Name student (incl. student number):	**Lonneke Minkhorst, 438228**
Name client:	REV'IT!
Name tutor:	Cees van Keulen
Names group members:	Demi Westveer, Milko van Valen and Remco Horstink
Project name:	Micro climate sensory measuring device
Project number:	131

A) What does my client think of our delivered results?

REV'IT's feedback

B) What does my tutor think of my contribution to the group process?

Feedback tutor: Cees van Keulen

C) What do my group members think of my contribution to the group process and the results?

Feedback for my groupmembers

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Words list

Embroidery	Embroidery is using a needle and thread to stitch on a fabric. It can be used to apply a given yarn material, or monofilament, to a textile substrate in a defined geometry.
Arduino	Arduino is very small mini computer based on easy-to-use hardware and software.
Velcro	A fastener for clothes or other items, consisting of two strips of thin plastic sheet, one covered with tiny loops and the other with tiny flexible hooks, which adhere when pressed together and can be separated when pulled apart.

Feedback from tutor: Cees van Keulen

Beoordeling tutor voor Lonneke Minkhorst:

Dit document is als volgt opgebouwd:

- *Inleiding*: hierin vindt u zeer korte introductie van de opdracht
- *Resultaat*: hierin vindt u een korte beschrijving van het resultaat en of het resultaat heeft voldaan aan de eisen van de opdrachtgever en het niveau wat de tutor voor ogen heeft.
- *Communicatie*: in deze paragraaf staat beschreven hoe de communicatie tussen de groep, het bedrijf en de tutor is verlopen
- *Individueel gedeelte*: hierin staat kort beschreven welke projecttaken en inhoudelijke taken de betreffende student heeft uitgevoerd en of dit naar tevredenheid van de tutor is geweest.

Inleiding opdracht:

Mijn projectgroep heeft een opdracht uitgevoerd voor opdrachtgever REV'IT!. REV'IT! ontwerpt motorpakken voor verschillende motortoepassingen, zoals voor de toerrijder, maar ook voor motor racing. De opdracht kan kort worden samengevat in de volgende drie punten:

1) Ontwikkel een kledingstuk om het microklimaat in een motorpak te kunnen meten.
2) Tijdens het meten van het microklimaat in het motorpak dient de meetdata draadloos verstuurd te kunnen worden naar een computer waar de meetdata direct (grafisch) weergegeven moet kunnen worden.
3) Het kledingstuk dient wasbaar te zijn.

Belangrijke grootheden die gemeten kunnen worden, zijn bijvoorbeeld luchtvochtigheid en temperatuur. Wanneer het microklimaat gemeten en geanalyseerd kan worden in een motorpak, kan, op basis van deze meetdata en analyse, het design van een motorpak geoptimaliseerd worden voor het rijden in zowel hoge als lage temperaturen.

Daarnaast wil REV'IT! het kledingstuk als 'marketingproduct' gaan gebruiken voor hun klanten. Dit houdt in dat ook het design van het kledingstuk van belang is. Het kledingstuk moet er mooi uitzien, maar ook de 'techniek' mag zichtbaar te zijn.

Resultaat opdracht:

Op basis van de gestelde opdracht heeft mijn projectgroep een shirt ontwikkeld. Dit hebben zij gedaan op basis van gedegen onderzoek en het maken van bijvoorbeeld 'proof of concepts', zoals ook beschreven in hun portfolio's.

Het shirt biedt REV'IT! de mogelijkheid om het microklimaat in een motorpak te meten en data 'on the fly' en van een afstand uit te lezen. Kort samengevat heeft het shirt de volgende mogelijkheden:

1) Accuraat meten van temperatuur en luchtvochtigheid aan de voor- en achterkant in motorpak.
2) Draadloos verzenden van data vanaf het shirt naar computer.
3) Real time weergave van meetgegevens op zowel kwantitatieve als kwalitatieve wijze.
4) Het shirt is wasbaar, doordat de elektronische componenten snel van het shirt kunnen worden verwijderd.

Zowel REV'IT! als ik, als tutor, zijn zeer tevreden over het opgeleverde werk. Het product is direct bruikbaar voor REV'IT! en voldoet volledig aan haar verwachtingen. Verder vind ik dat het proces, wat tot het product heeft geleid, zeer goed en nauwkeurig is uitgevoerd door mijn projectgroep.

Daarnaast hebben zij zowel het product als het proces zeer goed en duidelijk gedocumenteerd. Verder hebben zij het product ook zeer goed gepresenteerd aan REV'IT! en mijzelf door middel van een tweetal professionele presentaties en natuurlijk tijdens het symposium.

Daarnaast wil ik benadrukken dat elk groepslid een gelijkwaardige bijdrage geleverd heeft aan het project, zowel aan de opdracht als aan het groepsproces.

Communicatie:

Het groepsproces liep voorspoedig bij deze groep. Ik heb gewerkt met een hechte groep die goed samenwerkt. De groep hield zich aan de planning, wat tot een zeer goed resultaat heeft geleid.

De communicatie tussen groep en mijzelf als tutor verliep optimaal. De projectgroep heeft mij zeer goed op de hoogte gehouden door middel van wekelijkse meetings en via de mail en app wanneer er nieuwe ontwikkelingen binnen project waren. Ook de opdrachtgever is op professionele wijze op de hoogte gehouden en betrokken tijdens het ontwerpproces.

Individueel gedeelte:

Lonneke heeft naast haar inhoudelijke bijdrage aan het project een sturende rol als voorzitter van de projectgroep op zich genomen. Zij heeft onder andere de volgende taken uitgevoerd:

1) Sturing geven aan de projectgroep.
2) Taken verdelen binnen de groep.
3) Planning van het project opstellen en zorg dragen dat het project volgens planning wordt uitgevoerd.
4) Contact met tutor onderhouden.
5) Vergadering plannen en agenda opstellen.

Zij heeft bovenstaande taken met veel zorg en inzet uitgevoerd en naar volle tevredenheid van zowel de groep als de tutor en REV'IT!.

Daarnaast heeft Lonneke een belangrijke bijdrage geleverd aan het project. Zij heeft onder andere aan de volgende punten gewerkt:

1) Lonneke heeft, samen met Demi, testen uitgevoerd om te bepalen welk gebied van het lichaam het meeste opwarmt, zodat de relevante locatie van de sensoren kan worden bepaald.
2) Zij heeft onderzoek uitgevoerd welke stof het beste gebruikt kan worden voor het shirt, zonder dat het microklimaat door de stof van het shirt wordt beïnvloed. Op basis hiervan is het materiaal voor het shirt gekozen.
3) Ook heeft Lonneke gekeken naar de mogelijkheid van het toepassen van conductive yarns. Dit heeft zij samen met Milko bekeken. Het bleek wel mogelijk te zijn om deze garen te borduren in het shirt, maar het leidde wel tot ruis in sensordata. Daardoor heeft zij geen conductive yarns toegepast.
4) Daarnaast heeft zij nieuwe kennis opgedaan over de borduurmachine en hoe je deze machine kan toepassen wanneer elektrische bedrading geborduurd moet worden op een stuk stof.
5) Lonneke heeft op een juiste wijze de elektrische bedrading en sensoren geborduurd.
6) Zij heeft juiste verbanden gelegd tussen haar studie 'Technische Textiel' en 'Elektrotechniek'. Een voorbeeld hiervan is dat zij rekening gehouden heeft met het borduren van de sensoren, waarbij geldt dat de sensor na het borduren nog steeds in staat moet zijn juiste metingen te doen, zonder dat de sensor afgedekt is met borduurgaren.

Ik vind dat Lonneke bovenstaande punten uitstekend heeft uitgevoerd. Ook heeft zij haar werk op korte bondige wijze zeer goed verwoord in haar portfolio.

Enschede, 25-01-2019

ir. C. van Keulen
Docent werktuigbouwkunde

Feedback from the company: REV'IT

Over het algemeen genomen is REV'IT! enorm tevreden met het resultaat dat de studenten binnen het Smart Solutions project hebben neergezet. Normaliter vinden we het niet vanzelfsprekend dat we aan het eind van een traject als dit daadwerkelijk een eindresultaat ontvangen wat direct te gebruiken is. Dat deze groep in staat is geweest om een product te maken dat wel direct van waarde is binnen dit bedrijf, maakt het nog indrukwekkender.

- Deze groep voelde erg goed aan wat wij van dit project verwachtte, namelijk een bruikbaar prototype met een correcte (maar niet te uitgebreide) onderbouwing. Dit stelde hen in staat effectief naar het einddoel te werken. Het was ook duidelijk dat zij door de afwezigheid van een rapportage richting de opleiding sneller konden schakelen.

- Erg sterk in de communicatie. De contactmoment over de mail/telefoon waren duidelijk, professioneel en to-the-point.

- Goed productontwerp. Sommige eisen die wij gesteld hebben aan het product waren niet makkelijk om te implementeren. Voorbeelden hiervan zijn: wasbaarheid, draadloos gebruik en meetpunten op de voor- én achterkant van het kledingstuk. De groep studenten heeft het prioriteit gemaakt om deze doelen wel te bereiken en zijn daarin geslaagd.

- Positieve onderlinge samenwerking. Ook al hebben wij niet het gehele proces meegemaakt, was het duidelijk dat deze groep erg soepel met elkaar samenwerkte. De taken en verantwoordelijkheden waren onderling duidelijk wat voor weinig frictie zorgde. Hierdoor kwamen zijn eensgezind en gemotiveerd over richting ons bedrijf.

Feedback from my group members

Demi Westveer

Lonneke and I have been working together a lot during this project. I have seen how hard she worked, especially on the embroidery machine. Also, she did a great job being our project leader. Every week we had an organized and structured meeting. She kept everybody together during busy periods, took initiative, helped the group members when this was necessary and she has given a lot of input and ideas during the project. Lonneke and I spent almost every school day together working on the project, so our communication was very easy and without any misunderstanding.

Milko van Valen

Lonneke was the chairwoman of our project group, leading the meetings with our tutor and preparing the agenda. This was her first time in this role, but she learned quickly and led the meetings well. While working on my part of the project I worked closely with Lonneke to make sure my sensors would be able to be mounted to the shirt. Lonneke helped with making design choices so our parts combined well. Lonneke had learned the ins and outs of the embroidery machine at Saxion to create a good looking end product for our client and worked well in the group.

Remco Horstink

Lonneke was the president of our project and she did her job tremendously. Without doubt none of us would have executed this task more formidable. She was always perfectly on time with the meeting schedules and took responsibility for the group when necessary. She was very hardworking and determined to do her tasks as good as possible. She always made sure her ideas for implementing the cables into the shirt were okay with the rest of the group, even though Milko and I don't know much about how to embed technology into fashion. This was very comforting for us because we always knew what she was doing and what problems she was walking into. Overall it was great to have her as a project member and president of the project team. I would say no project can go wrong with her as president of the team.

The assignment

Sensor based microclimate measuring device for motorcycle garments

Introduction organization

REV'IT! Sport International designs and develops fashionable riding gear for motorcyclists. We work from our offices in Oss and New York. REV'IT! is a leading brand that produces the highest quality functional riding apparel available in more than 70 countries. Passionate motorcycle riders all over the world are wearing our brand.

Assignment

Within our Innovation & Design discipline, the Research and Innovation department is responsible for new developments to be integrated in the REV'IT! collection. These developments are based on thorough research and data collection that is supported by the REV'IT! lab.

Rather than assuming we know the source of a problem, we make it a practice to scientifically approach problem areas. Motorcycle garments maintaining a consistent micro climate enhance the rider's awareness. Using a vent to allow air to permeate outer shell materials is the most common solution to avoid overheating and to maintain a consistent micro climate. This brings us to the following project.

Project Goal:

To measure the effectiveness of ventilation, REV'IT! wants to develop a data collection device in the form of an under garment that will provide key information to base future ventilation solutions on. This device/under garment needs to be sensor based (e.g. Arduino) and should translate raw data regarding the garment's microclimate into presentable and understandable output.

Requirements

The to be developed device should..

- be able to measure temperature, humidity and (if possible) amount of airflow on different locations on the body.
- cover the whole body except for hands, feet and head, and can be used in every driving position (from sportive to upright).
- be able to be used autonomously on a riding motorcycle and communicate the test results in an understandable and presentable way afterwards.
- influence the microclimate around the users' body as minimal as possible.
- be aesthetically pleasing and not obstruct the user in any way.

What do we expect?

- A research on how these parameters can be analysed and what the density of sensors should be in order to obtain useful test results.
- A collection of designed construction solutions on how to embed these electronics in an undergarment.
- A physical and fully functional prototype that includes these electronic construction solutions and operating sensors.

The final product

Here one is able to see the final product we made for the REV'IT. It is a 100% polyester t-shirt for men. On both sides of the t-shirt there is a cable construction. This is attached with Velcro, so the whole cable construction is detachable. The cable constructions each consist of 12 sensors that measure the air humidity and the temperature. The tape in the middle is a tunnel with cables and expanders. These cables are all connected with the sensors. On the bottom of the tape in the middle the cables are connected with a power bank and an Arduino. The t-shirt has a pocket band on the bottom were the power bank and the Arduino are placed.

Assessment rubric Assessment criterium	How would you grade yourself?	Indicate the evidence provided and explain why this evidence is relevant. *	If the evidence indicated is part of a group project, describe your specific part of the group project here.
1. I applied knowledge from my own field of study and from other fields of study and I justified my choices based on (specialist) literature and experts.	I think I scored excellent on this, because for embroidering the cables and sensors I had to do research about embroidering electronics, which is not completely my own field of study. Also I embroidered cables and sensors, which I also hadn't worked with before since it is not a part of my study. The embroidering self is a part of my own study. For the part that I was responsible for in the project plan I used literature for writing methods, this is something I learned from my own study. The method we used is from a different field of study, the rapid prototyping method. I also used literature research about his method. Together with Demi, I also did research on the fabric and application methods. We did this research with literature and used this when deciding on the right fabric and an application method for attaching the sensors. Also decisions considering the design and the placement of the sensors is also something I worked on together with Demi. This was done with knowledge from my own field of study. After the fabric was chosen I tested the fabric in the mechanical and chemical textile lab at Saxion. For this I used my own knowledge of quality testing.	The evidence for this is research I did on embroidering electronics and the help I got from an embroidery expert, mister Groeneveld. He is a teacher at my study. He explained how the embroidery machine worked and helped with the first samples. In my embroidery process one can see that I embroidered the electronics. Research embroidering electronics (Evidence 8) Process embroidery (evidence 7) In the project plan I show research about the new method 'rapid prototyping' that is from another field of study and research of methods that I already knew about from my own field of study. Project Plan (Evidence 2) Here one is able to see the research Demi and I did on the fabric and the cable applications method. This shows we used knowledge from our own field of study and based this on literature. Research and brainstorming (Evidence 5) Design In the quality profile one is able to see the test results of the t-shirt's fabric. The results are compared to the standard of the European Clothing Group. This is an official organization and could be considered experts. Quality profile (Evidence 9)	My part in the project plan were the project activities and methodology and the quality control. In the research Demi and I did together, my responsibility were the fiber shape research the thermal/insulation, the breathability and research about the cable opportunities. My part in the design was helping Demi and brainstorming with her. Also together with Demi we decided on the placement of the sensors.
2. I conducted research with an appropriate research or design model and I justified the choice of the model and the (sub)steps taken.	I think I scored sufficient, because for choosing a fabric Demi and I conducted a test. The design model used is the rapid prototyping method,	The test report is relevant, because here one is able to see the results. Test fabric (Evidence 6)	I worked on the test with Demi together. Conducting the test we did with the two of us. My specific part was putting everything together in a

	because the aim of rapid prototyping is showing possibilities quickly, to just test things so designers are able to see early results and get feedback from which they can change the design. Also this makes the test reproducible. For the embroidery process I also used the rapid prototyping method, so I could easily and quickly get results and see progress. According to the rapid prototyping it is important that we created a realistic and comprehensive product, rather than doing a lot of research. This is also why we made a product manual, instead of a research report.	In the project plan one is able to see the choice of the model and the steps that had to be taken, under 'Project activities and methodology'. Project Plan (Evidence 2) The embroidery process is relevant, because here I explain the steps I have taken and why. Process embroidery The product manual is important, because it is part of the rapid prototyping method. It shows in a quick and simple report(manual) how the product works and what the recommendations are, this is something REV'IT valued more than a big research report. Product manual	report and writing the results and conclusion section. My part in the product manual is writing the washing instructions and the design recommendation.
3. I provided an innovative (potential) solution to the issue the client wants resolved.	I think I scored excellent, because the client (REV'IT) is very content with the product we made. We started with the assignment they gave us and we succeeded to give the product the most important requirements. The product we made is innovative, because the sensors are especially designed for being embroidered. They are adjusted in a way, (holes to stitch through, small and thin for comfort) that is the most optimal for embroidering.	The feedback we got from REV'IT is important, because it shows that the client is impressed by the end result we made and that we provided a potential solution for the problem. Feedback from the company: REV'IT The assignment shows the problem REV'IT had and the expectations they had. The assignment The process of the embroidery shows the change to different sensors and the way there are embroidered. Process embroidery (evidence 7)	My part in this was largely embroidering the sensors with the cables. I gave recommendations to Milko regarding the design of the sensors. These recommendations included the size of the sensors and that the sensors should have the ability to be stitched on something.
4. I adjusted my approach where necessary, based on reflections on my own actions and thinking, the process, and the product.	I think I scored excellent, because during the embroidery process I made a lot of samples and changed the embroidery design, application method and the materials used to meet the requirements from REV'IT.	The evidence is the process of the embroidery. In the evidence one can read why I did or didn't continue a method and the choices are explained. Process embroidery (evidence 7)	For the embroidery samples I designed and draw them on the computer and worked with the embroidery machine. Together with Demi we reflected on samples and changed them where necessary.
5. I collected, analyzed and processed relevant information from my own field of study and other fields of study with	I think I scored excellent, because for the project plan I collected information about different methods and analyzed them. We chose the	The project plan is relevant, because one can read about research of methods and the choice for rapid prototyping,	My part in the project plan were the project activities and methodology and the quality control.

