Biped prototype

TELE3001 - Bacheloroppgave Automatisering

Thesis preparation report

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Edvard Merkesvik
Stian Johan Olsen
Kristoffer Meggelæ Pedersen

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1 Abstract

Our assignment is to further develop a prototype of a biped walking robot so that it can be easily controlled by the BeagleBone micro-computer, as well as construct a git-hub/documentation environment for further development.

This is the preliminary report for the project, therefor it will contain a formulated problem statement, the goals set for the project and how we will work towards achieving these.

2 Preface

This report is the result of the preliminary study for our Bachelor thesis. The Bachelor Thesis is the conclusion of 180 credits and is in it self worth 20 credits. The assignment is given by the Department of Engineering Cybernetics at NTNU represented by Torleif Anstensrud. Pål Holte Mathisen is the groups supervisor.

Contents

3 Introduction

3.1 Background

An increasingly large part of modern society includes some form of robotics. In most cases this is fixed robots, however as new technologies are developed it is desirable to develop new robotics with higher mobility that can mimic human motion and operate outside the highly controlled environments where they are used today.

In conjunction with the desire to mimic human walk there is also a need to research and develop energy efficient gaits. At NTNU there have been developed several mathematical models for effective walking patterns. These models have been simulated but has yet to be tested on a physical model. The purpose of this robot is to do exactly that. Our bachelor thesis will look to bring the system close- and hopefully all the way to completion.

The robot in question is an under actuated bipedal that is restricted to move in a 2 dimensional plane. The robot consists of 2 stiff legs mounted to a torso at the ”hip”. With the mathematical models designed to work in two dimensions we have to make sure to prevent lateral tilt, consequently each leg has two points of contact as if you would stretch the robot sideways when you add the third axis.

The structure of the robot is already done, and a variety of electronics and sensors have been implemented. With most of the hardware done, the remaining work is largely software based and will largely consist of measurement and communication as well as making sure the previous work is still functional.

3.2 Assignment

The assignment for this project mainly consists of implementing real time measuring of the robot position using IMUs and make sure we have communication between all the different parts of the system. At the end we should ideally be able to control every component using R.O.S and get real time measurements of the robot position.

Another important part is to make sure that everything we do is well organized and documented for further research, hence it is essential that we make a well developed GitHub for the project.

3.3 Definitions

BeagleBone (Black): - A single board computer.

C/C++: - General-purpose programming language, often used in embedded systems and real time programming.

Encoder: - A device that converts angular position of a rotating joint to a digital- or analog signal.

I2C: - A serial communication protocol between a master and one or more slaves.

IMU "Inertia Measurement Unit": - A device capable of measuring angle, angular velocity and its orientation.

Linux: - An open source operating system used to run R.O.S. We will be using a version called "Ubuntu"

Microsoft Teams: A business communication platform, we use it mostly for video meetings and to store documents.

R.O.S "Robot Operating System": - A framework for robot programming to run on

GitHub - A code hosting platform for version control and collaboration.

Underactuated robotics - A type of robot where the number of actuators is lower than the degrees of freedom. E.g. a bipedal with actuators in the hip.

3.4 Structure of the report

The report is divided into 5 chapters, each describing a different part of the project.

1. Introduction: An overview of the project as a whole.
2. Technical: An introduction to the technical aspects on the project.
3. Work packages: We have divided the project into smaller tasks, each with it's own work description
4. Project organizing: Presentation of the group members and an overview of how we plan to distribute our time. Also has a list of equipment and resources.
5. Attachments: Various attachments related to this report.

4 Technical Details

4.1 Problem statement

The main goal is to get everything in this robot working by the end of the semester. To do this there is a number of problems that need to be solved.

4.1.1 Position tracking

For the robot walk reliably it needs to know the position of the legs and torso. To reliably track the position of the legs one IMU needs to be installed on each leg. The position of the torso can then be determined using the information from the IMUs and the information from the rotary encoders from each leg.We know from previous work that the IMUs reliability and accuracy is affected by the shock of the leg hitting the ground.

4.1.2 Retractable legs

For the robot to be able to swing it's hind leg to the front it need to shorten that leg to prevent it from hitting the ground. Two servos needs to be installed with their own housing.

4.1.3 GitHub/wiki

To make the project more easily accessible to other people the entire project needs to get moved to a GitHub repository. All assets and resources of the projects needs to be imported in a structured repository so that anyone that is interested in, or want to contribute, can find and share files.

4.2 Project Objective

4.2.1 Performance goals

- A Platform for testing algorithms for controlling the robot.
- A clean open-source environment for sharing and contributing to the project.

