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Analysing IoT Wheelchair Course

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Abstract

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This thesis deals with analysing a Dutch course on IoT. The purpose of this study is to analyse the course, document my experience in terms of communication with team members, my learning achievements, and the challenges, problems I faced and solved. While implementing a small part of the prototype. The Information was gathered and analysed through secondary research and quantitative research methods. This thesis went through four stages introduction to Dutch course, challenges, implementation, and conclusion. The timeframe was between April 2019-Decebmer 2019.

This thesis focuses on analysing the IoT course its resources, the wheelchair designs for feasibility, the learning achievements, and how I have met the learning objectives.

The conclusion of this thesis shows how the un-predictable and un-preventable challenges during this project effected the length of the thesis and the outcome of the prototype. Additionally, the results of this thesis show that there are many challenges like (very short timeframe) for a student with such little resources to accomplish all the outlined objectives in this course, however it also demonstrates how with all the challenges I manged to solve and complete the prototype. By displaying a timetable showing the before and after.

The final discussion is whole development journey and through that I provide a set of development ideas for future research.

Keywords: IoT, IIoT, IMoT, Frameworks, Models, Dutch course, Learning tendencies, python, micro-controllers, actuators.

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I would like to express my gratitude to my advisor Ohto Raino, and the professor of the dutch course who have guiding me. Thank you to your advice, inputs, and feedbacks

I am very grateful to my family and friends who have supported me throughtout this journey. Special thanks to my parents who are my role models, for the wise advices and for putting my education before everything. Thank you all.

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Symbols and Abbreviations

IoT	Internet of Things
IIoT	Industrial Internet of Things
IoMT	Internet of Medical Things

1 Introduction

This chapter is the introduction in which I describe the main subjects discussed in the document. This thesis is divided into two main heading.
The 1st part of this thesis is theoretical framework of the course which contains introduction to Dutch course, design of prototype, my objectives for this thesis, tools and technologies I used. Also, I discuss the different types of poster offered, their features, analyzed the architecture, Dutch course content, objective, full implementation.
The theoretical framework chapter has three different subheadings which are: Dutch course, Thesis outline, Technical documentation/explanation.

In the 2nd section I describe my skill level for this type of project, what I was expecting, how I improved to be able to accomplish the prototype, the type of learning skills I had to gain. For the 3rd chapter discuss the challenges I face throughout this process and I how I solved them and the challenges that could not be solved. One main challenge I faced is the timeframe in which this Dutch course occurred, and my lack of some technical devices.

In the 4th section I discussed the implementation, how I connected the devices, what I did with the skills I learned from the material to complete the prototype. The 5th section I started to analyze the data provided within this course, I created a technical documentation for the finished product. Finally, In the 6th chapter I wrote down my final thoughts on the project, any regrets I have and improving point for future students.

2 What Is IoT

The Internet of Things is the subject of connected objects to the internet, there is no limit to what the connected object is, from cars to toilets to refrigerators, washing machines, and so on. IoT is frequently implemented in four major industries, which are the manufacturing and industrial business which dominates 40.2% of the industry, then follows the healthcare with 30.3% in the industry, the security has 7.7% share in the industry, and lastly is the Retail industry with 8.3% share.

The type of IoT used in this thesis will be IoT that supports the health industry, like hospital devices. The goal of the IoT devices used in this thesis will be to support the daily activities of wheelchair users in a specific hospital. The hospital uses smart wheelchairs which are equipped with multiple IoT devices, which adds endless functionalities changing the environment around it drastically. In the health care industry, the IoT devices used are known as IoMT Internet of Medical Things.

Additionally, IoT devices have changed the lives of individual people immensely, to mentions a small but big successful project include smart watches which record the heart rate, footsteps, distance to further the goal of increasing the user's health.

3 Distance Learning

Distance learning is the process of obtaining knowledge, skills, new ideas, and new experiences from resources provided by teachers and professors of the course without physically being present during the teaching hours. To help attain the maximum benefits there are frameworks to follow in these types of scenarios, including the Kolb's experimental learning model which I used to follow this course and to achieve all my goals to finish the thesis. Distant learning in these days include video conferencing which is a very common learning style where teacher and students interact with each other through live video sessions.

