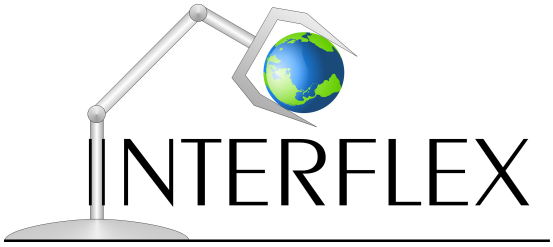
Phase 1

Nikolaj Iversen, Thomas Søndergaard Christensen, David Micka,
Xabier Martinez, Kirstine Winding Nielsen & Simon Wulff Frederiksen

December 2014



1 Collaboration

1.1 Belbin

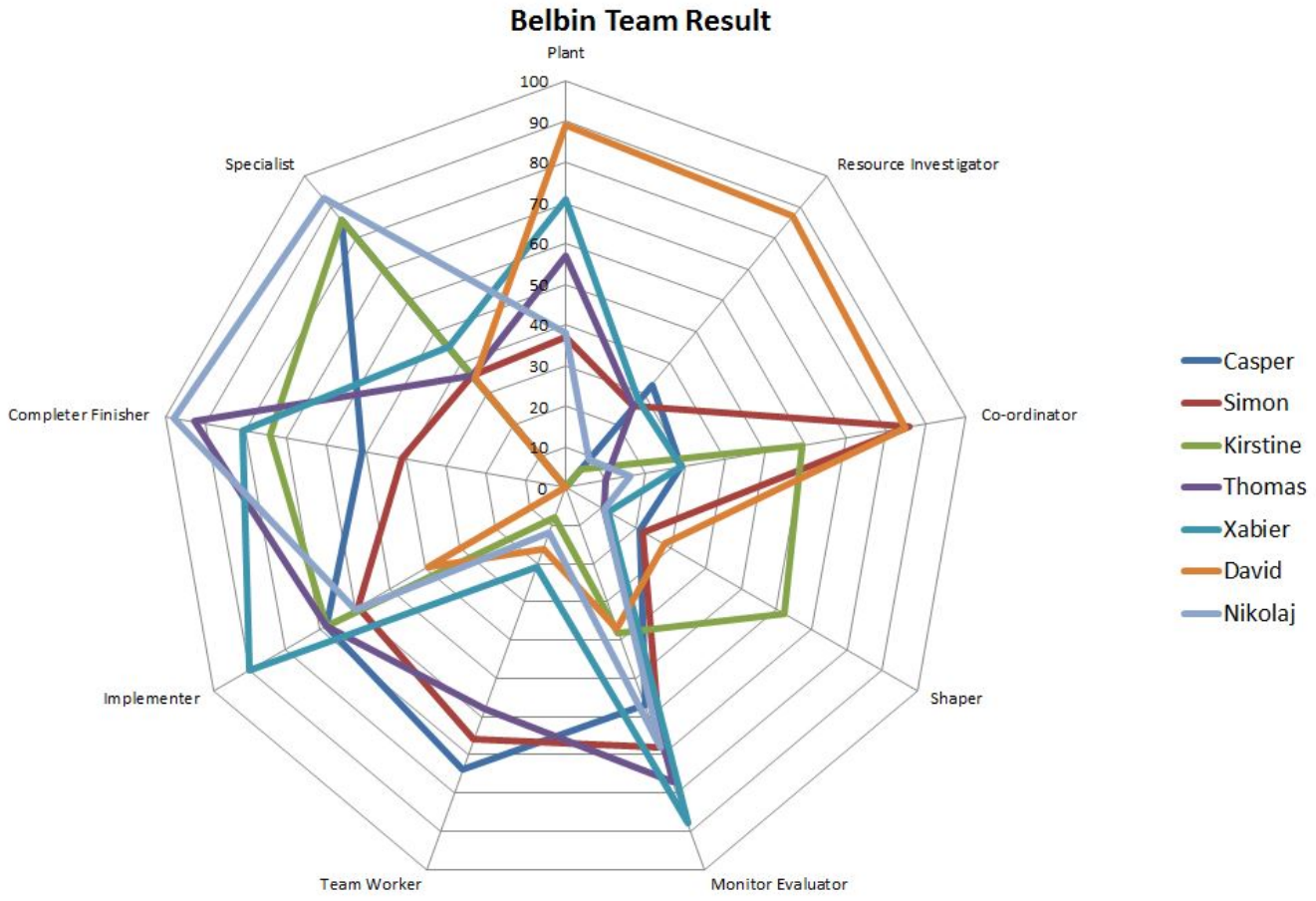


Figure 1.1: Belbin Self-perception "Spiderweb"

Table 1.1 is based on the results of the individual tests, which is also reflected by the spider web chart on figure 1.1. The table shows the strong and weak roles for the team profiles.

It is very clear that the group has a major potential when it comes to developing solutions to perfection, while being able to investigate the different possibilities. This could be explained by the amount of specialists in the group.

It is also very clear that the group lacks drive and a key person to set the pace of the work processes. The group has to be aware that the beginning of project can potentially cause issues. This is due to the lack of Plants and Resource Investigators. The Plants provide creativity and innovation, while the Resource Investigators validates the possibility of and idea.

Contribution:	*Allowable Weaknesses:*
Top 3 roles:	
Monitor Evaluator	
Sober, strategic and discerning. Sees all options and judges accurately.	Lacks drive and ability to inspire others. Can be overly critical to others.
Implementer	
Practical, reliable, efficient. Turns ideas into actions and organizes work that needs to be done.	Somewhat inflexible. Slow to respond to new possibilities.
Completer Finisher	
Painstaking, conscientious, anxious. Searches out errors. Polishes and perfects.	Inclined to worry unduly. Reluctant to delegate.
Bottom 3 Roles:	
Shaper	
Challenging, dynamic, thrives on pressure. Has the drive and courage to overcome obstacles.	Prone to provocation. Offends people's feelings.
Plant	
Creative, imaginative, free-thinking. Generates ideas and solves difficult problems.	Ignores incidentals. Too preoccupied to communicate effectively.
Resource Investigator	
Outgoing, enthusiastic, communicative. Explores opportunities and develops contacts.	Over-optimistic. Loses interest once initial enthusiasm has passed.

Table 1.1: Top/Bottom 3 Belbin Self-perception for the group

1.2 SWOT