4.2.2 Outcome goals

- Reliable tracking of all limbs of the robot.
- Fully retractable and extendable legs.
- A well organized and well documented GitHub repository.
- A program that visualizes the current state off the robot and its parameters.
- Easily accessible functions for reading the state of the robot as well as controlling it.
- A completed thesis and report by the 15th of May

4.2.3 Process goals

- Improve our Team-working abilities.
- To earn a good grade.
- Improve Problem-solving skills.
- Acquire practical Experience.
- Improve communication and cooperation skills.
- Learn ROS.

4.3 Project description

To secure the accomplishment of the set goals we have divided the project into 12 work packages. These packages will be used as a guidelines for "what, whom and when" by telling us the period we will be working on these lesser tasks, whom might be working on them, how much work is estimated to be required and what must be done to start on them. This will secure a continuous and balanced work flow throughout the project. To give more clarity of the time frames we will set up a Gantt-diagram. We will also track work time in case we need to make adjustments in work distributions to achieve an even workload.

Before the direct work on the robot starts, we are going to research documents from the two earlier bachelor thesis. This will give us the projects current status and tell us what has worked and give us tips for further work. We need to learn the fundamentals of ROS, C++ and Github. ROS and C++ are quite vast subjects, therefor we will only delve deeper into the relevant parts of these.

The work on the robot begins when acquired the essential knowledge. The first step will be to test the code already implemented by the previous groups. While doing this we will divide the group into two, where one part mainly focuses on the tests while the other takes on the task of designing and implementing cases for new servos.

After those two tasks are done we will yet again divide into to two work groups. One will install the IMUs and connect them to the Beaglebone. They will then conduct several test to decide how many and where to put the IMUs. The other group will work on the real time visualization of the robot.

When this is done we will further develop software for communication between Beaglebone, servo and motor. This work will hopefully result in some sort of walking capability for the robot.

All the work throughout the project will constantly be documented and uploaded to a Github repository. The repository will be used to optimize cooperation and make it easier for others to continue the project.

4.4 Specifications and standards

The primary code for the Beaglebone will be C++. The Linux distribution will be Ubuntu.

The last group that worked on this project used ROS as middleware. We will make the shift towards ROS 2 as we see this as more progressive. The primary coding language will be C++.

For communication between IMU and Beaglebone we will use I2C as communication protocol.

4.5 Problem areas

4.5.1 Coronavirus restrictions

This Project will be taking place during the corona pandemic. This might lead to restricted access to the robot which would significantly affect our ability to work on the robot. The level of restriction is going to be heavily dependent on the spread of the virus in the upcoming months and will be impossible to predict.

4.5.2 Builds on two previous bachelor thesis

As helpful as it is to have previous work done on the robot, inheriting a project like this comes with its own challenges. It is going to take a lot of work to understand the code to a point where we can continue the development of the project. Luckily the work done on the robot is well documented.

4.5.3 Time Estimate

With little to no experience on the different subjects it is hard to estimate the time we will use on the different packages. As a consequence there might be periods with a lot more workload than planned and the workload might be spread uneven between the students. To prevent this from happening, the time schedule is very flexible and the work packages spans over longer periods. We will also constantly track time to prevent any bigger unbalances in workload between the students.

5 Work Packages

Before we start the project we have divided it into several more manageable work packages. These includes a more detailed description of the tasks, as well as estimated time consumption and a risk assessment where this is necessary.

