Name student (incl. student number):	Name : Dimitar Rangelov Student Number : 445392
Name client:	REV'IT! Sport International B.V. - Jorrit Memel
Name tutor:	Jenny Hesse
Names group members:	Harold Kip(327132) Isabel Wesselink (434129) Femke Visser(435542) Le Van Hoang Minh (467475)
Project name:	Testing device membrane fabrics for motercycling
Project number:	L.26195

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

Feedback from REV'IT

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

Feedback tutor: Jenny Hesse

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

Feedback group members

Please add the pieces of evidence to this document.

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1. Words List

Arduino	Arduino is very small mini computer based on easy-to-use hardware and software.
Humidity	Humidity is the concentration of water vapour present in air.
Breathability	Air permeability is the ability of a fabric to allow air to pass through it. While air permeable fabrics tend to have relatively high moisture vapor transmission, it is not necessary to be air permeable to be breathable.

2. Feedback from tutor

COMING SOON!

3. Feedback from the company: REVI'T

COMING SOON!

4. Feedback from my group members

COMING SOON!

5. The assaigment

5.1 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.

6. Final Product

COMING SOON! AFTER RELEASE THE FINAL PRODUCT.

7. Assessment rubic

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. The student conducts research using a suitable research and design model and substantiates the choice of model and the steps taken.	I think I scored excellent Because I am making researches, after that discuss it with my team. After that add their ideas. And after that making experiments.	I showed this by Evidence 6. In the evidence are visible choices and design models and overall the evidence 6 is technical research.	My part in this is writing evidence 6 and making practical experiments.
2. The student collects, analyses, and processes relevant information in a traceable manner.	I think I scored excellent because I analyses and process the information in my Evidence 6 in traceable manner.	I showed this by Evidence 6. In the evidence are visible the analyses and is it example for traceable manner.	My part in this is writing evidence 6 in traceable way.
3. The student applies knowledge from their own particular discipline and substantiates their choices.	I think I scored excellent. Because I use knowledge from my specialty.	I showed this by Evidence 6. In the evidence I am applying knowledge from my speciality.	My part in this is writing evidence 6 and making experiments and using my knowledge from my specialty.
4. The student has provided an innovative solution or problem-solving approach for the client.	I think I scored excellent. I am providing the client really clear problem solving approach. And from his side everybody are happy about it.	I showed this by Evidence 6. The evidence is a problem solving approach for the client.	My part in this is writing evidence 6 in which I am providing innovative solutions and problem solving.
5. The student communicates in a respectful, purposeful, and professional manner with all internal and external stakeholders.	I think I scored excellent because I am keeping professional manner to the client and trying to be respectful with the members of my team.	I showed this by Evidence 2 and 4. We respect the work of other people. Evidence 4 is showing the proffesional way how we communicate with external stakeholders.	My part in this is the person who is helping in the communication between the team and client when is matter of technical knowledge.
6. The student takes responsibility within the group for the solutions and partial solutions as well as	I think I scored excellent because I also help and study from other people with other specialties than mine. Also I	I showed this by Evidence 3. This is picture from our	My part in this is Embedded Engineer and Software Engineer.

the processes.	am doing my responsibilities excellent.	project plan that is representing our roles and responsibilities. This is the closest example what we are doing in this project.	
7. I The student describes how they have looked at the project/question from the perspective of another discipline and what this means for the choices that were made.	I think I scored excellent because I am always trying to discuss the solutions that I doing with other specialties. Also I am trying to put their ideas in the real product.	I showed this by Evidence 5. Our main questions are made from the perspectives of all the specialties. Also Evidence 6 was provided to the team to explain the electrical work.	My part in this is making the question with team. I gave Ideas electrical engineering. I made Evidence 6 to explain my work step by step and also to request a feedback from other specialties. How they see these solutions.
8. The student reflects on their actions and adjusts these actions based on this reflection.	I think I scored excellent because I fix all parts of project plan after the feedback.	I showed this by Evidence 2. This is picture from whatapp how we divide again the parts for project plan.	My part in this is Problem Analysis, Research Objectives, Roles and Responsibilities.

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

8. Project Plan

Project Plan -
Smart Solutions Semester

REV'IT!

L.26195 Testing device membrane fabrics for motorcycling

Harold Kip, Isabel Wesselink,
Femke Visser, Dimitar Rangelov, Le Van
Hoang Minh

Saxion University of Applied Science
Mechatronica
Fashion & Textile Technologies
Electrical and Electronics Engineers

Project Plan -
Smart Solutions Semester

REV'IT

L.26195 Testing device membrane fabrics for motorcycling

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Femke Visser (435542)
Dimitar Rangelov (445392)
Le Van Hoang Minh (467475)
Saxion University of Applied Science
REV'IT!
Jorrit Memel
Jenny Hesse

3rd of October 2019

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Preface

This research report for REV'IT! is commissioned by Saxion University of Applied Science as part of the Smart Solutions Semester. The following study fields are involved; Electrical Engineering, Mechanical Engineering and Fashion and Textile Technologies.

The goal of this research is to provide REV'IT! a breathability testing device for membrane fabrics for motorcycling garments. The purpose of this report is to implement our knowledge and to combine the knowledge of each team member to fulfill the requirements of the company.

The group exists of five team members from different specializations: Harold Kip (MT), Le Van Hoang Minh (EIE), Dimitar Rangelov (EIE), Femke Visser (FFT) and Isabel Wesselink (FFT).

September 12, 2019

Enschede

1 Introduction

REV'IT! is a Dutch company, based in Oss, which develops innovative motorcycle clothing since 1995. REV'IT! is a worldwide known company with over a thousand dealers all over the world. After five years REV'IT! introduced the 'Engineered skin design' concept, a new method for product development. A groundbreaking method to deliver higher protective motorcycling products. In 2009 REV'IT! made a license agreement with Gore-Tex. By combining Gore-Tex with the Engineered skin, the performance and safety of the products have improved (REV'IT!, 2019).

REV'IT! makes motorcycle clothing for men and women from 18 years and older. The company creates collections which are divided in three different types of motorcycle garment categories: Sport, Adventure and Urban. These categories are based on the level of performance of the motorcyclist. REV'IT! also provides a lifestyle collection for both men and women.

With the lab located in Oss, REV'IT! tests their own fabrics at their own headquarters. Before the garments are produced the fabrics will first be tested in the lab. The fabrics are tested on their safety level to see if the products fulfill to the standards. Another important factor is to test the materials on the comfort level. REV'IT! aim is to provide protective and comfortable products towards their customers. A few examples of these tests are the tensile strength test, abrasion resistance, dimensional stability and many more. While performing these tests the seam strength, the stretch ability and the wear resistance of the products are for example tested (REV'IT!, 2019).

All information is acknowledged on the 5th of September 2019 by Mr. Memel, the Lab Coordinator at REV'IT! Oss.

1.1 Problem analysis

REV'IT! currently has a laboratory in Oss to test the materials. This lab was originally built to test the safety features of their motorcycling garments. By doing that REV'IT! was able to see if a suit would pass the European Union mandatory test for motorcycling garments. REV'IT! want to take this a step further. They reckon a driver who is comfortable is safer because they are not distracted by, for instance, the warmth of the suit or the humidity. It is therefore important to test the breathability of the fabrics. REV'IT! currently tests the breathability of membranes in combination with different types of fabrics according to the ASTM 96-95 standard. The standard defines the use of a predefined aluminum cup filled with 100 grams of distilled water. The fabric is placed on top of the cup with an airtight seal around the corners, so the only way for the water to get out of the cup is through the fabric. The whole setup of the cup and fabric is placed in an oven of 32 to 37 degrees Celsius, depending on the type of experiments. After 120 hours, the cup is removed from the oven for measurements which evaluates the amount of evaporated water through the fabric. This value will be extrapolated to the international standard of grams per square meter per 24 hours (Huang & Qian, 2008).