reference to the relevant literature.	rapid prototyping method and I used this method during embroidering and also during the fabric testing. Also I collected literature about embroidering electronics and used this information during the embroidery process. The rapid prototyping method is from an other field of study.	which literature was used for. Project Plan (Evidence 2) The test report of the fabric is also relevant, because here one can see that I implemented the rapid prototyping method. Test fabric (Evidence 6) The research I did on embroidering electronics is also relevant information that I collected, analyzed and then used when working on the embroidery machine. This also included research about electronics, which was new for me. Research embroidering electronics (Evidence 8)	
6. I communicated in a respectful, purposeful and professional manner with all internal and external stakeholders.	I think I scored excellent, because as the chairman I have to communicate with the tutor and the other group members via mail and I communicated in a professional manner. Also the client, REV'IT, my tutor and my groupmember were content about the professional communication.	In the feedback of the client, my tutor and my groupmembers one is able to read that the communication during the project was considered professional and pleasant with me. Feedback from the company: REV'IT Feedback from tutor: Cees van Keulen Feedback from my group members Also as a chariman, the agenda I made weekly and the mails I send are something that shows my professionality in communicating. Chairman (Evidence 4)	During the project I was the chairman, which meant I had to have a helicopter view over the project and check up on everyone's process. I also had to lead the meetings and write the agenda every week.
7. I took responsibility for the (sub)solution(s) and the processes within the group.	I think I scored excellent, because as the chairman I kept to check the group members to make sure that everyone made progress. Also my biggest responsibility in the group was embroidering the cables. This included designing the embroidery on the computer and making samples and also the research about the embroidery.	In the weekly meetings I made sure that everyone showed what they had done that week and this also gave the possibility to talk about obstacles the group encountered. Chairman (Evidence 4) The process I made during embroidering is very important for showing the responsibility I took during this project. The process shows the effort I put into it and responsibility that the design meets the requirements of the company. Also the research I did about embroidery was	My part in the project plan were the project activities and methodology and the quality control. In the test report of the fabric I wrote the results and the conclusion. In the product manual I wrote the washing instructions and the design recommendation.

	I also took care of the quality test on the fabric and making the test report of the test of the fabric, putting the test report of the fabric together and wrote the project activities and methodology and the quality control for the project plan. Making a part of the product manual was also my responsibility. I put the report together and added my own parts.	necessary to learn about the techniques I used. Process embroidery (evidence 7) Research embroidering electronics (Evidence 8) The quality profile, the project plan and the test report of the fabric also show that I take responsibility and deliver my part. Project Plan (Evidence 2) Test fabric (Evidence 6) Quality profile (Evidence 9) In the product manual I took care of the washing instructions and writing the design recommendation. Product manual	
8. I described how I viewed the project/issue from the perspective of a different field of study and what impact this had on the choices made.	I think I scored excellent, because when embroidering the sensor I had to consider that the sensor had to work. I had to think about the placement, the connection and that the sensor did not work when it was totally covered with yarns. I was looking at the electrical engineering perspective. This challenged and changed the choices I made during the embroidery process. I had to be careful and very precise when placing the sensors, so the needle of the embroidery machine wouldn't touch or break anything. I also had to consider that the sensors are not washable, so that is why we chose to make a detachable cable construction.	The process of the embroidery is important, because it shows that I made sure the that the sensor would not be bothered or influenced by the embroidery. It also shows that from a textile perspective I would have chosen to use the conductive yarn, however from the electrical engineering perspective the conductive yarn was not preferred because of the noise they gave in the connection. Process embroidery (evidence 7)	Together with the whole group we discussed this and made the decision. My part was thinking how we could embroider the sensors and the cables and then implementing this during embroidering.

**) Please add pieces of evidence (or a reference) to this document*

Product manual

Sensor Based Microclimate Measuring Device for Motorcycle Garments

Date 25-01-2019

Place Enschede

Project Members: Remco Horstink, Demi Westveer, Milko van Valen en Lonneke Minkhorst

Table of contents

1 Introduction

This is a manual for using the climate measuring t-shirt for motorcycling jackets, created for the company REV'IT. This t-shirt was created as a part of the Saxion Smart Solutions project of the first semester of 2018/2019. In this manual one can read about the hardware and software used for the end product, the design properties and a recommendation of the project group for improvement of the end product.

1.1 Reasons for the project

REV'IT! is a company that develops motorcycle garments. These garments need to be comfortable for the drivers, and need to be extensively tested in order to maximize the safety for the driver. The garments must have sufficient ventilation for the best driving experience. At this point this is tested by different motorcycle drivers. However, it would be extremely useful for the company if it had access to a measuring device, wherewith it can measure all the different factors for the perfect driving experience. This way the company can test their garments extensively and eventually develop the best motorcycle garments.

2 The hardware

2.1 Hardware inside the Shirt

The shirt has 2 wiring harnesses attached to it. These wiring harnesses connect al the 24 sensors on the shirt together using 4 I2C expanders inside the fabric of the harness.

All the wires from these harnesses om together at the bottom of the shirt with in total 8 wires, 2 red, 2 black, 2 green and 2 blue. The black and red wires are ground and 5 volt respectively, the green wire is the SDA data channel and the blue wire is the SCL clock wire. These can be connected to any microcontroller which supports I2C and the harnesses will also function on 3.3 volt instead of 5 volt.

2.2 Additional hardware

To use the shirt in its intended purpose as a data logging device there are three additional pieces of hardware required, a HC-12 Transceiver for communication with a computer, an SD card reader for local logging and a USB power bank to power the whole system.

2.3 Connections using an Arduino Uno Microcontroller

To connect the sensors and other harware from the shirt to an Arduino Uno which can be put away in the pockets of the shirt, please refer to Figure 1. The shirt is represented by a breadboard from which all the wires come. The connections are as follows:

Sensor wires:

- Red wires → 5 volt pin
- Black wires → gnd pin
- Green Wire → A4 pin
- Blue Wire → A5 pin

HC-12 Transceiver wires:

- Red wire (VCC) → 5 volt pin
- Black wire (GND) → gnd pin
- Orange wire (TXD) → pin 8
- Yellow wire (RXD) → pin 9

SD Card reader wires:

- Red wire (+5) → 5 volt pin
- Black wire (GND) → gnd pin
- Pink wire (CS) → pin 4
- Purple (MOSI) → pin 11
- Brown (SCK) → pin 13

- Blue (MISO) → pin 12

The USB power bank connects to the Arduino Uno USB B port using a USB A male to USB B male cable.

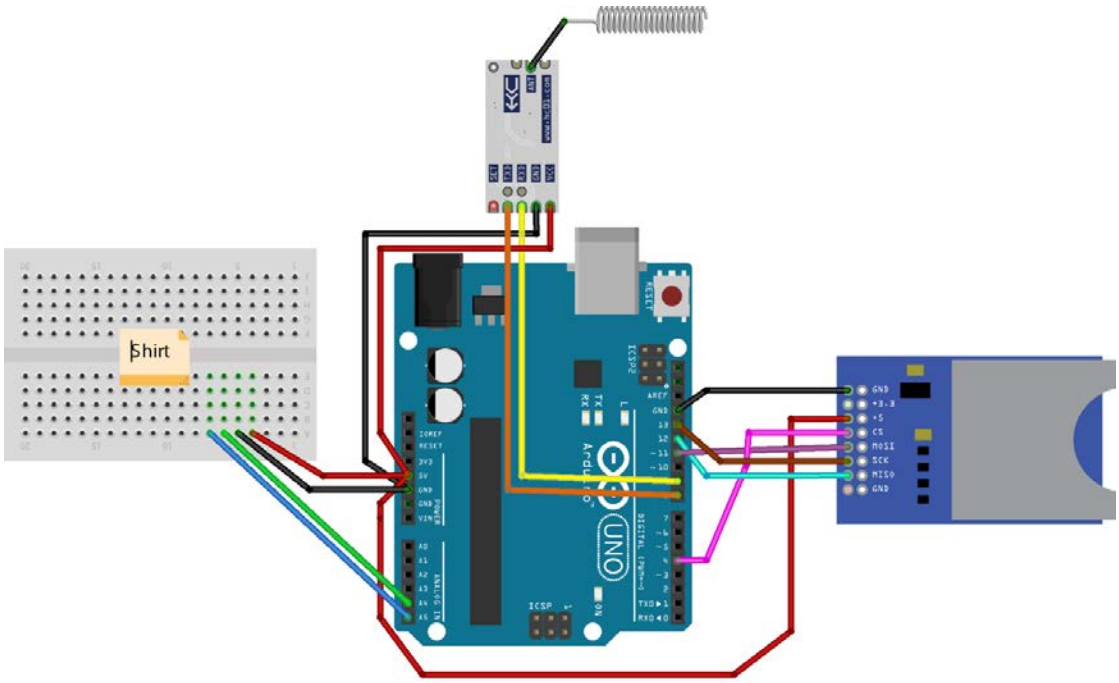


Figure 1 Shirt Hardware Schematic

2.4 Receiving hardware for the computer

The hardware on the receiving end to display and log data on the computer consists of an Arduino Uno and a HC-12 Transceiver.

2.5 Connections using an Arduino Uno microcontroller and a computer

To connect the Arduino to the computer, use a standard USB A male to USB B male cable. To connect the transceiver to the Arduino refer to figure 2, the connections are as follows:

HC-12 Transceiver wires:

- Red wire (VCC) → 5 volt pin
- Black wire (GND) → gnd pin
- Orange wire (TXD) → pin 8

- Yellow wire (RXD) → pin 9

3

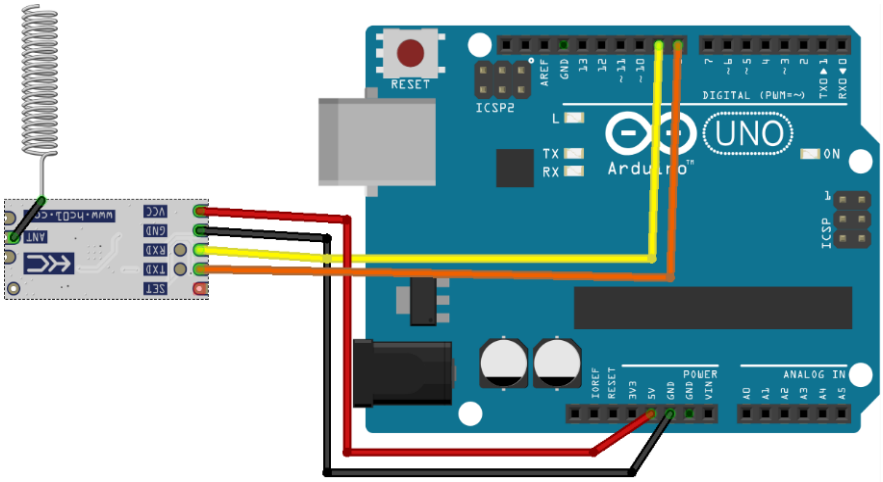


Figure 2 Receiving hardware Schematic

Software

The software contains a few buttons and plots, whereof the usage will be explained in this section. First the buttons will be explained.

3.1 Buttons

Select File Path	As expected the Select File Path button is used to select the file path of the file one wants to write data to or read data from. When clicked, a pop-up will appear where any folder can be selected. It is important that the background image files and the configuration file are in the same folder as the selected file path, or they will not load.
Filename	The filename can be selected here. This way different files can be saved, overwritten, or read.
COM-port	The COM-port is the port on which the Arduino communicates with the laptop. It is very important to select the proper COM-port. There is no auto detect feature in the software, so I use the Arduino IDE, which recognizes the device and shows the used COM-port. This will be further explained later.
Calibrate	The calibration button sets the values of the sensors all equal to each other. This is used because all sensors have a different offset. If one wants to see the changes in the values, it is very useful if these sensors have the same values at the start. It is important to only use this button when all factors are constant.
Start	The Start button will start the measurement. It will open the COM-port (and will give an error if it cannot be opened, which means the wrong COM-port is selected or the Arduino is not connected), and start reading data from this port. It will save the data to the selected file (file path + filename). Also, it will start plotting this data in the four figures.
Stop	The Stop button will stop the measurement and the plots. It will also close the file, so once stopped, the data can't be written to the same file (or it will be overwritten).
Start Plot	Start Plot will read the selected file (file path + filename) and plot it's data in the four figures.
Stop Plot	Stop Plot will stop the current running plot. It will stop the plot when measuring but also stop the plot when reading previously saved data.
Exit Program	Exit program will shut the program in a proper way, and will give a warning if the measurement is still running.

3.2 Plots

The first plot shows the Humidity of the sensors. All 24 sensors are plotted at the same time with a different color. The vertical axis shows the relative humidity in % and the horizontal axis shows the elapsed time. Due to unknown program executing time and no exact data sending time this might be not entirely accurate.

The second plot works the same as the first plot, but shows the temperature on the vertical axis instead of the humidity.

