTags used for computer vision also ended up being more time consuming than originally planned. The integration of AprilTags implementation in the sensor fusion network became more time consuming than originally planned, as well, mainly in terms of extensive testing and debugging.

2 Analysis of the Work and Problems

Phase 1

During phase one, the main problem was to get a grasp of the scope of the project, and put it into the required documents. The group found it very hard to plan in detail which "activities" would be needed, and even harder to estimate the time needed for them. A lot of time was spent making the time plan, and in the end several of the activities were not necessary. The division of work also became entirely different when the project's different parts did not advance at the expected pace.

Phase 2

During phase 2 a lot of time was spent attempting to implement Gmapping, ArUco and AprilTags. Unfortunately it was discovered that Gmapping and ArUco required ROS, and different solutions would have to be implemented for computer vision and mapping. Unfortunately a lot of time was already spent, leading to less time to optimise the solutions that were implemented.

The left angled gearbox broke twice during the project. While the Balrog was being repaired, the group was unable to test new solutions and algorithms, leading to some delays.

The group had hoped that the computer vision would have high accuracy and would allow a continuous estimate of the position. However, the raspberry lacked the processing power to handle images at full resolution at speeds high enough to be useful, so the resolution had to be lowered, This came at the cost of both range and accuracy. The group had to adapt to the fact that this performance was lower than expected.

Phase 3

Phase 3 has just begun, today, and thus we cannot analyse this part yet.

Collaboration Within the Group

The group held weekly meetings every Monday where the group discussed the work of the previous week, as well as planned the work for the current week. Larger decisions about the entire project were made all together, while smaller decisions sometimes were made by the people developing modules concerned by the decision.

Use of Project Model

The use of the LISP model has been more of a requirement than a natural integration in the project work flow. Parts of the documents produced early in the project, such as the system requirements and parts of the design specification, have been valuable to the continued work on the project. Other documents have been produced just to meet the

requirements without contributing to the project as a whole. Documents that fall in to this category are large parts of the project plan, as well as the mandatory group contract. Both of these documents have been left on a shelf after completion without further use in the project.

Relation to Client

The relation to the client has been good. Regular meetings between the project manager and the client has been held, updating the client on the progress of the group, and helping to guide the project manager.

The client's representation of Saab has come in second place leaving focus on requirements on the product from a examination standpoint, rather then what the wishes from Saab are on the requirements.

Relation to Supervisor

The relationship to the supervisor has been good. The supervisor has listened to the problems that the group has expressed and has been both flexible and responsive to our concerns. The Supervisor has been interested in the project, and helpful not only at request of the group, but also he has come with hints and ideas of his own when the group has has difficulties.

Technical Advances and Problems

During this project the group implemented a probability based mapping algorithm, as well as a method to fuse dead reckoning calculations with computer vision based positioning.

As previously mentioned, there were some issues regarding SLAM. However, with the help of the supervisor and client, the group managed to move away from this implementation, and successfully implement another solution.

3 Goals

The primary goal for the project was to implement a platform that could explore a designated area. In order to implement this, algorithms for positioning, mapping and navigation had to be implemented. The positioning needed to estimate the Balrog's position as accurately as possible and be able to use visual information to correct errors. The mapping needed to determine the locations of obstacles using a LIDAR and the estimated Balrog position. The navigation needed to determine new destinations and how to travel there in order to explore the map and avoid obstacles.

3.1 Achievements

The Balrog is able to estimate its position using dead reckoning and computer vision. The dead reckoning is assumed to have low noise but to drift over time. The computer vision is assumed to have more noise but is constant and does not drift. Therefore the computer vision is used to slowly correct errors that occur during dead reckoning. While the Balrog sometimes drifts and gets incorrect positioning estimations, it always returns to correct values if it observes enough AprilTags.

The LIDAR has high accuracy, but gives some erroneous values at edges of objects. As such the probabilities have been trimmed to deliver accurate probabilities. The quality of the mapping is highly dependent on the quality of the positioning, since incorrect positioning of the Balrog will result in equally incorrect estimations of obstacle positions. Despite this, during test runs the Balrog generates a map that corresponds to the actual world.

The navigation can continuously provide a route to the closest unexplored area, and the controller follows this route with very little deviation. However, the navigation is dependent on the quality of both positioning and mapping. With the current quality, the Balrog explores all of the map that it can determine is safe, and is currently highly capable of avoiding collision with obstacles.

3.2 Delivery

As the product has not yet been delivered, we can not currently comment on this.

3.3 Influence of/on Other Courses

The project has taken up a lot of time, and it has interfered with the other courses attended by the group members. Since we have had an open time planning, people have been able to prioritise the time as they have wished, which has helped with this situation. The project has probably had a bigger effect on the lives of the group members outside of school, with quite a few hours spent in evenings and weekends.

4 Summary

This project has included many different areas, including control, sensor fusion, AI, computer vision, probability and communication. The project took many unforeseen turns and developments, and the implemented solutions were not as expected. The delivered product still holds up to the standards set, and the group is pleased with having managed to solve these issues.

4.1 Important Experiences and Advice for Future Developers

During this project the group had to deal with unforeseen difficulties and obstacles, requiring changes of the solutions with sometimes little time to implement them. The group managed to overcome these obstacles however, and this may be considered a useful experience as projects often do not go entirely as planned.

The main experience drawn from this project is: do not hesitate to change the original plans if you are stuck or a better way has been found. It is possible to renegotiate the requirements and change the planning documents.

Another important experience is that there are always people who are willing to help. If you get stuck, or there is something you do not understand, the supervisors and technical experts are there to discuss, and they usually know more or alternative routes to take.