Table 1.2 shows the combination of the SWOT-analysis of the individual members. By combining each SWOT-analysis into one, we get a very good overview of the strengths and weaknesses for the group.

By looking at the two boxes with strengths and opportunities we see that there are a lot of words and sentences that indicate that our team can solve and work with problems, as well as being structured. The two boxes that contain weaknesses and threats indicates that the team is marked by stubbornness, non-shapers and non-innovative members. This implies that the team will probably have a hard time generating ideas and to start work on a problem.

It is a kind of a paradox when we take a look at the strengths and weaknesses of the team. We are very good at solving and working with problems, but at the same time we are having difficulties finding and or creating these problems. This means that the team should be aware of difficulties especially in the beginning of the project.

1.3 Competence triangle

In order to learn more about each group member a competence triangle was created (figure 1.2). The competence triangle separates competences that are on a personal, theoretical and experience level. This is done to get a better understanding of how people view themselves and what their education involves. Each member wrote down 2-3 things about themselves and each item and its relation to the project was discussed. The group has a lot of math and programming focused people, but lacks business oriented people.

1.4 Conclusion

The team has had a lot of difficulties finding a problem that we wanted to work with. We have been using innovative tools including brainstorming to come up with ideas particularly around e-waste but we never got anything useful. After a meeting with the supervisors, we decided to work with an idea that was mentioned in the introduction of the project.

By looking at the results from the Belbin and SWOT-analysis it is not surprising that the team ended in the situation that we did. It is very clear that the team has a weakness when it comes to idea generation and as well a strength in problem solving. Prospectively it would be a good idea to look at the results from the team tests so we don't end up in the same situation as we already have.