<table>
<tr><td colspan="2">Course:</td><td colspan="2">TELE3001 Bachelor Thesis</td><td>Date:
26.01.2021</td></tr>
<tr><td colspan="5">Project: Instrumentation of bipedal robot</td></tr>
<tr><td colspan="4">Activity: Create Workplan</td><td>Activity nr:
1</td></tr>
<tr><td colspan="3">Starting date: 19.01.2021</td><td colspan="2">End date: 26.01.2021</td></tr>
<tr><td rowspan="2">Dependency:</td><td colspan="4">Prerequisites:</td></tr>
<tr><td colspan="4">Following activities:</td></tr>
<tr><td colspan="5">Goal: Have finished work packages and Gantt-diagram.</td></tr>
<tr><td colspan="5">Description: Divide the assignment into work packages. Describe each work package and give them a reasonable time estimation. Look at possible expenses, resources and hazards. Divide the total workload between the team members.
Based on the work packages create a Gantt-diagram. Decide on deadlines, fixed time for weekly meetings with supervisor and fixed time for the team members to work together.
Create a sheet to track work hours.</td></tr>
<tr><td colspan="3">Total Workload:
50 hours</td><td colspan="2">Work distribution:
Stian Olsen 12.5 Hours
Edvard Merkesvik 12.5 Hours
Kristoffer Pedersen 12.5 Hours
Lars-Erik Panengstuen 12.5 Hours</td></tr>
<tr><td colspan="5">Cost: None</td></tr>
<tr><td colspan="5">Resources: None</td></tr>
<tr><td colspan="5">Risk: None</td></tr>
<tr><td colspan="5">Project supervisor:
Torleif Anstensrud
Project team members:
Stian Olsen
Edvard Merkesvik
Kristoffer Pedersen
Lars-Erik Panengstuen</td></tr>
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<table>
<tr><td>Course:</td><td colspan="3">TELE3001 Bachelor Thesis</td><td>Date:
26.01.2021</td></tr>
<tr><td>Project:</td><td colspan="4">Instrumentation of bipedal robot</td></tr>
<tr><td>Activity:</td><td colspan="3">Research old documentation.</td><td>Activity nr:
2</td></tr>
<tr><td colspan="2">Starting date: 20.01.2021</td><td colspan="3">End date: 28.02.2021</td></tr>
<tr><td rowspan="2">Dependency:</td><td colspan="4">Prerequisites: Made work packages</td></tr>
<tr><td colspan="4">Following activities:
Create thesis preparation report</td></tr>
<tr><td colspan="5">Goal: Understanding what is done.</td></tr>
<tr><td colspan="5">Description: This project builds on two prior bachelor theses, hence there is a lot of documentation to go through to have an understanding what is done.</td></tr>
<tr><td colspan="2">Total Workload: 40 Hours</td><td colspan="3">Work distribution:
Stian Olsen 10 Hours
Edvard Merkesvik 10 Hours
Kristoffer Pedersen 10 Hours
Lars-Erik Panengstuen 10 Hours</td></tr>
<tr><td colspan="5">Cost: None</td></tr>
<tr><td colspan="5">Resources: Old documentation</td></tr>
<tr><td colspan="5">Risk: None</td></tr>
<tr><td colspan="5">Project supervisor:
Torleif Anstensrud
Project team members:
Stian Olsen,
Edvard Merkesvik,
Kristoffer Pedersen,
Lars-Erik Panengstuen</td></tr>
</table>

<table>
<tr><td colspan="3">Course: TELE3001 Bachelor Thesis</td><td>Date: 26.01.2021</td></tr>
<tr><td colspan="4">Project: Instrumentation of bipedal robot</td></tr>
<tr><td colspan="3">Activity: Create thesis preparation report.</td><td>Activity nr:
3</td></tr>
<tr><td colspan="2">Starting date: 10.01.2021</td><td colspan="2">End date: 05.02.2021</td></tr>
<tr><td rowspan="2">Dependency:</td><td colspan="3">Prerequisites: Create Workplan</td></tr>
<tr><td colspan="3">Following activities:</td></tr>
<tr><td colspan="4">Goal: Have a complete thesis preparation report.</td></tr>
<tr><td colspan="4">Description: The preparation report shall contain as most information as possible about the project and how we plan to carry it out.
Description about problem and the topic question.
Framework, goals (project, impact and performance) and organization.
A plan for how the task will be accomplished and followed up.
Add work packages, Gantt-diagram, timeline, cooperation agreement and assignment.</td></tr>
<tr><td colspan="2">Total Workload:
100 hours</td><td colspan="2">Work distribution:
Stian Olsen 25 Hours
Edvard Merkesvik 25 Hours
Kristoffer Pedersen 25 Hours
Lars-Erik Panengstuen 25 Hours</td></tr>
<tr><td colspan="4">Cost: None</td></tr>
<tr><td colspan="4">Resources: None</td></tr>
<tr><td colspan="4">Risk: None</td></tr>
<tr><td colspan="4">Project supervisor:
Torleif Anstensrud
Project team members:
Stian Olsen
Edvard Merkesvik
Kristoffer Pedersen
Lars-Erik Panengstuen</td></tr>
</table>

Course: **TELE3001 Bachelor Thesis**		**Date: 26.01.2021**
Project: Instrumentation of bipedal robot		
Activity: Learn basic Beagle bone and ROS		**Activity nr:** 4
Starting date: 05.02.2021	**End date:** 19.02.2021	
Dependency:	**Prerequisites:**	
	Following activities: Testing earlier work	
Goal: Acquire necessary competence to use BeagleBone and ROS for the rest of the project.		
Description: Research how to use BeagleBone and ROS. This includes, but is not limited to: • Setup of ROS • Basic use of ROS • Beagle bone programming • Learning how the formers interacts with each other		
Total Workload: 140 hours	**Work distribution:** Stian Olsen 35 Hours Edvard Merkesvik 35 Hours Kristoffer Pedersen 35 Hours Lars-Erik Panengstuen 35 Hours	
Cost: None		
Resources: Beagle bone		
Risk: None		
Project supervisor: Torleif Anstensrud **Project team members:** Stian Olsen, Edvard Merkesvik, Kristoffer Pedersen, Lars-Erik Panengstuen		