To mention few other styles of learning there is the synchronous learning which is when the tutor is located at a different place to all the students in the class, asynchronous learning is when the students are provided with resources, tasks, deadlines and are expected to self-study to complete all the assignments, open-schedule learning are online courses with asynchronous learning ways, and additional few are fixed-time learning, computer-based learning, and hybrid learning.

Understanding my own learning tendencies played a major factor in this thesis. To get there I had to learn couple of new topics, I found myself struggling I later understood I had to re-assess my studying skills. While conducting my research into studying the subject. The learning concepts I came across included, Dependent learners, Independent learners, and the Kolb's experimental learning model.

I used the kolb's experimental learning model as a guide to understand this topic of learning to learn. Kolb's identifies a four-level learning cycle, he explains that "people naturally prefer a certain single different learning style. As people have different learning tendencies due to for example, social environment, educational experience, or cognitive brain structure of the person".

Kolb's also identifies four different learning styles which are converge, diverge, assimilator, and accommodator. He continues to say, "the key to effective learning is to adopt the appropriate learning style for the situation". To develop essential study skills, I started to document my experiences to follow the four-cycle learning method defined in the Kolb's learning model, which are concrete experience, reflective observation, Abstract Conceptualization, and active experimentation.

Concrete experience is the first step in the cycle which represents participation in a new activity or encountering a new situation. Second stage is reflective observation of the new experience which is the rethink process of trying to understand the new experience, then is the abstract conceptualization which is learning from the initial experience and developing ideas to better the learning achievements. Lastly is the active experimentation phase which is the applying of new ideas throughout other learning experiences, and includes understanding learning processes, identifying own learning preferences, elements that block the learning, and elements that influence the learning.

Another learning experimental model is the Honey and Mumford's learning style which identifies four tendencies, the activists, the reflectors, the theorists, and the pragmatists. Activists are individuals who prefer an open minded, challenging, and exciting environment, they also desire the attention of people. Reflectors on the other hand, are observing people, who put a lot of thought to their actions, they adopt a very quiet lifestyle, and they also stay away from being at the centre of attention. Theorist are more logically aspired, analysing, synthesising, problem solving are part of their personality, "they tend to display perfectionist traits" to developing essential study skills. Lastly are the Pragmatists who are more often known as realists, they like the testing theories into real situations, part of the personality traits are being on time, achieving deadlines, decision making with a practical thinking process, problem solving with experience, and lastly very impatience with sharing time for no important reason in their eyes.

Furthermore, there are known factors that help the learning experience to reach its most high potential which are following your own pace, studying before meals and after meals. Studying in small groups, with friend, working alone, in a quite area, early in the morning, very late at night, in a busy places, in a relaxed environments, reading something then trying out, trying something out then reading about it, and writing reflective logs or journals.

4 Objective

I will be part taking in a Dutch course for a research project, my aim is to learn as much as possible from this course, implement a small part of the prototype, while documenting my learning process, analyzing the course, and how well I achieved the learning objectives.

The objectives of the research are the following, Analyze the Dutch wheelchair designs for feasibility (the state or degree of being easily or conveniently done.), Analyze the Dutch course description and material document and in GitHub, Choose and describe a small part of the wheelchair for implementation, Collect feedback from the Dutch students, Implement a prototype level IoT-wheelchair (sensor based or more machine learning based angle), Reflect on the learning and co-operation with the Dutch course in the discussion part of the thesis.

5 Dutch for feasibility

Dutch Course

This course is has laid-out many learning objectives to achieve in the very short timeframe of eight weeks, which are the following, students will acquire the necessary knowledge and thinking of collaborating with developers and engineers throughout the design process, they will integrate data science and software engineering methods in the design process to develop innovative IoT products and services, also identify and select appropriate development tools and use them effectively throughout the development process, and use data science methods to generate insights and knowledge from IoT data and make it intelligible for stakeholders, Balance the interests of users, business and societal challenges regarding to ethical data issues such as data privacy, data confidentiality, data quality, data ownership, etc.

The resources offered in this course include, a GitHub page, project website, slack channel, posters, videos, course description.