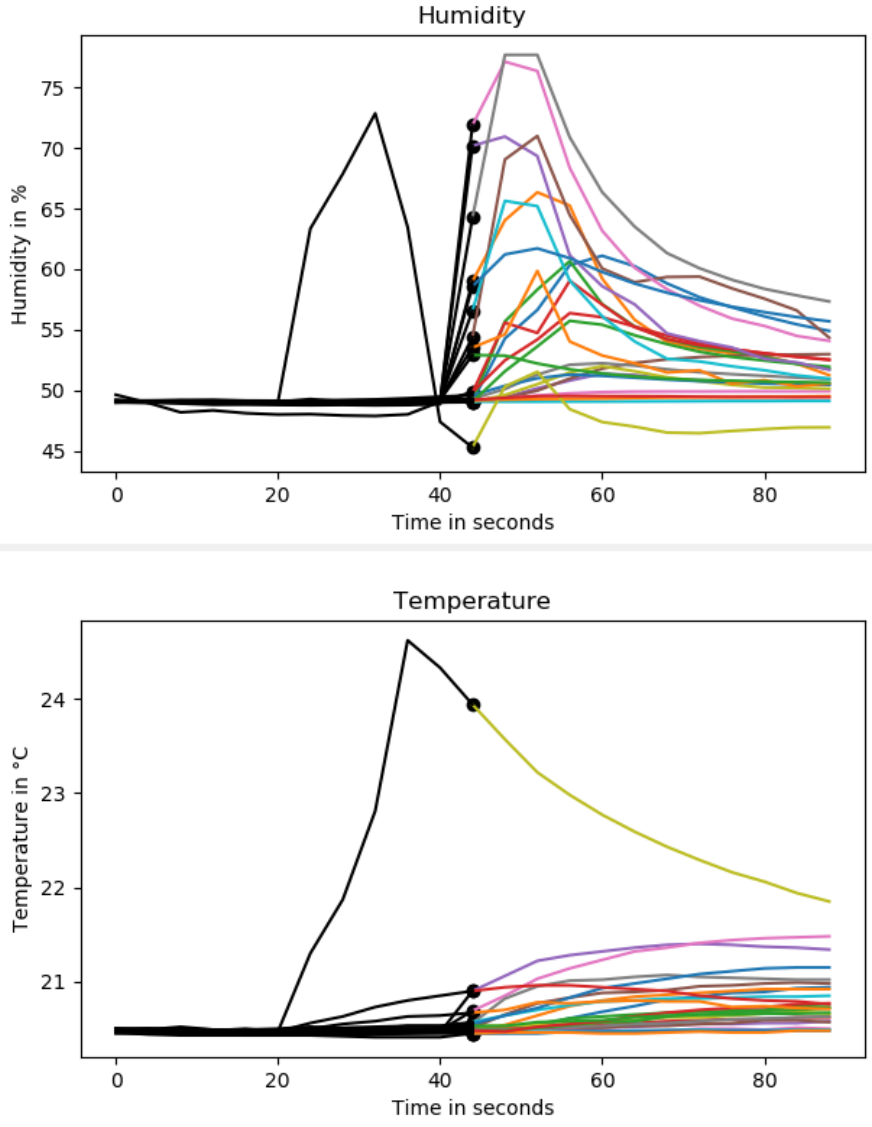


Figure 3 First and Second plots

The third plot shows the front of the shirt and plots the temperature and humidity at the point of every sensor. The color of the dots represents the temperature (red is hot, blue is cold). The colors are mapped to the range of the values, so when a lot of different colors are visible, the values are probably quite the same. This can be checked with plot 2. The size of

the dots represents the humidity. This size is experimentally determined so that big enough differences will be visible. This size is not mapped to the range of the values, so a very small dot means a low humidity.

The fourth plot shows the back of the shirt and also plots the temperature and humidity at the point of every sensor. This plot works the same as the third plot, but then for the back of the shirt.

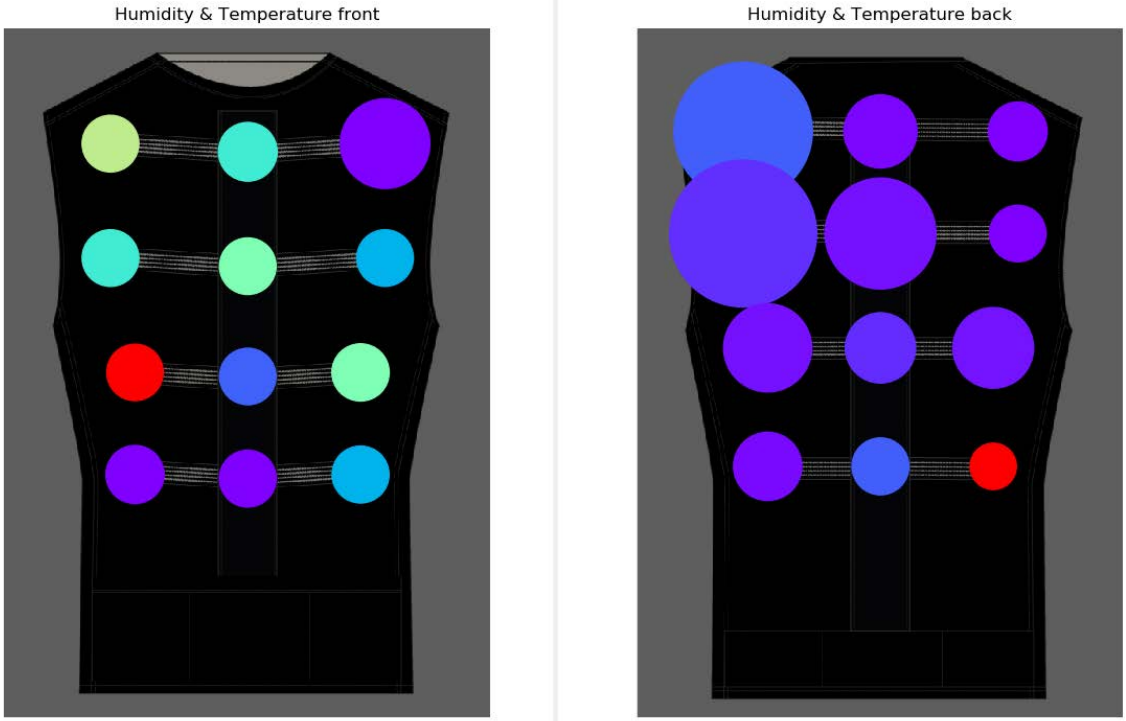


Figure 4 Third and Fourth plots

3.3 Installation instructions

Since the code does unfortunately not work as a standalone application yet, a python code runner and editor must be downloaded to use the program. Also some additional packages must be installed. To get the used COM-port, this can be determined experimentally (increase port until it works), or the Arduino IDE can be installed. This is mainly used for uploading code to the Arduino, but can also be used to read the COM-port which is used to connect the Arduino. The installation and usage instructions are displayed below.

- Download and install Anaconda 3 (Python program package).
- Open Spyder (Python code editor and runner, comes with Anaconda 3)
- Press *File -> Open* and select the Python program file, REVITGUIFINAL.py.

- Run the file by pressing the green triangular arrow button at the top. This will give you some errors in the IPython console at the bottom right. It will display something like “No module named Serial”.
- To install the missing modules, open Anaconda Prompt (comes installed with Anaconda 3).
- To install a missing module, for example the module Serial, type “pip install <module>” and press enter. In this case that will be “pip install serial”. The missing module will be downloaded and installed. The progress is displayed in the console window. There will be multiple missing modules; just use the pip install command to install a module and run the python script again to see if all the modules are installed, and if not, install the next missing module. Repeat until no errors occur.
- When no errors occur, shut down the program. A pop-up will have appeared (probably behind the Spyder program, so minimize this if not visible).
- In the REVITGUIFINAL.py code (in Spyder), find line 62: “pathconfig = ‘C:/Users/Remco/Documents/SSS’”. Change this file path to the path your config.txt file and the background images REVITfront.jpg and REVITback are located in. This will look something like this:
  “pathconfig = ‘C:/Users/<your.name>/Documents/<your.config.folder.name(s)>’”.
  Save the file.
- Connect the Arduino to your laptop (the one with only the wireless module). Also turn the shirt on by plugging the power bank into the other Arduino.
- Find the correct COM-port. To do this, either use one of the methods below:
  - Run the program REVITGUIFINAL.py in Spyder. Minimize Spyder if the GUI is not visible. Press OK on the “select sensors” pop-up and the GUI will appear.
    Set the file path and filename.
    Set the COM-port to 1.
    Press start. If there is no Error message and the program starts measuring, the right COM-port has been found.
    If an error message is displayed, repeat setting the COM-port to a higher value until no error appears. The value should normally be somewhere between 1 and 15.
  - Download and install the Arduino IDE.
    Open the Arduino IDE. Press *Tools -> Port*. This will show all the ports available. If there is only one Arduino connected, there will be only one port with the correct port number.
- Now open the config.txt file in Notepad. In this file the standard filename, file location and COM-port are set. The first line contains the filename, the second line contains the file path and the third line contains the COM-port. Set the file path to the location where you want to save the data files. The filename can be set to something like ‘test’ for testing the program. Most importantly, set the COM-port to the number found previously. Save the file.

The setup is now complete! To use the program, open REVITGUIFINAL.py in Spyder and run it by clicking the green triangle at the top. The rest can be done within the GUI using the buttons.

Final note: The GUI is based on a 1080 by 1920 pixel screen, so when using a smaller screen resolution part of the program will not be visible. This means a requirement to properly use this program is that the laptop has a full HD screen or larger (but then the program will appear smaller).

4 Design properties

4.1 Cable construction

The cable construction is specially created to cover all the cables and other electronic elements on the garment. Only the temperature and humidity sensors are visible on the surface of the fabric. The construction GUIdes the cables to the centre of the garment and then down into the pockets on the bottom of the garment.

4.2 Pockets

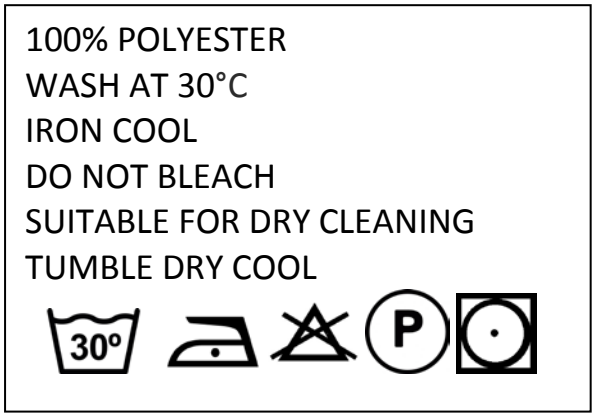
The pockets function to carry the electronic elements on the garment. The pockets carry an Arduino, breadboard, long range chips and a power bank. The pockets are divided by Velcro so all these elements can be switched through the pockets for the driver's own comfort.

4.3 Washability

Since the whole cable construction is attached to the garment by the use of Velcro, the cable construction is completely detachable. This causes that the garment is washable after use. Please follow the care instructions of the garment on the next page.

4.4 Washing instructions

The washing instructions for the t-shirt are described in the figure alongside. These instructions only apply for the fabric of the t-shirt and not for the cable constructions. The fabric can be washed at 30°C and ironed with low temperature settings. Also the fabric should not be bleached. For drying the fabric it can be dry cleaned or dried in a tumble dryer with cool temperature settings. The fabric is 100% polyester, this is tested with raw materials test in the chemical and mechanical textile lab at Saxion University.



5 Recommendations

5.1 Hardware

Sensors

The sensors used in the current prototype are relatively cheap. This was one of the constraints I put on myself while looking for a sensor to make the prototype not needlessly expensive. More expensive sensors can give better accuracy and extra functionality, but most importantly, there might be sensors on the market with faster response times.

Microcontroller

The microcontroller used on the shirt is an Arduino Uno. It is incredibly easy to use and prototype with, but for the current application it is a bulky unit, not easily concealed in the shirt. Research into different controllers would improve the user experience greatly in my opinion. There is even the possibility to use a microcontroller redesigned for this exact application, integrating the HC-12 and the SD-card reader onto one PCB.

Finish of the system

The systems currently functions with the connections made using jumper wires and a small breadboard. Returning to the previous point, this could be better using a PCB design for this project with a pair of connectors to connect the two harnesses of the shirt to the microcontroller

5.2 Software

There are many things that can still be improved concerning the software. In this section a few of these possible improvements will be discussed.

Calibration: The current calibration is acquired by calculating the average of all the sensors and setting these sensors to this value. However, there is no telling whether this value is actually accurate. For this, a professional measuring instrument is required, which is extensively tested. Also a very constant atmosphere must be present. Then the sensors can be set to this value. For this to work, this calibration should be read from a text or csv file. This way the calibration data can be adapted without changing the code from the program itself. This calibration should be done at different constant temperatures and humidities. If, when calibrating the sensors at a certain temperature and humidity, they are not accurate anymore at a higher or lower constant temperature and humidity, the sensors also need to be gauged.

Start SD card: The current setup writes data to the SD card from the exact moment that it is turned on. However, it would be way more convenient if it would start writing to the SD card when the user actually presses the start button on the python program. This is possible, because the wireless modules can both send and receive data, which means that by sending some kind of setting the Arduino would start executing a certain part of the code. For this to work, the Python program has to be adapted, as well as the code on both of the Arduino's.

Sensor selection: A great issue is that reading the sensors takes a lot of time. When the user wants to focus on only a small part of the body, it would be convenient if this section could be selected by the user. Then, using the same method as the idea for the SD card, the Arduino could be set to only read a limited amount of sensors, which will significantly increase the overall measurement times. In the program, the sensors could be divided into predefined sections. The user can then select a certain section he or she is interested in, after which the program can send a setting to the Arduino's, which should trigger a certain part of the code on the Arduino that only reads these specific sensors. However, this does require a lot of adaptions and will take some time to be realized.

More plot options: For documentation reasons it would be quite handy if the program could generate certain plots which illustrate the data from only one or only a few sensors in different ways. Possibly some plots would be interesting that show the sensors which had the highest temperature or humidity on average. It would be great if the plots could also be exported to a .png image for use in documentation. These new plots could be added in different tabs, because they wouldn't fit in one screen.

Add legends: Because of the many sensors, the legends in the humidity and temperature graphs have been deleted. However, it might be possible to put these legends more compactly next to the plot instead of into the plot itself. This way they don't cover any data. This might however cause some spatial problems. Also in the front and back plots, it would be very useful if there was an actual color bar, which displays which color represents which temperature. I tried adding this, but this was harder than expected because an updating plot is used, and when adding a color bar this gets added every time the plot gets updated. This causes the amount of color bars to increase forever and the plot to disappear. Somehow this must be possible so this is still worth looking into.

Add time: When executing an experiment, one would like to note the exact time and date this experiment was executed. This can be done two ways. There are real-time modules for the Arduino with a small battery that

keep track of the time. This way the time could be added to a measurement. A different way would be to import the laptop's device time into python and add this to the measurements, which also means sending this data to the Arduino. This way a real-time module is not needed.

The way the time axis is created is a little imprecise, since it is dependent of the time needed to execute the program and of the time needed to read the sensors and send the data. By using the device time and sending this time to the Arduino, the measurement frequency can be based on this device time. This way the time axis will be perfectly accurate, which is absolutely not the case at this moment.

Make .exe:

Because multiple people might want to use the software on different computers, it would be convenient to have the program in the form of an executable file. This way the user doesn't have to download Anaconda and this way the user can directly run the program without the delay of the code editor. Also, the program will be much faster this way. I tried doing this, however this appears to be not quite so simple. I tried many different methods and found one that worked best for me, however this meant disabling the plots. Apparently it works perfectly fine when no plots are displayed but when the plots are used the program doesn't start. For this executable to work the way of plotting in the python code probably has to be adapted, which means all the plots will have to be redesigned and built. This will take some time. Maybe in a new update this conversion will work with these plots.

5.3 Design

Recommendations considering the design are testing the fabric that is used. The choice of fabric is now based on the treadmill test that is performed with three different sport t-shirts. The fabric that had the best result was a t-shirt 1, with a 100% polyester fabric. With this result a fabric was chosen that should be similar to the fabric of t-shirt 1. However, finding a fabric that looks similar is very difficult because the only specifications that are mentioned online are the material and the grams per square meter. A fabric has a lot more specifications. After all, the recommendation considering the fabric is testing it again on the treadmill to compare the results with t-shirt 1. If the results deviate a lot, even more than t-shirt 2 or 3, then it is recommended to look for a fabric that is more similar to t-shirt 1. Another thing that one should keep in mind is the possible influence of the Velcro that is used under the sensors tapes. It is recommended to test the influence of the Velcro in some way.

During the presentation at REV'IT, it was stated that one should also look into placing sensors under the armpit to see the microclimate there since this is a place on the human body were perspiration occurs a lot.

Project Plan

131. Sensor Based Microclimate Measuring Device for Motorcycle Garments

Project plan

Company	REV'IT
Version	0.1
Date	05/09/2018
Place	Enschede

Project Members:

Name	Remco Horstink
Number	457958

Name	Lonneke Minkhorst
Number	438228

Name	Milko van Valen
Number	447888

Name	Demi Westveer
Number	434703

Table of contents

1 Background information

1.1 Reasons for the project

REV'IT! is a company that develops motorcycle garments. These garments need to be comfortable for the drivers, and need to be extensively tested in order to maximize the safety for the driver. The garments must have sufficient ventilation for the best driving experience. At this point this is tested by different motorcycle drivers. However, it would be extremely useful for the company if it had access to a measuring device, wherewith it can measure all the different factors for the perfect driving experience. This way the company can test their garments extensively and eventually develop the best motorcycle garments.

