NTNU

Norwegian University of Science and Technology
Department of Engineering Cybernetics
Department of Electronic Systems
TELE3001 Bachelor Thesis

Project Description Report
Biped Robot Prototype

Group E2023

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1 Abstract

This project has been given by the Department of Engineering Cybernetics at NTNU. The project revolves around a robot with two legs, and the main goal for the robot is for it to walk on its own. Right now the robot is in a development-phase, and our goal with this project is to push the robot one step closer to completion.

Our main focus in this project is to improve current hardware, wiring and communication between these parts. We will be working on how to collect real-time information from the system, and research implementation of a PID-controller. While doing this, we are creating a GitHub-based collection of the codes and data for this robot.

This report includes a description of the robot, an overview of the problems we will be working on, and how much time we will be using on each subject. The last pages of this report consists of different attachments that further explains different sections.

2 Preface

This report is just a preliminary report. The main report will be handed in on May 20th 2020. This project is the final part of our 3-year study here at NTNU. It is weighted with 20 school points, that is equivalent of 500 hours of work for each student. The assignment is given by the Department of Engineering Cybernetics, NTNU.

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4 Introduction

4.1 Background

In todays world robots make out one of the most important pillars of industry and aviation. If we as engineers wish to stay in touch with today's achievements and today's trends in industry, we must try to understand what is the theory and practical applications behind implementations of robots. Robots are meant to do a job humans can't do or just replace humans altogether despite the fact that humans are capable of executing certain tasks.

All of the things mentioned above are the reason why it is imperative for us as the young engineers to do the research on these kind of subjects since we are sooner or later going to encounter robots in one form or the other in our respected fields.

One of the things that are interesting to us are robots which are able to mimic human or animal like way of walking. Applications for these kind of robots are numerous. Most of the robots which are performing these kind of movements are required to perform certain tasks outside of the factory floor that is either in nature or in some other kind of pre-prepared ground. Here at NTNU we have a robot which has been built with aluminum squared tubes. It has a torso and a pair of legs. Torso has no practical functionality other than to mimic the weight of the robot and to store some of the instrumentation that we are going to use in this project. Legs on the other hand are going to allow the robot to walk and are made in a way which secures the robot, or at least they are meant to give the robot greater stability when it comes to lateral movements which can occur during walking.

That is the reason why our robot legs are not typical legs where we have a single rod that is touching the ground, but instead they are almost like chair legs where each leg has two contact points with the ground at all times.

With all of this said we can say that our robot is already finished when it comes to its structure. It is also important to note that in our work we are going to use the work of the group that wrote their bachelor thesis last year and build upon it. Some of the shortcomings which have been noticed in the instrumentation and communication are going to be fixed.

4.2 Glossary

Arduino is an open-source platform and a software used to program it. Distribution and usage of this platform is unrestricted by anyone.

Beagelbone Black is a low-cost, community-supported development platform for developers and hobbyists. It is unregulated platform and is programmed using Linux.

Microcontroller is a small computer that is present on an integrated circuit which is meant to perform different tasks and execute different commands.

Servo is a small motor that has a built in circuitry that allows us to control it using either Arduino or some other software.

Encoder is en electronic device which translates physical movement of the measured object and converts it to digital signal such as BCD code.

C/C++ is a general purpose programming language that can used to program an Arduino or other hardware.

Linux is an open source operating system based on the linux kernel.

dSpace is an open source repository software package.

Microsoft project is project management software developed and sold by Microsoft.

IMU or *Inertial measurement unit* is an electric device which measures and reports angle, angular valocity and orientation to the object it is attached to.

Matlab is a high-performance language for technical computing that is very easy to use and is suitable for automation simulations.

Servo controller is a device which is used to control power output of servo motor to a desirable value.

PWM or *Puls-width modulation* is the signal tasked of controlling amount of power motor or some other device is subjected to.

Dual power supply is device that allows us to give our instruments and actuators a precise amount of power which is constant and stable in nature. It also secures equipment from any system damage which might occur.

PRU is a programmable real-time unit, a specialized chip on the BeagleBone that are separate from the main CPU.

5 Group members

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About me: Youngest guy in the team and of the bosnian origin. Lived in Bergen for four and a half years where I finished high school before moving to Trondheim in 2017. I'm a guy who spent a long time in team sports which has made me aware of how groups work and how one should behave when it comes to engaging themselves and others in the team for the better of the whole project. Other than that I am a person who likes to work in groups especially when I'm around people who have the same amount of enthusiasm as me.

Competence: I finished general studies in high school and after that I started to university so I have no practical experience. With that said I am very good in theoretical subjects like math and physics. When it comes to programming only experience I have is in Matlab/Simulink and Arduino based C++ but I am very much open minded when it comes to learning new stuff especially Linux.

Schedule and motivation: As of right now and further into the semester I am pretty free from monday to friday. Weekends are a bit more busy since I work part-time as a basketball referee. Other than that I am more than motivated to work on this project and. I thing that it is interesting and hope that I will learn a lot of new skills.

Expected result: When it comes to expected result thing are quite straight forward in a way that I expect myself and my colleagues to give our best effort which would resoult in grade A.

Name: **Christoffer Bakken [CB]**

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Studying: Electrical Engineering, Automation

About me: Born in Fredrikstad and spent my years as a child in Råde before moving to Trondheim in 2015. After trying different studies the first years, I settled for Electrical Engineering at NTNU in 2017. In high school I specialized within subjects concerning natural science while working at a local McDonald's restaurant on the side, especially during the summer. In my freetime I spend my time cheering on Liverpool FC, watching Netflix, spending time with friends and having an abnormal big interest in American politics.

Competence: I consider myself very good in theoretical subjects like math, physics and so forth. When it comes to programming I only have experience with MatLab and Arduino, but I would concider myself very adaptable to new languages.

Schedule and motivation: Right now my schedule is filled, and I am planning on applying for a temporary leave at my current part-time job here in Trondheim. After doing that, my only commitments will be working as a student assistant for the university and working with the other subject I have to attend this semester.

Expected result: I expect my group to put in an effort that results in the grade **A** for this bachelor thesis.

Name: **Martin Skårerverket [MS]**

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About me: Born and raised in Lørenskog, Akershus. After i finished my high school education, which included studying one year abroad in The United States, I decided to pursue an education in science or engineering. I moved to Trondheim in 2016 to complete a preliminary course in science and then went on to studying electrical engineering with a specialization in industrial instrumentation. In my spare time i enjoy riding my road bike and playing golf, before i moved to Trondheim i also played ice hockey. I am a huge football fan and a supporter of Liverpool FC, but i am also interested in many other sports, especially American sports such as American football and ice hockey.

Competence: I Graduated from Mailand VGS in general studies and completed a preliminary course in science at NTNU. I started studying electrical engineering with a specialization in industrial instrumentation in 2017, this has given me practical and theoretical skills in electronics and programming.

Schedule and motivation: My schedule is very flexible and most of my time this semester, will be used to work with this bachelor thesis. My motivation for this project is to work efficient throughout the whole project period, apply my knowledge from my studies to the thesis and acquire new knowledge during the bachelor thesis.

Expected result: My goal for this bachelor thesis is to achieve the grade A.

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Studying: Electrical Engineering, Electronics

About me:
Grew up in the Small city of Måløy. i'm a very curious person with many hobbies that range from, electronics and rocket science, to sports and politics. In my "free" time i read books about science fiction, fantasy or self improvement. Other than books, i have an interest in programming and a big supporter of "open source". apart from electronics and other technical skills i love scuba diving and try to run a half-marathon once a year.

Competence:
Graduated from Måløy videregående skole in General studies, finished a bachelor's degree in automation at Høyskolen på Vestlandet. I started studying my second degree in electrical engineering, with a specialisation in electronics in 2017 at NTNU. I feel i can bring some knowledge to the group in the fields : C++ programming, C#, web programming and networking in general, raspberry pi, micro-controllers, FPGA programming and a "knack" for solving difficult problems.

Schedule and motivation:
I plan to use as much time as possible on this assignment, i have a really flexible routine, and can work long hours each day. my motivation on this project is to learn more about how robots are build, from a technical view. i also thing its going to be interesting to see how my knowledge is going to be used in this project, and to share my knowledge to the other members of the group.

Expected result:
I expect both me and other members to work towards the grade A, but also to learn from each other and end up better prepared for team projects of this kind later on.