The main purpose of the GitHub page is to offer all the needed code and additional assistance to implement a functioning prototype. The course is divided into eight workshops, with each one focusing on one learning objective. By studying and implementing each section, the student would have completed the whole prototype

The sections are as follows:

- Getting started,
- Workshop1, Building an Internet-Connected Wheelchair
- Workshop2, Integrating and Visualising Sensor-Based Data
- Workshop3, Developing Algorithms and Controlling Actuators
- Workshop4, Developing and Conducting a Data Collection Campaign
- Workshop5, Implementing a Machine Learning Pipeline
- Workshop6, Developing a Product Analytics Dashboard

Each workshop was focused on to achieving one of the learning objectives, the objectives did not plan to achieve are, Developing Algorithms and Controlling Actuators, Developing and Conducting a Data Collection Campaign, Implementing a Machine Learning Pipeline.

I followed the Instructions of the remaining workshops which are; Building an Internet-Connected Wheelchair, Integrating and Visualising Sensor-Based Data, Developing a Product Analytics Dashboard. The programming languages use in this course are, Python and C for micro-controllers.

The GitHub page also contains all the code needed for the sensors and micro-controllers and it contains links to the programs that need to be installed on the local computer, it also contains an overview diagram of the structure in which the technical devices will be setup.

The website is an overview of the whole project targeted towards individuals who seek information about the projects, it contains all external resources and links that might be needed by the developers.

This page also highlights the main objective of the project which is to optimize and explore new technologies.

The course described in a word document was the first document provided to me about the course, it was a very formative document, it introduces the course objectives, timetable, and so on. The Cloud folders contained the posters, and videos. Also, there was a slack group, the students and teachers would post solutions for some errors and problems people where facing.

I personally did not use this channel much, when I was implementing the prototype the chat was full of problems and solutions that it was extremely confusing to follow through, and the course had long finished so I could not ask a question.

With the assistance of the course professor I got a list of all the devices I need to implement the small prototype of the hospital connected wheelchair for this thesis project.

6 Design

1. Wheelchair Design

There are eight different wheelchair designs offered to implement in this course, each has its unique features. A small part of the hospital connected wheelchair design is applied into a prototype in this research. The following is a list of the all designs:

- Physical activity tracking wheelchair (Wheely)
- Comfortable wheelchair (Willie)
- Amusement Park Wheelchair
- Hospital Connected wheelchair (Transit)
- Basketball player wheelchair
- Museum Visiting Assistant
- Rental Wheelchair (Paddy)
- Smart Wheelchair

I chose the hospital connected wheelchair because of its simplicity and that also it introduced me to a variety of devices. The hospital connected wheelchairs technical details are demonstrated and explained in the posters 1 to 4. Wheelchair Objectives, Technical Components, And Technical Architecture

Figure 1. Transit wheelchair design

With my learning objectives for this research being only the first three objectives from the course, I did not implement the whole prototype.

The transit wheelchair is introduced in the 1st poster, the purpose this design is directing individuals throughout the hospital, reduce time wasted, predict the availability of the wheelchair, and for wheelchair management.

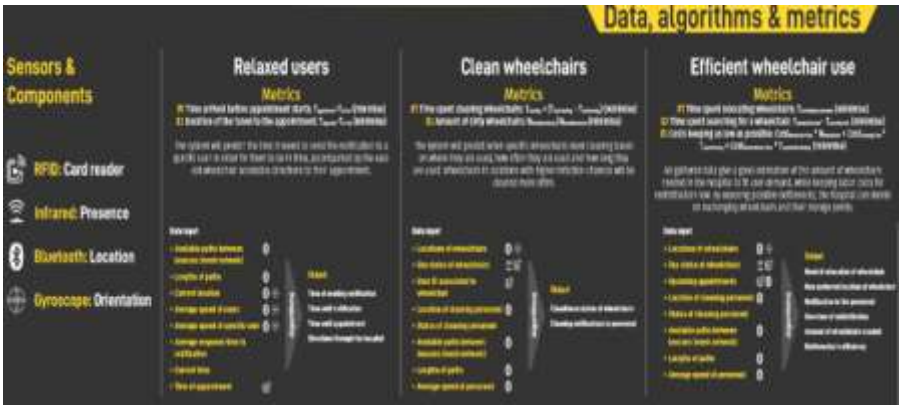

Figure 2. Prototype details

The 2nd poster shows the technical components required for the prototype, and three types of user cases for the wheelchair, which are relaxed user, clean wheelchairs, efficient wheelchair use.