1.2 Current situation

Previous semester another project group was occupied with the exact same assignment. They developed a prototype; however, this prototype did not meet the wishes of the principal. Their research is very valuable, but the garment should be redesigned. The previous garment was not useful for the principal, because the sensors were too slow, the garment was not easy to use and the method of reading the data could not be used by the company due to the lack of licenses. For the current project these points have to be improved.

2 The project result

2.1 Problem analysis

Motorcycle garments which maintain a consistent microclimate enhance the driver's awareness. As a common solution to avoid overheating and to maintain a consistent microclimate a vent is used to allow air to permeate outer shell materials. However, there is no method for testing the effect of these vents. The effect of these vents were never scientifically proven. Therefore, a method to test the effects could support the research into making ventilation more effective.

2.2 The result

The project result is a sensor based undergarment which can measure the microclimate inside a REV'IT motorcycle garment necessary for the perfect driving experience. The sensor based undergarment must be able to measure the temperature, humidity and if it is possible the amount of airflow at different locations on the body. The undergarment must function, look presentable and can be used in every driving position. The undergarment should affect the temperature as least as possible. The data gathered from this undergarment should be translated into presentable and understandable output.

3 Project activities and methodology

The main activity is creating a sensor that can measure the microclimate inside a REV'IT! motorcycling garment. REV'IT! wants the product to work, look professional and be able to translate the data in a presentable way. To accomplish this one will investigate the following topics:

- Finding the most suitable fabric for the undergarment where the sensors will be placed on. The fabric should affect the result of the sensors as least as possible.
- Finding the most suitable places for the microclimate measuring sensors on the human body.
- Finding an advisable sensor system to measure the microclimate inside a motorcycling garment.
- Researching the most functional and least comfort affecting way to connect the sensors.
- A presentable way to read and translate the date of the microclimate measuring sensor.

The project will be carried out according to the rapid prototyping method. This method involves creating a three-dimensional product. The aim of rapid prototyping is to show possibilities quickly by building prototypes so designers are able to see early results and get feedback from which they can change the design. The method is also used to test the efficiency before a product will be manufactured in larger quantities (Ranson, N.D.) (Rouse, 2014).

Rapid prototyping enables designers to realize their concept beyond virtual visualization. The designer can see the look and test the prototype, rather than basing in on assumption. It also provides a proof of concept for clients in the market who seek for a more realistic and comprehensive product designer rather than just a design on screen. Changes that have to be made in the design can be incorporated immediately (Saurabh, 2018).

Rapid prototyping fits this project since the case is already examined by a conventional method. The recommendation of the other project group that already worked on this subject was to invest more time in prototyping.

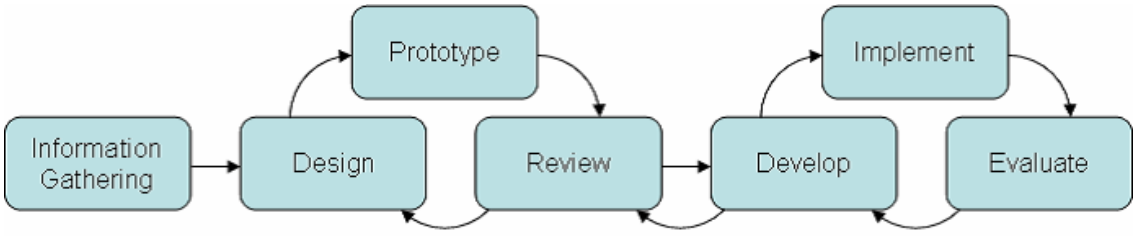


Figure 2 Rapid prototyping set scheme (Boulet, N.D.).

3. 1 Methods

During the project different methods will be used to come to the end product. The following methods will be used and explained.

Desk research

Desk research is data collected by others. This kind of research is used within the literature review. Scientific books, articles and reports can be collected and used. Desk research will be done and is necessary for all the topics aforementioned in the project activities. During the process other subjects can be found that need desk research.

Experimental research

Experimental research is a quantitative research method. It includes any research with a scientific approach, where a set of variables are kept constant while other variables are being manipulated to see the effect. This method will be used during prototyping and the testing of the prototypes.

Laboratory research

This method will be used in a laboratory or another artificial setting. It is important that strict conditions are taken into consideration to keep control over the different influences. Laboratory research will be used during testing of prototypes, regarding fabrics, sensors, the attachment of the sensors and the combinations of these three factors.

Comparative investigation

Within comparative investigation two or more situations are compared. It is relevant to measure the situations the same way. This method will be used when two or more prototypes are made to compare them.

Quantitative study

This method is based on measuring variables like speed and temperature. This method will for example be used when measuring the body temperature of a person riding on a motorcycle with a infrared camera.

4 Project limits

The project is scheduled to take one semester, which means it will end in about 20 weeks. After 20 weeks the project should be finished. This a fully functional undergarment has been produced that measures important factors of the microclimate inside a motorcycling garment. The company values a working undergarment that only covers the core more than an under garment that covers the whole body but does not work properly. This means that the scope of the project will be focussed mainly on the core body. However if there is a sufficient amount of time left at the end of the project, it is possible to expand the undergarment to cover the whole body.

Another important aspect of the project is presenting the data. The previous project group acquired the data through Matlab, but since the company does not have a license for Matlab it is not possible to use the scripts. This makes the programming part useless for the company. The programming scope is using a program or creating a program that REV'IT can use. When these two aspects are fulfilled, the project is a complete success.

5 Products

The goal of the project is to produce an undergarment that measures the humidity and temperature inside a motorcycling garment, which REV'IT will be able to use in order to determine how effective the vents of their motorcycling garments are. Prototypes will play a huge part during the project, these prototypes will give an understanding of which requirements the end product needs.

The following milestones are scheduled to measure the progress of the project, to make sure that the deliverables are based on relevant information:

Week 1.5: Tests with an infrared camera will be done to confirm the warmest areas under a motorcycling garment.

Week 1.6: The relevance of sensors will be discussed and the project group will decide the placement based on their gathered information.

Week 1.9: The project group will have a meeting to discuss the first prototype. New requirements will be set to upgrade the first prototype.

Week 2.3: The project group will have a meeting to discuss the second prototype. New requirements will be set to upgrade the second prototype.

The following deliverables are scheduled to measure the project's progress, to make sure that the end goal of a fully functioning garment will be met:

Week 1.7: The first design of the garment will be ready. This design gives a visual idea of the goal product and shows where the sensors need to be placed.

Week 1.8: The first prototype of the garment will be ready. This prototype is the first product of gathered information, which will show how accurate this information is when tested.

Week 2.2: The second prototype of the garment will be ready. This prototype is based on the test results of the first prototype. The gathered test results will give a better understanding of the requirements for the goal product.

Week 2.6: The third prototype will be close to the end product. Last changes will be made in the closing weeks of the project.

6 Quality control

The quality of the end product will be assured by different forms. The first guarantee is that the investigation will be done according to a methodology and in the end a technical report will be presented with substationed decisions.

To control the quality of the end product it is necessary to keep in mind the requirements stated by the client. The company, REV'IT! is aiming the end product to be able to measure temperature, humidity and (if possible) amount of airflow on different locations on the body. The focus is to make an undergarment that covers the upper body and that the undergarment can be used in every driving position (from sportive to upright). It should also be able to be used autonomously on a riding motorcycle and communicate the test results in an understandable and presentable way afterwards. Another important requirements are that the undergarment influences the microclimate around the users' body as minimal as possible and that it is aesthetically pleasing and does not obstruct the user in any way.

For the intermediate deliverables it should be clear what the relevance is of these products. The technical report and other additional reports should be according to APA standards.

Checks that will be done to guarantee quality include a quality report of the fabric, testing the effect and operation of the sensors, fitting of the undergarment on a model and meeting with REV'IT! to see if the company is convenient with where the project is going.

7 Project Organisation

7.1 Team members

The project team consists of 5 members from different backgrounds

Name	Student Number	Email	Phone Number	Study Program	Role
Remco Horstink	457958	horstinkhjc@gmail.com	+31 621979443	Applied Physics	Secretary
Lonneke Minkhorst	438228	lminkhorst1@gmail.com	+31 630142187	Fashion and Textile Technologies	Chairman
Robin Sikkema	425822	r.sikkema@hotmail.com	+31 40807440	Media, Information and Communication	
Milko van Valen	47888	mvanvalen@gmail.com	+31 636375428	Electrical Engineering	
Demi Westveer	434703	demiwestveer@gmail.com	+31 642051101	Fashion and Textile Technologies	

7.2 Roles and Availability

For this project the members are divided in the following roles:

Chairman:	Lonneke Minkhorst
Secretary:	Remco Horstink
Quality Manager:	_____
Textile Engineer:	Lonneke Minkhorst
	Demi Westveer
Designer :	Robin Sikkema
Electrical Engineer:	Milko van Valen
Physics Engineer:	Remco Horstink
Communication:	Robin Sikkema

The team members are expected to to be available for work 4 days or 32 hours each week. To fill these hours rooms are available at Saxion to work from 8:30 to 17:00, but in in consultation with the group members can work at home to finish their tasks.

7.3 Tasks and communication

The available tasks for each part of the project are recorded in the web based application “Trello”. Here everyone can see what the current tasks are, if they are already assigned or not and if they are being worked on, ready for review, or done. Which tasks there are depend on where in the project the focus is at the moment. This is decided during the meeting of the team. The tasks can be created during these meetings or on the fly when needed.

For communication the project team has started a “Whatsapp Group” to keep all the members updated on their current progress and the make fast decisions. Every week we have a meeting with our Saxion coach, this meeting is planned each Tuesday at 10:00. The rest of the week the aim is to work together at a location provided by Saxion.

Communication with the company coach and Saxion coach will be handled by Robin Sikkema. Every two weeks Robin will update the company and Saxion with the current progress and ask any question the have come up.

7.4 Saxion and Company Coach

From saxion a tutor has been assigned to guide us through the project:

Cees van Keulen - Docent Werktuigbouwkunde Saxion Hogeschool Enschede

c.vankeulen@saxion.nl

+31 6 15141808

From Rev'It there are two contacts for this project, with our main contact being:

Luca Pulskens - Design Engineer

lpulskens@revit.eu

+31 412 696 739

The secondary contact is:

Ruud van Berlo - HR manager

rvanberlo@revit.eu

+31 412 696 730

8 Schedule

One is able to see the project planning in the appendix. The most important deadlines are:

Week 4	Hand-in research plan
Week 6	Individual portfolio 1
Week 8	SSS festival preparations
Week 10	Individual portfolio 2
Week 15	Individual portfolio 3
Week 17	Final report
Week 18	SSS festival
Week 19	Final individual portfolio

9 Costs and benefits

The costs for the project can be declared at the company REV'IT, after conciliation with the contact person, Luca Pulskens (see chapter 7). There exists no specified limit for the costs.

The benefits of this "income" is that fabrics and electronics can be bought to test the designed setups. This way one can choose the best combinations in order to create the best product. This reduces the chance on uncalculated errors, and causes the final product of the project to be useful for the client.

Since there has not been done much research on the costs of the necessary items, it is hard to specify the exact costs of the project. The estimated costs are around €200,-. However, this might differ significantly from the final costs.

10 Risk analysis

The full risk analysis can be found in appendix A.

The following conclusions are taken from the risk analysis.

The risk of failure for this project is 37% according to the risk analysis. The following internal and external risks have the biggest impact on the feasibility of this project:

Internal Risks

The biggest risk during this project is the complexity of the subject. All the members of the team have participated in projects before, but not with such a variety of members from different technical backgrounds. Another risk is the Project leadership not being experienced with leading a project. The leadership has a lot to learn, and fast, but this should not be a big issue if addressed early on in the project.

To solve the issue with the complexity of the subject, the team members have to be assigned to tasks within their region of expertise. If each individual can solve a small part of the problem the complexity will be greatly reduced. To accomplish this, all the tasks for the project need to be clearly defined.

The leadership issue should be a personal goal to overcome. Part of the project for this leadership is how to act as a leader and guide the team to success.

External Risks

The company/customer gave us a lot of freedom for the project, so it is up to the project team to clearly define the scope of the project, which is done in chapter 2, 3, 4, and 5 of this project.

A project is not viable if the risk percentage is above 50%, so this project should be able to come to a complete finish if the bigger issues are fixed in the beginning of the project.

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Appendix

Risk analysis

	Risicoanalyse	Print			
	SSS 131	30-9-2018			
Bij een risicopercentage > 50% dient het project niet in deze vorm te worden uitgevoerd.					
Categorie	Risico	Waarde *	Factor **	Zwaarte **	Risicotot.
Tijdsfactor		↓maak keuze↓			
1	Geschatte looptijd van het project	3 - 6 maanden	1	4	4
2	Kent het project een definitieve deadline?	Ja	2	4	8
3	Is de tijd voldoende om het project te realiseren?	Voldoende	1	4	4
Complexiteit van het project		↓maak keuze↓			
4	Aantal functionele deelgebieden dat betrokken is	3+	3	4	12
5	Aantal functionele deelgebieden dat gebruik gaat maken van de resultaten	1	0	2	0
6	Gaat het om een aanpassing of een nieuw project?	Grote aanpassingen	2	5	10
7	In hoeverre zullen bestaande verantwoordelijkheden moeten wijzigen?	Gemiddeld	2	5	10
8	Zijn er andere projecten afhankelijk van dit project?	Nee	0	5	0
9	Wat zal de houding zijn van de gebruikers?	Geïnteresseerd	1	5	5
10	Zijn er deelprojecten, is de voortgang afhankelijk van de coordinatie hiertussen?	Sterk	3	3	9
De projectgroep		↓maak keuze↓			
11	Welke medewerkers werken aan het project mee?	Voorn. interne	0	4	0
12	Wat is het geografische spreiding van de projecten?	1	0	2	0
13	Aantal projectleden dat op piektijden > 80% betrokken is	1-5	0	5	0
14	Verhouding materiedeskundigen tov projectdeskundigen	Redelijk	2	5	10
15	Nemen gebruikers deel aan de projectgroep?	In beperkte mate	3	3	9
De projectleiding		↓maak keuze↓			
16	Is de projectleiding materiedeskundig?	Redelijk deskundig	2	3	6
17	Hoe deskundig is de projectleiding mbt de projectplanning?	Redelijk deskundig	2	3	6
18	Hoeveel ervaring heeft de projectleider met projecten als deze?	Weinig ervaring	3	3	9
19	Hoe deskundig zijn de adviseurs op het te onderzoeken gebied?	Redelijk deskundig	1	5	5
20	Hoe deskundig zijn de materiedeskundigen op het te onderzoeken gebied?	Zeer deskundig	0	5	0
21	Hoe betrokken zijn de verantwoordelijke lijnmanagers bij het project?	Redelijk betrokken	2	5	10
22	Is de kans groot dat de samenstelling van de projectgroep wijzigt tijdens het project?	Kleine kans	0	5	0
23	Worden door de projectgroep standaardmethoden gebruikt?	Ja, een aantal	2	4	8

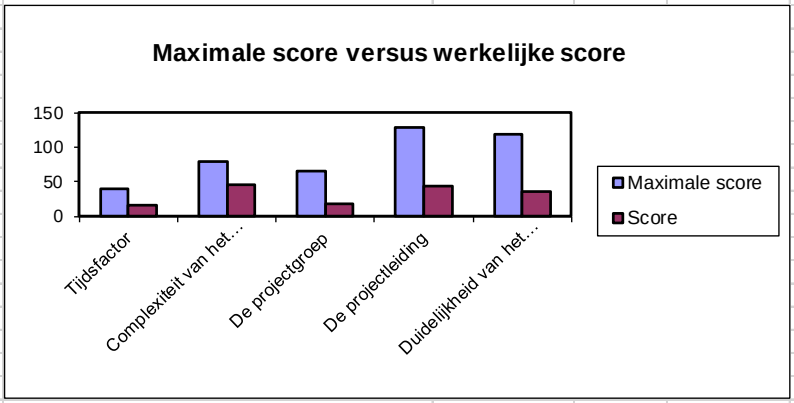
Vervolg risicoanalyse

Categorie	Risico	Waarde *	Factor **	Zwaarte **	Risicotot.
Duidelijkheid van het project		↓maak keuze↓			
24	Zijn probleem en doelstelling voldoende bekend bij alle projectleden?	De meeste wel	1	5	5
25	Is het onderzoeksgebied nauwkeurig vastgelegd?	Redelijk	2	5	10
26	Is er voldoende afbakening met andere projecten?	Redelijk	1	4	4
27	Is er voldoende tijd gepland voor afstemming en besluitvorming?	Redelijk	1	4	4
28	Zijn de randvoorwaarden duidelijk?	De meeste wel	1	4	4
29	Werken de randvoorwaarden beperkend genoeg?	Redelijk	2	5	10
			Totaal		**162**
			Risicopercentage ***		**37,41%**

** Waarde gekozen door projectleider.*
*** Hoogte factor en waarde staan vast.*
**** Risicopercentage is de totaalscore gedeeld door 433 (maximale score) maal 100.*

Aangezien het risicopercentage een totaalbeeld geeft, kan het zijn dat een bepaalde categorie wel voor een hoog risico zorgt. Hieronder een specificatie per categorie om eventuele verbeterpunten zichtbaar te maken.