REV'IT! is defining the current testing procedure as not efficient and would like to change it. They are not able to monitor the cup and testing environment as their only data points at the moment are the weighting of the cups before and after the test. The testing device does not have sensors which could collect data as temperature, humidity, weight of the cups at all times during the test. However, one of the most important things is to be able to monitor and test the behavior of the fabrics in combination with the membranes for breathability in different phases of the test. For example, the well-known Gore-Tex fabric requires a certain amount of time to start functioning in full capability. It is important to know when fabrics in combination with a membrane becomes breathable. This variable is of great importance for

REV'IT! as they offer biker wear for different kinds of motorcyclist, each with different requirements. Furthermore, these values and information will result in a more efficient match of fabrics with membranes for the type of bike activities (Sport, Adventure and Urban). Each activity has its own requirements for motorcycling garments as intensity and duration of the drive differs between them.

1.2 Research objectives

The most important factor for designing a motorcycling suit is protection, but the suit must also protect the rider from weather conditions such as rain, sun or wind. Ventilation is therefore key. In summer the suit can overheat the motorcyclists' body. Therefore, the appropriate protection should not disturb the thermal balance. The vapor permeability of the motorcycling garments must be high so the sweat can be evaporated. Motorcycling clothing is mainly made out of leather or textile materials, for instance nylon, polyester, polyamide etc. Suits made out of leather is more durable but makes it impossible for the human body to breathe. The clothing made out of textile currently provide protection against weather conditions while the perspiration will get through. Different fabric compositions are required for each type of motorcyclist. The fabrics for the garments are combined with membranes so it feels comfortable on the skin (de Rome, 2019) (Zwolińska, 2013).

The most commonly used membrane is from GORE-TEX. The GORE-TEX membrane is a thin stretched layer of polytetrafluorethylene (ePTFE). ePTFE is also known as Teflon. The membrane is attached to an outer fabric and the lining. GORE-TEX prevents water from penetrating the product and allows evaporation of sweat, which is known as the wicking-effect. Because of the membranes the products become windproof, waterproof and breathable. Gore-Tex provides the wearer a thermal protection, reduces heat and allows the wearer to move.

The membrane that GORE-TEX uses is only 0,01 mm thick and has about 1,4 billion pores. These pores are twenty thousand times smaller than a raindrop and seven hundred times bigger than a water vapor molecule. Because of this, the membrane is fully waterproof, but the perspiration will get through. GORE-TEX's membrane is also windproof because it has a structure of a hedge. You can only see this under a microscope (Anitlope Outdoor, 2019). (Ismal & Paul, 2018).

Another company that makes membranes is eVent. eVent is also one of the most and biggest known alternatives for the GORE-TEX membrane. The eVent membrane is made out of the same materials as GORE-TEX. But the membrane of eVent uses a dry system. This makes it possible to get the moisture out in an instant. This is also called DirectVenting, a design of the brand itself (Norway Geographical, 2019).

In combination with the membranes, the breathability of the membranes depends on the fabric its laminated to. It is important to know which combination of fabric and membrane is breathable, to make the best usable motorcycling suit. Therefore, it is important to measure the temperature, humidity, evaporation time and weight of the fabrics (Zwolińska, 2013).

While the water evaporates in the oven, humidity will develop. Inside the oven there will be an absolute humidity. Absolute humidity is the mass of water vapor divided by the mass of dry air in an amount of air at a given temperature. This means, when the air gets hotter the more water the air can contain (Chandler, 2019).

The fabrics used within the products must meet certain quality standards. One of these standards is the ISO standard. The American version of this standard is the ASTM standard. REV'IT! is currently using for permeability the ASTM 96-95 standard. REV'IT! has developed a permeability device according to the ASTM 95-96 standard. The aim is to determine when the fabrics breathe during the whole test, but this is not achieved with the current test. Therefore, the aim of the research is to create a testing device for REV'IT! which can determine the breathability of a fabric by measuring the weight of the cup, the temperature and the humidity. These measurements are taken throughout the test and displayed in a graph. With this data REV'IT! can determine how long it takes for a fabric to breathe. The device will be a REV'IT! standard and therefore the ISO and ASTM standard does not need to be followed exactly.

1.3 Research question and sub questions

To address the problem, as described in 1.1 Problem Statement, the following main and sub-questions have been composed.

Main question
To what extent can a test device be developed to get a better understanding of the breathability of fabrics?

Sub-questions
Sub question 1: What kind of equipment is required to measure the weight of the cups at all times?
Sub question 2: What kind of equipment is required to measure the temperature inside the oven at all times?
Sub question 3: What kind of equipment is required to measure the humidity inside the oven at all times?
Sub question 4: How does the outside humidity affect the breathability of fabrics?

Preconditions and project deliverables
The smart solutions semester project is completed successfully when a testing device is developed which can determine the breathability of a fabric by measuring the weight of the cup, the temperature and the humidity in the oven and can display these measurements in a graph for REV'IT!

2 Methods

This chapter describes the methods used within the research for REV'IT!

This research is a combination of quantitative and qualitative types of research. Qualitative Research is primarily exploratory research. It is used to gain an understanding of underlying reasons, opinions, and motivations. It provides insights into the problem or helps to develop ideas or hypotheses for potential quantitative research. Quantitative Research is used to quantify the problem by way of generating numerical data or data that can be transformed.

2.1 Literature research

A qualitative literature research has been carried out to answer all sub questions to obtain general information about the subjects. A lot of information will be gathered from international standards as they form the basis for the current testing procedure and include a lot of in-depth information on the why and how.

2.2 Interviews

Semi-structured interviews will be conducted to answers sub questions. Interview schemes will be made before the interviews and there will be possibilities for extra questions during the interviews. As Jorrit Memel is the sole person in charge of the testing at REV'IT! he is the only person available to interview to gather more information about the current testing device and the requirements for the new testing device. Therefore, the population and the sample of the interview is one. The interviewee will be approached for the interview by email and the interview will be held at Saxion Enschede via Skype.

To make the testing device additional help and information is needed from different experts. Therefore, to gather more information about the use of the sensors and the electronics parts for the testing device the Hardware Lab/Electronics teacher at Saxion University of Applied Science, Umit Guler will be interviewed.

To collect more information about the equipment which can measure the weight of the cups and the construction of the cup the employee Mechanical Systems/High Precision Fabrication at Van der Beek's Beheer B.V. Romar Willems will be interviewed. The population and the sample of the interviews with the experts are two. The interviewee will be approached for the interviews by email and the interviews will be held at Saxion Enschede and at Van der Beek's Beheer B.V.

2.3 Measurement

Measurement will be made to test and evaluate the behavior and characteristics of fabrics and membranes. These measurements will be carried out in the chemical laboratory at the Epy Drost building of Saxion Enschede. There are already premade measurements by Jorrit Memel in the lab at REV'IT! that will be used in the research as reference. However, also the research will contain technical measurements based on the performance and accuracy of the device. This will help to develop a device which is more efficient.

Once the testing device for REV'IT! is developed various membranes in combination with the fabrics provided by REV'IT! will be tested on their breathability.

2.4 Simulation

Simulations will be used to test and evaluate the behavior and characteristics of fabrics and membranes. Also, to try to predict the ratio of the humidity inside and outside of the cups. However, the simulation will be used mainly in the developing process of the hardware and the software. On the other hand, the simulations will also help to track how the real device will behave and perform in a real environment before its even developed. Later on, this will be beneficial for the accuracy and speed of the product.