Strength	Opportunities
Patient(2)	Problem solving(3)
Tolerant	Good presenter
Open minded	Broad contacts
Working with others	Interested in management
Communicative	Solve problems on time
Strong work ethics (2)	Able to structure the report
Adaptable	Can finish a project.
Team player	Can work from somebody's schedule
Open minded	Can work late
Communicating	Not afraid to delegate and face impacts
On time	Mindful of others and open for com-
Social	munication for instance the workload
	Can work in different areas
Experience (work)	Idea generation
Effective	Technical skills
Technically skilled	Easily can learn other subjects
Clever	Team worker
Logic thinking	
Able to prioritize	
Well organized	
Decisive(2)	
Ambitious	
Thorough	
Decisive	
Dedicated to solving issues/problem	
Comprehensive	
Discipline on my own	
Creativity and innovation	
Weaknesses	**Threats**
Stubborn(2)	Not a specialist
Impatient	Easily get stressed
Inflexible	Impatient, if others don't understand
Being on time	Might be difficult to understand
Express my ideas	Bad at solving problems myself
Unwilling to recognize the value of my	Bad at remembering details
work	Might ignore good suggestions when focused on oth-
	er/own ideas
Not starter (If goal is unclear)(2)	The development phase might be slowed
Loses focus easily(3)	down
Not very innovative/creative (2)	Reduced working time
Overview	I like parties and going out/I prefer fun
Working fully on my own	over work
Skeptical within my area	Focus on too many areas
Not a perfectionist	We might never get started
Bad at keeping track of who knows what	Bad at getting ideas to startup a project
Meeting deadlines	Losing focus
Uncomfortable with uncertainty	Need things planned in good time
	Get stalled in some point of the project
	Don't finish on time