Categorie (met maximale score versus werkelijke score)				
Tijdsfactor	Maximaal	40	Score	16
Complexiteit van het project	Maximaal	80	Score	46
De projectgroep	Maximaal	65	Score	19
De projectleiding	Maximaal	129	Score	44
Duidelijkheid van het project	Maximaal	119	Score	37



Conclusie:

The full risk analyses can be found in appendix A.
The following conclusions are taken from the risk analysis.

The risk of failure for this project is 37% according to the risk analysis.

Internal Risks

The biggest risk during this project is the complexity of the subject. All the members of the team have participated in projects before, but not with such a variety of members from different technical backgrounds. Another risk is the Project leadership not being experienced with leading a project. The leadership has a lot to learn, and fast, but this should not be a big issue if addressed early on in the project.

External Risks

The company/customer gave us a lot of freedom for the project, so it is up to the project team to clearly define the scope of the project, which is done in chapter 2, 3, 4, and 5 of this project.

A project is not viable if the risk percentage is above 50%, so this project should be able to come to a complete finish if the bigger issues are fixed in the beginning of the project.

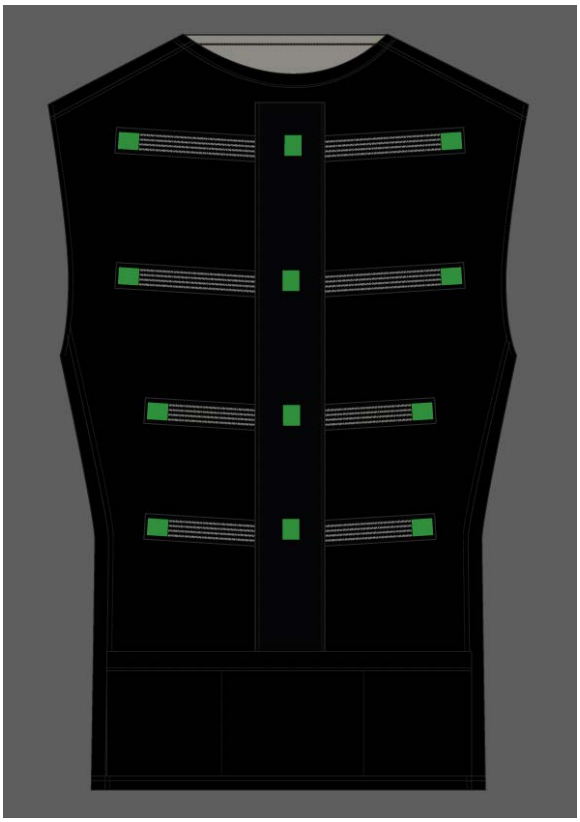
Schedule

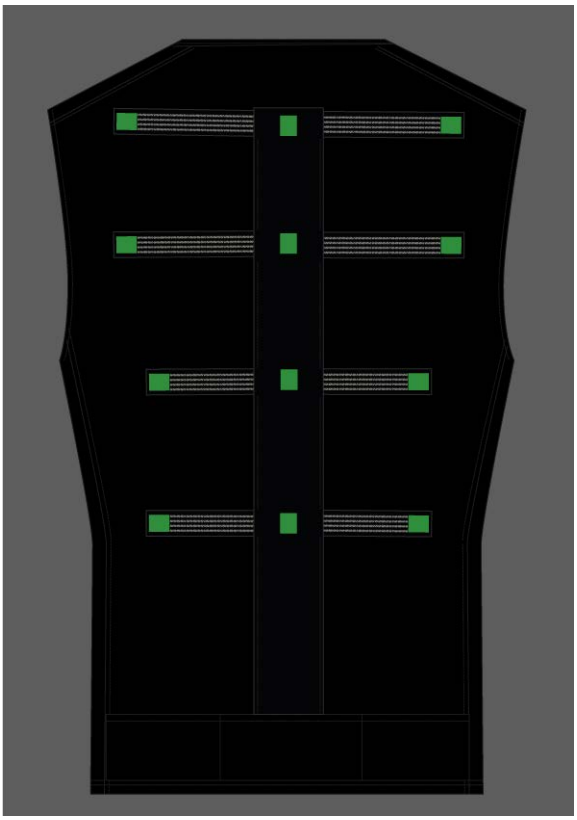
PROJECT PLANNING

Week	Remco	Milko	Robin	Lonneke	Demi	Allemaal	Afspaken	Facilities	Deadlines
1						Getting to know eachother	Meeting with tutor		
2						Dive into project brief and V model	Meeting with tutor, Meeting with Hilde		
3						Dive into project brief, prepare research plan	Company visit		
4						Finalize research plan, System requirements (V)	Meeting with tutor		Research plan
5	Programming language	Sensor requirements	Sensor placement locations	Non-influence fabrics	Non-influence fabrics	System requirements	Meeting with tutor	Textile lab, Fablab, Knitting lab, hardware lab, Atelier	
6	Important factors for a stable microclimate	Finding sensors	Sensor placement locations	Non-influence fabrics	Non-influence fabrics	Functional design (V)	Meeting with tutor	Textile lab, Fablab, Knitting lab, hardware lab, Atelier	Individual portfolio 1
7	Important factors for a stable microclimate	Testing sensors	Product design	Fabric selection	Fabric selection	Functional design (V)	Meeting with tutor, Company visit	Textile lab, Fablab, Knitting lab, hardware lab, Atelier	
8	Reading data from the sensors	Sensor circuit design	Product design	Sensor attachment on fabric	Sensor attachment on fabric	Technical design (V)	Meeting with tutor	Textile lab, Fablab, Knitting lab, hardware lab, Atelier	SSS Festival preparations
9	Reading data from the sensors	Shirt circuit design/wiring diagram	Creating shotlist for Behind-The-Scenes	Sensor attachment on fabric	Sensor attachment on fabric	Technical design (V)	Meeting with tutor	Textile lab, Fablab, Knitting lab, hardware lab, Atelier	
10	Reading data from the sensors	Reading data from the sensors	Creating shotlist for Behind-The-Scenes	Conductivity opportunities	Conductivity opportunities	Testing/prototyping/ documentation	Meeting with tutor	Textile lab, Fablab, Knitting lab, hardware lab, Atelier	Individual portfolio 2
11	Testing sensor/cable combinations	Testing sensor/cable combinations	Filming company visit	Conductivity opportunities	Conductivity opportunities	Testing/prototyping/ documentation	Meeting with tutor, Company visit	Textile lab, Fablab, Knitting lab, hardware lab, Atelier	
12	Testing sensor/cable combinations	Testing sensor/cable combinations	Finalizing product design	Prototyping	Prototyping	Testing/prototyping/ documentation	Meeting with tutor	Textile lab, Fablab, Knitting lab, hardware lab, Atelier	
13	Calibration of the sensors	Calibration of the sensors	Filming the production of the prototype	Prototyping	Prototyping	Testing/prototyping/ documentation	Meeting with tutor	Textile lab, Fablab, Knitting lab, hardware lab, Atelier	
14	Data software	Data software	Filming the production of the end product, infographic	Creating the end product	Creating the end product	Documentation	Meeting with tutor	Textile lab, Fablab, Knitting lab, hardware lab, Atelier	
15	Data presentation	Data presentation	Data presentation, filming the company visit, editing film material	Creating the end product	Creating the end product	Documentation	Meeting with tutor, Company visit	Textile lab, Fablab, Knitting lab, hardware lab, Atelier	Individual portfolio 3
16	Testing	Testing	Presentation preparations, editing film material	Testing	Testing	Documentation	Meeting with tutor	Textile lab, Fablab, Knitting lab, hardware lab, Atelier	
17	Finalizing	Finalizing	Presentation preparations, editing film material	Finalizing	Finalizing	Final report	Meeting with tutor	Textile lab, Fablab, Knitting lab, hardware lab, Atelier	Final report??
18							Meeting with tutor		SSS Festival
19							Meeting with tutor		portfolio

Design

Here one is able to see the design of the t-shirt. Demi design the t-shirt and I helped her with ideas and gave her input sometimes. The placement of the sensors is based on a test that is performed. One can read more about this here: Test fabric In this test we used a heatmap to see where most of the heat emitted from the body. The result was that the upper part of the torso emits most of the heat, so that was an important area to measure the air humidity and the temperature.





My role as the chairman

Vergadering Project REV'IT!

{03-10-2018} Lokaal Z1.15
Aanwezig:
Afwezig:

Agenda

1. Opening: 10.30
2. Notulen vorige vergadering (zie volgende pagina)
3. Vaststellen agenda
4. Mededelingen
5. Punten:
   - Research plan is ingeleverd, wat is de volgende stap voor iedereen?
   - Er is gekozen voor rapid prototyping, belangrijk dat iedereen het template gebruikt.
   - Individual portfolio deel 1, deadline is volgende week. Wat is iedereen van plan er in te doen?
   - Contact REV'IT! Research plan sturen?
   - Testen verschillende t-shirts op een loopband? Locatie zoeken
   - Geen stof gebruiken
   - Onderzoek naar plek van sensors op het lichaam
6. WVTTK
7. Rondvraag

Notulen 25-09

Begintijd: 10.00
Eindtijd: 10.38
Aanwezigen: Cees, Lonneke, Robin, Demi, Milko, Remco.

Hoe staat het met het project plan? (Vrijdag deadline)

- Milko alles af, maar nog gecheckt worden
- Remco alles af, maar moet nog gecheckt worden
- Demi af, maar interview nog uittypen
- Robin nog wat milestones toevoegen en dan af
- Lonneke nog project activities afmaken

Onze gestelde deadline: Donderdag.

Eindproduct; hoe groot moet het onderzoeksverslag zijn?

- Hoeft niet per se onderzoeksverslag te zijn, maar Saxion verwacht dit wel. Bedrijven vinden dit niet fijn. Er is nog discussie hoe dit aangepakt gaan worden.
- Eventueel Technisch Rapport (**max 20 pagina's**) ipv volledig onderzoeksverslag. Niet per se V-model.
- Proces moet goed onderbouwd zijn.

Is een hoofdvraag (en sub-vragen) noodzakelijk?

- Hoofd en deelvragen niet noodzakelijk.
- Klantvragen wel nuttig: wat wil de klant precies?
- Hoeft niet per se als een vraag, maar wel puntsgewijs.

Methode Rapid Prototype: ipv V-model, is methode om snel prototypes op te bouwen.

Hoe gaan we elkaar op de hoogte houden? ➔ Trello.

Portfolio

- In portfolio moet je bijdrage aan het project te zien zijn.
- Voor projectplan bijvoorbeeld: Gewoon projectplan inleveren met taakbeschrijving.
- Kijk maar hoe je het vormgeeft. Hierna feedback. Niemand weet hoe portfolio er precies uit moet zien.
- Assessment van Cees voor de eindbeoordeling.
- Eindbeoordeling 2e tentamenweek?

Nieuwe taak Robin

Robin maakt video van het proces van het project voor festival en verslag.

Wel kijken met de IR camera. Deze moet verkregen worden bij het bedrijf óf bij LED.

Agenda vergadering morgen 13-11

Lonneke Minkhorst
ma 12-11-2018, 17:21
Remco Horstink; Milko van Valen; Demi Westveer; Cees van Keulen