<table>
<tr><td colspan="2">Course: TELE3001 Bachelor Thesis</td><td>Date:
26.01.2021</td></tr>
<tr><td colspan="3">Project: Instrumentation of bipedal robot</td></tr>
<tr><td colspan="2">Activity: Testing earlier work</td><td>Activity nr:
5</td></tr>
<tr><td>Starting date: 08.02.2021</td><td colspan="2">End date: 26.02.2021</td></tr>
<tr><td rowspan="2">Dependency:</td><td colspan="2">Prerequisites: Learn basic Beagle bone and ROS</td></tr>
<tr><td colspan="2">Following activities:</td></tr>
<tr><td colspan="3">Goal: Find out what part of the previous work can be used</td></tr>
<tr><td colspan="3">Description: Test code and wiring and evaluate what works as intended and can be reused, what we think can be modified to work and what will be discarded entirely.</td></tr>
<tr><td>Total Workload:
220 hours</td><td colspan="2">Work distribution:
Stian Olsen 50 Hours
Edvard Merkesvik 60 Hours
Kristoffer Pedersen 60 Hours
Lars-Erik Panengstuen 50 Hours</td></tr>
<tr><td colspan="3">Cost:</td></tr>
<tr><td colspan="3">Resources: Bipedal, BeagleBone, Access to robot</td></tr>
<tr><td colspan="3">Risk: Electrocution</td></tr>
<tr><td colspan="3">Project supervisor:
Torleif Anstensrud
Project team members:
Stian Olsen
Edvard Merkesvik
Kristoffer Pedersen
Lars-Erik Panengstuen</td></tr>
</table>

Course:	**TELE3001 Bachelor Thesis**	**Date: 26.01.2021**
Project:	Instrumentation of bipedal robot	
Activity:	New cases for servos	**Activity nr:** 6
Starting date: 19.02.2021	**End date:** 26.02.2021	
Dependency:	**Prerequisites:**	
	Following activities:	
Goal: Design and implement cases for the new servos to replace the old ones		
Description: New servos for the extendable part of the leg has been bought but has yet to be implemented. To do this we must: • Design new casing that fits the new servos • Order these from the mechanical workshop • Implement them on the robot		
Total Workload: 20 Hours	**Work distribution:** Lars-Erik Panengstuen 10 Hours Stian Olsen 10 Hours	
Cost: None		
Resources: None		
Risk: Electrocution		
Project supervisor: Torleif Anstensrud **Project team members:** Stian Olsen Edvard Merkesvik Kristoffer Pedersen Lars-Erik Panengstuen		

<table>
<tr><td colspan="2">Course: TELE3001 Bachelor Thesis</td><td>Date:
20.01.2021</td></tr>
<tr><td colspan="3">Project: Instrumentation of bipedal robot</td></tr>
<tr><td colspan="2">Activity: Create GitHub repository with a clear wiki/description</td><td>Activity nr:
7</td></tr>
<tr><td>Starting date: 05.02.2021</td><td colspan="2">End date: 01.05.2021</td></tr>
<tr><td rowspan="2">Dependency:</td><td colspan="2">Prerequisites:</td></tr>
<tr><td colspan="2">Following activities:</td></tr>
<tr><td colspan="3">Goal: Creating a GitHub repository and learn to how to use GitHub</td></tr>
<tr><td colspan="3">Description: Setting up a GitHub repository to optimize cooperation and make it easier for others to continue the project. This will be used throughout the entirety of the project.</td></tr>
<tr><td>Total Workload: 200</td><td colspan="2">Work distribution:
Stian Olsen, 65 Hours
Edvard Merkesvik, 65 Hours
Kristoffer Pedersen, 35 Hours
Lars-Erik Panengstuen 35 Hours</td></tr>
<tr><td colspan="3">Cost: None</td></tr>
<tr><td colspan="3">Resources: None</td></tr>
<tr><td colspan="3">Risk: None</td></tr>
<tr><td colspan="3">Project supervisor:
Torleif Anstensrud
Project team members:
Stian Olsen,
Edvard Merkesvik,
Kristoffer Pedersen,
Lars-Erik Panengstuen</td></tr>
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<table>
<tr><td colspan="2">Course: TELE3001 Bachelor Thesis</td><td>Date:
20.01.2021</td></tr>
<tr><td colspan="3">Project: Instrumentation of bipedal robot</td></tr>
<tr><td colspan="2">Activity: Further develop software for communication between BeagleBone, servo and motor.</td><td>Activity nr:
8</td></tr>
<tr><td>Starting date: 19.02.2021</td><td colspan="2">End date: 01.05.2021</td></tr>
<tr><td rowspan="2">Dependency:</td><td colspan="2">Prerequisites:
Learn BeagleBone
programming and ROS</td></tr>
<tr><td colspan="2">Following activities:</td></tr>
<tr><td colspan="3">Goal: Fully implement control of servos and motor by the BeagleBone microcomputer.</td></tr>
<tr><td colspan="3">Description: Wire up and develop code for calculation positions of each part of the bipod using information from the IMU’s, wire up and develop code to allow the BeagleBone to control the motor and servos.</td></tr>
<tr><td>Total Workload: 400 Hours</td><td colspan="2">Work distribution:
Stian Olsen, 100 Hours
Edvard Merkesvik, 100 Hours
Kristoffer Pedersen, 100 Hours
Lars-Erik Panengstuen 100 Hours</td></tr>
<tr><td colspan="3">Cost: None</td></tr>
<tr><td colspan="3">Resources: BeagleBone computer, 2x Inertial measuring units, 2x Servos</td></tr>
<tr><td colspan="3">Risk: None</td></tr>
<tr><td colspan="3">Project supervisor:
Torleif Anstensrud
Project team members:
Stian Olsen,
Edvard Merkesvik,
Kristoffer Pedersen,
Lars-Erik Panengstuen</td></tr>
</table>

