Volvo CoPilot Safe Assist
Group 3
Project Report

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1 Background

Volvo Construction Equipment is a company that develops, manufactures and markets equipments for construction and related industries. One of the problems that they have encountered in their construction sites is the high risk of accidents due to the close proximity of the worker with the machines at work.

As an assignment in the Software Engineering 2 course at Mälardalens University, Björn Brattberg, acting as a representative of Volvo CE, contracted the Optimus Octavian group to create an application to reduce the number of accidents at construction sites. This application, called Safe Assist, runs on both the workers' handheld devices and the machines' CoPilot. It is Android-based and issues alarms to both machine driver (through machine's CoPilot) and laborer whenever there is close proximity between the former and the latter. More importantly however, it gives the driver of said machine a warning that there are unprotected people close by.

1.1 Terminology

- Co-Pilot - a display used in Volvo's construction vehicles. It is an Android-based tablet with applications that have the ability to provide the driver of the vehicle with real-time intelligence from the vehicle. Custom applications that gather information such as the speed of the vehicle, the direction of the movement, the load size, fuel consumption are run in it. Currently, the Co-Pilot offers applications like Dig Assist, Load Assist and Pave Assist.
- Worker - any person designated to do any kind of work inside the construction site. These people are considered vulnerable to an accident with a machine.
- Operator - a kind of worker which is currently working with a machine or close to it. This operator could be performing different types of work, such as driving, repairing, or any other type of work next to a machine for a long time.
- Laborer - every worker who is not an operator. Therefore, when the situation of proximity between the laborer and a machine happens, it will be considered as a critical situation.
- Unit - every element stored in the database which has one-point coordinates. Elements such as workers and machines are included in this definition, but not construction sites.
- Construction site - An area defined within the system, within which the proximity between workers and machines are monitored.

2 Organization

The project was appointed to the Optimus Octavian group as part of the Software Engineering course. All development and documentation have been carried out by the members of the Optimus Octavian project group. More detailed information about the project group members and their general tasks to be completed throughout the course duration, together with their availability can be found in the Project Plan document.

During the duration of the project, Optimus Octavian has been in contact with the steering group (consisting of Jan Carlson, Juraj Feljan) every week, to get feedback on our work such as the documentation and also to help us keep on track. The group has also maintained contact with the client in monthly basis in order to verify the group's development efforts to his requirements.

2.1 Organization and Routine Changes

Throughout the duration of the project, many changes have been done to the distribution of work and responsibilities to the group members. Initially, all team members worked together since the primary task was to decide on the organization of the work and possible solutions to the problem presented to us. During the designing phase, work was split between all members in order for every task to be done efficiently. However, lack of communication brought lack of cohesion between the developed solutions parts. Therefore, the group decided to work in separated smaller groups, but important aspects that the whole group should have knowledge about were discussed and explained to all the members.

After some work with the project, the group came to the conclusion that three were the main tasks needed to be focused on: the Android Application, its connection to the CoPilot framework and the

web interface. This lead to a division of the members in three different focus groups: handheld device, CoPilot and web interface. Every group worked on their target feature according to all the designing and important decisions made by the whole team. Periodically, meetings between two or all the groups were planned where specific features or implementations to be done in collaboration were discussed. Finally, some people from the groups separated to work in a documentation group. The documentation group took care of finishing the deliverable documentation.

2.2 Distribution of Work and Responsibilities

The distribution of the work and responsibilities during the development of the project is represented in Table 1.

Task	**Responsible Member(s)**
Server Development	Dara, Rickard
CoPilot Development	Dara, Fernando, Pablo, Rickard
Web Development	Sidorela, Vasja
HandHeld Development	Alvaro, Jonas, Rickard
CoPilot Development	Dara, Fernando, Pablo, Rickard
Project Plan	All group members
Design Description	All group members
Project Report	Alvaro, Dara, Fernando, Pablo, Vasja, Sidorela
Application Testing	Alvaro, Dara, Fernando, Pablo, Rickard
Project Presentations	All group members

Table 1: Distribution of work and responsibilities

3 Project Work

3.1 Worked Hours

The actual distribution of the worked hours per member is displayed in Table 2.