Additionally, the in-depth technical feature explanation is in the 3rd poster. In the poster it illustrates the step by step information flow of this design, how and what each component uses and passes the information to the next stage.

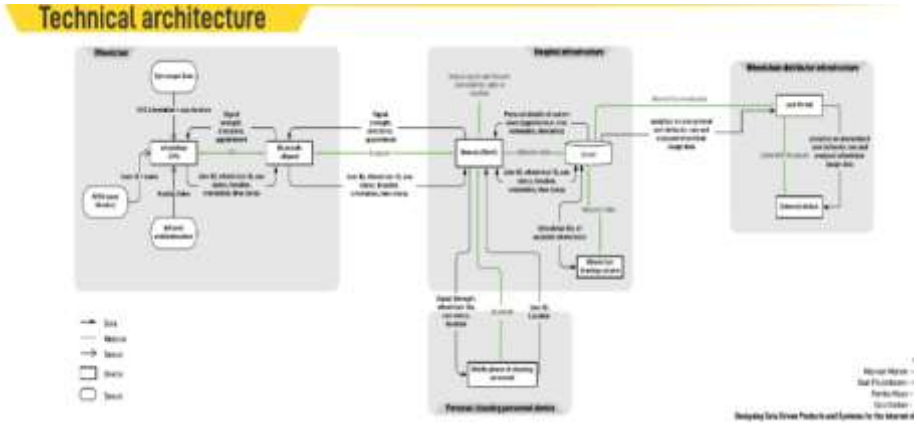

Figure 3. Technical architectecture

The four main components here are Wheelchair, Hospital Infrastructure, Wheelchair distributor infrastructure, and personal cleaning personnel device. To give a scenario, a hospital which uses our wheelchair has outsourced the cleaning service, each personal has a device which locates the wheelchairs, in this case there are chairs which need to be cleaned. There are beacons installed in different parts of the hospital, which locate the

nearest wheelchairs and the cleaning personal through their phone which have a user ID as identification.

The beacon sends data like Signal strength, wheelchair IDs, use statues, and location through Bluetooth to the personals phone. The beacons on the hospital architecture communicate with a Bluetooth chip on the chair to exchange information like, location, signal strength, directions, appointment, user ID, wheelchair ID, time stamp, and orientation all through Bluetooth. Also, there is a server part of the hospital infrastructure which connect the outside distributor infrastructure to the whole system.

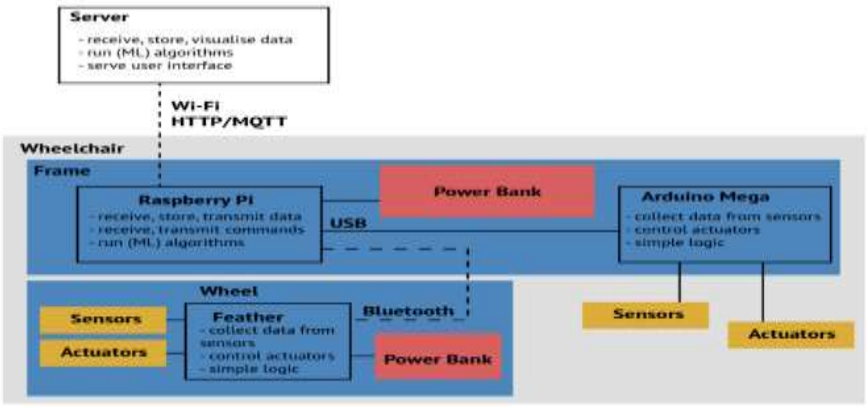

Figure 4. Prototype Framework

Lastly the 4th poster is a data flow diagram which shows the step by step communication flow between the wheelchair components and cloud server. The grey outer layer represents the wheelchair where all the devices will be attached. The technical components consist of a frame branch and a wheel branch. I will be only implementing the frame branch in this project, which consists of a raspberry pi, Arduino mega, three sensors; cables like USB wire that connects the rasp and Arduino, and a power bank for raspberry pi, and different type of jump wires.