6 System description

This paragraph is going to quickly describe how our system works and how was it built by the engineers here at NTNU. It is important for us to highlight that here we will not give our opinion on how it should work. Nor what our goals for it are going to be, but rather how it performs as of right now taken in consideration what job was done prior to us on the same hardware. Here we are also going to include parts list which includes hardware parts that are incorporated on our frame.

Description	**Product name**	**Manufacturer**
Flexible actuator coupler	4779823	Ruland
Hip bearings	6004-C	Fag
Electric motors for leg actuation	14887	Maxon Motor
1-to-6 Gearbox for motors	Planetary Gearhead	Maxon Motor
Servo controllers for motors	ESCON 70/10 (422969)	Maxon Motor
Servos for retractable feet	S9254	Futaba Corporation
Encoders for relative leg angles	2RMHF	Seancon
IMU (accelerometer, gyro, magnetometer)	Breakout-LSM9DS1	Sparkfun
Power supply	QPX600D	Aim-TTI
BeagleBone Black	BeagleBone Black	BeagleBone

Table 1: Hardware components that are found on the body

6.1 Frame

The structural part of our mechanism is the frame. It is made from aluminium square tubing which are hollow and most of them have pre-drilled holes so that screws could be used for either attachment of some other components, tubes or simply to give us an opportunity to adjust some sort of gadget on a specific place where it is desired.

6.1.1 Torso

When it comes to the torso, we note that its has a large plate on it who's task is to accompany all of our instrumentation equipment. The soul purpose of the torso is such that it stores all of the most important parts of our system, those that are used to control the robot. Besides that one of the other intentions behind torso is that makes robot more realistic in a way that it ads weight to the whole structure and introduces another degree of freedom to the already inherently unstable structure.

6.1.2 Legs

Our contraption has rather interesting legs, something which one would not normally consider when word robot is mentioned. Just as the rest of the body it is made out of aluminium square tubing where multiple holes are drilled in the lower part with the basic purpose to accommodate different devices that have to be secured with screws on a specific spot where it must be located due to technical requirements. In a way these legs bear resemblance to the legs we find on old school chairs. Where we have two rods that are connected and are parallel to each other. The purpose of this design is to eliminate lateral

movement which would occur while the whole body is on the move, thus eliminating the possibility of robot tipping over to its side and falling down in that kind of manner.

6.2 Communication and control

Our robot's nervous system is the BeagelBone circuit which processes all data and information that comes from sensors and controllers. All components utilized on the robot are communicating either directly or indirectly with the BeagelBone which has direct control of the actuators. Currently all I/O was controlled by dSpace, something that we concluded would not be necessary in our case.

6.3 Power supply

Power supply that we are using is capable of delivering 600W of power. Range for the voltage is from 0-80V and for current it is from 0.01-50A. It has two channels where each has its own power terminal and ground terminal. As off right now, one channel is reserved for motor while other is reserved for instrumentation. Power supply offers diverse envelope of voltage/current combinations that we can use in order to get certain power output, which one we will use shall be determined by component consumption and cable characteristics.

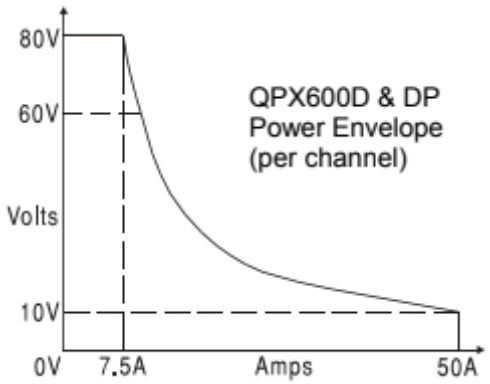

Figure 1: Chart showing power envelope this unit is capable of delivering across both channels

6.4 Actuators

On this robot we have altogether six actuators. Four on the lower legs and two on the upper side of the legs. Those two that are found on the upper side are motors which control each leg separately. They are operating motors that are capable of exhibiting 3Nm of maximal torque force. Their sole purpose is to drive the legs and to supply the force to the lower part of the robot which is in turn going to make legs move forwards mimicking the human walk.
Motors are controlled by a ESCON Maxon servo controller ensuring precision in power that is delivered to the motor whos job it to make sure the movement of the leg is as precise as possible. In addition to all of that motors are also equipped with a encoder who is monitoring position of the motor axis thus also monitoring position of the leg.

On lower side of the legs we have four small size servo motors who's job is to drive the spike that is found on the end of each leg. There are four of those motors and each one uses 4,8V PWM signal which comes from our BeagelBone. They have an important role of lowering and extending the spikes that in turn allows it to make a next step without tripping forward.

6.5 Measurements and instrumentation

In order for us to be successful in this task, proper instrumentation must be present. It is tasked of measuring precisely all the values relevant for us. With that said the most important condition that has to be monitored is the inertia/speed structural parts are moving in certain direction, and position of the motor axis used to move the legs.
On torso we can find an IMU device who's responsibility is to measure and detection movement and position. Our IMU has 9DOF or 9 *Degrees Of Freedom* that would in term mean that it can measure acceleration, angular velocity and magnetic field. Acceleration, angular velocity and magnetic field each can be measured in three axis and that is why it is said that this IMU has 9DOF. Components like this can detect accelerations that are quite big in amplitude but since our IMU will not be installed on a rocket, we do not need to use setting that can detect grater forces than $\pm 5G$ since our IMU has adjustable range from 2 to 16G. Setting the range to $\pm 16G$ would lead to inaccuracies in measurement of small accelerations and forces.

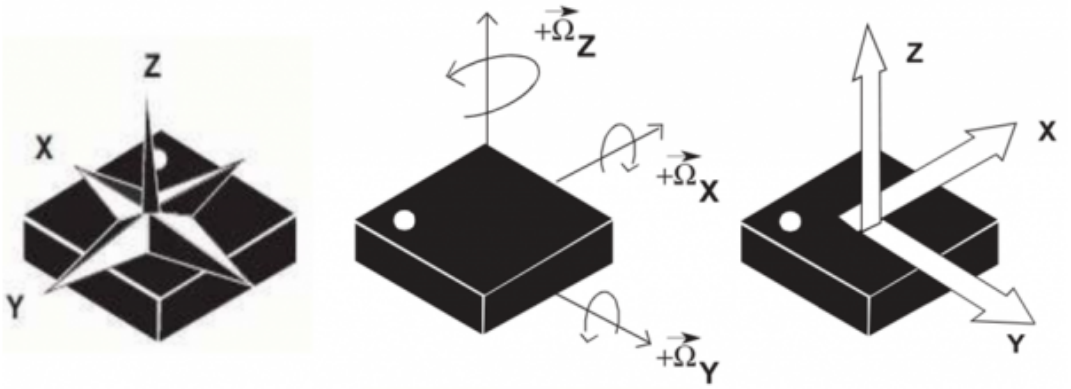

Figure 2: Axis orientation for accelerometer, gyro and magnetometer

On the lover half of our robot we have motors which are driving the legs. For us it is imperative that we are aware of the position of the legs at all times. We are going to achieve this through the use of encoders that are directly connected to the motor shaft. Position of the motor shaft shall be used to determine in which position legs are currently in. Our encoder is powered by 5V and and a max current of 0,35mA. It possesses resolution of 3000PPR and can go up to maximum 7500 PPR (*Pulses per revolution*) according to the datasheet, which means that we will be able to detect changes in the position of the leg quite precisely.

7 Problem statements

In this section we explain what the main priorities our research will focus on.

7.1 Hardware documentation and improvements

We need to get to know in detail how the robot's wires is connected right now, and we are planning on replacing the current PCB with a more structured one. The robot currently uses SPI as transmission protocol to transfer data from the IMU to the BeagleBone, this has caused problems in previous work. Our job is to improve the current way of transmitting data from the IMU to the BeagleBone or find an alternative solution.

7.2 Establishing GitHub collaboration

GitHub is a company that provides hosting for software developments. It serves the same purpose as "Dropbox", "OneDrive" and so on, but specializes towards software coding and makes that accessible to other people who wants to work on the relevant software.

7.3 Further development of BeagleBone

Currently not all the desired functionality of the robot are preformed by the BeagleBone, our goal is to further develop a solution where the robot is operational with only the embedded hardware mounted on the robot and a external power supply.