3 Role & Responsibility

Every person who is part of this project has a specific role and responsibility which corresponds to his or her specialty and interests. In this way everyone can use their full potential, and this will affect the end result.
See table 1 for the roles and responsibilities for everybody within the group.

Table 1
Roles & Responsibilities

Role	*Identity*	*Responsibilities*
Chairman and Quality Manager	Femke Visser	Establishing a connection with the client and playing a role as contact person. Testing and evaluating the behavior and characteristics of fabrics and membranes. Also writing detailed quality reports.
Quality Manager	Isabel Wesselink	Testing and evaluating the behavior and characteristics of fabrics and membranes. Also writing detailed quality reports
Mechatronic Engineer	Harold Kip	Testing and developing the mechanical system of the device. Also forming mechanical electronics of the sensors in the final product. Testing and evaluating the behavior and characteristics of fabrics and membranes.
Embedded Engineer and Software Developer	Dimitar Rangelov	Developing hardware and embedded software meeting the criteria and characteristic of the project. Also adapting or creating a firmware for representing the data of the tests. Testing and evaluating the behavior and characteristics of fabrics and membranes.
Embedded Engineer	Le Van Hoang Minh	Developing hardware and embedded software meeting the criteria and characteristic of the project. Testing and evaluating the behavior and characteristics

	of fabrics and membranes.

7

4 Planning

See table 2 for the planning for all weeks during the project including facilities (working place (e.g. working space).

Table 2
Planning

Week	*Outcome*	*Responsible*	*Facilities*	*Time (Hours)*
1.1	- First group meeting - Kick-Off Smart Solutions Semester - Research on REV'IT! - Meeting with REV'IT!	All All All All	Saxion Enschede Saxion Enschede Home office REV'IT! Oss	24
1.2	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Researching ISO and MVTR standards. - Research different sensors for the device - Work on project plan - Send Project Plan to Jorrit and Jenny - Request cup, membrane, fabrics and standards - Develop a firmware	All All All Harold, Femke & Isabel Dimitar, Harold & Minh Lê All Femke Femke Dimitar	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede Saxion Enschede, home office Saxion Enschede, home office Saxion Enschede Saxion Enschede Home office	32
1.3	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Brainstorm for ideas testing device - Interview with Jorrit Memel about the project plan - Literature research of the provided standards by Jorrit - Send final project plan to Jenny and Jorrit - Personal Deadline 20/09/2019: Project Plan - Deadline 22/09/2019: Final Project Plan	All All All All All Harold, Femke & Isabel Femke All All	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede Saxion Enschede, Skype Saxion Enschede Saxion Enschede Saxion Enschede, home office Saxion Enschede, home office	32
	- Group meeting: Monday, Tuesday, Wednesday and			

1.4	Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Receive cup, fabric samples, membrane and standards from Jorrit - Create a technical drawing of the cup - Remake the original cup for testing - Research: Received standards of the test by Jorrit - Research: How to attach the sensors to the cup - Test the compositions of the received fabrics - Update Jorrit about project progress	All All All Harold Harold Femke, Isabel Dimitar, Minh Lê Femke, Isabel Femke	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede Van der Beek's Beheer B.V. Saxion Enschede Saxion Enschede, home office Chemical lab - Epy Drost Saxion Enschede	32
1.5	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Test: How does the original cup relate to the remake cup - Test: The behavior of the sensors with the cup	All All All Harold Dimitar, Minh Lê	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Chemical lab Hardware lab - Wolvecamp	32
1.6	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Research: Choose the best option sensor for the cup - Start prototyping - Update Jorrit about project progress	All All All Dimitar, Minh Lê All Femke	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede Hardware lab - Wolvecamp Saxion Enschede	32
1.7	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Prototyping - Personal deadline 20/10/2019: finish prototype - Deadline 20/10/2019: First version personal portfolio	All All All All All All	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Hardware lab – Wolvecamp Saxion Enschede, home office Saxion Enschede, home office	32
1.8	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working	All All	Saxion Enschede Home office	32

	- Meeting with Jenny (tutor) - Test prototype - Test different types of fabrics with prototype - Start quality report - Update Jorrit about project progress	All All Femke, Isabel Femke, Isabel Femke	OTSWO 3rd Floor - Epy Drost Hardware lab - Wolvecamp Chemical lab - Epy Drost Saxion Enschede Saxion Enschede	
1.9	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Quality report - Buffer week	All All All Femke, Isabel	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede	32
1.10	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Analyze breathability testing results of the fabrics (120 hours test) - Update Jorrit about project progress - Personal deadline 17/11/2019: finish quality report	All All All Femke, Isabel Femke All	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede Saxion Enschede Saxion Enschede, home office	32
2.1	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Analyze breathability testing results of the fabrics (120 hours test)	All All All Femke, Isabel	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede	32
2.2	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Update Jorrit about project progress	All All All Femke	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede	32
2.3	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Deadline 08/12/2019: Second version personal portfolio	All All All All	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede, home office	32
2.4	- Group meeting: Monday,	All	Saxion Enschede	32

	Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Update Jorrit about project progress	 All All Femke	 Home office OTSWO 3rd Floor - Epy Drost	
2.5	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Preparations presentation Smart Solutions Festival	All All All All	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede	32
2.6	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Finalize presentation Smart Solutions Festival	All All All All	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede	32
2.7	- Group meeting: Monday, Tuesday, Wednesday and Thursday - Friday: Remotely working - Meeting with Jenny (tutor) - Deadline 17/01/2020: Smart Solutions Festival	All All All All	Saxion Enschede Home office OTSWO 3rd Floor - Epy Drost Saxion Enschede, home office	32
2.8	- Deadline 26/01/2020: Final version personal portfolio - Deadline 26/01/2020: Final group products	All All	Saxion Enschede, home office Saxion Enschede, home office	

5 Budget

To find the best solution a few prototypes need to be built, this so different tests can be run to see the effect of different sensors, the placement of the sensors and the ability to modify the cups for sensor usage. See table 3 and 4 for the budget which is needed for building the prototype. All products above are without VAT and shipping + handling

Table 3
Electronic devices budget

Electronic device	*Amount*	*Costs per piece*	*Source*
SHT85 Humidity, Temperature Sensor	1	€25	Mouser
ADA 2857 Humidity, Temperature Sensor	1	€15	Mouser
FlexiForce A301 Sensor 1lb	1	€15	Antratek
MINI LOAD CELL - 500G, STRAIGHT	1	€10	Antratek
LOAD CELL AMPLIFIER - HX711	2	€10	Antratek
Controller	1	€20	Antratek

Table 4
Mechanical devices budget

Mechanical device	*Amount*	*Costs per piece*	*Source*
Cups	2	€150	Solidworks Cost Analisys
Oven Memmert UN30	1	€1000	Dijkstra Vereenigde

6 Risk analysis

To address the risks that can impact the research during the project a table has been made on how to manage the risks. See table 3 for the risk analysis and table 4 for the comparation of the maximum score and the actual score.