The server will be connected to the raspberry pi via WIFI HTTP/MQTT. Each component has a special role in this project which will be discussed in depth the following chapters.

2 Feasible

To conclude, the implementation of all the features mentioned, in this type of research is not achievable based on the following reasons, too many technical components, very short timeframe, many different technical solutions need to be implemented like machine learning, and product analysis, not enough learning material i.e. lectures.

3 Challenges

My learning achievements both skill wise and self-development has very much increased.

I was to mostly alone to figure out the solution for the problem I was facing.

During this thesis process I was faced with many challenges, in order to move forward with the implementation of the prototype. I will be in the following section listing down the difficulties, afterwards I will discuss each of them in depth. To mention some challenges, timeframe, lack of some equipment, lack of skill, lack of communication, too many errors (not in communication with the Dutch course), dutch web server error, Wires arriving really late (additional time till finish), Changing the ESP to Arduino, No video lessons, Technical evaluation/implementation, Improvements: for me, and the course

1. Timeframe of the Dutch course

The IoT course states in the course description document the schedule, on the timetable it demonstrates 8 weeks of schoolwork in which one subject will be focused on for each day. Each of these days has a workshop on the GitHub pages that takes the students through step by step.

Day1**:** 25th February will be the introduction day, which includes material intro, installing and setting up the development environment for Python and Arduino, installing Atom, and installing. The workshop for the intro is names a “Getting Started” on the GitHub page.

Day2**:** 4th of March subject is on Sensors and data, the students will follow the second workshop for this day, is named as the “Workshop 1: Building an Internet-Connected Wheelchair”. Five learning objectives are set for this workshop which are forking the GitHub folder of the Wheelchair design platform to your own GitHub account so you can

Day3**:** 11th of March, Actuators and closing the loop will be on the learning agenda, with the third workshop named “Developing Algorithms and Controlling Actuators”

Day4**:** 18th of March, As the following and coming days there is always a theme for each day, for this data actuators and closing the loop is the theme of the day. The workshop name is “Developing and conducting a data collection campaign. In the workshop the

learning objectives are listed before diving into the reading, which are the following, data for training, machine learning algorithms.
As this algorithm learning area was not part of my thesis objective I left this chapter un-read.

Day5**:** 25th of March, was the Product Analysis day, the learning objectives for the fifth workshop which is used in this lesson are, Training, Evaluating, and Setting the model on the wheelchair. The workshop named as “Implementing a machine learning pipeline”.

Day6**:** 1st April, 8th of April, 15th of April. These last three days of the course most of the learning has been done, and the objectives stated in the course description has been met. The theme for these day responsive design, poster and video exhibition and finally exam.

Term Schedule

Week	**Date**	**Location**	**Theme**
3.3	25 February, 2019, 8:45 – 12:30		Introduction – wheelchair design platform
3.4	4 March, 2019, 8:45 – 12:30		Sensors and data
3.5	11 March, 2019, 8:45 – 12:30		Machine Learning
3.6	18 March, 2019, 8:45 – 12:30		Actuators and closing the loop
3.7	25 March, 2019, 8:45 – 12:30		Product analytics
3.8	1 April, 2019, 8:45 – 12:30		Responsible Design
3.9	8 April, 2019, 8:45 – 12:30		Poster & Video Exhibition
3.10	15 April, 2019, 8:45 – 12:30		Exam

Figure 5. Timetable

As illustrated and described above the learning time frame set for this course was exponentially short, and the learning objective set were very many.

2. Lack of some equipment

I did not have the technical devices needed for the prototype available at the start of this thesis, I was supposed to have the sensors by the second lectures which was on the 4th of march, and but I instead received the order on May, which was a month after the course was completed. For this reason, I concluded that is very unlikely for a student with my circumstances to accomplish much with in this timeframe.

In the recourses, mainly the GitHub page it did not mention the different types of wires needed to connect the sensors to the Arduino and Breadboards. Here are the challenges:

- All the types of wires
- How to install the devices on the chair

3. Lack of skill

As a student who was not very familiar with the topic of the course IoT, and with very little resources needed to achieve my own learning objectives, it become impossible to finish this course within the set time frame, and as excepted I faced many challenges to get to the finish line.