7.4 Real time logging

As of this moment, there is no way of reading measured data from the robot in real time. Implementing a real time logging system of measurements will make interacting and developing control systems of the robot much more efficient.

7.5 Research PID-controller implementation

An underlying established fact about robots in daily life is that they can work independently from humans in one way or another. With this robot, the overall objective is for it to be able to walk on its own without human interaction. Implementing some kind of PID-controller is something we will be researching.

7.6 Documentation

All programming, physical changes and implementations regarding the robot during this work period is to be documented in an efficient and structural manner. This will make it easier for other people to work on and learn about the features of the robot in the future. The documentation is of course the main part of our Bachelor thesis also, including the discussions around the documentation.

8 Technical Details

8.1 Project objective

This robot has been in the development phase for some years now. It has been the subject of several assignments at NTNU, including Bachelor-, Masters- and PhD-dissertations. Our overall goal of this assignment is to contribute with research and implementations that pushes the robot one step closer to a finished product.

8.2 The preliminary goal

Our preliminary goal is to use all of the research and achievements of the group that worked on the same robot while they were writing their bachelor thesis back in spring of 2019. Our goals may change as we are going forward with our research. All aspects of the system that are in our opinion not sufficient or are lacking some major parts will be changed or replaced. With all of this said it has to be noted that we are using old research as a baseline for ours which means that certain parts can be changed if there is an obvious need for it.

8.3 Specific outcome goals

- Develop a real time logging system for the robots dynamic variables.
- Improve current hardware and build new PCB
- Gather all software data in a GitHub collaboration.
- Research the implementation of PID controller on the robot.
- Repair the current or implement a new servo system for the legs.

8.4 Specific process goals

- Develop a realistic, efficient and good work environment that reflects how a major project would be handled in the business-world.
- Produce a product that the client would consider a valuable investment with time and resources.
- The group will work together following the internal rules established in the work agreement that all group members have signed.
- Ensure good communication with our mentor/employer and have a organized, joint system of collecting and saving documents and files.

9 Risk assesssment

9.1 Physical hazards

Since our work is going to be based on a piece of hardware that in itself includes moving parts, it can be said that in those kind of conditions there are always going to be certain hazard we need to address. The most prominent one is the possibility of getting our finger, or a piece of cloth stuck in a moving part. Which in turn could result in harm to both us and the robot. Other physical damages that can be done to us and to the robot is electrical shock.

These can occur while being in direct contact with the robot or the wiring that is supplying the components with energy. As of right now the power supply is the most dangerous peace of equipment found in our proximity. That in term forces us to take precautions when we connect equipment to the power supply. The precautions are as follows: At every moment we must be aware of which voltage and current our hardware can handle in order to prevent worst case scenario from happening, and have full control over the different wires and connections.

9.2 Planning and time tabling aspect

The most important part of any project is the planning itself and how we distribute time and tasks amongst ourselves. Making mistakes in time management where we either underestimate or overestimate our use of time can have bad consequences for us. This can result in inefficient use of time in our work or in worst case scenario we don't have enough time to finish our task or the rapport. With all of that said we consider this area as one of the greatest possible problem areas for us. Making a mistake in work distribution, or that one of us has problems with accomplishing a certain task is not our biggest issues. Because at any time we can expect other members to help each other in solving those tasks together.

9.3 Exams

Possible problem areas could be exams in March and May, since our work plans does not takes those exams into account time wise. We decided, that these exams are not going to take up much time in our time tables, since studying for the exams are expected to be done in our "free" time and not work hours. The exams have no dates yet, so a possible collision of dates or a slowing of progress could happen.

10 Work structure and environment

In this section we discuss how we are planning the work that has to be done and the benefits of having an organized structure within in the group.

10.1 Agreement between group members

The first thing that was established when the group got together was to put in place a group agreement. This agreement can be seen as the group's constitution. It establishes the rules for how group members are gonna handle and react to different situations that might occur. It addresses how everyone is expected to put in their best effort for this project, how to notify the group about not being able to attend a meeting or a work day, how the group should handle internal difficulties if that should happen, and much more regarding the efficiency and structure of the group. This agreement is written in Norwegian and is included in this report as "Attachment B".

10.2 Agreement with mentor/employer

An agreement between the bachelor group and the mentor, who also acts as the employer on behalf of NTNU, has been signed and is included in this report as "Attachment A". It is the official document that establishes our bachelor thesis for this semester.

10.3 The benefits of having written agreements

The fact that everyone has put their signature on a piece of paper that dictates this project period makes the whole project it self look much more serious. Everyone in the group knows that not following the established rules will result in some sort of consequences. By signing a group agreement, each member is expected by everyone else to put in an effort that gives a results the group is satisfied with. It makes it much harder to be lazy and not taking this assignment serious. And of course, each member can now rely on the fact that everyone will do their best to make the project succeed and strive toward a work environment.

10.4 Time management

We have put a lot of time into planning how much we are expecting to work with different problem areas. This is to ensure that we deliver a good project in time. It is very difficult to assume how much work will go into each problem area since this is our first major project, and there is a lot of new theory and software that we need to use. The current timetable that is presented in this report is therefor subject to changes in the future, depending on how the project evolves. In order for us to have a good structure of time, each member is expected to follow the guidelines outlined in the group agreement.

10.5 Work structure

After deciding on what to work with in this project, we created work-packages for every problem statement. These are attached to this report as attachment C. Here we outline how much time is expected for each problem, who is assigned to work with each problem and a specific description of work that is planned to be done.

In order for us to get a clearer view of the work packages, we used an application called *Microsoft Project 2016*. This program gives us the ability to put in every work package created, and it produces a figure showing the work that is planned over a period of time, a so called Gantt-diagram. The Gantt-diagram makes it much easier to keep track of the progression we have made.

10.6 Work strategy

In 2019, there was another group working with this robot for their bachelor-thesis. They structured their work by making one part of the group working on one subject, while the others worked on something else. We have gone in a different direction.

We are planning on making everyone in the group work together on every problem statement outlined in this report. We want everyone to gain as much knowledge as possible, and since we have specialized in different subjects at our study, we are eager to also learn from each other. We have structured our work packages in such a way that the work-packages don't overlap each other when it comes to time. Instead we have structured it in such a way that they glide into each other. There is one exception to this in our planning, and that has to with implementing the PID-controller and establishing real-time logging. For those two problems, we decided that we will not be spending equal time. There is a risk by having every group member work on one issue. It could result in someone not having anything to do because the amount of workforce available exceeds the available workload. That is why we made the problem statements glide into one another over time. Should this occur, it is possible to start on the next work package earlier than planned.

10.7 The Gantt-diagram

The way we have built the work packages gives the project 4 milestones. A milestone is defined as the end of a major part of the project.

Figure 5 shows the first milestone that will be achieved. We refer to this period as "Phase 1". It consists of improving the hardware while establishing and documenting it in GitHub. We will also start learning Linux and C++ coding during this phase. Each phase in this project has been given its own work-package called "Documentation". This is to ensure we start writing on the main project as early as possible.

Task Name	Duration	Start	Finish
1 Old documentation	5 days	Mon 03.02.20	Fri 07.02.20
2 Get to know GitHub	5 days	Mon 03.02.20	Fri 07.02.20
4 Documentation - Part 1	20 days	Mon 03.02.20	Fri 28.02.20
3 Improve wiring and PCB	15 days	Mon 10.02.20	Fri 28.02.20
5 Learn Linux and C++	21 days	Mon 17.02.20	Sat 14.03.20
6 Learn BeagleBone	20 days	Mon 02.03.20	Fri 27.03.20
7 Documentation - Part 2	20 days	Mon 02.03.20	Fri 27.03.20
8 Realtime OS	20 days	Mon 30.03.20	Fri 24.04.20
11 Documentation - Part 3	31 days	Fri 03.04.20	Fri 15.05.20
9 PID-controller	20 days	Mon 20.04.20	Fri 15.05.20
Editing final report	4 days	Fri 15.05.20	Wed 20.05.20
Prepare oral presentation	8 days	Thu 21.05.20	Sun 31.05.20

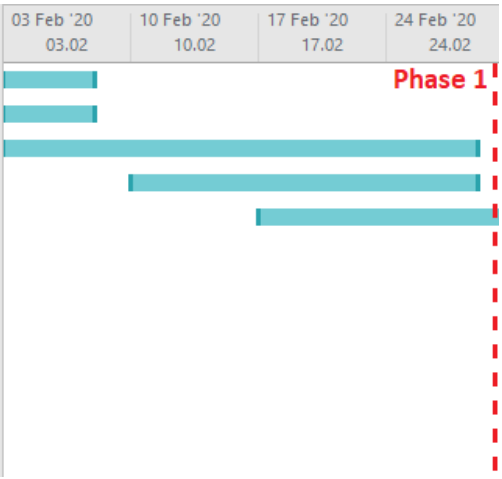

Figure 3: Phase 1 of project plan

Phase 2 consists of further developing the BeagleBone. The goal is that the robot is operational with only the embedded hardware mounted on the robot and external power supply.