Table 1.2: SWOT-analysis

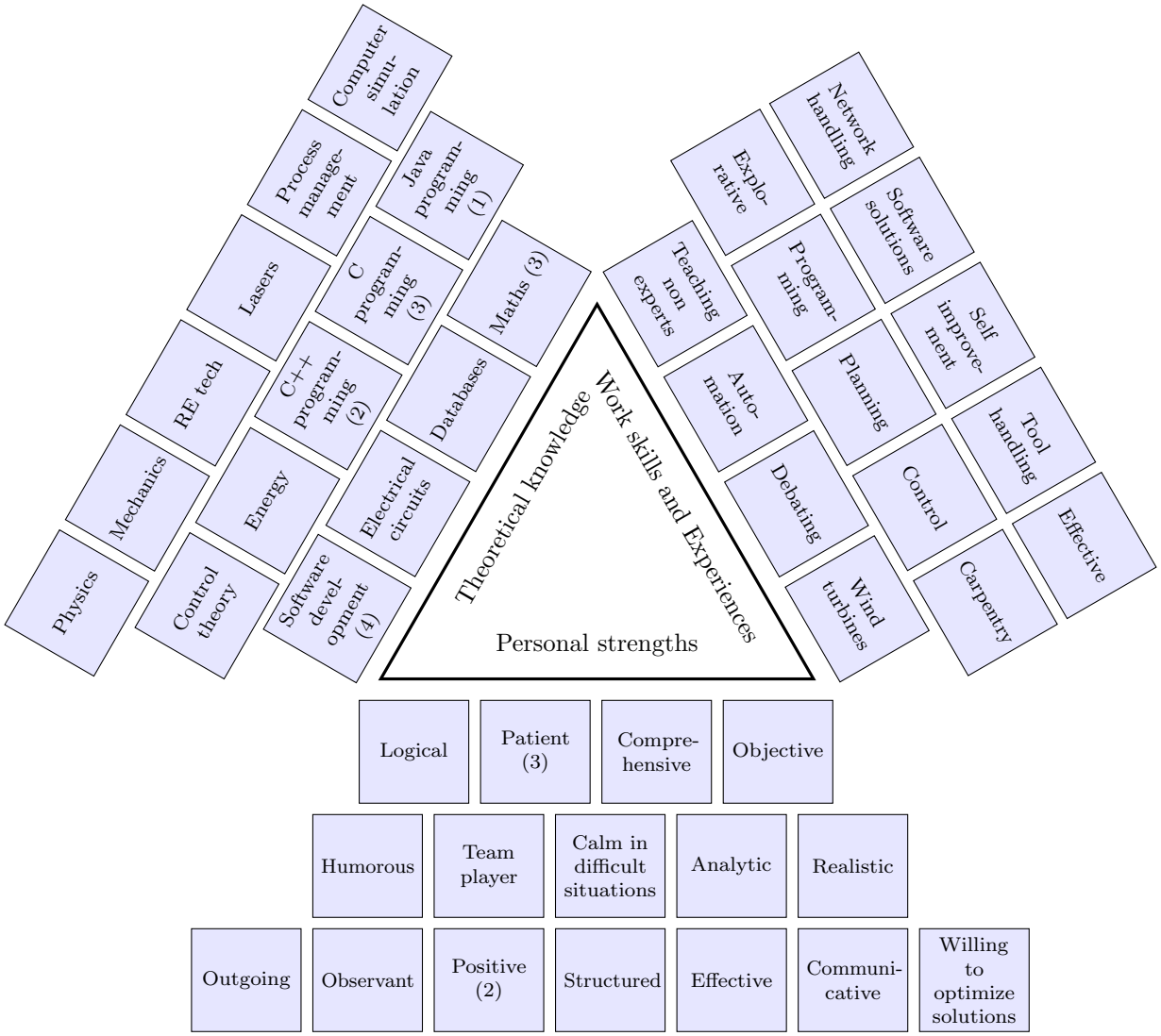


Figure 1.2: Competence triangle

2 Innovation and business

2.1 Pictures

For an idea generation process we all sat around the same table and passed around pictures. We started with the pictures face down so we would pick them at random. When passing the pictures around, each of us said what came to mind when looking at the pictures, always keeping in mind that we were to make a creative functional robot. We made sure not to comment on each others thoughts so all thoughts were allowed.

It was very interesting to see how different pictures generated different thoughts. There was a picture of an opera singer, and the thoughts there were: "Loud", "Hard work", "Love for your work", "Human interaction", "Service provider", "Sound recognition" and "Training algorithms". Another picture was of a cellphone and the thoughts there were: "Interface", "Monitoring", "Portability", "Connectivity", "Extension/Multi-functional", "Compact", "User experience", "New experience", and "Awareness/focus".

(a) Picture of opera singer used in the idea generating process.

(b) Picture of cellphone used in the idea generating process.

Figure 2.1: Pictures used in the idea generating process

In the beginning of this process several of us found it to be somewhat a waste of time. It was difficult to see how a picture of an opera singer should help us design a robot. After the process, however, we all agreed that we had come up with some really good words, and a lot of them were words that we would like to describe our product, e.g.: "Mobility", "Safety", "Combined knowledge", "Service provider" and "Precision". Other words we would have to make sure would not end up describing our product, e.g.: "Loud", "Danger", and "Legal issues".

2.2 Business Model Creator (IDEA - BMC)

After defining the business idea we wanted to specify problems that our idea could solve. To get the maximum from our idea, we decided to make a business plan. The question was how to generate cash flow and to create value for the customers and this helped us answer it. It helped us to better define the situation in which we found ourselves and the direction we should take.

We started with "Value Proposition", which should help us define the services we would like to provide and the products we will develop the business model for. We saw this step as very important and that it will define the course of our business plan, so we decided to spend some time thinking about how we could define what we are going to do and the value we want to create for potential customers.

In the end, we defined our customers as the companies in the welding industry. Companies working on improving the welding technology and companies with non-mass production. We expect the first to be interested in acquiring the technology to implement it to their own system to gain a competitive advantage and the latter one can use it to improve their production and facilitate flexibility of the production, making it possible for further customization of their products and reduction of costs and time.