- Familiarity
- Assembling the devices

With my lack of skill in this topic, it became a struggle to, put the project together. To overcome this problem, I had to formalize myself with the general use of the devices.

4. Lack of communication

From the challenge of timeframe, it led to another difficulty for this project, which is zero communication with other students, because the course was done for one month when I

started. Although, I did contact the teacher two times during the project time, one was to discuss the components I need for the small prototype, and the second was about DCD hub server. In general, I had no contact with anybody else form the course.

8. Implementation Process

The purpose of this chapter is to show case the prototype and the steps taken to implement it, describing the process, the tools and the technologies used to achieve it.

As mentioned in the earlier chapters one of the objectives of this thesis is to implement a small prototype from one part of one wheelchair. I will implement a small part of the hospital connected wheelchair which is the wheel part shown in the image below:

Once I figured all the needed technologies, I gave the list to my advisor who put in an order for them. The devices came in way later than the originally planned time, with this mix-up in the timetable I could not achieve some objectives outlined in the beginning related to communicating and cooperating with the students and collecting their feedback at the end of the course.

Since I was not implementing the whole project plan, I had to focus on one area. I consulted with the professor of the IoT course on exactly what devices I would need and how I was to use them. It was only I season and guided me very well.

Additionally, due to lack of some wires there was one sensor I could not include in the prototype, which was the proximity beacon.

In the first part of this chapter I will explain the tools and technologies used in the framework, and in the second part I show case the prototype I implemented, and the steps taken to achieve it.

Once everything was set the next step was to structure the phases of the implementation: I started with reading through the workshop so I could get a clear picture of the

steps, which then I started to implement each workshop the content of each I have explained on chapter 3.

I had to also found external resources on the internet to know how to connect the breadboards, Arduino Mega 2500 and the sensors.

In this stage I faced the problem with the Beacon sensor, to connect this type of sensor to the breadboard or a micro controller it needs a special type of wire which I could not obtain without further extending the time of the thesis.

Shortly after I realised it was not easy to connect raspberry pi with the Esp32, so I decided to leave this device out of the project and instead use the Arduino Mega 2500

During this stage I had:

- Installed all needed software
- Setup Arduino and Raspberry pi
- Setup the DUC hub server
- Run the example code on each micro controller
- Connected each sensor to the Arduino and run the example code
- Connected the Arduino to Raspberry pi through USB port

At this point I was receiving the sensor data to the Arduino, I had to find a solution to collect that data through to the raspberry, there was two possible options for this to be implemented, but in this project, it was done through the serial port.

From this point on words the implementation was finished I followed all of the course material and used my own research to reach this point.

9. Learning Curve

The learning process started with looking through the course online material in which everything was written in micro-python and C. Micro-python was quite familiar to me from previous personal projects, I followed the examples provided in the course material to setup the IoT devices, beforehand I needed to understand the meaning of the codes before implementation.