Task Name	Duration	Start	Finish
1 Old documentation	5 days	Mon 03.02.20	Fri 07.02.20
2 Get to know GitHub	5 days	Mon 03.02.20	Fri 07.02.20
4 Documentation - Part 1	20 days	Mon 03.02.20	Fri 28.02.20
3 Improve wiring and PCB	15 days	Mon 10.02.20	Fri 28.02.20
5 Learn Linux and C++	21 days	Mon 17.02.20	Sat 14.03.20
6 Learn BeagleBone	20 days	Mon 02.03.20	Fri 27.03.20
7 Documentation - Part 2	20 days	Mon 02.03.20	Fri 27.03.20
8 Realtime OS	20 days	Mon 30.03.20	Fri 24.04.20
11 Documentation - Part 3	31 days	Fri 03.04.20	Fri 15.05.20
9 PID-controller	20 days	Mon 20.04.20	Fri 15.05.20
Editing final report	4 days	Fri 15.05.20	Wed 20.05.20
Prepare oral presentation	8 days	Thu 21.05.20	Sun 31.05.20

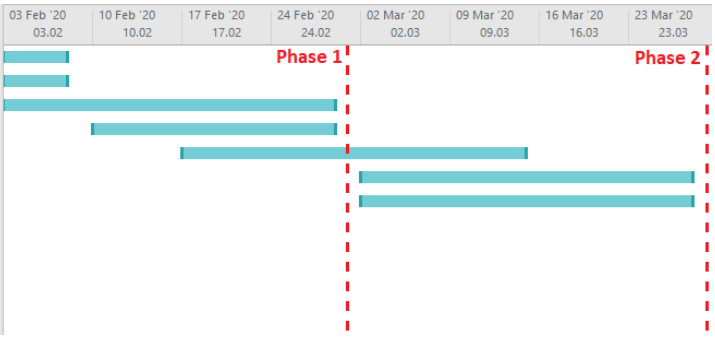

Figure 4: Phase 2 of project plan

Phase 3 consist of researching a real-time logging system for the robot. While doing this, the group will split into groups of two, and someone will start working on a PID-implementation for the system.

Task Name	Duration	Start	Finish
1 Old documentation	5 days	Mon 03.02.20	Fri 07.02.20
2 Get to know GitHub	5 days	Mon 03.02.20	Fri 07.02.20
4 Documentation - Part 1	20 days	Mon 03.02.20	Fri 28.02.20
3 Improve wiring and PCB	15 days	Mon 10.02.20	Fri 28.02.20
5 Learn Linux and C++	21 days	Mon 17.02.20	Sat 14.03.20
6 Learn BeagleBone	20 days	Mon 02.03.20	Fri 27.03.20
7 Documentation - Part 2	20 days	Mon 02.03.20	Fri 27.03.20
8 Realtime OS	20 days	Mon 30.03.20	Fri 24.04.20
11 Documentation - Part 3	31 days	Fri 03.04.20	Fri 15.05.20
9 PID-controller	20 days	Mon 20.04.20	Fri 15.05.20
Editing final report	4 days	Fri 15.05.20	Wed 20.05.20
Prepare oral presentation	8 days	Thu 21.05.20	Sun 31.05.20

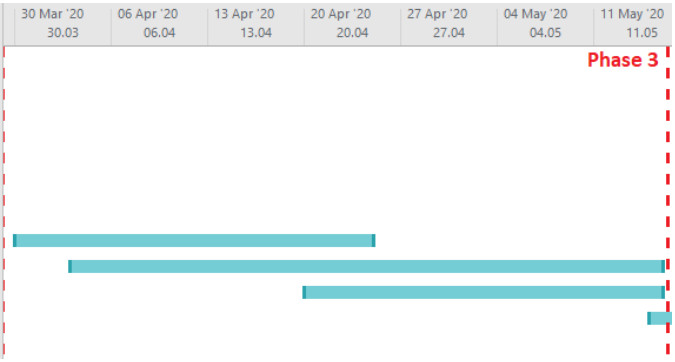

Figure 5: Phase 3 of project plan

The last phase, "Phase 4" is not included in this Gantt-diagram. It consists of finalizing the main report for this project and start preparing for the oral presentation in late May/early June. The complete Gantt-diagram is included in this report as attachment E.

10.8 Project meetings

During this project we plan on conducting 2 project meetings each month. These meeting will be attended by this group and the supervisor. The project meetings will consist of us summarizing the work that has been done so far and the supervisor giving us feedback he seems necessary. We will contact the supervisor during Phase 1 of the project to arrange and agree on fixed times for the project meetings.

11 Expected outcome

11.1 Educational benefit

Each member of the group has a desire to learn as much as it is possible from this project in a time frame that was set upon us. With that said our goal is also not just to educate us on different programming languages but also to have more cross field learning that would mean that we will collaborate between us in order for every member to learn something from each other's study direction. as an example automation students are going to get better at programming and instrumentation than what we know now, and instrumentation/electronic engineers are going to get better at automation aspect of the project like implementing and programming controllers and actuators.
With everything said the most important outcome for everyone is the fact that this bachelor thesis is going to be an excellent challenge rooted in real problems and that crosses different fields of industry, booth automation,electronics, and Instrumentation in one project. This is something engineers have to tackle every day in many job positions.

11.2 Communication

At the conclusion of this project, the group is expected to present a comprehensive report that explores and enlightens the previously stated problem statements and can give a basis for future work with the bipedal robot project. The group will continually have communication throughout project with the project supervisor, this communication will primarily be in the form of scheduled meetings where progress and problems during the project will be discussed. At the end of the project period the group will present their final thesis with an oral presentation for the project supervisor.

11.3 Robot

At the conclusion of this project we expect the robot to be fully controlled by the embedded hardware mounted on the robot and an external power supply. This means we have successfully incorporated all or most of the existing instrumentation and development off the robot into a functioning development platform for future work. We expect to preform simulations on both legs of the robot, and continue the work of prior projects containing simulation and modeling of the robot. We also expect to create extensive documentation of the robot using GitHub, to make future work with the robot project easier in the future.

12 References

[1] Hjulstad, J. *et al.* "Instrumentation of biped prototype - Project description report". Norwegian University of Science and Technology, Trondheim, Norway.

A Agreement between group and supervisor

NTNU

FAKULTET FOR INFORMASJONTEKNOLOGI OG ELEKTROTEKNIKK

AVTALE

Avtale for gjennomføring av bacheloroppgaven mellom NTNU, oppdragsgiver (firma, etat) og student(er).

Avtalepartnere

NTNU Institutt for teknisk kybernetikk	Veileders navn/telefon/e-postadresse.: • **Torleif Anstensrud** • 95808760 • **torleif.anstensrud@ntnu.no**
Oppdragsgiver (Firma/etat): NTNU Institutt for teknisk kybernetikk	Kontaktperson/navn: **Torleif Anstensrud**
	Telefon/e-postadresse/adresse: 95808760 **torleif.anstensrud@ntnu.no** **Elektro D/B2, D439, Gløshaugen, O. S. Bragstads plass 2**
Student: **Christoffer Bakken**	
Student: **Jonas Brunsvik**	
Student: **Irfan Ljevo**	
Student: **Martin Skårerverket**	
Prosjekt-tittel/arbeidstittel	**Videreutvikling og testing av tobeint robotprototype**
Prosjektnr.	**E2023**

Andre relevante dokumenter: Prosjektmanual Bacheloroppgaven.