In the next step, we began to define ideas related to the product. We saw an opportunity in creating value from our product as an innovation in areas, where the competitors failed to achieve it. We decided that the best option in terms of price of the final product would be to suit the current market price, as it would be almost impossible to sell it under the price and selling it with a high price would not be profitable for our customers as the value it creates for them is not crucial for their production.

Will have to make the following comments in reference to the product configuration:

- We are trusted partner in a highly integrated value chain. We focus on adding value in a very specific chain.
- As we focus on developing the technology necessary for the development of sensing system lines for automation of welding, a strong relation with our partners will be necessary, as we need the rest of the technology and components, in order to create the full product.
- Our processes will be quite the same as the industrial production in general:
  - Inbound logistics
  - Production
  - Outgoing logistics
  - Sales and marketing

There is also the financial part. Our prices depend on the product features. The more or the better the features, the higher the price, so it will be more expensive if we had to develop a new type of product with different specifications than if they buy the standard product. We will try to make a price list suitable to all kinds of potential customer's production.

Finally, we have the customer configuration table 2.1. We have an extremely narrow area of focus, but we can develop the product in response to the customer needs, which we know. As this is not a cheap product and the market is not that big, we will try to keep our customers through loyalty programs, where customers are rewarded for remaining loyal to our product. This is also a good way to acquire new customers, because if they are happy with the service/product we provide them, it is very likely that they will provide positive references and recommendations and spread the message about our product.

Customer Configuration Channel				
Channel	Awareness	Evaluation	Purchase	After Sales
Internet	✓	✓	✓	✓
Product brochures		✓		
Journals	✓			

Table 2.1: Customer configuration

2.3 Brainstorm

One of the main techniques applied in the ideation process was brainstorming. In order to get the best outcome from this technique it is important that any idea, no matter the absurdity, is allowed on the drawing. Others may benefit from these seemingly absurd ideas. Early on in the ideation process there was a strong consensus in the group that we find our project in the waste recycling domain. Figure 2.2 shows the first brainstorm the group made.

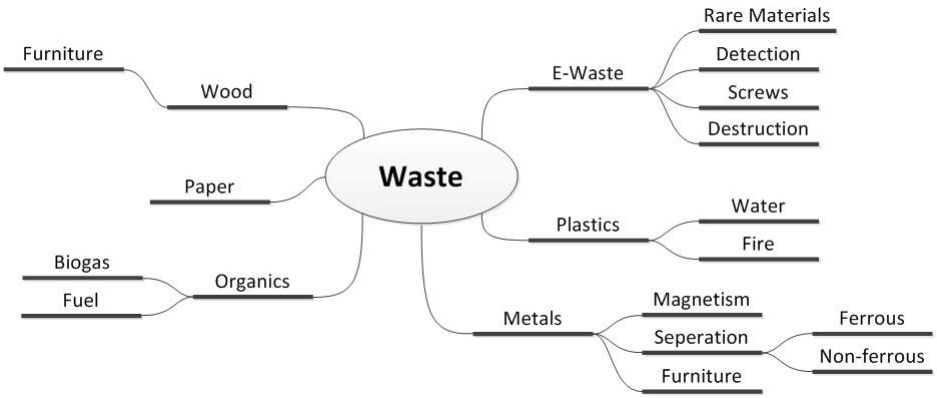


Figure 2.2: Brainstorm on different areas of waste recycling and possible ways of sorting

As can be seen, the two fields of metals and E-waste received the most interest. A vote was held to decide which of the two fields we were going to continue our research on. E-waste was chosen. To further specify the problem of our project another brainstorm was started, this time on different problems within the field of E-waste. The result can be seen in figure 2.3.