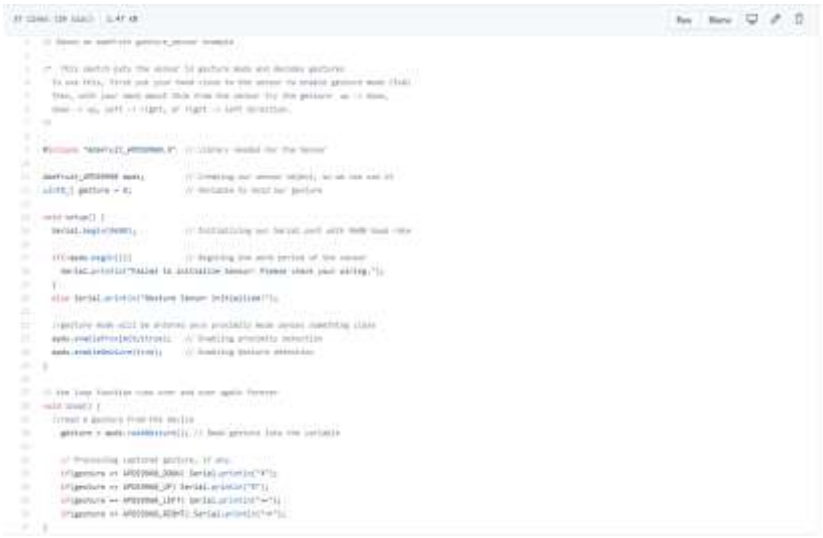

Figure 6. Gesture Sensor

The aim of the code above is to set the device into gesture mode, detect the movements around it and display them as up, down, left, right. This is implemented by importing the needed library Adafruit_APDS9960.h which is used to setup the sensor object. The ports where initialized through the setup method, if the ports are initialized correctly it will print “Gesture Sensor initialized” the apds.enableProximity and apds.enableGesture are both set to true which will detect the objects close to it and the movement direction of the object. Finally is the loop which runs over and over again, assigns the gesture variable to apds.readGesture and puts the content of the gesture through an if arguments and printing the arrows for each direction.

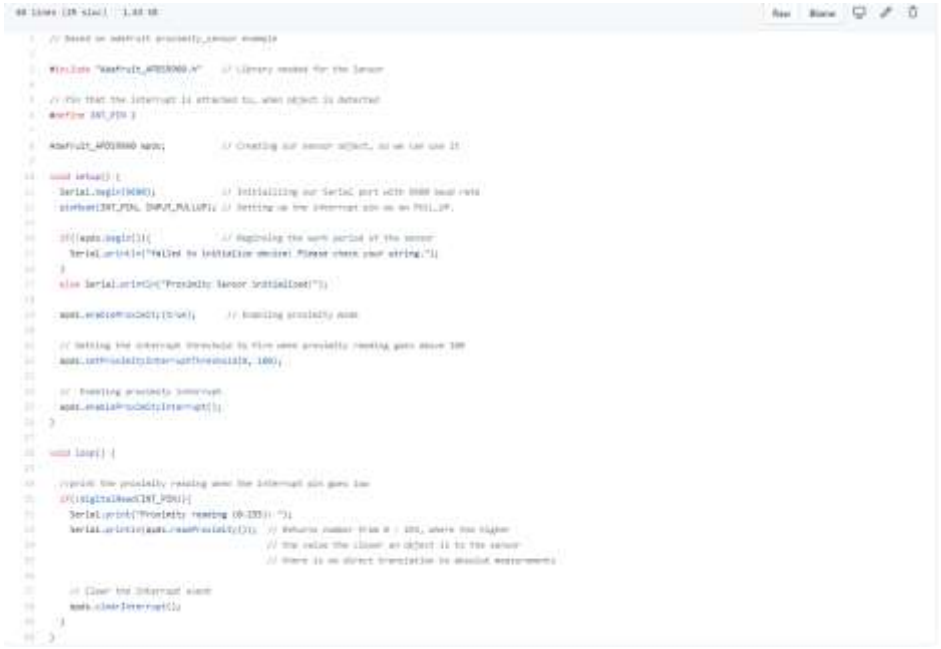

Figure 7. Proximity Sensor

The proximity sensor example is based on the Adafruit sensor which is a different to the one I used but the examples works on both. The Adafruit_APDS9960.h is imported, the int_pin 2 and apds is set. Setup method is next which initializes the serial port and the interrupt pins. If the apds.begin does not start it prints “failed to initialize device! Please check your writing.” Or if it has been initialized the code the prints “Proximity Sensor initialized!” and enables the proximity mode which makes the device sensor objects close by.