Avtalen angir avtalepartenes plikter vedrørende gjennomføring av prosjektet og rettigheter til anvendelse av de resultater som prosjektet frembringer.

1.
Studenten(e)/prosjektgruppen skal gjennomføre prosjektet i perioden fra januar 2020 til 20. mai 2020.

Studentene skal i denne perioden følge en oppsatt fremdriftsplan der NTNU og oppdragsgiver yter veiledning. Oppdragsgiver stiller til rådighet kunnskap og materiale som vil kunne bidra til gjennomføringen av prosjektet. Det forutsettes at de gitte problemstillinger det arbeides med er aktuelle og på et nivå tilpasset studentenes faglige kunnskaper. NTNU skal stille til rådighet egen veileder. Oppdragsgiver plikter å gi en evaluering/sensur av prosjektet vederlagsfritt.

2.
Kostnadene ved gjennomføringen av prosjektet dekkes på følgende måte:
Oppdragsgiver og NTNU dekker hver sin del av den veiledningstid som gis. Dekning av reiser og opphold langt fra studiested dekkes enten av studentene eller av oppdragsgiver ut fra den part som er aktiv for at reise og opphold er nødvendig. Studentene dekker evt. utgifter for trykking og ferdigstillelse av den skriftlige besvarelsen vedrørende prosjektet med mindre oppdragsgiver yter slik bistand.

3.
Eiendomsrett
Besvarelsens spesifikasjoner og resultat kan anvendes i oppdragsgivers egen virksomhet inklusiv publisering. Gjør studenten(e) i sin besvarelse, eller under arbeidet med den, en patentbar oppfinnelse, gjelder i forholdet mellom oppdragsgiver og studentene bestemmelsene i Lov om retten til oppfinnelser av 17. april 1970, §§ 4-10.

Eiendomsretten til eventuell prototyp tilfaller den som har betalt komponenter og materiell mv. som er brukt til prototypen. NTNU skal ha rett til vederlagsfri utnyttelse av besvarelsen og resultatene fra bachelorarbeidet til undervisnings- og forskningsvirksomhet inklusive publisering. Dette gjelder også data som underbygger resultatet i besvarelsen med mindre det vil være i strid med lov/forskrift eller godkjennelser som er gitt av Regional komité for medisinsk og helsefaglig forskningsetikk (REK), Norsk samfunnsvitenskapelig datatjeneste (NSD) eller andre institusjoner.

NTNU

FAKULTET FOR INFORMASJONTEKNOLOGI OG ELEKTROTEKNIKK

AVTALE

Hvis kandidaten skal utføre forskningsprosjektet som del av et større prosjekt, gjelder det som er avtalt om IP-rettigheter i dette prosjektet. Dette beskrives her:

4.
Hvis arbeidet medfører publisering og studentenes bidrag tilfredsstiller Vancouver-konvensjonens krav til medforfatterskap, skal studentene oppføres som medforfattere. Dersom bidraget deres ikke tilstrekkelig for medforfatterskap, skal de anerkjennes for bidraget.

5.
NTNU står ikke som garantist for at det oppdragsgiver har bestilt fungerer etter hensikten. Prosjektet må anses som en eksamensrelatert oppgave som blir bedømt av faglærer/veileder og sensor.

6.
Offentliggjøring.
Papirkopi av besvarelsen registreres og plasseres i et åpent arkiv ved instituttet. Oppdragsgiver kan ved prosjektstart kreve at prosjektet skal behandles som *lukket prosjekt* det vil si ikke publiseres eller plasseres i det åpne arkivet dersom dette kan begrunnes i lov eller forskrift eller ut fra kommersielle hensyn. I tilfelle av lukket prosjekt, skal allikevel besvarelsen normalt kunne publiseres og plasseres i åpent arkiv etter en på forhånd avtalt periode, som normalt ikke skal overskride 3 år.

7.
Når NTNU også opptrer som oppdragsgiver, trer NTNU inn i kontrakten både som utdanningsinstitusjon og som oppdragsgiver.

8.
Taushetserklæring
Ved underskrivelse av denne avtalen erklærer studentene ved sin underskrift alminnelig taushetsplikt vedrørende tekniske innretninger, fremgangsmåter, drifts eller forretningsforhold hos oppdragsgiver som det er av betydning å behandle konfidensielt.

9.
Eventuell uenighet vedrørende forståelse av denne avtale løses ved forhandlinger avtalepartene imellom. Dersom det ikke oppnås enighet, er partene enige om at tvisten løses av voldgift etter LOV 2004-05-14 nr. 25: Lov om voldgift.

10.
Denne avtalen utferdiges med et eksemplar til hver av partene. Signert dokument godtas på pdf-fil. På vegne av NTNU er det intern veileder som godkjenner avtalen.

12.
Signaturer

Dato/ Veileder NTNU Institutt for teknisk kybernetikk 31.01.2020	Torleif Anstensrud
Dato/Oppdragsgiver/kontaktperson 31.01.2020	Torleif Anstensrud
Dato/Student 30.01.2020	IRFAN LJEVO Irfan Ljevo
Dato/Student 30.01.2020	CHRISTOFFER BAKKEN Christoffer Bakken
Dato/Student 30.01.2020	JONAS BRUNSVIK Jonas Brunsvik
Dato/Student 30.01.2020	MARTIN SKÅRERVERKET Martin Skårerverket

B Internal agreement for bachelor group

Samarbeidsavtale for Gruppe E2023

Betydning av Avtalen :

Dette er en samarbeidsavtale mellom Jonas Brunsvik, Martin Skårerverket, Irfan Ljevo, Christoffer Bakken. Hensikten med avtalen er å sette rammebetingelser rundt samarbeidet til bachelor oppgaven «Videreutvikling og testing av tobeint robot protype», slik at dette prosjektet blir gjennomført på en god måte.

Holdninger og Innstillinger:

Det forventes at hvert enkelt medlem legger mye arbeid i dette prosjektet og prioriterer dette prosjektet foran trivielle ting. Personlige hendelser og annet er selvfølgelig akseptert.

Medlemmer skal prøve å være med på alt som planlegges så godt det lar seg gjøre. men andre gruppemedlemmer må også respektere andres liv og godta at ikke alle kan møte til en hver tid.

I kreative sammenhenger skal ingen kritisere hverandres ideer, Vi skal da heller prøve å forbedre og fordype ideene.

Kritikk er forbeholdt slutten av kreative perioder der en må korte ned til en eller flere.

Mål for samarbeidet

Felles mål for denne gruppen er at dette prosjektet skal oppnå høyest mulig karater.

Gruppen ønsker å bli bedre på tverrfaglig samarbeid i større prosjekter, slik at hvert enkelt medlem er mer komfortabel med å jobbe i grupper.

Mange av medlemmene ønsker å lære så mye som mulig innenfor andres fagområde, men også andre medlemmers personlig opparbeidet kunnskap. f.eks. Linux, programmering, og annen kunnskap.

Gruppekultur/Samarbeid :

Gruppen har blitt enige om at alle skal jobbe noen lunde samlet rundt en kjernetid 10-15 der alle er tilstede. Det forventes likevel at hvert enkelt medlem legger ytterliggere tid til side for dette prosjektet utover denne «kjernetiden».

For at kritiske informasjon og kunnskap blir fordelt på alle medlemmene er det ønskelig at alle jobber sammen og minst mulig alene.

Alle medlemmer skal så langt det lar seg gjøre være tilgjengelig på Messenger til vanlige tider, unntaket er helger, som i starten er fritid.

Helgene kan ved enighet «omgjøres» til arbeidsdag om tiden ikke strekker til.

Møtetider og kommunikasjon :

Hver enkelt er ansvarlig selv for å møte i tide, til viktige møter og andre «tidsviktige» ting.

Alle er selv ansvarlig å si ifra ved forsinkelser til planlagte tider, og spesielt ved viktige møter med veileder. Ved forsinkelse skal det meldes på Messenger, til minst to andre medlemmer, slik at misforståelser ikke oppstår. Om et medlem kommer gjentagende forsinket til disse tidene vil tiltak innføres for forbedre dette.

Om et medlem ikke kan komme på grunn av sykdom eller en annen hindring på kort varsel så skal det meldes så fort som mulig til minst to andre medlemmer.

Om et medlem planlager å være borte to dager eller lengre, skal dette meldes ifra til gruppen i god tid.