Allen beantwoorden

Vergadering Project Rev...
17 kB

Downloaden Opslaan in OneDrive - Saxion.nl

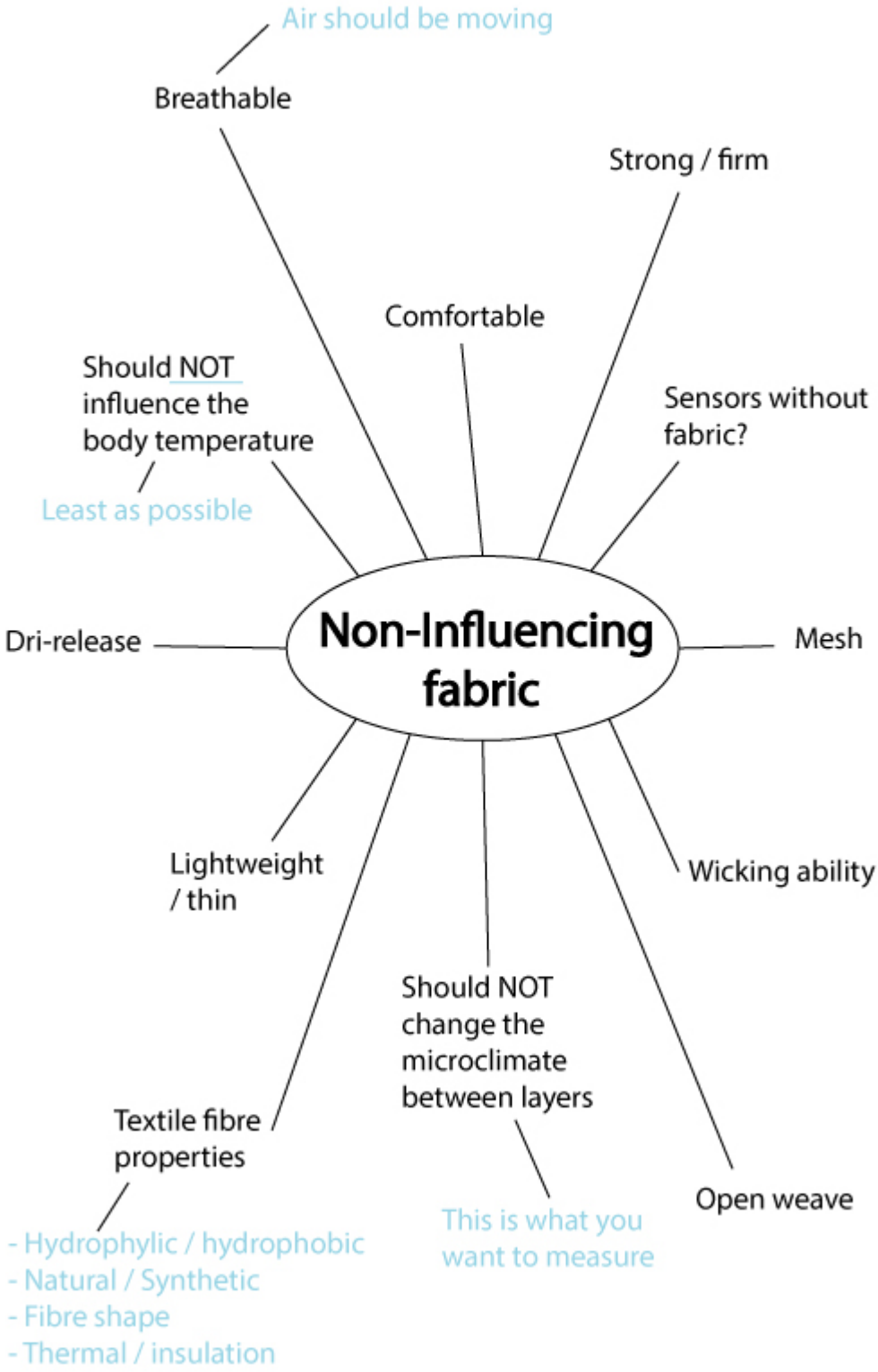
Hallo allemaal,

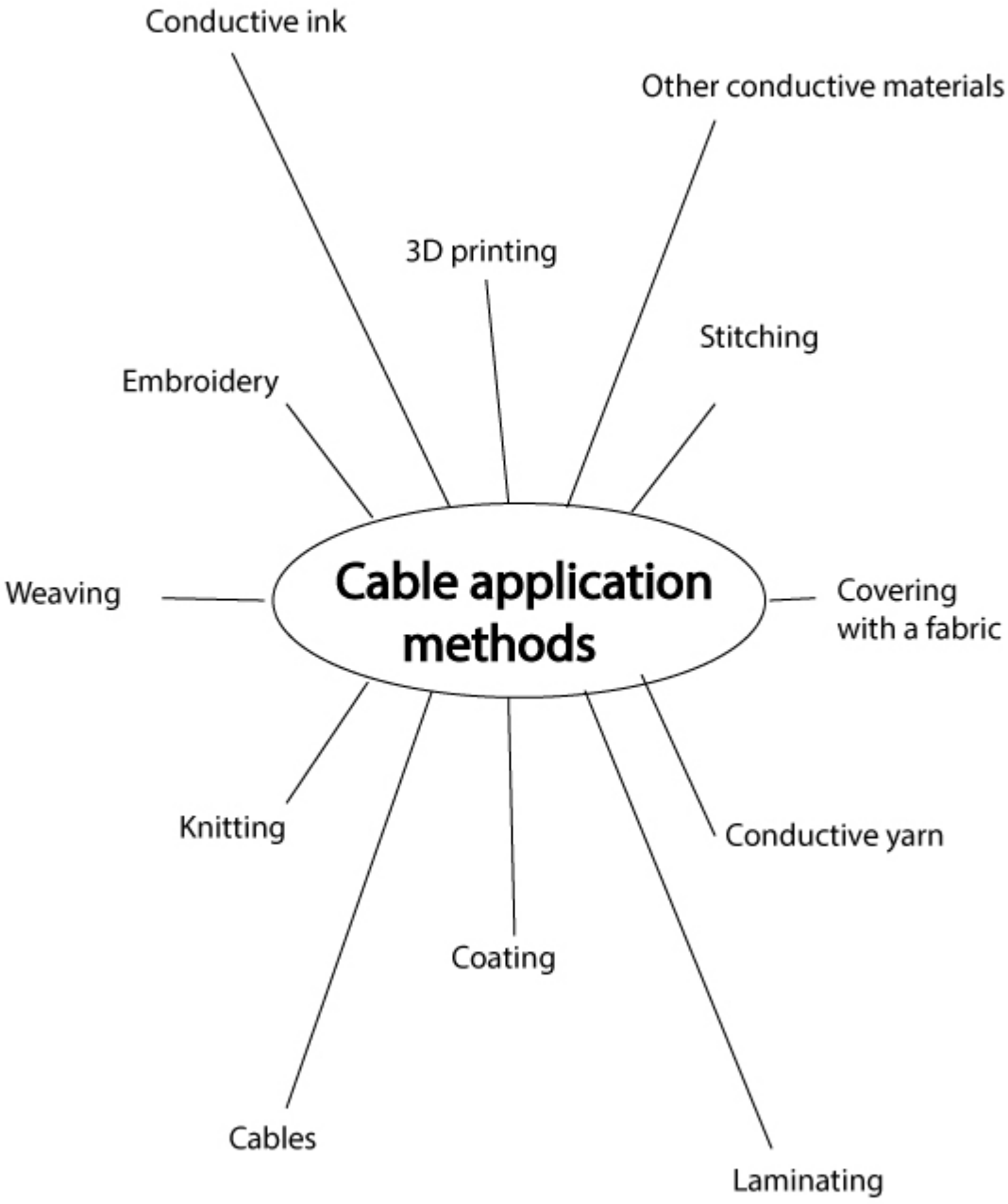
Hierbij de agenda van de vergadering van morgen om 10.00 uur en de notulen van de vorige keer.

Tot morgen,

Lonneke

Research and brainstorming




Conductive ink
Other conductive materials
3D printing
Stitching
Embroidery
Weaving
Cable application methods
Covering with a fabric
Knitting
Conductive yarn
Coating
Cables
Laminating

Research Lonneke & Demi

1. Fabric Research

1.1. Textile fiber properties

1.1.1. Hydrophilic / Hydrophobic

Moisture regain is an important fiber property that determines whether a fiber is classified as hydrophilic (water-loving) or hydrophobic (water-hating). This property is largely dependent on the chemical nature of the fiber, or in other words, the polymer of which it is made. Moisture regain of a fiber has a large influence on the comfort properties of that fiber. In general, hydrophilic fibers are more comfortable to wear (North Carolina State University, 2008).

1.1.2. Fiber shape

Fibers have various shapes and configurations. Most fibers have a round cross-sectional shape, but there are also triangular and multilobal fibers. Some fibers have smooth edges and others are serrated. Fibers can sometimes, but not always, be identified by their shape and appearance under a microscope. Most synthetic fibers are difficult to positively identify under a microscope based on their shape alone because most are round. Other optical techniques such as measurement of birefringence must be used. The shape of a fiber can affect the luster, appearance, and stiffness of the end-use fabric (North Carolina State University, 2008).

Textile fibers can be classified as coarse, fine and microfibers. Apparel fabrics are usually made from fine fibers and microfibers. Finer fibers make softer, denser, and more comfortable fabrics, with better drape (Eberle, et al., 2013).

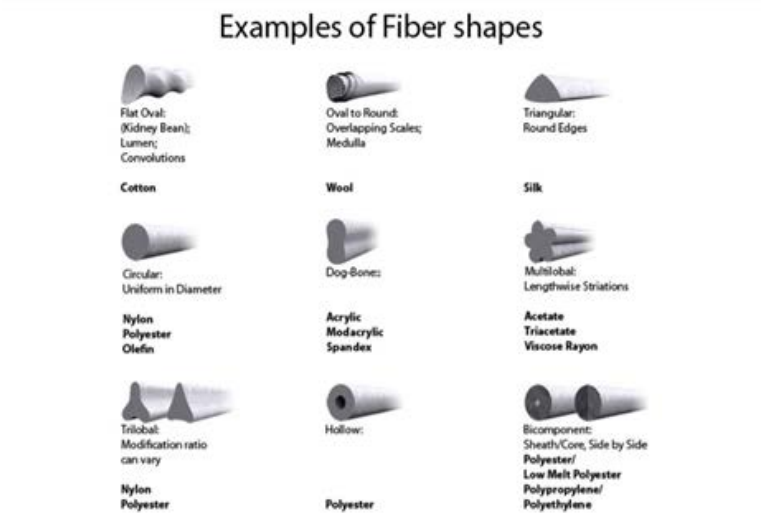


Figure 3 Various fiber shapes (North Carolina State University, 2008).

1.1.3. Thermal / Insulation

Insulation properties depend on whether the fiber is produced as flat filament, textured filament, or staple yarn. Flat filaments entrap very little air and have low insulation. Texturing increases the specific volume and allows more air to be enclosed for better insulation. Staple yarns may be either fine and smooth or more voluminous (Eberle, et al., 2013).

1.2. Textile characteristics

1.2.1. Breathable

The breathability is an important characteristic for the product, because the fabric should allow the skin to breath. The fabric should not be completely closed. Breathability is relevant for the product purpose, because the product should not influence the test results, so heat should not be retained by the fabric.

To maintain an equable balance of heat and moisture in the microclimate, between skin and clothing, some ventilation is required. Air exchange is regulated mainly by three factors. Firstly it depends on the surface texture, mediated by fiber type, yarn and fabric construction, and finishing. Secondly it depends on the garment construction. Tight-fitting garments will restrict more ventilation and may lead to discomfort due to a build-up of heat and moisture. Loose garments can promote ventilation like a chimney. The third influence is motion which can be provided externally by wind or by transportation, or internally by pumping action of body movements such as working and running. Motion disturbs one or more of the various air layers and thus reduces heat insulation considerably (Eberle, et al., 2013).

1.2.2. Comfortable

The fabric should be comfortable for the user in terms of not distracting the driver or changing the motor riding experience. The driver should notice the fabric as least as possible.

Comfort is a perception of well-being in which the human body is in psychological, physiological and physical harmony with the environment where it is situated. Clothing is an integrated part of this. The physiological and psychological conditions include a number of issues such as:

1. Thermo-physiological comfort: achieving a comfortable thermal and humid condition in which the thermo-regulating capacity, the thermal insulation and the moisture-regulating capacity of the garment are considered as a function of environmental conditions (climate) and the working conditions (level of effort). Thermo-physiological comfort is strongly affected by the fabric, the style and the fit.
2. Skin sensorial comfort: the induction of various nerve impulses when the textile is in contact with the skin in which the softness, mobility, skin tolerance and adhesion effects are considered. Sensorial comfort is strongly affected by the fabric, the fit and the assembly technique.
3. Ability to move, which is mainly affected by the fit and ease allowance.
4. Aesthetics: the subjective perception of a garment that contributes to the overall sense of well- being which is in relation with the design, the fit and the overall quality of the garment.

Scientists agree however that the thermo-regulating and moisture regulating properties of a garment are the main factors in comfort as it is of vital importance that the heat generation and heat loss of man is in balance over a long term (heat generation=heat loss) (Alexandra De Raeve, 2018).

Knitting is defined as forming a fabric by means of interloping the yarn. Knitting machines do the same interloping of yarn that a hand knitter does. Knit fabrics have stretch because of the looseness of the fabric's yarn structure (compared to knits and most nonwovens) (Know Your Fibers: Wovens vs. Nonwovens and Knit Fabrics, 2017). This stretch is one of the most important factors for comfort. since the fabric adjusts to the body. This is why a knitted fabric would be a good option for the end product for REV'IT.

1.2.3. Strong & firm

It is important for the fabric to be strong and firm enough to keep the sensors and the cables on the right place. The fabric should not hang.

1.2.4. Wicking

Wicking is transporting moisture from the body to the outside of the fabric so it can be evaporated there. This is critical because moisture that is staying on the skin or in the fabric will influence the body temperature therefore the test results.

1.2. Opportunities

Keeping cool

Thin garments generally incorporate fewer insulative air spaces. They also tend to allow air and water vapor to pass more easily through the fabric structure. Thin fabrics are particularly important for evaporative cooling (Watkins & Dunne, 2015).

2. Cable Application Research

2.1. Cable opportunities

An important part of any electronic circuit is the conductor or conductive material that forms connections between electronic components. The electrical connection between the components can be one of the most significant influences on both the comfort of the garment and the durability of the system.The ability to conduct electricity using a textile is usually achieved by weaving, knitting, laminating, printing or stitching conductive materials into or onto the textile structure (Watkins & Dunne, 2015).

2.1.1. Cables

One of the possibilities to connect the sensors and transfer the data is to use regular cables or wires. Wire can be made of a single piece of metal (called solid core) or a lot of smaller pieces of metal twisted together (called stranded). Stranded is easier to bend, but you need to solder the end of it in order to get it to fit in a breadboard. Wire usually comes with some kind of coating that doesn't conduct electricity (Nussey, 2013).

2.1.2. Conductive yarns

Conductive yarns is also a possibility to connect the sensors. Conductive yarns are created out of conductive filaments, from metal or carbon. Often conductive yarns are very brittle and not strong enough for a lot of applications. To make the conductive yarns stronger they can be blended with non conducting fibers. Non conducting yarns can also be coated with a conductive coating.

One of the challenges regarding conductive yarns is that integrated conductors need to be electrically isolated from each other. This in order to prevent short circuits or unintended pathways. Also the conductive pathway should be insulated from the outside so that the circuit is not affected by external moisture (Watkins & Dunne, 2015).

2.1.3. Conductive Ink

Conductive pathways can be added to a textile by printing or surface treatment. Most conductive inks, paints and adhesives are made by mixing conductive particles into a binder or base liquid. These materials are hard to work with, because there needs to be enough conductive material to bring the particles close enough to each other for energy to flow (Watkins & Dunne, 2015).

2.1.4. Other conductive materials

Electrically conducting strips could also be a opportunity. the 2-mm-wide strips contain the metal bond pads and interconnect to link components and are woven into the textile in the weft direction in place of standard yarns. Another approach is to print conducting lines onto insulating plastic strips (Mecnika, Scheulen, Anderson, Hörr, & Breckenfelder, 2015).

2.2. Cable application methods

The conductive pathway and the PCB need a stable and durable electrical connection. The connection between the board and the conductive thread is a weak point in the circuit and must be reinforced in order to withstand the forces of everyday wear (Watkins & Dunne, 2015).

Stitching

The integration method followed in the present work was done by stitching the two conductive yarns onto the surface of woven fabric. In general, it can be concluded that there is no clear difference between the conductivity of the samples made by using the two types of yarns for different stitches except in stitch No. 4 (the chain stitch) the nano particle yarn sample showed higher values of conductivity than core/sheath yarn sample. Some typical conclusions can be drawn as follows: The highest value of dc conductivity was obtained for herring bone stitch using core / sheath yarn (about 40 times the chain stitch), while the values of open chain and fly stitches were nearly the same. The range of dc conductivity was 0,007 *10-2 (chain stitch) to 0,307 * 10-1 (herring bone stitch). The same result as above is obtained using copper nano particle yarn but with a different range 2, 3*10-5 s/cm (chain stitch) to 0, 32*10-1 s/cm (herring bone stitch). There is no difference between conductivity of core / sheath yarn using fly stitch, open chain stitch and herring bone stitch. However, significant difference between conductivity of the two yarns is found upon using chain stitch. (R. F. El-Newashy, 2012)

Coating

Another important aspect is using coated conductive fibres. Coating can be applied through various techniques. Conductive polyester yarns and filaments of this kind are used in many application areas. Highly conductive fibres can be produced by metallic or galvanic coating, but these methods have some limitations with adhesion and corrosion resistance and suitability of the substrate. Metallic salt coatings have some limitations in conductivity. (Conductive Yarns And Their Use In Technical Textiles, 2018)

Test fabric

1. Measuring the heat emitted by a clothed body

This test was preformed to make a decision about the fabric that will be used for a sensor based undergarment which can measure the microclimate inside a REV'IT motorcycle garment. Three different sport t-shirts were selected based on materials, characteristics and fit. The goal is to find a fabric that influences the body temperature as less as possible.

1.1. Test plan

Title:	Measuring the heat emitted by a clothed body
Date:	16-10-2018
Students:	Demi Westveer and Lonneke Minkhorst

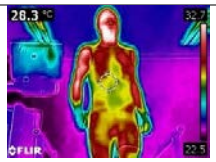
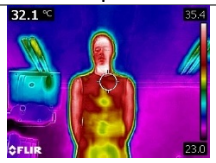
Purpose: The purpose of this test is to measure the different influences of t-shirts on the body temperature while performing physical effort. Also, the result without t-shirt is measured to have an idea how warm the body gets while exercising. This can be used to compare the results of the t-shirt with and to find the warmest areas of the upper body.