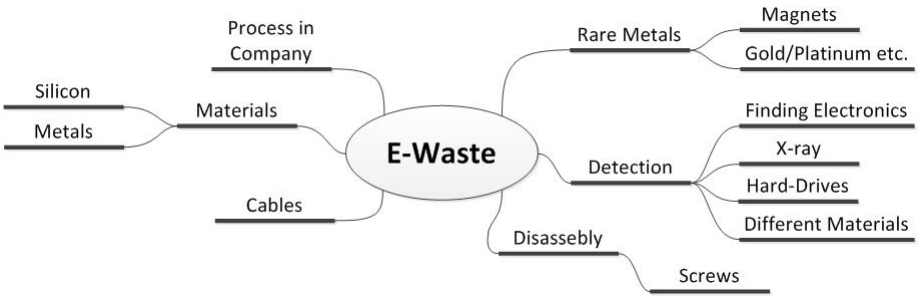


Figure 2.3: Brainstorm on problems within the field of E-Waste

No real result came from the brainstorm on E-Waste, and we came to the realisation that more research was needed for us to finalize our project idea. A list of questions was devised and each member assigned to do research on some of these questions.

At this point we were advised by the supervisors to either make a choice based on the research we had already done, or to go in another direction entirely. It was decided to do a brainstorm entirely focused on concepts, this can be seen in figure 2.4.

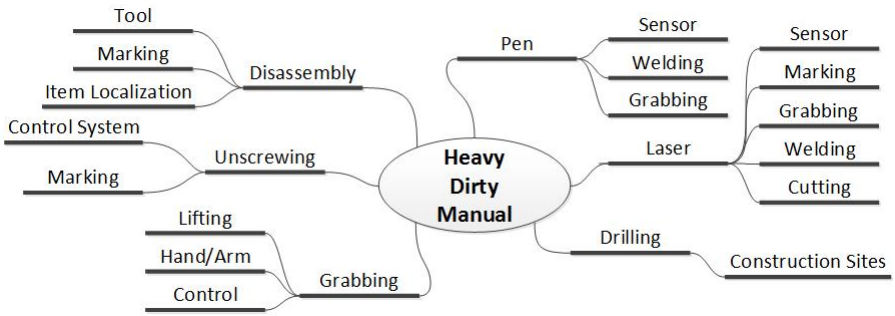


Figure 2.4: Brainstorm on possible concepts

Upon finishing the brainstorm the team split into two groups, each group discussing applications for each concept. Ultimately, we decided to focus our project on the development of a flexible welding robot, using a derivation of the pen principle.

3 Customer

Our direct customers are the companies that package and sell welding systems to other companies. These companies are responsible for getting in contact with the end users. They will know their needs and how to reach them. These users tend to be companies that produce small to medium batches, which typically have experience with the automation of welding robots.

We want to make it easy for our customers to package our solution with their existing products. To do this we will adapt our solution to be able to work with existing welding robots.

We can add value to our customers by letting them expand to business that requires a more flexible solution.

Despite all robots differences in protocol, the basic principal stays the same. To make a product as soon as possible we would start working with a single company so there is only one type of robot programming protocol.

3.1 End users

Our end users is the our customers clients and a lot of our considerations. Since we don't have a direct relation with the end users we get information about their needs from our customers. The end user want to spend the smallest amount of time on programming and the highest amount of welding time out of their robots. We want to make robot programming more intuitive to achieve these demands.

4 Market

We want to focus on distributors located in Denmark. This makes logistical issues easier and until we have a product that we can send out everywhere we want to work closely with our customers.

One of our first customers would be Valk Welding. This company creates welding systems based on Panasonic robots. They try to create programs that makes easier the welding process, minimizing the time required to program the robot.

Valk weldings customers is mainly using offline programming. With a complete knowledge of the item that should be welded and the positioning of the robot they can program the way an item should be welded. The programming is made in a very high level language that keeps track of the coordinates, the speed and the angles of the weld. With macros that aid the programmer making the same routines in different places the time it takes to program the robot is drastically reduced.

Another of our first customers would be the company Weld-Tech Aps. This company is already working with automatic welding, but currently has the restriction that all work pieces need to have a similar pattern. This might hinder their ability to attracting new customers.