<table>
<tr><td colspan="2">Course: TELE3001 Bachelor Thesis</td><td>Date:
20.01.2021</td></tr>
<tr><td colspan="3">Project: Instrumentation of bipedal robot</td></tr>
<tr><td colspan="2">Activity: Implement IMU’s</td><td>Activity nr:
9</td></tr>
<tr><td>Starting date: 19.02.2021</td><td colspan="2">End date: 01.05.2021</td></tr>
<tr><td rowspan="2">Dependency:</td><td colspan="2">Prerequisites:
Learn BeagleBone
programming and ROS</td></tr>
<tr><td colspan="2">Following activities:
Develop software
for real time visualization
of robot</td></tr>
<tr><td colspan="3">Goal: Fully implement IMU’s into the machine</td></tr>
<tr><td colspan="3">Description: Install the inertial measuring units on the machine and connect the IMU’ to the BeagleBone-Computer.</td></tr>
<tr><td>Total Workload: 40 Hours</td><td colspan="2">Work distribution:
Stian Olsen, 20 Hours
Edvard Merkesvik, 20 Hours</td></tr>
<tr><td colspan="3">Cost: None</td></tr>
<tr><td colspan="3">Resources: IMUs</td></tr>
<tr><td colspan="3">Risk: None</td></tr>
<tr><td colspan="3">Project supervisor:
Torleif Anstensrud
Project team members:
Stian Olsen,
Edvard Merkesvik,
Kristoffer Pedersen,
Lars-Erik Panengstuen</td></tr>
</table>

<table>
<tr><td colspan="3">Course: TELE3001 Bachelor Thesis</td><td>Date: 20.01.21</td></tr>
<tr><td colspan="4">Project: Instrumentation of bipedal robot</td></tr>
<tr><td colspan="3">Activity: Develop software for real time visualization of robot</td><td>Activity nr: 10</td></tr>
<tr><td colspan="2">Starting date: 10.03.15</td><td colspan="2">End date: 01.04.21</td></tr>
<tr><td rowspan="2">Dependency:</td><td colspan="3">Prerequisites: IMU in place</td></tr>
<tr><td colspan="3">Following activities:</td></tr>
<tr><td colspan="4">Goal: To have working software that visualizes the robot</td></tr>
<tr><td colspan="4">Description:
After installing the IMU we need to develop software that allow the robot to use the information gathered from the IMU in order to know where the legs and the torso are in comparison to each other.</td></tr>
<tr><td colspan="2">Total Workload: 100 Hours</td><td colspan="2">Work distribution:
Kristoffer 50 Hours
Lars-Erik 50 Hours</td></tr>
<tr><td colspan="4">Cost: None</td></tr>
<tr><td colspan="4">Resources: Computer</td></tr>
<tr><td colspan="4">Risk: None</td></tr>
<tr><td colspan="4">Project supervisor:
Torleif Anstensrud
Project team members:
Stian Olsen,
Edvard Merkesvik,
Kristoffer Pedersen,
Lars-Erik Panengstuen</td></tr>
</table>

Course: **TELE3001 Bachelor Thesis**		**Date: 20.01.21**
Project: Instrumentation of bipedal robot		
Activity: Finish bachelor thesis		**Activity nr:** 11
Starting date: 01.04.21	**End date:** 15.05.21	
Dependency:	**Prerequisites:** Finished work on the bipedal robot	
	Following activities:	
Goal: Have a completed thesis		
Description: While doing work on the robot we will have to write the thesis in order to present the work that has been done. This will be the documentation for the project.		
Total Workload: 200 Hours	**Work distribution:** Stian Olsen 50 Hours Edvard 50 Hours Kristoffer 50 Hours Lars-Erik 50 Hours	
Cost: None		
Resources: None		
Risk: None		
Project supervisor: Torleif Anstensrud **Project team members:** Stian Olsen, Edvard Merkesvik, Kristoffer Pedersen, Lars-Erik Panengstuen		