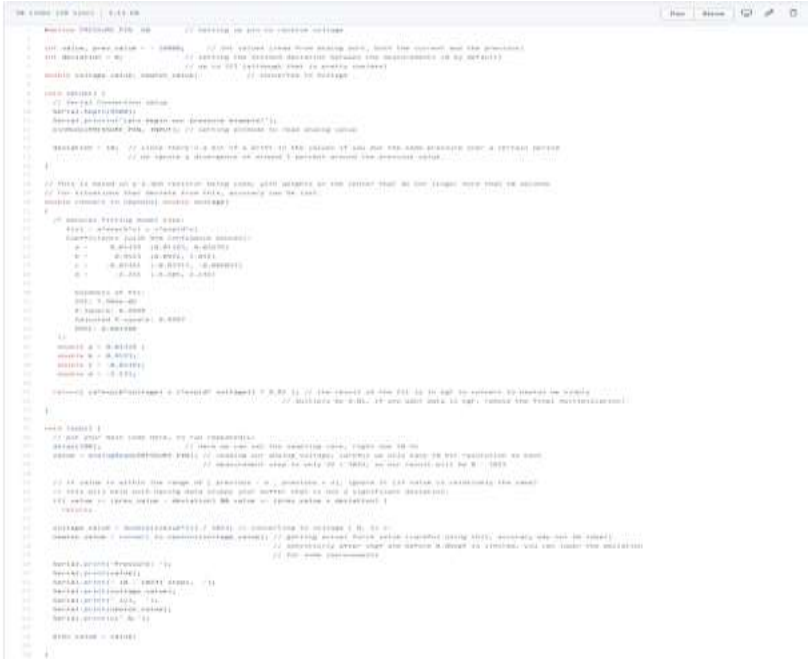

Figure 8. Force Sensor

First the PRESSURE_PIN variable was set to A0 which is where the code reads the voltage from, which was followed by setting and initializing the value, previous value, deviation, voltage value, and newton_value variables. The setup convert_to_newtons, and loop contain the code login. Serial connection is setup first in the method which prints “Lets begin our pressure example”, and pressure pin modes which read analog signal. In the second method newton_value the return value of the is set mathematically. Finally the loop prints the serial values of analog Read and newton_values.

On the other hand, the C language was complete new to me, I went through online websites which detailed the basic functional operations of the language and how to use them.

10. Discussion

This thesis was conducted during May-November 2019. It was particularly easy to write the documentation and analyses phase as I had to already completed most parts of the prototype and just was writing about my experience.

While analysing I utilised all the resources on the course including student chat area to obtain data that supported my conclusions.
For implementing the prototype, I was very anxious in the beginning but later I came to the understood that the main goal was to implement, analyse and document and not the proficiency of the prototype.

There was one course offered in my curriculum that had helped me in some parts of the implementation phase, so I was familiar with connecting micro-controllers to sensors, collecting the data and analysing it. Which in result I managed to follow the course material and external resources to get the tasks done.

The main goal I achieved from this experience is understanding independent learning is unique, and each person has their own style of processing information. So, I examined my learning tendencies, preferences, habits and changed my environment to meet those so that I could be as efficient as needed.

Here is an evaluation of my own learning skills before and after this project:
Dependent learning:
The level of my learning tendencies during the start of the project included needing assistance from tutors in which they had to take responsibility for my learning experience, I expected them to be experts in the field, assess and examine my progress, also to provide constant encouragement and reinforcements. On the other hand, I assumed my responsibilities included being willing to learn, follow the instructions given, and learn only the re-

quired material. Although these are very important points for basic level learning with tutors who are in the same physical location, these qualities are not enough for students who are distant learning in isolation.

I developed all these learning tendencies starting from my childhood. Which I was dependent on mentors, parents, in need of guidance to push me forward.

Independent Learning

I evolved to an Independent learner, Collaborator, Self-evaluating researcher, these skills will be very useful for my future independent studies. From this point on in my new learning experiences I will anticipate my instructors to be a listener, consult me, evaluate, develop, and encourage in moments of sharp change.

The overall conclusion of this thesis is good, since I learned a lot, but all of the learning objectives were not met regarding the implementation of the prototype, I did not fully implement the small part of the hospital wheelchair I choose in the beginning of the project, and I have mentioned the reasons in the previous chapters.

To recap there was additional wire missing needed for the proximity beacon. I tried to obtain the specific wire, but after some miss understandings it was impossible to get this without extending the timeframe of the thesis which was not something I could afford. Regarding collecting feedback from the students, it was not possible to achieve this also as mentioned multiple times in this document, the Dutch IoT course had already finished when I was starting the project.

In regards of the overall learning objectivises of this thesis and the research question outlined in the beginning which where analysing Dutch IoT course for feasibility, choosing and Implementing a small prototype, and reflecting on the learning and co-operation with the Dutch course students. All of these where met and written about in this document.

Future student doing this type of thesis, I would advise not to start working on the project before main course starts, if so these types of difficulties will be met which can be avoided.

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