Table 5
Risk Analysis

Category	*Risk*	*Value**	*Risk Chance*	*Risk Impact*	*Risk Tot*		
Time factor							
1	Estimated duration of the project	2 quarters	1	4		4	
2	Does the project have a deadline?	Yes	0	4		0	
3	Does the project team have enough time to finish the project?	Yes	2	5		0	
Complexity of the project							
4	Is it an adjustment or a new project?		New project		2	2	4
5	Are there other projects dependent on this project?		No		0	5	0
6	Is the project divided by parts? And is the Project dependent on the connection between them?		Yes		3	4	12
The project group							
7	Who are the project members?		Students		3	4	12
8	Will the project members feel responsible for the result?		Yes		1	5	5
9	Can the project members help each other?		Yes		0	5	0
10	Are there any users of the end result in the project group?		Yes		0	3	0
The Scrum master							
11	Have the Scrum master any experience being scrum		No		2	2	4
12	Does the Scrum master feel responsible for the result?		Yes		1	5	5
13	Can the Scrum master help the project members with starting to work?		Yes		2	4	8
The tools							
14	Can the hardware crash?		Yes		4	5	20
15	Can we lose all code when lap top crashes?		No		0	5	0
16	Do we have backup hardware?		No		1	5	5
17	Does every project member have experience with hardware		No		3	4	12
18	Does every project member have experience with the programing languages?		No		3	4	12
					Total Points		113
					Total risk percentage**		25.1 %

*Value chosen by leader
**Total risk percentage is the total amount of points divided by 450 (max score) multiplied by 100

Table 6
Maximum score vs actual score

Category (with maximum score vs actual score)	*Maximum*	*Score*
Time factor	75	14
Complexity of the project	75	16
The project group	100	17
The Scrum master	75	17
The tools	125	49

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9. Technical Research

SAXION UNIVERSITY OF APPLIED SCIENCES

Technical Research

Smart Solutions Semester 1
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Contents

Introduction

REV'IT! is a Dutch company, based in Oss, which develops innovative motorcycle clothing since 1995. REV'IT! is a worldwide known company with over a thousand dealers all over the world. After five years REV'IT! introduced the 'Engineered skin design' concept, a new method for product development. A groundbreaking method to deliver higher protective motorcycling products. In 2009 REV'IT! made a license agreement with Gore-Tex. By combining Gore-Tex with the Engineered skin, the performance and safety of the products have improved (REV'IT!, 2019).

REV'IT! makes motorcycle clothing for men and women from 18 years and older. The company creates collections which are divided in three different types of motorcycle garment categories: Sport, Adventure and Urban. These categories are based on the level of performance of the motorcyclist. REV'IT! also provides a lifestyle collection for both men and women.

With the lab located in Oss, REV'IT! tests their own fabrics at their own headquarters. Before the garments are produced the fabrics will first be tested in the lab. The fabrics are tested on their safety level to see if the products fulfill to the standards. Another important factor is to test the materials on the comfort level. REV'IT! aim is to provide protective and comfortable products towards their customers. A few examples of these tests are the tensile strength test, abrasion resistance, dimensional stability and many more. While performing these tests the seam strength, the stretch ability and the wear resistance of the products are for example tested (REV'IT!, 2019).

All information is acknowledged on the 5th of September 2019 by Mr. Memel, the Lab Coordinator at REV'IT! Oss

1. Temperature and Humidity Sensor

The aim of this chapter is to define which sensor is most suitable for the research project. This has been done to up efficiency and the accuracy of the device that will be built.

The sensors are divided on different classes and the priority of this research is mainly sensors that are high class and also has high specification. Because of that the DHT11 and overall the DHT family are clearly a different class of sensor with substantially lower specification and has been dropped from further investigation. In previous tests it performed perfectly well with respect to its specification.

The sensors are mainly from several families and manufactories but with almost same specifications and class. Furthermore will be simulated the eventual behavior in humidity domain and temperature domain separately. After that will be shown the results and the Function Simultaneously of Temperature and Humidity that will represent clearly in 3d the relationship between temperature and humidity and how this affects the sensor by its own.

1.1 Simulations on Humidity domain

In the pictures below are representing the results of the simulation for humidity of each of the sensors. In the first graph is visible that as big is the graph as less accurate and more percent difference has the sensor. And other way around as small is the graph as more accurate is the sensor.

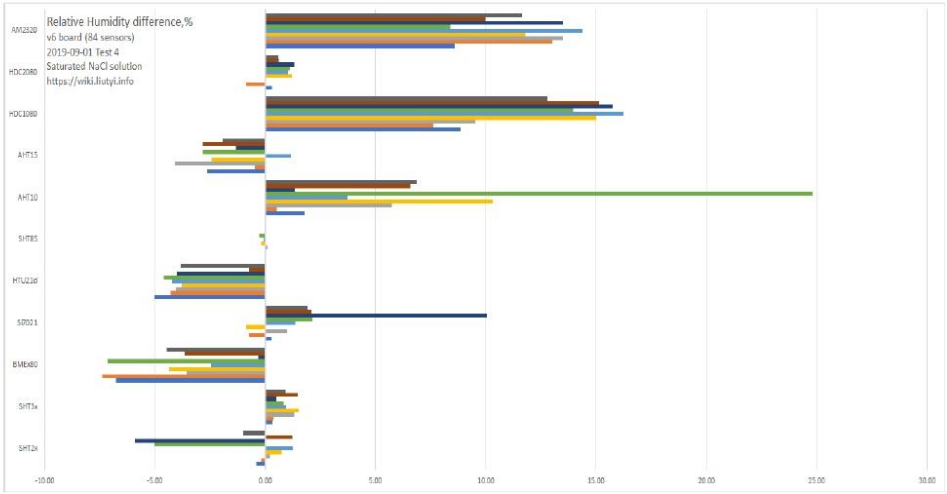

Figure 1 Relative Humidity difference [1]

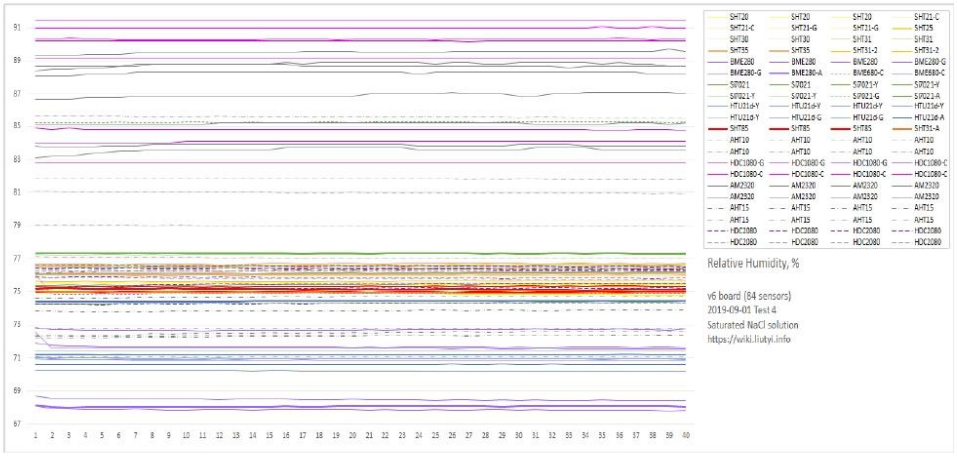

Figure 2 Relative Humidity Sensor [1]

1.2 Simulations on Temperature domain

In the pictures below are representing the results of the simulation for temperature of each of the sensors. In the first graph is visible that as big is the graph as less accurate and more percent difference has the sensor. And other way around as small is the graph as more accurate is the sensor.