<table>
<tr><td colspan="3">Course: TELE3001 Bachelor Thesis</td><td>Date: 20.01.21</td></tr>
<tr><td colspan="4">Project: Instrumentation of bipedal robot</td></tr>
<tr><td colspan="3">Activity: Test the robots walking ability (If time)</td><td>Activity nr:
12</td></tr>
<tr><td colspan="2">Starting date: 01.04.2021</td><td colspan="2">End date: 15.05.2021</td></tr>
<tr><td rowspan="2">Dependency:</td><td colspan="3">Prerequisites: Everything else technical we set out to do is in place</td></tr>
<tr><td colspan="3">Following activities:
Documentation</td></tr>
<tr><td colspan="4">Goal: The robot takes a step or two unassisted.</td></tr>
<tr><td colspan="4">Description:
Given that everything else is in place, we will test to see if the robot can take a couple of steps unassisted using a simple regulator.</td></tr>
<tr><td colspan="2">Total Workload:
50 hours</td><td colspan="2">Work distribution:</td></tr>
<tr><td colspan="4">Cost: None</td></tr>
<tr><td colspan="4">Resources: The robot</td></tr>
<tr><td colspan="4">Risk: Minimal risk to the robot itself</td></tr>
<tr><td colspan="4">Project supervisor:
Torleif Anstensrud
Project team members:
Stian Olsen,
Edvard Merkesvik,
Kristoffer Pedersen,
Lars-Erik Panengstuen</td></tr>
</table>

6 Project organization

6.1 Team Members

6.1.1 Edvard Merkesvik

- Age: 23 years old
- Phone: 94172487
- Mail: Edvardbm@ntnu.no
- Studying: Electrical Engineering, Automation

Competence: In highschool I went general studies with focus on science. After high school i served the initial service in the Norwegian Navy. From the age of 13 to 17 I worked for my local municipality during the summer. Mostly basic maintenance of buildings, but also as a lifeguard. From the age of 18 I've worked within production of aluminium for Norsk Hydro during the summers.

About me: I consider myself both ambitious and an easy learner with the ability to be "hooked" on certain things if I find them interesting. I consider my focus, especially if I find the subject to be less relevant and with no clear goal, my biggest weakness. Even though enjoy I starting the day early, I am a clear b-type person and works best during the evening/late early night.

Schedule and motivation: I took the subject "Ingeniørfaglig systemtenkning" last year. Hence the only subject on my schedule will be the bachelor. I also work out 5-6 times a week, but I have no problem skipping those and it wont affect my schedule. My plan is to apply for a masters at NTNU next year and I consider getting a good grade necessary. I also find several aspects of the task interesting and relevant, especially ROS, so the learning factor itself will be highly motivating.

6.1.2 Stian Johan Olsen

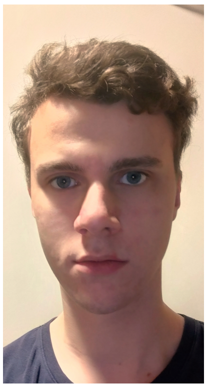
- Age: 22 years old
- Phone: 98816551
- Mail: stianjol@stud.ntnu.no
- Studying: Electrical Engineering, Automation

Competence: I went general studies on High School mainly focusing on science. For the last 6 years i have worked in the fish business both as a retailer, and in a wholesale facility. This has caused me to work with a lot of different people and personalities and i think it has prepared me well for working in a team.

About me: I am very much an interest driven person, i often get hooked on certain subjects for shorter periods of time, spending a lot of time learning about said subject. Creativity is also a big part of my personality and my solutions to problems can for better or worse differ from others. Outside of school i enjoy being active in some form or another. I enjoy skiing climbing and being outdoors in general.

Schedule and motivation: I am very exited to work on this project. I find that working with actual problems is key to keeping me interested over time. I will have to retake a few exam close to summer so i hope to finish this project a bit early to have time for that. I am confident that this group can perform well and that the op

6.1.3 Lars-Erik Nes Panengstuen



- Age: 22 years old
- Phone: 48120804
- Mail: lepaneng@stud.ntnu.no
- Studying: Electrical Engineering, Automation

Competence: I graduated Nes VGS in general studies, specialized in physics, chemistry and maths. I think the previous two and a half years have prepared me well for this Project. The last three summers i have been working For Siemens by maintaining their database on circuit breaker characteristics. I also have some experience in both 3D-modelling and programming on personal projects witch i hope will come in handy.

About me: I consider myself very much a ”logical” person as opposed to a creative one. I like to work on tasks where i know there is a ”best” or correct solution to be found. I consider my biggest weakness to be focus. I can easily become distracted and spend far too long thinking about something else if I’m not careful, especially if its something I’m not interested in. In my spare time i like to work on personal projects, I’ve designed and 3d printed a catamaran RC-speedboat, built a quad-copter drone and upgraded my 3D printer. i also hope to build a CNC-machine more or less from scratch once i graduate and get my own place.