Forberedelse og tidsplanlegging :

Før møter med veileder forventes det at alle i gruppen har lest møteinnkalling, og at hvert enkelt gruppemedlem er forberedt til dette møtet.

For at gruppen skal unngå for mye arbeid rundt viktige tidsfrister så forventes det at hvert enkelt medlem setter av nok tid til arbeid med prosjektet, slik at vi slipper å jobbe sene kvelder.

Likevel forventes det at alle medlemmer setter av god tid til denne oppgaven rundt viktige milepæler og tidsfrister slik at arbeidet blir jevnt fordelt.

Rollefordeling :

Gruppen har én kontaktperson : Christoffer. som har ansvar med å holde kontakt med veileder, og være gruppens kommunikasjon-bindeledd. Dette innebærer informasjon om fremskritt og annen viktig informasjon som forventes av veileder.

Ellers prøver gruppen å ha en demokratisk modell med valg ved uenigheter, der hvert enkelt medlem har en stemme. om dette skulle gå dårlig vil gruppen stoppe opp og bli enig i en bedre måte å løse uenighetene på.

Ved lite fremgang og mye intern frustrasjon i gruppen, kan hvem som helst i gruppen kalle inn til et møte der en tar opp og prøver å løse disse problemene. Alle medlemmer er da forpliktet å møte opp til dette møtet og stille med et åpent sinn.

Hvert enkelt medlem jobber hovedsakelig med sitt fagfelt, men siden gruppen er enig at alle skal lære av hverandre, så oppfordres det til samarbeid om små og store problemer på tvers av fagretningene hvert medlemmene har.

Noteringer og referat :

Gruppen har blitt enige om at det skal lages et daglig referat på hvordan dagen har vært. Dette referatet skal inneholde en liten personlig refleksjon av hver person, og en gruppereflekSjon. Referatet må være på minst en halv side og følge en forhåndsbestemt mal.

Ansvaret for dette referatet roteres ukentlig på hvert medlem slik at alle får være med å skrive dette referatet.

Eksterne kilder som en antar skal brukes videre i prosjektet skal loggføres i løpet av dagen, på et dokument som alle har tilgang til (google Docs eller lignende)

Mislighold av Avtalen

Om en eller flere av deltakerne «gjentagende» kommer forsinket til møter med en time eller mer uanmeldt så innføres en snacksstraff som straffetiltak. Om forsinkelsene er tydelig er irriterende for andre medlemmer i gruppen tas dette opp i plenum på en rolig, forklarende og tydelig måte.

Problemer med dårlig arbeidsinnsats og dårlig samarbeidsvilje tas opp så raskt som mulig i plenum for alle medlemmer i gruppen. Gruppen skal da ta opp problemet på en respektabel og forklarende måte som ikke bidrar til økt spenning internt i gruppen, slik at gjeldende part forstår irritasjonen til motsatt part. Om problemet fortsatt ikke blir løst vil oppdragsgiver/ veileder informeres om problemet.

Varighet

Denne avtalen gjelder fra avtalen er signert til vi gjør en muntlig fremføring av oppgaven, altså prosjektets slutt.

Reformulering

Avtalen kan endres underveis, men må være enstemmig godtatt.

Signatur :

Jonas Brunsvik

Martin Skåreverket

Irfan LJevo

Christoffer Bakken

Dato : 22.01.2020

C Work Packages

NTNU

Department of Engineering Cybernetics,
Automation Technology Programme

Course: TELE3001 Bachelor Thesis			**Date:** 03.02.2020
Project:			
Activity: Old Documentation			**Activity nr:** 1
Starting date: 03.02.2020		**End date:** 07.02.20	
Dependency: none	**Past Activities:**	Writing pilot project	
	Following Activities:	Get to know GitHub, improving wiring and PCB	
Goal: Get to know how every sensor, and motors are connected to each other. Make part-lists of everything related to the robot, and get an general overview.			
Description: Document all the wiring from sensors to BMU, and make part lists and explanations on Github.			
Total Workload: 40 hours		**Work distribution:** Jonas Martin Christoffer Irfan	 10 hours 10 hours 10 hours 10 hours
Expenses: none			
Resources: none			
Hazards: Voltage, Moving limbs			

Project supervisor:	**Mail:**	**Tlf:**
Torleif Anstensrud	torleif.anstensrud@ntnu.no	95808760
Project team members:		
Irfan Ljevo	irfanl@stud.ntnu.no	97156783
Christoffer Bakken	chrbak@stud.ntnu.no	45279120
Martin Skårerverket	marskaar@stud.ntnu.no	47349759
Jonas Brunsvik	brunsviken@hotmail.com	99356689

NTNU

Department of Engineering Cybernetics,
Automation Technology Programme

Course: TELE3001 Bachelor Thesis			**Date:** 03.02.2020
Project:			
Activity: Get to know how GitHub Works			**Activity nr:** 2
Starting date: 03.02.20		**End date:** 07.02.20	
Dependency:	**Past Activities:**	Document existing connections	
	Following Activities:	Improve wiring and documentation on Github.	
Goal: Learn how to use GitHub and how use it to document important things for later use.			
Description: Learn how to use GitHub and how to implement this into the documentation process.			
Total Workload: 16 hours		**Work distribution:** Jonas Martin Christoffer Irfan	 4 hours 4 hours 4 hours 4 hours
Expenses: none			
Resources: none			
Hazards: none.			

Project supervisor:	**Mail:**	**Tlf:**
Torleif Anstensrud	torleif.anstensrud@ntnu.no	95808760
Project team members:		
Irfan Ljevo	irfanl@stud.ntnu.no	97156783
Christoffer Bakken	chrbak@stud.ntnu.no	45279120
Martin Skårerverket	marskaar@stud.ntnu.no	47349759
Jonas Brunsvik	brunsviken@hotmail.com	99356689

NTNU

Department of Engineering Cybernetics,
Automation Technology Programme

<table>
<tr><td colspan="3">Course: TELE3001 Bachelor Thesis</td><td>Date: 03.02.202</td></tr>
<tr><td colspan="4">Project:</td></tr>
<tr><td colspan="3">Activity: Improve Wiring and PCB design</td><td>Activity nr: 3</td></tr>
<tr><td colspan="2">Starting date: 10.02.2020</td><td colspan="2">End date: 28.02.2020</td></tr>
<tr><td rowspan="2">Dependency:</td><td>Past Activities:</td><td colspan="2">Documenting existing connections, Get to know Github.</td></tr>
<tr><td>Following Activities:</td><td colspan="2">Learn Linux and C++ class programming</td></tr>
<tr><td colspan="4">Goal: Clear out old wiring and have a clear and functioning electrical system, fix communication between the different sensors.</td></tr>
<tr><td colspan="4">Description: Clear out the old wiring and replace with a more robust and modular system .
Find a new communication protocol if the old one is the issue,
Find new Servo motors for the robot legs, and order them.
Design a more clear and intuitive main wiring PCB and document the new wiring and pcb’s on GitHub</td></tr>
<tr><td colspan="2">Total Workload: 148 hours</td><td>Work distribution:
Jonas
Martin
Irfan
Christoffer</td><td>
40 hours
40 hours
40 hours
28 hours</td></tr>
<tr><td colspan="4">Expenses: Cables to and from sensors and servos, cable thighs, New PCB to improve wiring and modularity. New servo motors for the robot legs, components for PCB.</td></tr>
<tr><td colspan="4">Resources: multimeter, soldering iron, Kicad/Altium software.</td></tr>
<tr><td colspan="4">Hazards: Electrical shock from power supply. Pinching fingers.</td></tr>
<tr><td colspan="2">Project supervisor:
Torleif Anstensrud
Project team members:
Irfan Ljevo
Christoffer Bakken
Martin Skårerverket
Jonas Brunsvik</td><td>Mail:
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irfanl@stud.ntnu.no
chrbak@stud.ntnu.no
marskaar@stud.ntnu.no
brunsviken@hotmail.com</td><td>Tlf:
95808760