Materials needed:

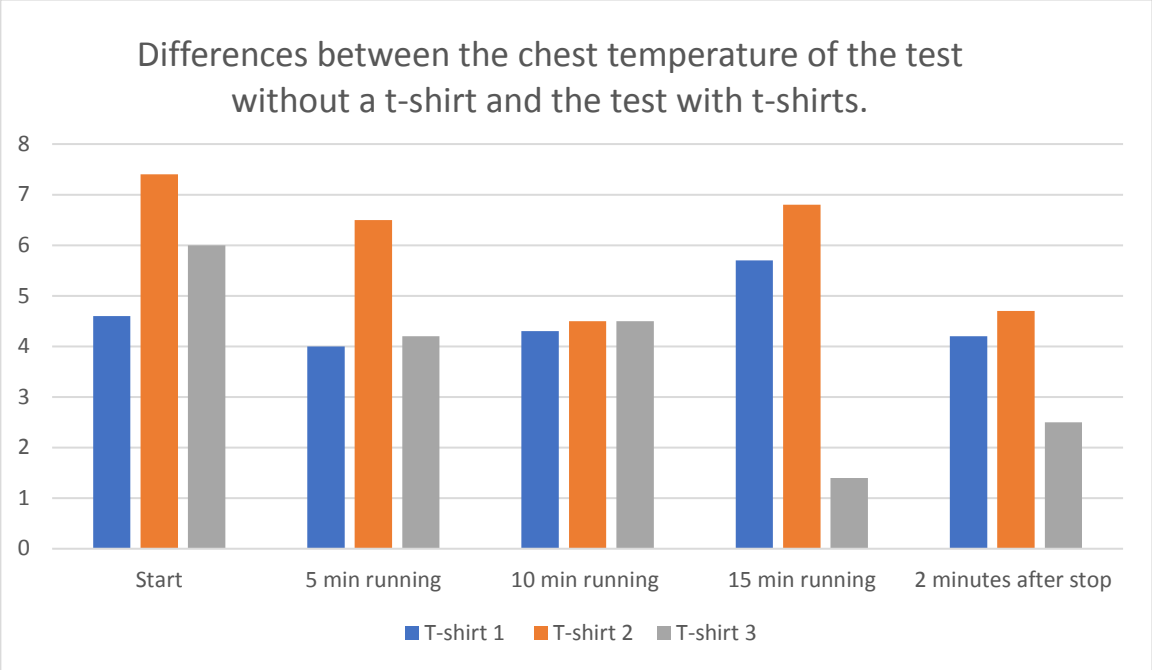
- Treadmill
- Test person
- Infrared camera
- Test shirt 1: 100% polyester, knitted
- Test shirt 2: 95% polyester/5% lycra, knitted (closed) mesh
- Test shirt 3: 84% polyamide/14% elastane/2% polypropylene, knitted (open) mesh

Research method: This test is performed four times. One time without t-shirt and the three other times with different t-shirts. The infrared camera should be set up in front of the tests person and the body until the knees should be visible. A picture should be made before the test starts and after every 5 minutes. Two more pictures should be made 2 minutes after the test with and without t-shirt. The test person runs on a treadmill for fifteen minutes. The person start running for 5 minutes with a speed of 12 km/h, after 5 minutes the speed is increased to 13,5 km/h and after 5 more minutes the speed is increased to 14,5 km/h. The incline should be set to 0.0%. The km/h are based on the personal preferences of the test person.

1.2. Results

Temperature	No shirt	Shirt 1	Shirt 2	Shirt 3
At start	 Chest temp: 35.1 High temp: 35.5 Low temp: 23.0	 Chest temp: 29.2 High temp: 33.7 Low temp: 22.2	 Chest temp: 29.4 High temp: 31.8 Low temp: 17.2	 Chest temp: 29.5 High temp: 32.8 Low temp: 18.5
After 5 min running	 Chest temp: 33.8 High temp: 34.3 Low temp: 22.5	 Chest temp: 29.4 High temp: 33.0 Low temp: 23.0	 Chest temp: 28.2 High temp: 30.9 Low temp: 18.0	 Chest temp: 28.3 High temp: 31.4 Low temp: 18.8
After 10 min running	 Chest temp: 30.8 High temp: 34.4 Low temp: 23.0	 Chest temp: 28.3 High temp: 32.7 Low temp: 22.5	 Chest temp: 29.8 High temp: 32.2 Low temp: 18.7	 Chest temp: 26.1 High temp: 31.9 Low temp: 19.3
After 15 min running	 Chest temp: 33.0 High temp: 35.0 Low temp: 22.3	 Chest temp: 28.2 High temp: 33.7 Low temp: 22.7	 Chest temp: 28.3 High temp: 33.3 Low temp: 18.8	 Chest temp: 31.2 High temp: 33.4 Low temp: 19.7
2 min after stop	 Chest temp: 35.0 High temp: 35.7 Low temp: 23.1	 Chest temp: 32.1 High temp: 35.4 Low temp: 23.0	 Chest temp: 29.7 High temp: 34.1 Low temp: 19.0	 Chest temp: 33.6 High temp: 34.3 Low temp: 19.6
2 min after stop, no shirt		 Chest temp: 34.1 High temp: 35.4 Low temp: 23.3	 Chest temp: 33.6 High temp: 35.0 Low temp: 19.2	 Chest temp: 34.8 High temp: 35.0 Low temp: 19.6

Note that the results of the test are not 100% reliable since it was not possible to perform the test in a room that has the same temperature at any time. Since the four tests are all performed on different days the starting temperature of the room is different every day. Also, the circle in the centre of the pictures that represents the chest temperature is not accurate since the test person is moving during the test and the circle is not always measuring the same spot. However, the results can help to point to the right direction for the research into a fabric which influences the body temperature the least as possible.



In this graph one is able to see the difference between the results of the test without a t-shirt compared to the test with t-shirts. The value stands for the difference with the result of test without a t-shirt. The goal is to have a difference that is as small as possible.

1.3. Conclusion

In the graph one is able to see that t-shirt 1 deviates the least from the test without a t-shirt. However, t-shirt 1 was rather loose in comparison to the second and third t-shirt. This could have had influence on the temperature differences. A looser t-shirt could mean more insulation so it would maintain the body's temperature. Of course, this is fully dependent of the body shape of the person wearing the shirt. The second best t-shirt was t-shirt 3. After 15 minutes of running and 2 minutes after stopping, t-shirt 3 deviates the least from the test without a t-shirt. However, this t-shirt is made out of very open mesh fabric. This would mean that the body heat could easily go out and that the infrared camera could have measured the surface of the body instead of the surface of the fabric.

Click on this image to see an impression of the test:

treadmill test.mp4

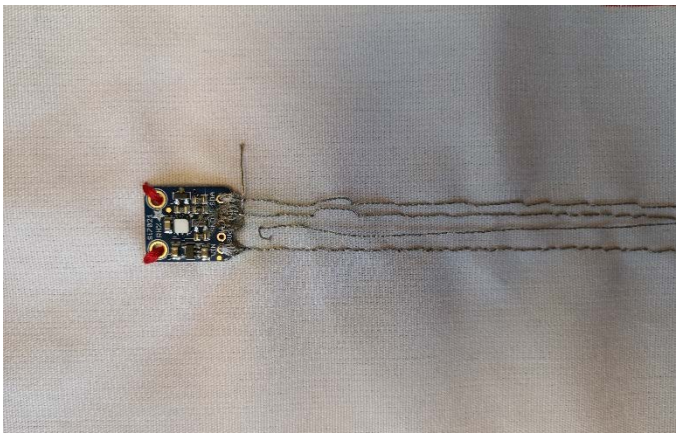
Doel van de test:

Met deze test willen wij verschillende materialen vergelijken en kijken naar de invloed op de lichaamstemperatuur. We gaan dit doen doormiddel van het filmen van een testpersoon die aan het rennen is op een loopband met een infrarood camera.

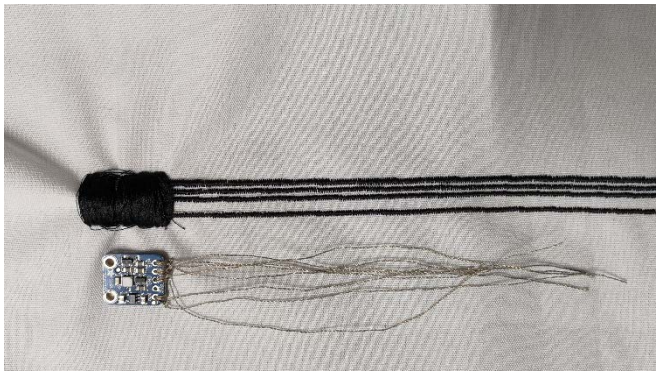
	Materiaal	*Eigenschappen*	*Prijs*
	Hoofdstof: 100% Polyester Inzetstuk: 90% polyester en 10% elastaan	Zweetafvoer, ademend vermogen, zachtheid	€8,99
	95% Polyester 5% Lycra Mesh	Ventilatie/koeling bewegingsvrijheid Vochtafvoer Zachtheid	€23,95 – €32,95
	84% Polyamide, 14% Elastane, 2% Polypropelene Mesh	Lichaamswarmte wordt afgevoerd Ventilatie Aangename pasvorm	€24,95

Process embroidery

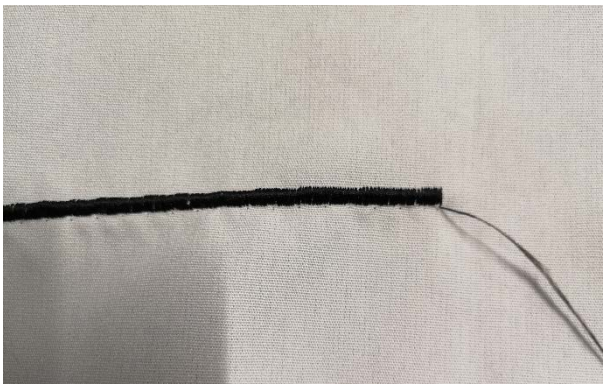
Embroidery samples – attaching the sensors and cables to the t-shirt.



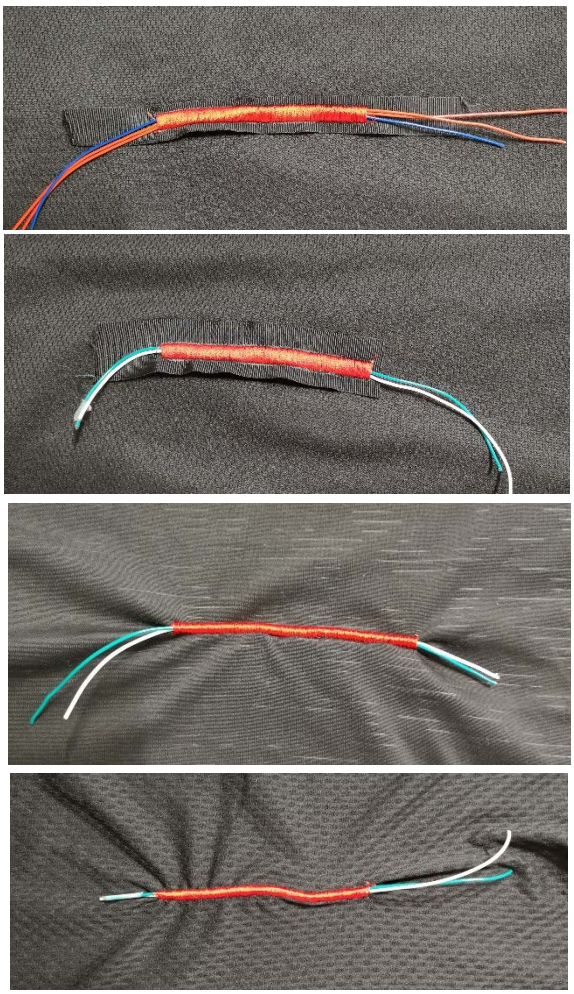
Sensors
This sensor is attached by stitches through the hole in the corner of the sensor. That worked out well. This sample was also used to try to embroider conductive thread through the four little holes on the right side of the sensor. This resulted in two broken needles. Because of this we decided not to connect sensors with conductive threads. We started to use cables.



Sample for a sensor with conductive yarns
The problem with this embroidery is that there are too many yarns used to cover the sensor. There are no problems with the embroidery covering the conductive thread. The sensor next to the embroidery has conductive yarns stitches through the holes, this is done by hand. However, this method was not preferred, because the yarns will not stay straight and on one place.

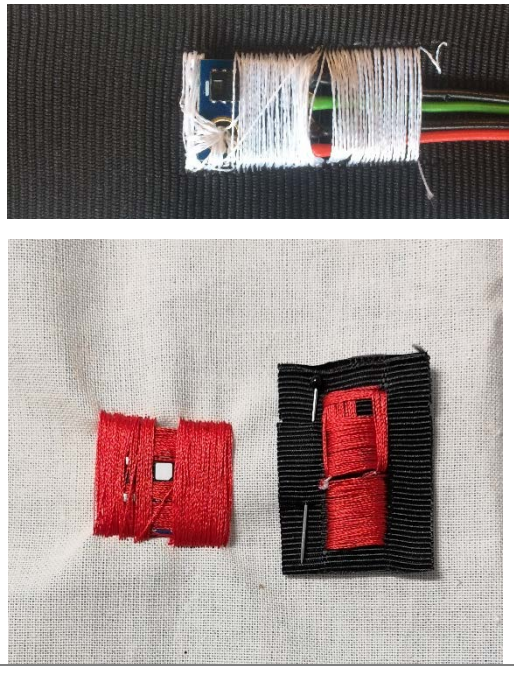


Conductive thread covered with yarns
This conductive thread is laid down by the embroidery machine itself instead of us laying the yarn down. There was a problem with this method. The conductive thread was meant to be in the middle of the embroidery, however it was not. It was not straight and even deviated from the embroidery.



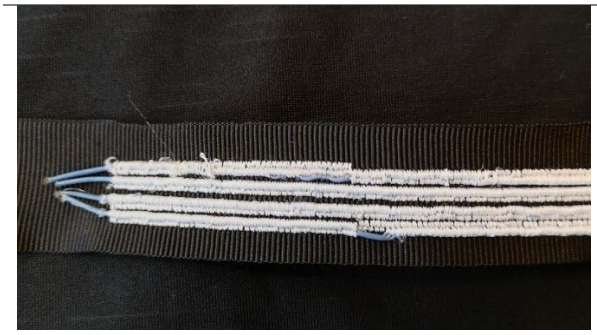
Embroidering the cables to the fabric

After the previous samples, we decided to embroider with cables. The top two samples are embroidered on a woven cord. The down two samples are embroidered on two different sports t-shirts (the ones that were used for the heat emitted by a fabric test). The same embroidery design was used and one is able to see that the yarns on the down to samples are more pulled together than the top two samples. For the down two samples the fabric gets pulled together. This will be an issue when the whole fabric gets embroidered. This will result in a t-shirt where the fabric gets pulled on different spots. With this information we decided to embroider the cables on a tape and this also made the cable construction detachable and the t-shirt washable.



Covering sensors

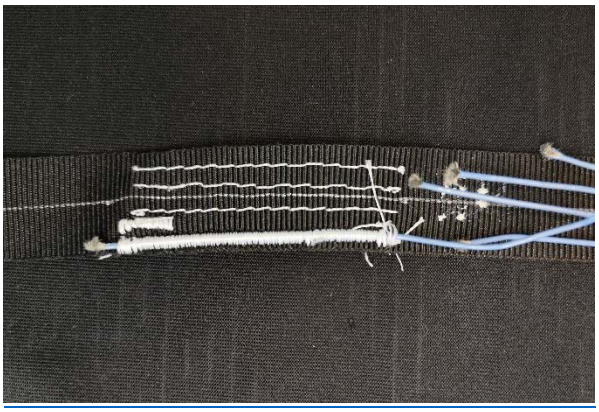
For REV'IT it is important that the final product also looks professional. Therefore we tried to cover the sensor and only the little square (black in the first picture and white in the second picture) should not be covered with yarns. The result so far is not neat and presentable yet for the company. However, during a meeting with REV'IT they told that they preferred the sensors to be visible to give the t-shirt a technical look.