Schedule and motivation: Bachelor is definitely going to be priority number one so everything else is going to be scheduled around it. I am hoping to improve my grades in some other subjects this semester. I don’t think this will take too much of my time, since most of the knowledge i need in these subjects are prerequisites in the subjects i have had since. I am highly motivated to work on this project. Watching a machine doing something you designed it to do all on its own is very satisfying and gratifying and i am confident we can get this robot walking in some form by the end of this semester.

6.1.4 Kristoffer Meggelæ Pedersen

- Age: 22 years old
- Phone: 94169397
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- Studying: Electrical Engineering, Automation

Competence: I studied general studies with a focus on science. After graduating i served first-time service in His Majesty The King's Guard. Since i have been studying electrical engineering at NTNU. I have also worked a couple of months as a prison officer substitute. In addition i am also currently the leader of a volunteer group at samfundet, called "KSG"(Kafe- og serveringsgjengen). This requires organizing a group of over 340 volunteers who actively do serving at a professional level.

About me: I enjoy keeping myself busy. I am very good at handling stress as well as large workloads. Although i enjoy having clear goals, i am flexible when it comes to my path to get there. I prefer spreading my work sessions out according to a schedule in order to make sure i can keep full focus when i am actually working.

Schedule and motivation: I have a relatively full schedule, however that only helps with my motivation. I consider the work interesting, and also something that i might learn something from. My highest priority this semester will be the work on this thesis. I am hoping to feel like i accomplished what i wanted this semester, and as such i will work hard to achieve it. Managing my schedule itself is also something i consider myself good at, which makes it easy to have a lot on my plate as i can mange it effectively.

Preliminary equipment and components

The bipedal robot itself is made up of a variety of different components. This section is meant to be the description of the system itself, and the different parts it is made up of. It is worth noting that the configuration of the robot has been worked on by at least two previous engineering groups. If there is a need for extra equipment further down the line, it will be added to the list. As of now the work we need to do don't require much outside of what already is in place. The only clear exception being some brackets for the pistons at the ends of the legs. This is the current list of all the hardware parts incorporated on the 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	Scancon
Inertial measurement unit chip	LSM9DS1	STMicroelectronics
IMU Breakout board	Breakout-LSM9DS1	Sparkfun
Power supply	QPX600D	Aim-TTI
BeagleBone Black	BeagleBone Black	BeagleBoard.org

Table 1: Equipment & Components

6.2 Frame

The main structural part of the robot is the frame itself. It is made of square aluminum tubing. The tubing is made in a shape very vaguely meant to resemble the parts of a standing person that are necessary for bipedal movement. The tubing itself is hollow and has pre-drilled holes made in order to have an easy way to affix components. Both the torso and the legs are part of the full frame, but as they serve somewhat different functions, it is appropriate to differentiate between them.

6.2.1 Torso

The torso is mainly used to have a place for the plate that harbours all of the instrumental equipment. It can be considered the "brains" of the robot. All of the components used to control the robot are situated on the torso. This for example includes the beagle bone. The torso also serves to add a bit of weight and to make the robot more akin to a walking person. This also ads another degree of freedom and serves as a way to make a natural reference point for the IMU.

6.2.2 Legs

The robot has legs that are of a somewhat peculiar design. In order to make balance easier, the two legs each consist of two sets of aluminum tubing. The easiest way to describe it is that it very much so resembles school chairs. This makes it so that the robot won't wobble or fall over when moving. In addition the legs all have pointers in order to make sure the legs don't scratch at the ground when moving. The movement of the legs them-self are done using actuators. Which are servo motors that allow the legs to swing back and forth. Each of the four ends on the legs also have servo motors in order to move the pointers up and down.

6.2.3 Controlling the robot

The communication between the different parts is done by a BeagleBone. It is used to communicate between the parts mentioned earlier. The data collected from the sensors is used as a basis in order to allow the BeagleBone to controll the servos as needed.

6.3 Project delivery

There are various deliveries to be made during the project. This mainly boils down to three things. The reports them-self, the hardware upgrades to the robot and the software required to make the robot walk.

The reports are each written documents that has information based on different stages of the project. They included this report as well as the final report when all the practical work is complete.

6.3.1 Physical deliveries

The IMU's have to be implemented on the frame in the best way possible. The current plan is to affix one IMU on each leg and one on the torso. This will make it possible to visualize the movement of the robot based on the position these are in relation to each other.

There is also a need to install the brackets for the pointers on the legs of the frame. These are mainly required in order to make sure the servo motors are comfortably in place.

6.3.2 Software delivery

In order to make use of the IMU's there is also a need for software that can visualize the data they provide. In addition it is necessary to develop code for calculating positions of each part of the bipedal robot using information from the IMU's, as well as develop code to allow the BeagleBone to control the motor and servos.