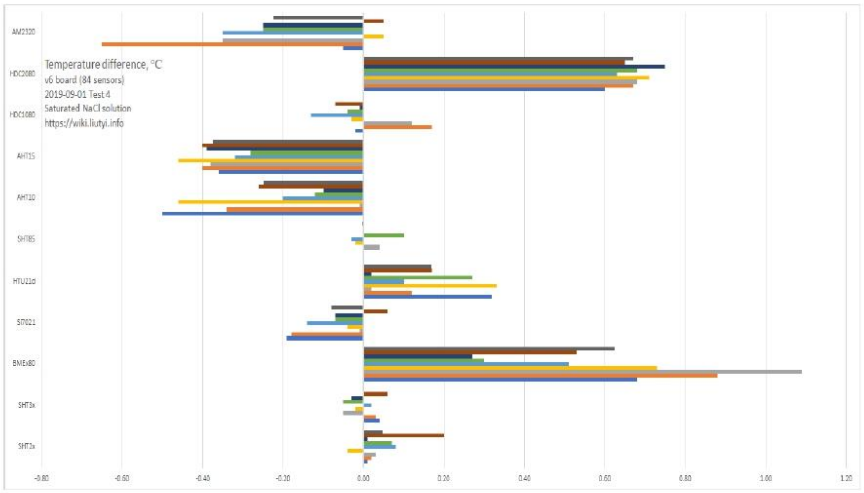

Figure 3 Temperature difference [1]

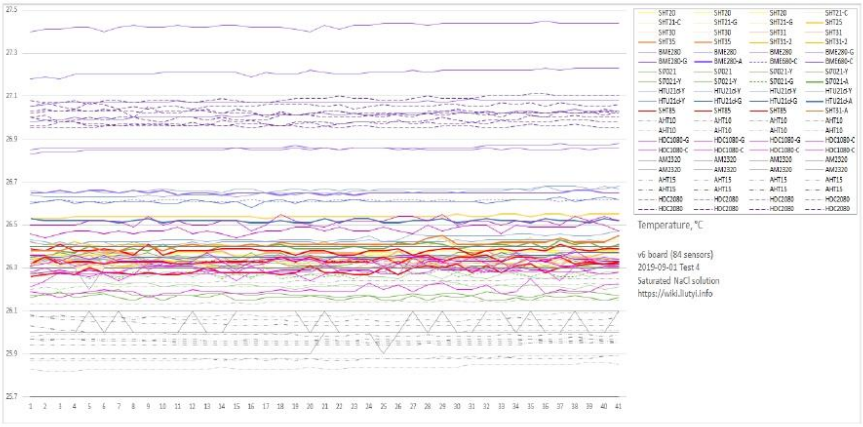

Figure 4 Temperature measurements [1]

1.3 Results for Humidity

` The plot below showing the deviation of humidity values from the known reference value. These plot show the error of each sensor as a function of humidity. The shaded grey region is the specified tolerance from the manufacturers' datasheets. All data collected, irrespective of temperature, are shown as blue dots. Red crosses are just those obtained at 25±1°C, so any that lie above or below the shaded region fail to meet the advertised specification. Where blue dots scatter outside the shaded region it indicates a drift in the calibration as a function of temperature. Red lines are quadratic fits to the 25±1°C data.

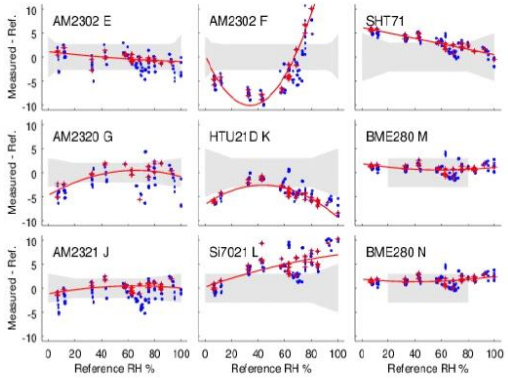

Figure 5 Plots showing the deviation of humidity values from the known reference value. [2]

1.4 Results for Temperature

The plot below is showing in red boxes and a linear fit line are measurements for all sensors with saturated ammonium nitrate over the temperature range 5–35°C. Plotted for comparison are values taken from the published literature. Cyan data from O'Brien (1948) and yellow from Wexler (1954). The thin black line is an equally weighted fit to both. [2]

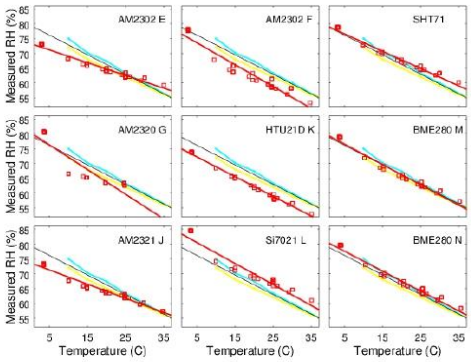

Figure 6 All sensors with saturated ammonium [2]

The plot below is showing as red boxes and a linear fit are measurements for all sensors with saturated magnesium chloride over the temperature range 5–35°C. Plotted for comparison are values taken from the published literature. Blue data are from Greenspan (1977), cyan data from O'Brien (1948), green from Rockland (1960), magenta are the CRC Handbook (1977) and yellow, Wexler (1954). The thin black line is an ensemble fit to them all, weighting all equally. [2]

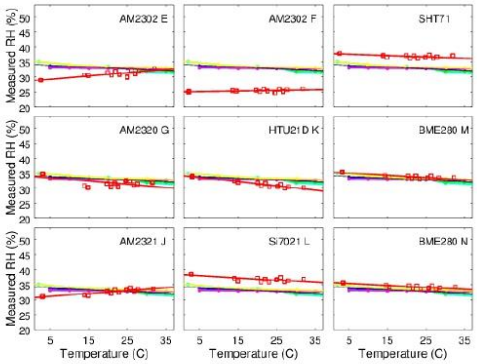

Figure 7 All sensors with saturated magnesium [2]

1.5 Function Simultaneously of Temperature and Humidity

Surfaces are showing deviation of each sensor from the true relative humidity as a function of temperature and humidity. A 'perfect' sensor would be a featureless green-yellow plane at zero. Blue shows low readings and red are high.

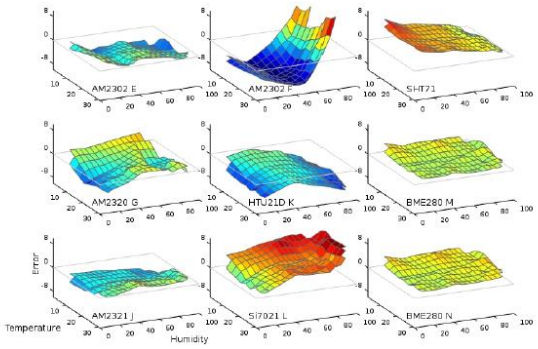

Figure 8 Temperature and Humidity [2]

1.6 Hysteresis

Deviations from the known reference value as humidity is systematically cycled from high to low and back to high. Two complete cycles of 92%, 60%, 33%, 7%, 33%, 60%, 92% are shown. For most sensors the traces followed on rising and falling humidity are reasonably close together, showing little hysteresis bias. A couple of sensors do show a strong effect. (Notes on particular sensors: AM2302 F output saturates at 99.9% for K_2NO_3 so no values are plotted. The AM2321 generally failed to give any output for K_2NO_3. It occaisionally provided an intermittent reading, but largely fails for humidity >90%. The AM2320 generally failed to give any output for NH_4NO_3. It occaisionally provided an intermittent reading, but largely fails for humidities around 50-70%.)