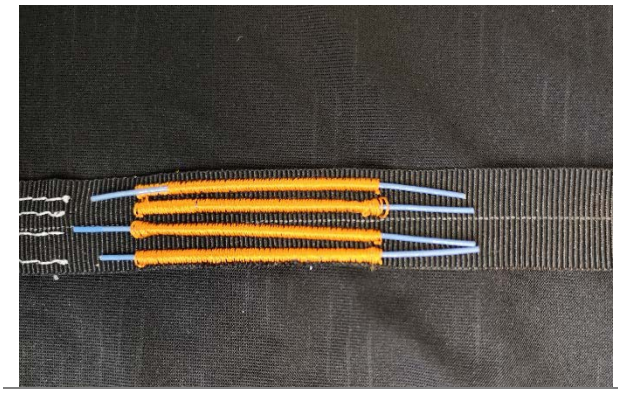


Embroidering with inlay yarn by machine

After a meeting with REV'IT the company let us know that they would like the cables to be embroidered separately in lines. To make this work I started by attaching the cables to the fabric by the embroidery machine itself. The machine lays the cable on the fabric and secures it with transparent elastic yarn. Then the machine embroiders with normal thread over the cables. On the left one can see the result.

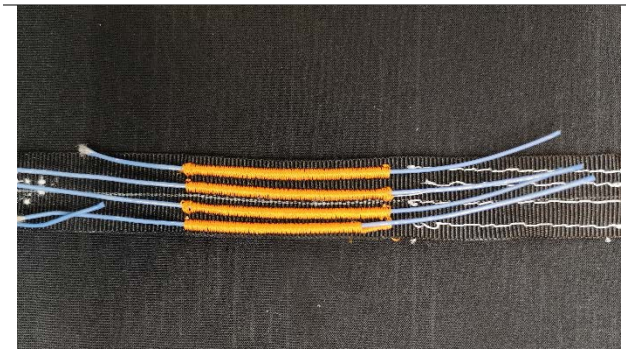
The outcome of this sample was that the embroidered cables made the tape very stiff. The working process of this method was also slow and difficult, since the transparent elastic yarn breaks often. Every time the elastic yarn broke it was necessary to thread it in again and this took a lot of time compared to laying a cable in by hand. This is the reason why we switched to the method of laying a yarn in by hand.

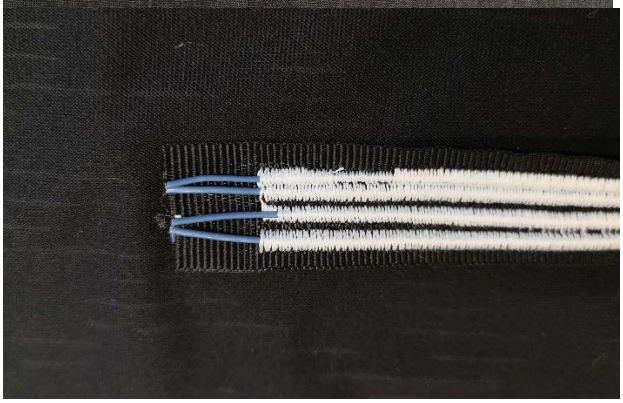


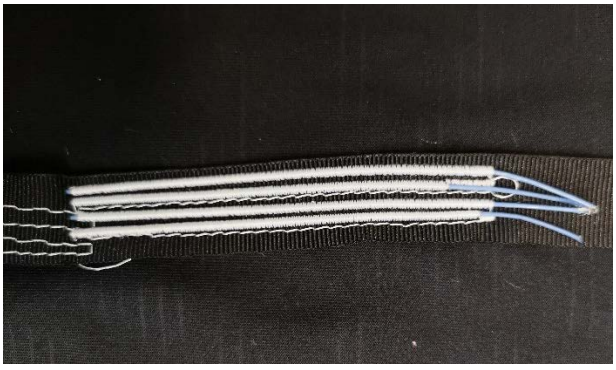


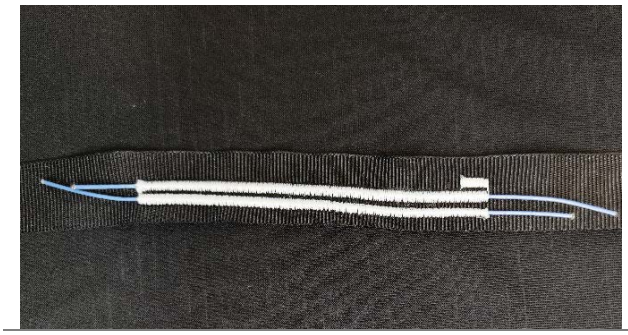
Embroidering with inlay yarn by hand

After the decision was made to use the inlay by hand technique I started with making a lot samples. In the beginning it was difficult to get the tunnels straight on the tape, but after a lot of trying it finally worked out. Here one is able to see the samples.

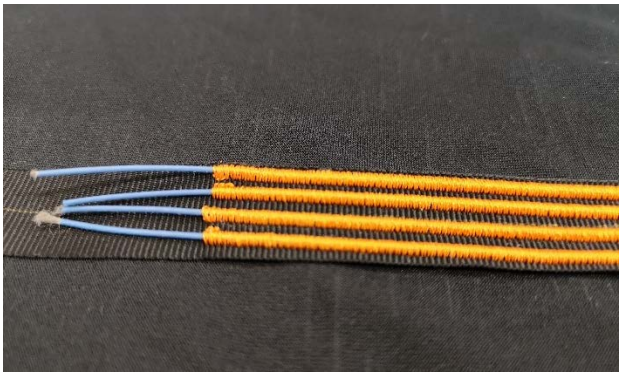




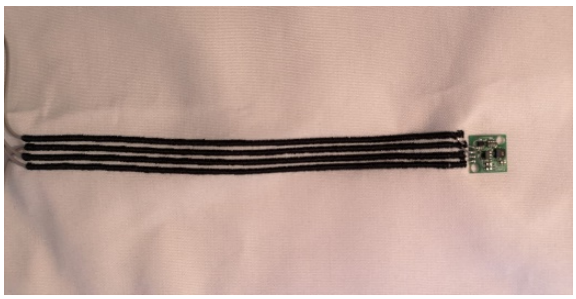




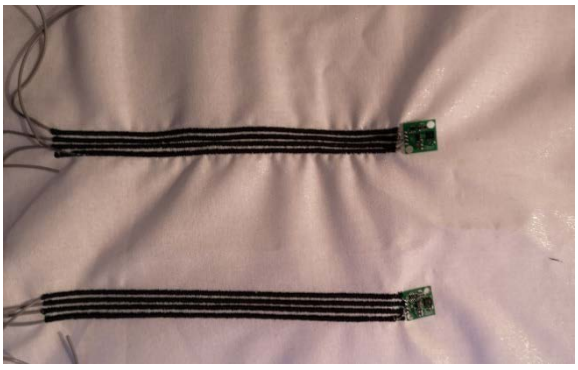
More process

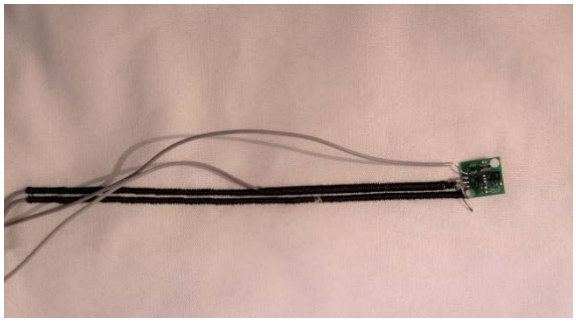


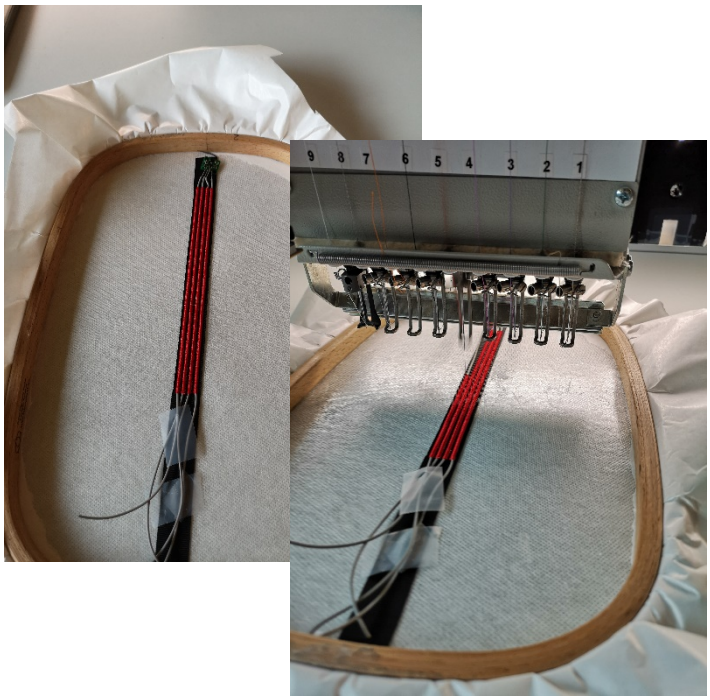
Embroidering with the final sensors
After Milko created the sensors I could start embroidering them. In the beginning I had some struggles with getting the cables straight under the sensor. Paying a lot of attention while the cables were being embroider was really important, because this way I could adjust and shift the cables where necessary.



Placement of the band under the machine
When you look at the red samples below, you can see how the tape was placed under the needles. I first put a interfacing paper in the embroidery frame that had a glue layer on one side. On this layer I would put the tape and then I could embroider.

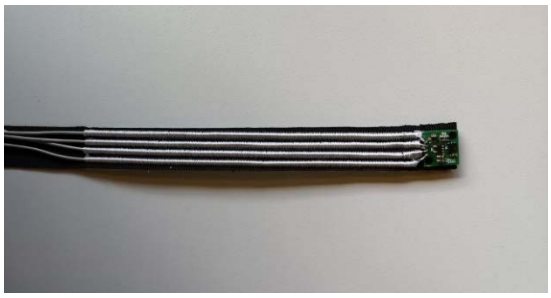





9 8 7 6 5 4 3 2 1

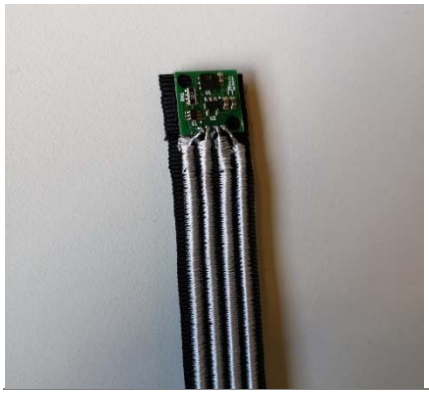
The tape

We decided to make cable construction detachable from the t-shirt. This meant that on the back of the tapes Velcro was attached. First I sew the edge of the tape, so the tape would not unravel. After that I sew a little piece of Velcro on the back of it. The tape with Velcro could then be put under the embroidery machine.



Final sensor embroidered

Here one is able to see the final result. I made 16 of these. We chose to use the silver/metallic yarns to give the design a more technical look. After the cables were embroidered, the sensor was stitched through the holes on the tape. This way the sensors was secured.



VID_20190110_193336.mp4

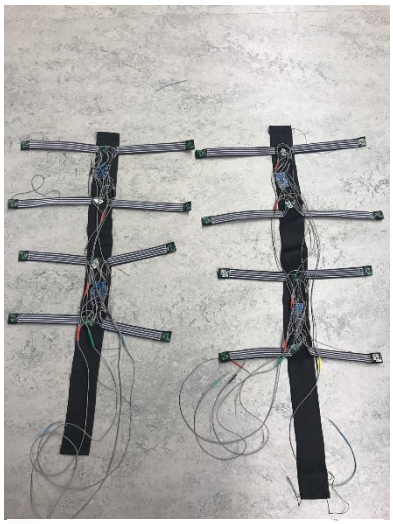
VID_20190110_193732.mp4

The making off video

Here one can see a picture and videos of how I embroidered the cables with the embroidery machine.

Process after the embroidery is done

After I embroidered all the cables and sensors on the tapes, Milko would connect all the cables with the arduino and with each other. Then Demi would start to make the cable construction.

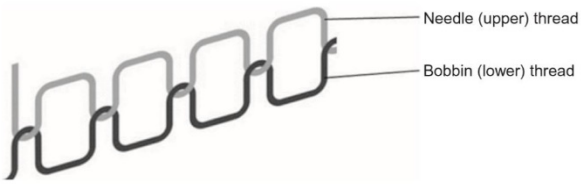


Research embroidering electronics

Basic principles and theory embroidery

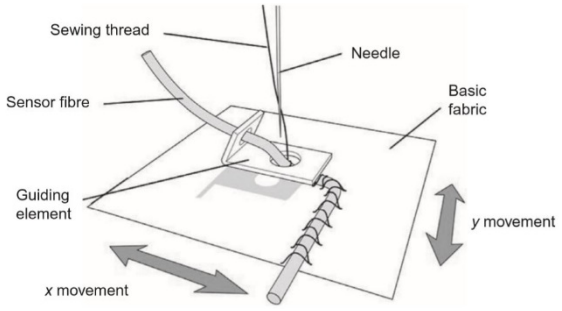
Embroidery is using a needle and thread to stitch on a fabric. It can be used to apply a given yarn material, or monofilament, to a textile substrate in a defined geometry. Two kinds of embroidery methods will be defined: standard embroidery and tailored fiber placement embroidery.

Standard embroidery



The standard embroidery technique is a double lock stitch with a two-thread system. The needle thread is stored on conical bobbin. The bobbin thread forms the stitches on the underside of the garment. The bobbin thread hold the top embroidery thread to the garment. The fabric is held under tension with the use of an embroidery frame. This frame provides tensions that helps the accuracy and a clean and predictable stitch. The frame is moved in the x- and y- directions in order to create the programmed pattern. The needles punches through the fabric and interlaces the upper thread with the bobbin thread with the help of a rotating gripper located below the base fabric.

Tailored fiber placement



The TFP method is a three-thread system. This technique is based on the principles used in sewing. This technique provides for a continuous placement of a selected roving material. The fibrous material is fixed by an upper and lower stitching thread onto the base material. Different kinds of materials can be applied an combined, such as carbon, glass, basalt, aramid, natural, thermoplastic, ceramic and also metallic threads. There are limitless applications of TFP technology.

Future trends in embroidery

Current trends such as flexible circuit boards are designed to be used directly on fabrics. The biggest advantage is comfort. In the end the goal is to have circuit boards which are hardly recognized or sensed by the user. It is important to separate the electrodes from exterior electromagnetic influences. This can lead to interference in the signal (Mecnika, Scheulen, Anderson, Hörr, & Breckenfelder, 2015).

Quality profile

FABRIC QUALITY PROFILE

General fabric/yarn information					
Construction (knitted/woven)	Weft knitted		Paste original sample in here		
Content (%)	Polyester				
Weight (g/m^2)	138,9				
Cut width (cm)	160				
Density	N.A		Gauge (ndls/inch)	40 ndls/inch	
Denier	150/36				
Coloring (dyed, printed)	Disperse dye				
Special finishes	Chemical	N.A			
	Mechanical	Textured polyester yarn			

Standard tests	Important (yes/no)	Testing standard (ISO/BS/ASTM)	Rating (scale/value)	Requirement (Min./max.)	Results	
Abrasion	Yes	EN ISO 12947-2	revs	16.000 revs	16.000 revs	
Color fastness tests						
Wash fastness	Yes	EN ISO 105 C10	Grey scale	Change: 4 Staining: 4	Diacetate: 4 Bleached cotton: 4/5 Polyamide: 3/4	Polyester: 3/4 Acrylic: 5 Wool: 5
Perspiration fastness	Yes	EN ISO 105 E 04	Grey scale	Change:4 Staining: 4	**Alkaline** Diacetate: 5 Bleached cotton: 5 Polyamide: 4/5	Polyester: 5 Acrylic: 5 Wool:5 **Acidic:** for all materials 5.
Crocking fastness	Yes	EN ISO 105 X 12	Grey scale	Dry: 4 Wet: 3/4	Length Dry: 3/4 Wet: 4/5	Width Dry: 4 Wet: 4/5
Water fastness	Yes	EN-ISO 105 E01	Grey scale	Change: 4 Staining: 4	Diacetate: 4/5 Bleached cotton: 5 Polyamide: 4/5	Polyester: 5 Acrylic: 5 Wool: 5

(European Technical Clothing Group, 2009)