97156783
45279120
47349759
99356689</td></tr>
</table>

NTNU

Department of Engineering Cybernetics,
Automation Technology Programme

Course: TELE3001 Bachelor Thesis			**Date:** 03.02.20
Project:			
Activity: Documentation Part 1			**Activity nr:** 4
Starting date: 03.02.2020		**End date:** 28.02.2020	
Dependency:	**Past Activities:**	Documenting old wiring, learning GitHub, New Wiring an PCB.	
	Following Activities:	Linux and C++ programming.	
Goal: Document everything done with the robot up to this point.			
Description: Document everything on GitHub, and make it clear so that groups later can use this "wiki".			
Total Workload: 150 Hours		**Work distribution:** Jonas : Martin: Irfan: Christoffer:	 40 hours 40 hours 40 hours 30 hours
Expenses: none			
Resources: github			
Hazards: none			

Project supervisor:	**Mail:**	**Tlf:**
Torleif Anstensrud	torleif.anstensrud@ntnu.no	95808760
Project team members:		
Irfan Ljevo	irfanl@stud.ntnu.no	97156783
Christoffer Bakken	chrbak@stud.ntnu.no	45279120
Martin Skårerverket	marskaar@stud.ntnu.no	47349759
Jonas Brunsvik	brunsviken@hotmail.com	99356689

NTNU

Department of Engineering Cybernetics,
Automation Technology Programme

Course: TELE3001 Bachelor Thesis			**Date:** 03.02.2020
Project:			
Activity: Linux and C with classes			**Activity nr:** 5
Starting date: 17.02.2020		**End date:** 14.03.2020	
Dependency:	**Past Activities:**	Documentation	
	Following Activities:	Beaglebone	
Goal: Learn how Linux functions, with focus on the command line. Learn how to code with classes in C++.			
Description: Learn how to efficiently use Linux, and how to install all the necessary programs and how to make scripts for the robot. Learn how to code with classes in C++, and how to use the command line interface to connect to BeagleBone, and run the code there. Receive the measurements from IMU's			
Total Workload: 480 Hours		**Work distribution:** Jonas Martin Christoffer Irfan	 120 Hours 120 Hours 120 Hours 120 Hours
Expenses: none			
Resources: Linux, Beagle bone, IMU's			
Hazards: none			

Project supervisor:	**Mail:**	**Tlf:**
Torleif Anstensrud	torleif.anstensrud@ntnu.no	95808760
Project team members:		
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Christoffer Bakken	chrbak@stud.ntnu.no	45279120
Martin Skårerverket	marskaar@stud.ntnu.no	47349759
Jonas Brunsvik	brunsviken@hotmail.com	99356689

NTNU

Department of Engineering Cybernetics,
Automation Technology Programme

<table>
<tr><td colspan="3">Course: TELE3001 Bachelor Thesis</td><td>Date: 03.02</td></tr>
<tr><td colspan="3">Project:</td><td></td></tr>
<tr><td colspan="3">Activity: Learning Beaglebone</td><td>Activity nr: 6</td></tr>
<tr><td colspan="2">Starting date: 02.03.2020</td><td colspan="2">End date: 27.03.2020</td></tr>
<tr><td rowspan="2">Dependency:</td><td>Past Activities:</td><td colspan="2">Linux C++ with classes</td></tr>
<tr><td>Following Activities:</td><td colspan="2">Documentation part 2.</td></tr>
<tr><td colspan="4">Goal: Learn how to program a Beagle bone. And look at wireless solutions for the Beagle Bone.</td></tr>
<tr><td colspan="4">Description: Learn how to use a Beagle bone, how to use SSH to send files to it.
See if Beagle Bone AI is at better alternative to our current one.
Also look at Wireless solutions for the beagle Bone.</td></tr>
<tr><td colspan="2">Total Workload: 200 Hours</td><td>Work distribution:
Jonas
Martin
Irfan
Christoffer</td><td>
50 Hours
50 Hours
50 Hours
50 Hours</td></tr>
<tr><td colspan="4">Expenses: New Beagle Bone.</td></tr>
<tr><td colspan="4">Resources: Beagle Bone</td></tr>
<tr><td colspan="4">Hazards: none</td></tr>
<tr><td>Project supervisor:
Torleif Anstensrud
Project team members:
Irfan Ljevo
Christoffer Bakken
Martin Skårerverket
Jonas Brunsvik</td><td colspan="2">Mail:
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Automation Technology Programme

<table>
<tr><td colspan="3">Course: TELE3001 Bachelor Thesis</td><td>Date:
03.02.2020</td></tr>
<tr><td colspan="4">Project:</td></tr>
<tr><td colspan="3">Activity: Documentation Part 2</td><td>Activity nr: 7</td></tr>
<tr><td colspan="2">Starting date: 02.03.2020</td><td colspan="2">End date: 27.03.2020</td></tr>
<tr><td rowspan="2">Dependency:</td><td>Past Activities:</td><td colspan="2">Linux, c++, beagle bone.</td></tr>
<tr><td>Following Activities:</td><td colspan="2">Realtime OS.</td></tr>
<tr><td colspan="4">Goal: Document everything we did from the work with Linux, C++ and Beaglebone on GitHub.</td></tr>
<tr><td colspan="4">Description: Upload everything one</td></tr>
<tr><td colspan="2">Total Workload: 160 Hours.</td><td>Work distribution:
Martin
Irfan
Jonas
Christoffer</td><td>
40 Hours
30 Hours
30 Hours
60 Hours</td></tr>
<tr><td colspan="4">Expenses: none</td></tr>
<tr><td colspan="4">Resources: none</td></tr>
<tr><td colspan="4">Hazards: none</td></tr>
<tr><td>Project supervisor:
Torleif Anstensrud
Project team members:
Irfan Ljevo
Christoffer Bakken
Martin Skårerverket
Jonas Brunsvik</td><td colspan="2">Mail:
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chrbak@stud.ntnu.no
marskaar@stud.ntnu.no
brunsviken@hotmail.com</td><td>Tlf:
95808760

97156783
45279120
47349759
99356689</td></tr>
</table>

NTNU

Department of Engineering Cybernetics,
Automation Technology Programme

<table>
<tr><td colspan="3">Course: TELE3001 Bachelor Thesis</td><td>Date: 03.02.2020</td></tr>
<tr><td colspan="4">Project:</td></tr>
<tr><td colspan="3">Activity: Realtime OS</td><td>Activity nr: 8</td></tr>
<tr><td colspan="2">Starting date: 30.03.2020</td><td colspan="2">End date: 24.04.2020</td></tr>
<tr><td rowspan="2">Dependency:</td><td>Past Activities:</td><td colspan="2">Documentation from Linux, c++ and Beagle bone.</td></tr>
<tr><td>Following Activities:</td><td colspan="2">PID regulator.</td></tr>
<tr><td colspan="4">Goal: find a good Linux Distro that functions well with the robot (low latency) and learn how to program in this environment.</td></tr>
<tr><td colspan="4">Description: Research how latency affects the robot, and how fast the system needs to respond.
Find a compatible Linux distros that is fast enough for this system. And learn more about PRU’s.</td></tr>
<tr><td colspan="2">Total Workload: 400 Hours</td><td>Work distribution:
Jonas
Martin
Irfan
Christoffer</td><td>
120 hours
120 Hours
80 Hours
80 Hours</td></tr>
<tr><td colspan="4">Expenses: none</td></tr>
<tr><td colspan="4">Resources: Beagle bone</td></tr>
<tr><td colspan="4">Hazards: none</td></tr>
<tr><td>Project supervisor:
Torleif Anstensrud
Project team members:
Irfan Ljevo
Christoffer Bakken
Martin Skårerverket
Jonas Brunsvik</td><td>Mail:
torleif.anstensrud@ntnu.no