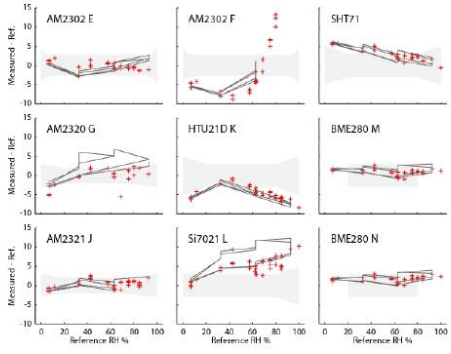

Figure 9 Deviations from the known reference value as humidity is systematically[2]

1.7. Response speed

Time response of the devices when exposed to a sudden upwards and downwards change in humidity. Left panel shows data directly from the sensors. Since the AM23xx devices return a previously cached value, they show the step change with a lag of one data point. In the right hand panel the lag has been arbitrarily removed and the values normalised in order to compare the intrinsic response speed of the sensor elements.

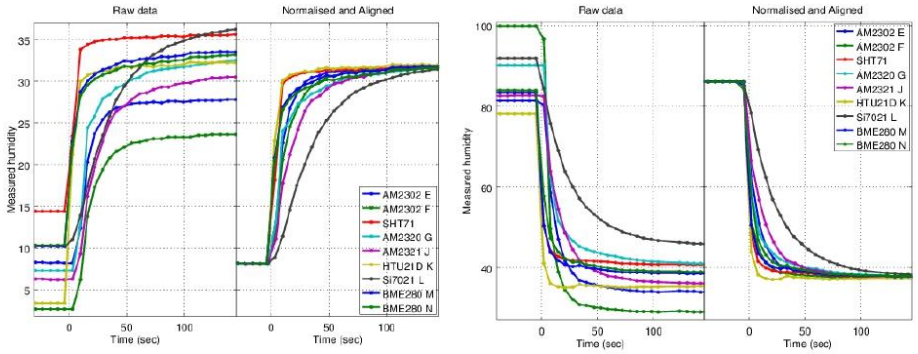

Figure 10 Time response of the devices when exposed to a sudden upwards and downwards change in humidity. [2]

1.8 Testing and evaluating

Overall the SHTxx sensor family is the best for the research project and because of that the final decision was made to be compared SHT31-D and SHT85 in real life situations. In the picture below are shown the inner of both of the sensors. In the left part is SHT85 and in the right side is SHT31-D.

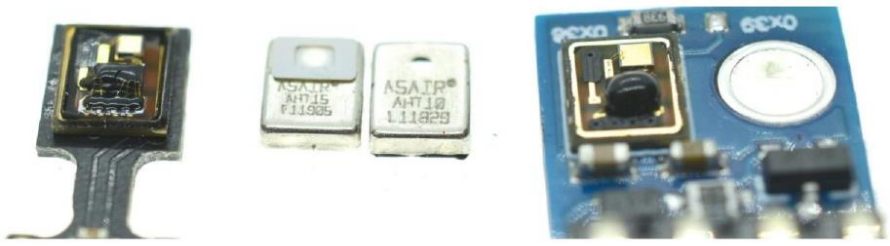

Figure 11 Microscope pictures of the sensors

The pictures below are representing practical productions made specifically for experiments that follow. Furthermore there will be made the experiments and will be compared the characteristics of both of the sensors.

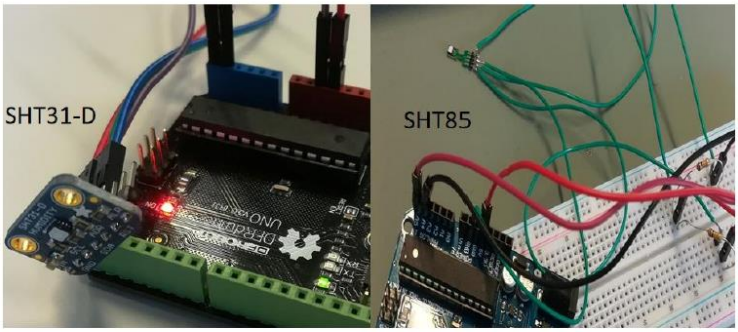

Figure 12 Practical productions

The experiments were done with SHT85, SHT31-D and also a measuring device with 99.8% accuracy. From the picture below is visible that SHT85 is more near by the real value and also it is faster at the normalizing the data flow. The SHT31-D has almost 0.30 degrees Celsius error from the real value and that it does not meet the requirements and needs of the project. Overall SHT85 it is with better characteristics and accuracy. Furthermore this sensor will be used in the building of the prototype.

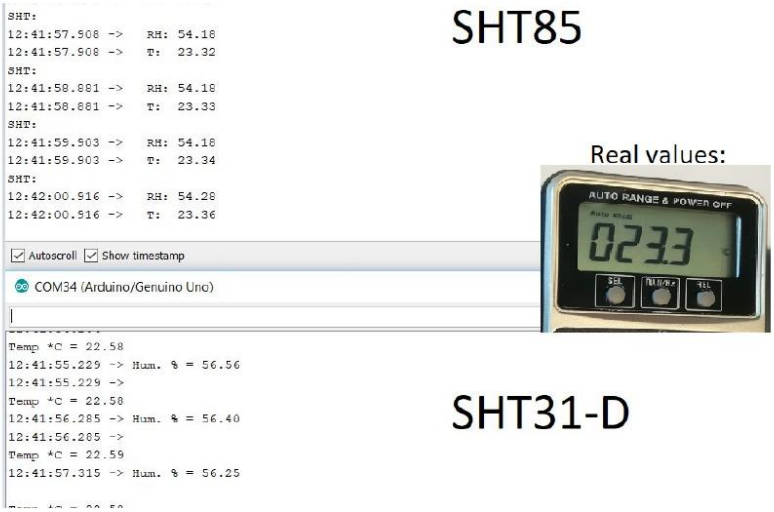

Figure 13 Results from experiments

2. Weight Sensor

The aim of this chapter is to define which sensor is most suitable for the research project. This has been done to up efficiency and the accuracy of the device that will be built.

The sensors are divided on 3 main categories – load cell, strain gauge and force-sensitive resistors. In this research will be test the characteristics and accuracy of two classes that are most accessible to the research team – load cells and FSRs.

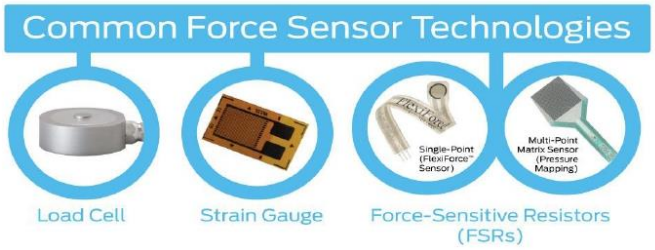

Figure 14 Types of common force sensors

2.1 Load Cell Basics

A load cell is a physical element (or transducer if you want to be technical) that can translate pressure (force) into an electrical signal.

2.1.1 Hydraulic Load Cells

Hydraulic load cells use a conventional piston and cylinder arrangement to convey a change in pressure by the movement of the piston and a diaphragm arrangement which produces a change in the pressure on a Bourdon tube connected with the load cells.

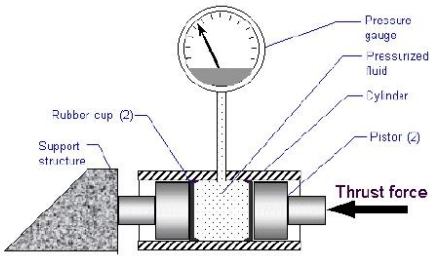

Figure 15 Diagram of a Hydraulic Load Cell [3]

2.1.2 Pneumatic Load Cells

Pneumatic load cells use air pressure applied to one end of a diaphragm, and it escapes through the nozzle placed at the bottom of the load cell, which has a pressure gauge inside of the cell.