This makes us able to solve one of their problems.

When the product is finished we want to expand to be able to use this technology for bigger and more complex welding jobs.

In the case of Valk welding we want to be able to replace the training course and the end customer will save money by having a smaller staff or producing more items. Currently a training course in online programming costs around 100,000 DKK. The average yearly pay of a welding robot programmer in 2012 was 300,000 DKK.

We need to find numbers from welding unions or something

5 Trends

The trends in the welding industry are constantly changing. Companies invest heavily in new technologies to gain a competitive advantage. This means that there are always incorporating new ideas to this sector, but we must always look at the cost stemming and the final price of the product, as SMEs are not willing to pay much for slightly improve welding method.

We need some kind of source on this

There are two programming paradigms that is used today.

One method is online programming, where programming is done by physically moving the robot around and logging the points it has to move. For a complex product, this may take up to 3 or 4 weeks.

Another method is offline programming where programming is done my making a program around a CAD model of the product. It usually takes 2 to 3 days to make a similar program.

The field of automatic programming is still in development and many companies create their prototypes. What stops these products to become popular is it´s tradeoff with a higher price without adding flexibility.

6 student to student teaching

6.1 Nikolaj

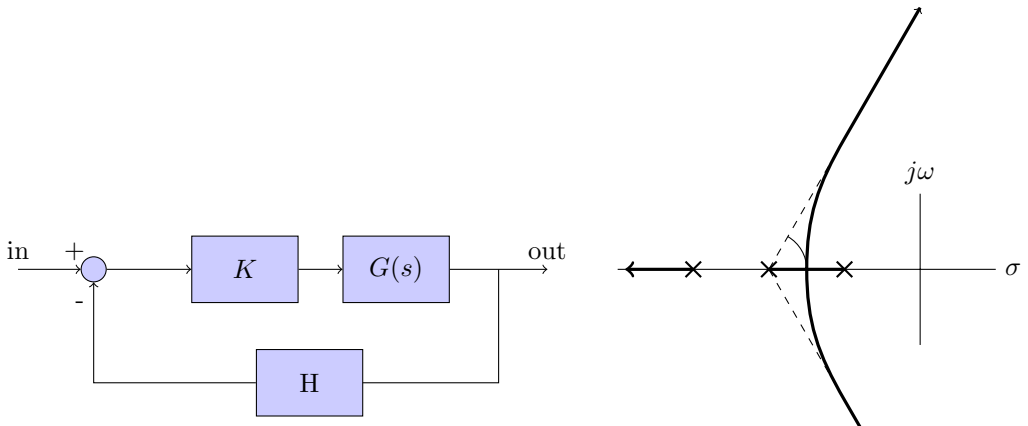
I am studying robotic systems and as part of my education I had a course on classical control theory.

Control theory works with creating models and controllers for linear systems.

6.1.1 Session topics

The quick intro touched on what control diagrams looked like and how open loop and closed loop systems behave on an intuitive level.

To show an example of where transfer functions exist in the real world, the transfer function for a motor was calculated. We talked about the different ways to represent a transfer function. Stability was defined and examples of unstable systems was given. We talked about how to read a pole zero transfer function and what pole positions meant for stability and how it affects the system in the time domain. We talked about overshoot, damping and settling time. We talked about what second order systems look like in the time domain. Then an example was calculated to show how you would design a controller given requirements to it's performance in the time domain.



(a) closed loop system

(b) Root Locus

Figure 6.1: Topics introduced in "student to student" teaching about control theory

Root Locus was defined and it was shown how to read a Root Locus plot and how to draw it by hand. We talked about PID controllers and what the parameters meant. We talked about systems that uses PID in the real world. We talked about ways to chose parameters for PID using the Zigler Nichols method.

6.1.2 Evaluation

A lot of topics were chosen and it was impossible to get explore a single topic withe the given time constraints.

This made it possible to give an overview so people with little to no prior knowledge of control theory could visualize what is possible and how to design a controller.