6.4 Time-and resource management

In order to make sure the project has consistent flow, a thorough plan for the work has been made. This is very important in order to deliver a good project. A lot of the planning at this point are based on rough estimates. There are a decent amount of new software as well as hardware we need to familiarize our self with for this project. Something that is especially difficult to plan for very accurately. It is therefor worth noting that the plan represented here is subject to change. An imortant part for time management will therefor be communication and a certain degree of flexibility.

6.4.1 Gantt diagram

The Gantt diagram is based on the agreed upon milestones in the work-packages. As such the diagram is a very useful way to visualize the timeline of the project. There is a certain amount of overlap in some of the work. This is mainly because of how the work itself is split up between us.

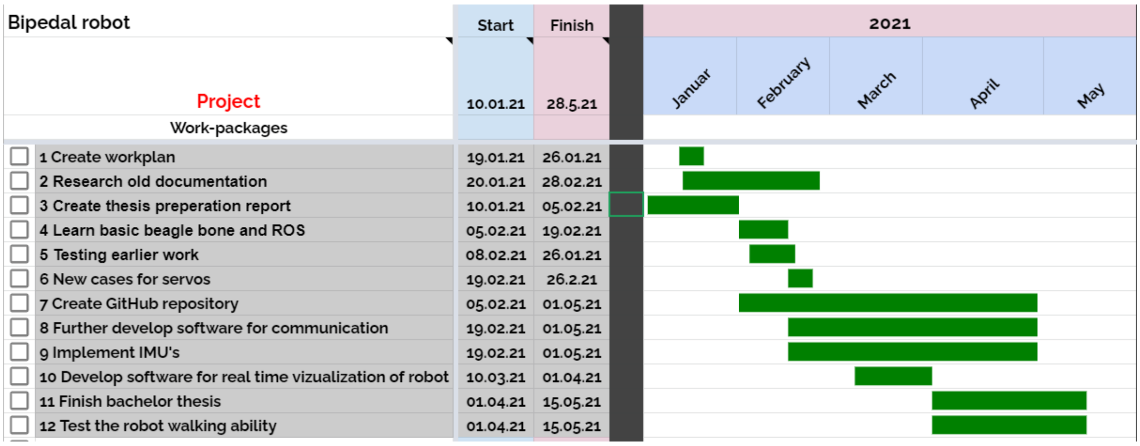

Figure 1: Gantt Diagram

6.4.2 Cost-plan

The project is currently not expecting to have any major cost. This might change later, but for there is no plan to to use any money as far as resources go.

6.4.3 Quality assurance

In order to make sure the quality of the project is where it needs to be, it will be necessary to have certain criteria for success. As such there will be a need to test the work being done at various intervals. In addition there must be thorough documentation in order to make sure the work and their results are reliable.

Regular updates In order to communicate our progress on the project, there will be regular meetings with the project supervisor. Here it will be possible to let it be known how the project is currently doing compared to the planned timetable. In addition a comprehensive report of all the work done on the robot will be written at the conclusion of the project. Finally there will be an oral presentation to show the finished work.

6.5 Risk assessment

6.5.1 Corona Virus

As previously mentioned, this project is taking place during a pandemic. As a consequence we need to have a precautionary approach to everything we do. Some of the most relevant measures are to limit our social contacts, hold meetings over Microsoft Teams and use a lot of disinfection.

6.5.2 Physical hazards

We have mechanical hazard in form of the moving parts on the Robot, but it does not contain enough energy to do any major damage. A worst case scenario might be getting a finger pinched.

We also have electrical hazard when working physically on the robot. This can give us electrical shock or, as the previous group got to experience, destroy one of the components. In that case 7.4 Volts got connected to one of the Beaglebone pins, which only can handle 3.3 Volt, and the Beaglebone got destroyed. For the safety of us students and the robot we need have full control over the wires, connections and what voltage the different components can handle.

6.6 Attachments

6.6.1 Assignment

NTNU

Institutt for elektroniske systemer
Institutt for elkraftteknikk
Institutt for teknisk kybernetikk

Oppgaveforslag bacheloroppgave elektroingeniør i Trondheim, vårsemester 2021

Navn bedrift: 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 og 2020.

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 vedlikehold av GitHub repository, wiki, etc
- Implementere måling av overkroppens vinkel med IMU, inkludert elektronikk og software filtrering
- Tilkobling av servoer for kontroll av fotlengde
- Videreutvikle software med ROS for kommunikasjon mellom embedded hardware (BeagleBone) og styring av servoer og motorer, samt sensoravlesing
- Utvikle software for (sanntids)logging/visualisering av robottilstand basert på sensoravlesninger
- Hvis tid: Gjøre enkle tester av bevegelse/skritt

Hvis utført arbeid egner seg til publisering oppfordres det til å bidra til å produsere en vitenskapelig publikasjon.

Det er ønskelig at rapporten skrives på engelsk, men dette er ikke et krav.

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