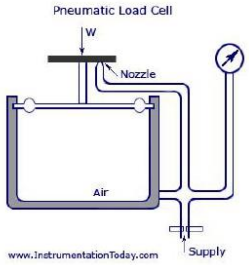

Figure 16 Diagram of a pneumatic load cell [4]

2.1.3 Strain Gauge Load Cells

And lastly (though there are many other less common load cell set ups), there is a strain gauge load cell, which is a mechanical element of which the force is being sensed by the deformation of a (or several) strain gauge(s) on the element.

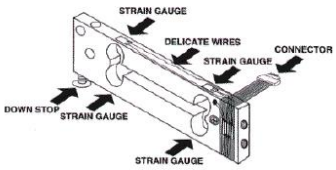

Figure 17 Strain gauge load cell diagram [5]

In bar strain gauge load cells, the cell is set up in a "Z" formations so that torque is applied to the bar and the four strain gauges on the cell will measure the bending distortion, two measuring compression and two tension. When these four strain gauges are set up in a wheatstone bridge formation, it is easy to accurately measure the small changes in resistance from the strain gauges. [5]

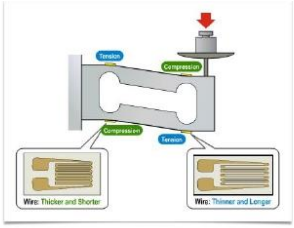

Figure 18 More in depth diagram of strain gauges on bar load cells when force is applied [5]

2.2 Testing and evaluating

2.2.1 Reference research

The experimental setup shown in the picture below was developed to measure the reflection of the hip force. The change in the sensed voltage from the Wheatstone Bridge of the two FSR sensors and the additional two resistances was measured with an AD converter during which a force was provided to the hip force sensing part. Three axis precision stages with a manual positioner that was able to move the sensing part and load cell with a precision of <1 μm were used to apply force to the sensing part with 1 mN resolution. The sensing part contacted the tip of the load cell and force was applied to it in each direction and at each position. b) shows the *z*-axis force measurement setup. Dynamic testing was performed using the measurement setup consisting of repeatedly loading and unloading the sensor 4 times. Identical measurements were performed for force applied to the *z*-, *y*- and *x*-axes [6]

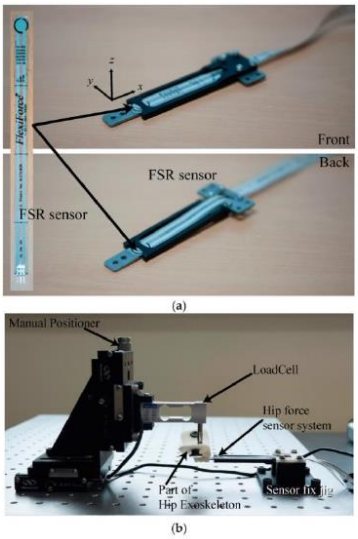

Figure 19 a) The developed sensor system and (b) force measurement and calibration system setup [6].

The picture below shows the experimental results of the relationship between the input force and the voltage variation of each sensor. a, b shows graphs of the relationship between the loading force on the *z*-axis and the measured voltage at the two sensors. For this system's structural characteristics, variation output occurred in one sensor when applying force to the system while the other sensor did not register any change. During the loading stage, the sensors followed the upper curve, while during the unloading stage, they followed the lower side of the curve. Subplot c–e shows graphs of the relationship between the loading force on the *y*- and *x*-axes and the measured voltage at the two sensors. The sensing accuracy is 1.5 N due to the nonlinearity of the FSR sensor and hysteresis of the sensor. The sensing accuracy is

below the Weber fraction, which is allowable for a wearable device, because a human cannot discriminate the force difference. [6]

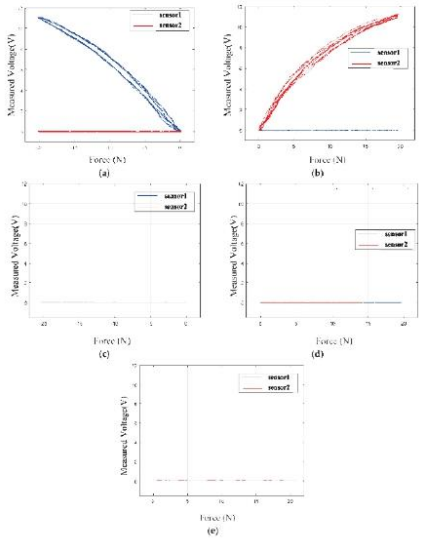

Figure 20 Experimental results of the relationship between the input force on the z-axis (a,b), the y-axis (c,d) and x-axis (e) and the voltage variation of each sensor. [6]

2.2.2 Applying the reference research

The experimentals productions show in the pictures below are the prove of the hypothesis that FSR are not accurate enough and also that the load cell is the only class of weight sensors that meets the requirements of the research.

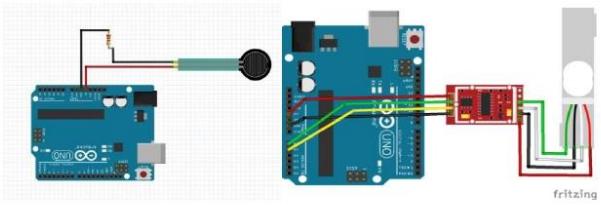

Figure 21 Productions for experiments

2.2.2.1 FSR testing

In the pictures below is show the prototype that was made for testing the FSR . The object that is measured in that case is lighter with around 200-250 grams weight. From the test was finding out that the surface under the FSR sensor was in close relationship with the accuracy.

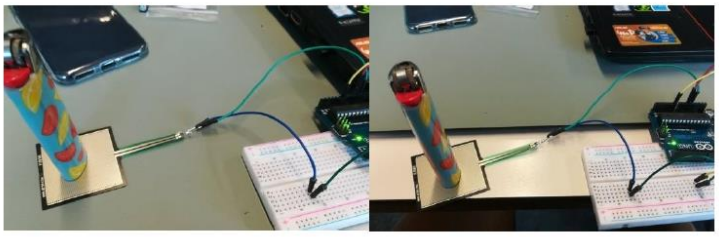

Figure 22 Experiments with FSR

Also the position of the lighter was in relationship with the accuracy of the sensor. Overall the FSR sensor is really not accurate as shown in the picture below because of the nonlinearity of the resistance.

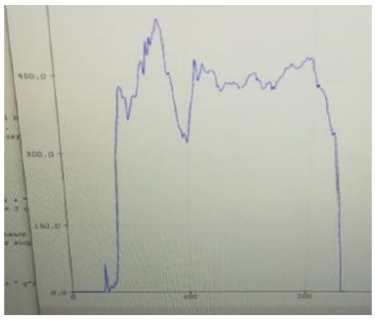

Figure 23 Results from FSR

2.2.2.2 Load cell testing

The object of measurement of the test with the load cell was coin of 10 cent with 34 grams weigh. First experiment was done by measuring the coin in three different states - the moment when the coin was put, moment of stabilizing and normalizing the data and finally when the coin was taken out from the load cell. In the graph below are really visible the three states. And the result is with 99.8% accuracy.

Figure 24 Experiment with load cell and coin

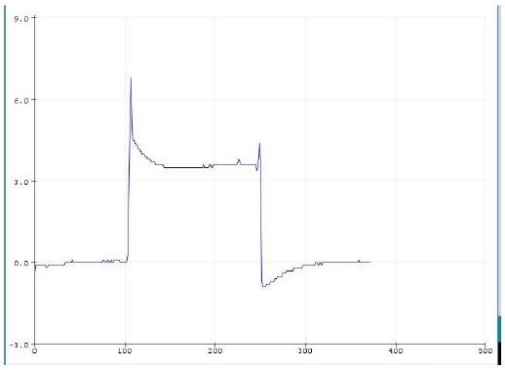

Figure 25 Results from load cell experiment

The second test was made with real predefined REVIT cup to finally test the accuracy of the sensor. And the results from the experiment is proves that this class of sensors are most suitable for this technical research.