irfanl@stud.ntnu.no
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<table>
<tr><td colspan="3">Course: TELE3001 Bachelor Thesis</td><td>Date:
03.02.2020</td></tr>
<tr><td colspan="4">Project:</td></tr>
<tr><td colspan="3">Activity: PID Regulator</td><td>Activity nr: 9</td></tr>
<tr><td colspan="2">Starting date: 20.04.2020</td><td colspan="2">End date: 15.05.2020</td></tr>
<tr><td rowspan="2">Dependency:</td><td>Past Activities:</td><td colspan="2">C++ class programming.</td></tr>
<tr><td>Following Activities:</td><td colspan="2">Walking the robot.</td></tr>
<tr><td colspan="4">Goal: Implement PID controller in the Beagle bone’s PRU cores.</td></tr>
<tr><td colspan="4">Description: Learn how to implement a PID controller with C++ in Beagle bone.</td></tr>
<tr><td colspan="2">Total Workload: 400 hours</td><td>Work distribution:
Jonas
Martin
Irfan
Christoffer</td><td>
80 Hours
80 Hours
120 Hours
120 Hours</td></tr>
<tr><td colspan="4">Expenses: none</td></tr>
<tr><td colspan="4">Resources: beagle bone</td></tr>
<tr><td colspan="4">Hazards: none</td></tr>
<tr><td>Project supervisor:
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<table>
<tr><td colspan="3">Course: TELE3001 Bachelor Thesis</td><td>Date:</td></tr>
<tr><td colspan="4">Project:</td></tr>
<tr><td colspan="3">Activity: Implement PID regulator to walk</td><td>Activity nr: 10</td></tr>
<tr><td colspan="2">Starting date: optional</td><td colspan="2">End date: optional</td></tr>
<tr><td rowspan="2">Dependency:</td><td>Past Activities:</td><td colspan="2">Linux and programming, pcb design, improved wiring.</td></tr>
<tr><td>Following Activities:</td><td colspan="2"></td></tr>
<tr><td colspan="4">Goal: Control the robot legs from beagle-bone. Implement PID controller and make the robot walk a step.</td></tr>
<tr><td colspan="4">Description: Program the legs to move with beagle bone. learn the simulation program, and implement the new robot into the environment. Add a PID controller to the code, and use rules of thumb to tune the regulator, lastly make the robot move!</td></tr>
<tr><td colspan="2">Total Workload:</td><td>Work distribution:</td><td></td></tr>
<tr><td colspan="4">Expenses: none</td></tr>
<tr><td colspan="4">Resources: beagle bone, computer.</td></tr>
<tr><td colspan="4">Hazards: Moving robot, Fingers could get pinched</td></tr>
<tr><td>Project supervisor:
Torleif Anstensrud
Project team members:
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Course:	**TELE3001 Bachelor Thesis**		**Date:** 03.02.2020
Project:			
Activity:	Documentation part 3		**Activity nr:** 11
Starting date: 27.03.2020		**End date:** 15.05.2020	
Dependency:	**Past Activities:**	PID, Real timeOS, Walking the robot.	
	Following Activities:		
Goal: Document what we learn about Realtime OS and PID controller to GitHub.			
Description: Explain how to implement real time in the robot, how PRU cores work, and how to implement a PID regulator to this system, upload all this to GitHub.			
Total Workload: 160 Hours.		**Work distribution:** Jonas Martin Irfan Christoffer	 40 Hours 40 Hours 40 Hours 40 Hours
Expenses: none			
Resources: none			
Hazards: none			

Project supervisor:	**Mail:**	**Tlf:**
Torleif Anstensrud	torleif.anstensrud@ntnu.no	95808760
Project team members:		
Irfan Ljevo	irfanl@stud.ntnu.no	97156783
Christoffer Bakken	chrbak@stud.ntnu.no	45279120
Martin Skårerverket	marskaar@stud.ntnu.no	47349759
Jonas Brunsvik	brunsviken@hotmail.com	99356689

D Assignment

NTNU

Institutt for teknisk kybernetikk

Oppgaveforslag bacheloroppgave elektroingeniør i Trondheim, vårsemester 2020

Navn bedrift: **NTNU Institutt for Teknisk Kybernetikk**		**Kontaktperson: Torleif Anstensrud** **Epost: torleif.anstensrud@ntnu.no** **Telefon/mobil:**		
Tittel på oppgave: **Videreutvikling og testing av tobeinet robotprototype**				
Hvilke studieretninger passer oppgaven for (kryss av for alle aktuelle retninger):	Automatisering x	Elektronikk x	Elkraftteknikk	Instrumentering x
Er oppgaven reservert for noen bestemte studenter? I så fall skriv navnene på studentene til høyre.				

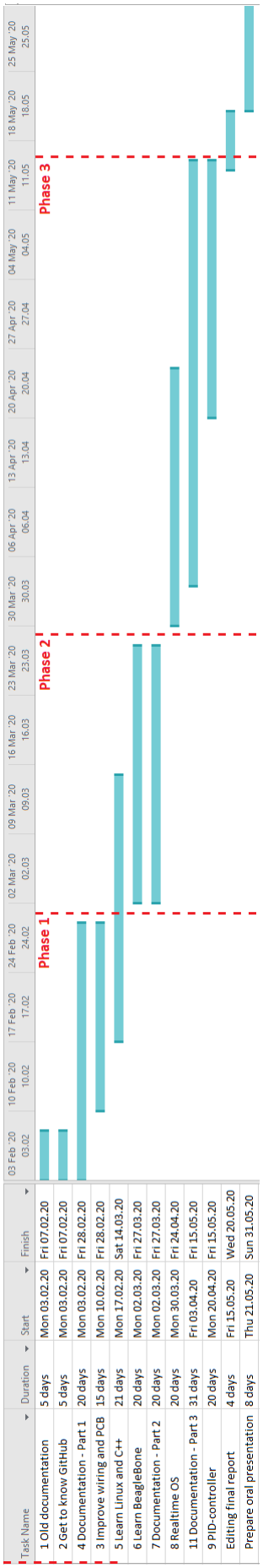
Kort beskrivelse av oppgaven med problemstilling.

En stadig økende del av arbeidsoppgavene i samfunnet vårt blir utført av statisk monterte industriroboter. For å løse framtidens teknologiske og humanitære utfordringer er vi avhengige av å utvikle nye robottyper som i større grad etterlikner menneskelig framdriftsegenskaper. Dette stiller krav til utviklingen av avanserte matematiske metoder for å generere et stort utvalg energieffektive gangmønstre for gående roboter.

For å validere de teoretiske resultatene fra dette arbeidet, har man startet utviklingen av en enkel fysisk prototype på en tobeinet robot med overkropp. Roboten er begrenset til å bevege seg i et 2D – plan, og har 3 frihetsgrader (2 stive bein og 1 stiv overkropp), der beina er aktuert med DC – motorer i hoften.
De mekaniske delene av prototypen er allerede produsert og satt sammen ved ITKs verksted, i tillegg er en rekke sensorer og styringsenheter implementert av Bachelor-studenter våren 2019, men det mangler fortsatt software som knytter alle systemer sammen.

Det er tiltenkt at studentene skal arbeide med følgende problemstillinger
• Skaffe oversikt over tidligere utført arbeid, og kartlegge utbedringsområder
• Organisere videre prosjektutvikling med blant annet opprettelsen av GitHub repository, wiki, etc
• Undersøke mulighet for å benytte ROS
• Videreutvikle software for kjøring på embedded hardware (BeagleBone) for styring av servoer og motorer, samt sensoravlesing
• Utvikle software for (sanntids)logging/visualisering av robottilstand basert på sensoravlesninger
• Implementere enkle reguleringsalgoritmer for beinplassering
• Undersøke mulighet for bruk av strømforsyning via batteri
• Utvikling av en testrigg som lar roboten gå langs en tredemølle, og støtter denne ved fall
• Systemidentifikasjon av fysiske komponenter basert på sensordata
• Utføre enkle skrittester
Det er ønskelig at rapporten skrives på engelsk, men dette er ikke et krav.

E Gantt-diagram



Task Name	Duration	Start	Finish
1 Old documentation	5 days	Mon 03.02.20	Fri 07.02.20
2 Get to know GitHub	5 days	Mon 03.02.20	Fri 07.02.20
4 Documentation - Part 1	20 days	Mon 03.02.20	Fri 28.02.20
3 Improve wiring and PCB	15 days	Mon 10.02.20	Fri 28.02.20
5 Learn Linux and C++	21 days	Mon 17.02.20	Sat 14.03.20
6 Learn BeagleBone	20 days	Mon 02.03.20	Fri 27.03.20
7 Documentation - Part 2	20 days	Mon 02.03.20	Fri 27.03.20
8 Realtime OS	20 days	Mon 30.03.20	Fri 24.04.20
11 Documentation - Part 3	31 days	Fri 03.04.20	Fri 15.05.20
9 PID-controller	20 days	Mon 20.04.20	Fri 15.05.20
Editing final report	4 days	Fri 15.05.20	Wed 20.05.20
Prepare oral presentation	8 days	Thu 21.05.20	Sun 31.05.20

Figure 6: Gantt-diagram