The used math was not explained in this session as all the students knew about this already.

This was well received and people seemed to follow the conclusions without going into detail about Laplas transforms and second order systems.

The illustrations used was either examples from the book

name and number

or drawn myself.

a. Topics of your session. b. Evaluation of the session in general, the teaching materials, the relevance of the topics and planning and conduction of the session. c. The material used in the session might be enclosed in Appendix.

Documentation and feedback on/evaluation of your lessons from your team members must be included in the project report by each subgroup of students.

7 Expert skills

7.1 Technology description

The idea consists of a welding robot, which is able to recognize a line prepared for welding. To be able to do this, we have to use different technology, as it is a complex case that requires a variety of components to carry out this project.

It is necessary to have a welding robot with a lot of sensors to allow the robot to be more independent. Standard welding robot, which can support up to 6kg with a range of 810mm (to 5 axis) would be used. These robots are perfect for arc welding, assembly, cleaning etc. so it is ideal to use this type of robot.

We also have to take into account all types of protection needed for the implementation of these robots, in this case the following would be used:

- Foundry Plus
- Wash
- Clean Room ISO Class 6

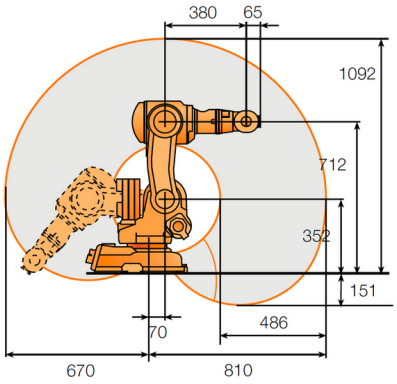


Figure 7.1: Possible type of robotic arm used

We would like the robot to be able to precisely weld holes, which can be as small as 0,1 mm. Precision of the robot is a key component for this task so we have to use a measuring tool.

The decision fell on a laser sensor capable of measuring the distance between the laser and the item prepared for welding, so knowing the position of the laser, we are able to calculate the position of the tool tip, in this case a welding pen. This will serve to correct deviations and obtain a uniform weld, because welding is performed at the same distance.

8 Business plan

8.1 Industry structure and environment

A meeting with Valk Welding in Nr. Åby gave us some insight in the robotic welding industry. Valk Welding sell total robotic welding solutions from Panasonic but with their own modified software. The market had a total sale of 22 units across the industry in 2013 in Denmark and with a few competitors[1] the market seems pretty tough. Valk Welding said that they did not do canvassing, the production companies came by themselves. Valk Welding offer two kind of programming solutions an online an a offline. The online solution means that the robot is programmed with the controller that is connected to the robot, so you can see how the robot is moving while programmed. This means that the robot can't work while being programmed and this can take up to several weeks. The offline solution takes place in a software program where a 3D-drawing of the object is uploaded. Here the programmer can program the robot while it is working. It takes 5-10 times as less time to program offline compared to online. The demand on the market is offline programming solutions because it gives a lot of flexibility.

A at robot exhibition in Copenhagen the 17th of November 2014 Valk Welding announced their "pistol[2]" for robotic welding. Within a 3D camera zone you take the pistol and place it where and how you want to weld, click it and then place it where the welding should end and click it[3]. Then the robot welds the marked area. This is though a slower process than the offline programming if a lot of weldings is needed.

8.2 Entry barriers

There are several entry barriers on the market. A big one is to compete with companies already in the industry with many years of experience and insight in customer demand and behavior. These companies are already working on solutions on what the marked demand. Flexibility.

8.3 Competitors

Valk Welding...

Megatronic

Fanuc

...

8.4 Competitive advantage and strategy

Our biggest advantage will be at SME where change in production and adjustments is happening very often and where no 3D-drawing has been made. In this situation our concept useful because a lot of programming time is need online as offline.

[1] See 8.3
[2] Looks like the last joint of a welding robot
[3] Only works in a straight line though