Member	W45	W46	W47	W48	W49	W50	W51	W52	W1*	W2*	Total
Planned work time	*12*	*18*	*22*	*23*	*23*	*23*	*23*	*12*	*12*	*12*	*180*
Alvaro	17	10	14.5	0	7	22	12.5	8	22	12	125
Dara	23	14	15.5	14.5	6	23	31	14.5	13.5	5	160
Fernando	18	21	16	20	9	21.5	25.5	2	9	25	167
Jonas	15	8	19	22	16	12	22	0.5	1.5	15	138
Pablo	16	14	13	20	9	24	28	2	7	25	158
Rickard	16	18.5	23.5	19	36.5	22	27	5.5	9	15	192
Sidorela	15	15.5	14	34.5	25	26	23	7	7	11	178
Vasja	16	14	15	19	9	19.5	28	10	8	18	157

Table 2: Worked hours per member

3.2 Total Project Effort

Table 3 shows the average working hours in person days for each task. The total project meetings consist of hours spent on meeting the client, as well as the group and steering meetings. The total project presentations also include the hours spent on the presentations the group have done during the steering meetings, the group presentations and also the ones done for the client.

Furthermore, the actual effort in person days is calculated with 4 hours per each day. The reason is that the course is running as a half-time course where a working day is equal to 4 hours of work and not

8. To calculate the person days for each task, we have added the hours each member has put for the individual task and divided those hours with 4.

Task	Actual Effort (person days)
Total project meetings	≈ 82
Total project presentations	≈ 48
Documentation	≈ 86
Testings	≈ 14
Server development	≈ 9
Web development	≈ 25
Application development	≈ 57
Total	≈ **321**

Table 3: Effort of tasks

4 Project results

4.1 Key features of the project

The goal of the system is to warn when two devices, in a construction site, are at a distance that may be harmful or dangerous by constantly locating the units present in that construction area.

The system consists of two types of graphical interface, the first being shared by the mobile device (handheld device) of the worker and the device present in Volvo's construction vehicles (CoPilot) and the second consisted of the web through which the administrator performs a series of operations that can only be executed through this web.

All interfaces are responsible for collecting and displaying data that will be sent and received through the server that supports the system itself.

4.2 Requirement Compliance

The main requirements, as presented in Table 4 have been set by our client. All requirements have been met and fulfilled 100%. Requirement with ID-5 was not implemented as defined in the beginning as changes were made throughout the project. This task was decided to be done by a web interface, which not only would set, edit and delete construction site, but would have the same rights on workers.

ID	Requirement Description	% Completed
ID-1	The Safe Assist should work on hand-held Android mobile devices and the Volvo CoPilot System.	100%
ID-2	The Safe Assist should not issue an alert when the driver approaches his/her own machine.	100%
ID-3	The Safe Assist should issue a proximity alert for both the machine operator and workers on site.	100%
ID-4	The Safe Assist should issue an alert to the worker on entering a work site.	100%
ID-5	Working areas should be defined in the Safe Assist.	100% *
ID-6	Increasingly degree of warning as a worker gets closer to a machine.	100%
ID-7	The application should have a lower power consumption when a device is outside a working site than otherwise	100%

Table 4: Requirement Definition Compliance

4.3 Acceptance testing

As a last phase of the software development, we managed to finish the acceptance testing (Beta, End-User or Application Testing), and achive its goal. The acceptance test took place at the Volvo simulator

located in the IDT corridor of the Mälardalen University. We have shown to the client an example of a real situation in a construction site, simulating the location of a worker and driving the excavator. During UAT, actual software users test the software to make sure it can handle required tasks in real-world scenarios, according to specifications.

We also paid attention to the changes in the CoPilot (alarms and notifications). It worked as we expected. In conclusion, the client was satisfied with the obtained results in the simulation.

4.4 Functionality improvement areas

- A graphical method of editing working areas.
- Multiple construction sites: Ability to establish several separate construction site within a general construction zone. For example, in the case of a road, a river dividing the construction site.
- A map from above: Top-down view of a construction site, showing the position of workers and machines.
- Gateway-zone (like a buffer zone between construction site and non-construction site, in which we can handle login, logout/adding and removing to/from construction site automatically).
- Emergency button: Set an emergency button on the application GUI to create the possibility of, in the event of an accident or some kind of emergency, within the construction site, alerting all devices within that construction site and enabling easier assistance from the emergency services.
- Mutable alarms: Add the possibility for the worker to silence the alarms under a period of time.
- Specific hardware to improve accuracy: The use of specific NFC hardware and the use of Bluetooth version 5.0, as this would provide greater accuracy in locating the units present in the construction area and, consequently, increase safety at work, in addition to optimizing the use of the battery of workers' devices. A research, to be taken into consideration, has been done by our group on this matter and the results of this research are presented in a document named "Bluetooth research report" in our git repository in the Deliverables folder.
- Checking the speed and direction of each vehicle and calculate if a machine is approaching too fast towards a worker.
- Implementing advanced algorithms for handling exception when vehicles are close enough to issue alerts to the worker and the operator but the vehicle is actually moving away from said actors.
- Adding a third dimension to the location-data. This could be useful for mining facilities or construction sites when you have different altitudes for the same x/y location.
- Connecting the app and the web-part with a button in the app.
- Forget password option for administrator and manager when logging into the webpage..