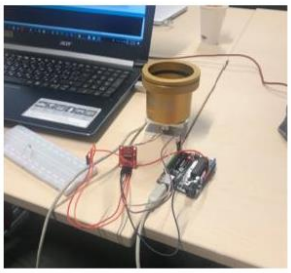

Figure 26 Experiment with REVIT cup

3. Micro controllers

3.1 Arduino UNO

The UNO is arguably the most popular Arduino. It is powered by an Atmega328 processor operating at 16MHz, includes 32KB of program memory, 1KB of EEPROM, 2KB of RAM, has 14 digital I/O, 6 analog inputs, and both 5V and 3.3V power rails.

Figure 27 Arduino UNO [7]

The Arduino UNO has a pin header arrangement that is rapidly becoming the industry standard for development boards, making it compatible with most development board shields on the market.A power jack is included on the UNO, allowing it to be powered by an external wall wart. There is also a VIN option available for connecting the UNO to batteries.The physical dimensions of the UNO (69mm x 54mm) make it a small development board that can easily fit into many projects and the four screw holes allow designers to securely fit them into place.

3.2 Arduino NANO

The Arduino Nano is essentially an Arduino UNO shrunk into a very small profile, making it very convenient for tight spaces and projects that may need to reduce weight wherever possible.Like the UNO, the Nano is powered by an Atmega328 processor operating at 16MHz, includes 32KB of program memory, 1KB of EEPROM, 2KB of RAM, has 14 digital I/O, 6 analog inputs, and both 5V and 3.3V power rails.

Figure 28 Arduino NANO [7]

The Nano, unlike the UNO, cannot connect to Arduino shields but it has pin headers which make it useful for breadboard prototyping or in PCBs with the use of a socket. Often, Arduino Nano boards are the cheapest Arduino board option available making them cost-effective for larger projects.

3.3 Arduino DUE

The Arduino Due is one of the larger boards and is also the first Arduino board to be powered by an ARM processor.While the UNO and Nano operate at 5V, the Due operates at 3.3V—this is important to note, because overvoltage will irreparably damage the board. Powered by an ATSAM3X8E Cortex-M3 running at 84MHz, the Due has 512KB of ROM and 96KB RAM, 54 digital I/O pins, 12 PWM channels, 12 analog inputs, and 2 analog outputs.

Figure 29 Arduino DUE [7]

The Due does not have any on-board EEPROM and is one of the more expensive Arduino boards. While the Due has a large number of pin headers for connecting to the many digital I/O, it is also pin-compatible with standard Arduino shields. Software compatibility with the Due cannot be guaranteed.

3.4 Arduino MEGA 2560

The Arduino Mega is somewhat similar to the Due in that it also has 54 I/O. However, instead of being powered by an ARM core, it instead uses an ATmega2560.The CPU is clocked at 16MHz and includes 256KB of ROM, 8KB of RAM, 4KB of EEPROM, and operates at 5V making it easy to use with most hobby friendly electronics.

Figure 30 Arduino MEGA [7]

The Arduino Mega has 16 analog inputs, 15 PWM channels, a pinout similar to the Due, and is hardware compatible with Arduino shields. Like the Due, software compatibility with the Mega cannot always be guaranteed.

3.5 Comparison

Arduino code can be easily transferred to different boards with virtually no changes which is highly beneficial to any designers wanting to change their mind about what board their project will use.The deciding factor each project will use comes down to two basic things: hardware and cost. While the cost aspect of each Arduino is obvious (the lowest cost option is always the preference), the hardware may not be so easy to determine. When looking at hardware the following should be considered:

- Physical dimensions
- CPU power
- Memory size
- I/O capabilities
- On-board peripherals
- Weight
- Connectivity

When it comes to physical dimensions the Arduino Nano is the smallest and is a very portable device. The UNO is a medium sized development board but is still small enough to be mounted to many projects including remote-controlled devices such as RC cars and boats. The Mega and Due are much larger boards which makes them difficult to use in space restricted applications.

Board	Best Applications	Example Projects
Arduino Nano	Low cost, small profile, simple projects	RC planes, portable electronics, and sensor gathering
Arduino Uno	Desktop prototyping and use with Arduino shields	Simple robot controller, RC cars, simple games console, IoT sensors, and device testing
Arduino Mega	High I/O requirements with more memory space	DIY bench tools, multi-device controlling, machine controller, home automation
Arduino Due	High performance prototyping with superior analog I/O	Data processor of multiple sources, home automation, machine controller

Figure 31 Comparison table

4. Architecture

The graphic below is representing the basic method of operation of the device that should be built in the end of these technical research. Basically there are 6 sensors for humidity and temperature and 6 sensors that are measuring the weight of the REVIT cup continuously. After that all of them send the raw data to microcontroller. Furthermore the raw data is normalize and is send to the firmware that will be discussed in next chapter.

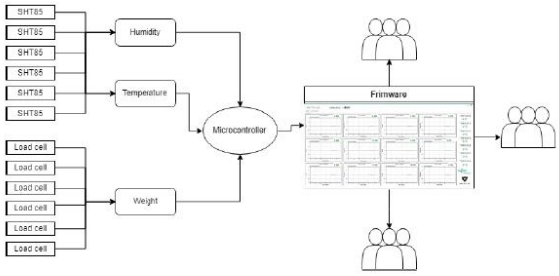

Figure 32 Method of operation

5. Graphical user interface

In the picture below is representing the concept how should look the final firmware. It should represent continuously the humidity and weight levels. Also to make log book of all the data that is received.

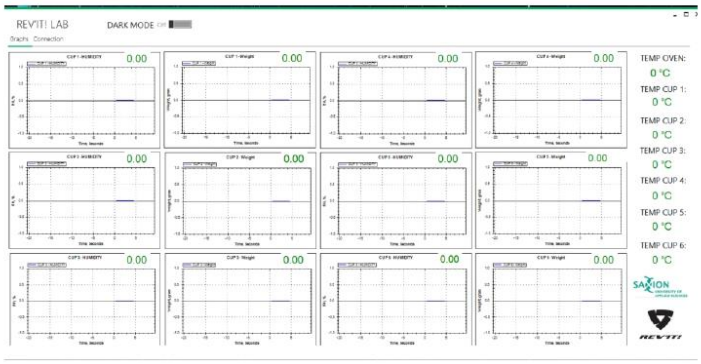

Figure 33 Firmware front page

The firmware has a window for establishing connection with the microcontroller. Also has dark mode that is making all of the components black and white. Only the graphs in dark mode are not going to be black. They will be gray.

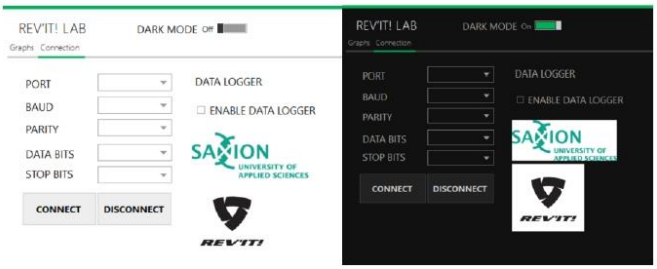

Figure 34 Firmware connection page

6. Bibliography

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