4.5 Work products and Deliverables

Table 5 gives a general overview of the deliverabled files created for this project. Three PowerPoint presentations have been delivered to the Steering group as part of the presentations planned between the working groups and the Steering group to present the up-to-date development effort on the project. Weekly presentations have been delivered to the Steering group as part of the weekly Steering group meetings.

The final product was a successful, executable prototype of the application which works on both the workers' handheld device and the machines' CoPilot.

5 Project Experiences

5.1 Positive experiences

Throughout this project, we have benefited in many ways working with the group and on the project. Working with a group of people which we did not know beforehand, coordinating the direction of the

Date planned	Date finished	Name	Description
16/11/2017	16/11/2017	Project Plan	The project plan should get a general understanding of what the project is about, and what is the timeplan for the project. The document should also describe how the work will be organized.
22/11/2017	21/11/2017	Project Presentation (1st)	First mandatory presentation of the project plan.
30/11/2017	30/11/2017	Design Description(First version)	The design document should capture important design decisions you have made in the project, and should provide a good basis for understanding the implementation.
30/11/2017	30/11/2018	Product(First version)	Initial version of the Product prototype
06/12/2017	05/12/2017	Project Presentation (2nd)	Second mandatory presentation of the design project
10/01/2018	09/01/2018	Project Presentation (3rd)	Third mandatory presentation of the project
11/01/2018	10/01/2018	Design Description	Final design description with the changes made in the the design of the product
11/01/2018	10/01/2018	Product	Final deliverable product
11/01/2018	10/01/2018	Project report	The project report should summarize the outcomes of the project, both in terms of results produced and experiences from the project work.

Table 5: Delivered Files

project was taking through group communication (either in person or with the help of social networks such as WhatsApp, Facebook) were all challenges that we had to face ourselves with.

After being able to get to know the members of our group in more depth, the next step was to start distributing the work and tasks, which, although it seems easy, was not. This due to the fact that dividing tasks to a group of people, whose background experience differs, is not an easy task but we managed to organize our work in the most efficient way.

In addition to estimating the hours of work, something else was learned (or improved) in this project. And for the division and estimation of the tasks among the members of the group we have been helped by a tool that for some people was new: Trello, a tool that we will keep in mind when developing a project.

As each member of the group had knowledge in different areas of programming, we have learned to work in other skills that are not ours, leaving our comfort zone, training at a personal level in new areas.

Something that is also important is the interaction with the client, an interaction in which the university was not involved. In addition, we have learned that there is nothing fixed in the development of a project and that it is always necessary to be prepared for any change that the client proposes on his product. In our case, we had to change the architecture of the system after having started working with it, so we had to respond to that important change and not waste time.

Furthermore, although the development of the project is largely agile, and something established in the manifesto of this software development methodology is: "Working on software over Documentation", you can not lose sight of the documentation. So even though the product has a priority in the development phase, time must be organized in order to allow for documentation to happen in parallel with

the development phase of the project. To avoid this problem you have to find that middle point that is achieved through practice. So, thanks to this course we understood the importance of documentation.

In conclusion, this course has given us the opportunity to work as a group with a real customer of a real company, in the real world. Project which has trained us all both personally and as a group.

5.2 Improvement possibilities

Coming to the end of the project course, we have a lot of experience on our shoulders and a lot of improvement possibilities for future group projects within the same scope.

The collected suggestions from our members are as following:

- *Start working as early as possible.* Try to use the first weeks to do some basic work division of the group work and try to design as soon as possible.
- *Be realistic in the expected outcomes.* This project is still a course project with a 50% pace and not a real job so take that into consideration when assigning the expected outcomes of the project.
- *Stick to the ground.* Do not try to add extra features which would look nice on the project, but focus on the main basic requirements of the project. You can always have time to make it better, but first concentrate to make your product functional.
- *Do not put too much work during the holidays.* Be realistic that this time of the year is a break period for everyone so do not expect much work to be done during this period. Try to finish most of the work before the holidays.
- *Practice your presentation skills.* Not everyone is born with skills like talking in public or presenting. Use the weekly Steering group meetings to practice everyone's skills in this field as they comprise an important part of the project as well.