



# Software Development Project

## Motion primitives for Freddy

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# Definition

**Motion primitives** are pre-computed motions that the robot can take.

<sup>1</sup>

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<sup>1</sup>Search-Based Planning Lab



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# Freddy robot

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- Modular mobile robot platform
- Four identical pair of wheels, which can be actuated independently
- Communication with wheel-units (in master-slaves architecture) is made over EtherCAT
- Available sensors: motor encoder, gyroscope, accelerometer, IMU (Inertial Measurement Unit)
- Motion control: velocity and force
- Programming language: C

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<sup>2</sup>EBuilding blocks for complicated and situational aware robotic and cyber-physical systems





(a) Top view



(b) Rear view

Figure 1: Top and rear view of Robot Freddy



# Problem definition

Safe ramping behaviour of Freddy robot using motion primitives.



# Velocity control - video



# Safe ramping behaviour - video



# Push/pull configuration - video



# Wheel configuration



# Top view of 2 castor and 2 active wheels configuration



# Project goal

Successfully perform the ramping motion on the Freddy robot safely.



# Required libraries

- Simple Open EtherCAT Master (SOEM) - communication between robot and the actuators.<sup>3</sup>
- robif2b - robot control interface<sup>4</sup>

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<sup>3</sup> SOEM github repository

<sup>4</sup> robif2b github repository



# User story 1

<b>Unique Identifier :</b> D1	<b>Estimate :</b> 2 weeks
<b>Task Description :</b> <ul style="list-style-type: none"><li>Understand force control distribution on Freddy robot.</li><li>Test previous SDP code on Freddy.</li><li>Evaluate overlap between previous SDP and ramping behaviour</li><li>Implement relevant code required for ramping.</li></ul>	<b>Acceptance Criteria :</b> <ul style="list-style-type: none"><li>The code should run successfully on Freddy.</li><li>The overlapped code should be implemented for ramping behaviour.</li></ul>
<b>Risk :</b> Minimum	<b>Real Effort :</b>



# User story 2

<b>Unique Identifier :</b> D2	<b>Estimate :</b> 2 weeks
<b>Task Description :</b> <ul style="list-style-type: none"><li>Orient wheel units to the desired configuration w.r.t. base of the robot.</li></ul>	<b>Acceptance Criteria :</b> <ul style="list-style-type: none"><li>Bring the wheels to 0, 90, 180 and 270 degrees.</li></ul>
<b>Risk :</b>	<b>Real Effort :</b>

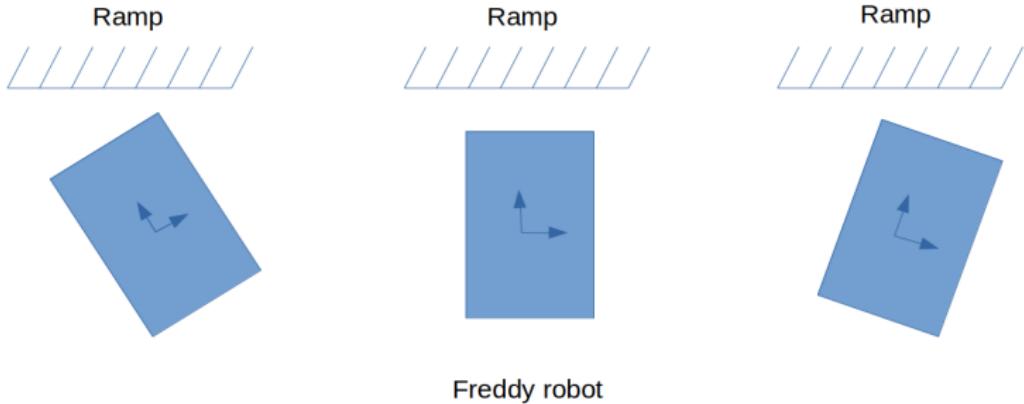


# User story 3

<b>Unique Identifier :</b> D3	<b>Estimate :</b> 3 weeks
<b>Task Description :</b> <ul style="list-style-type: none"><li>Align the robot with a ramp baseline.</li></ul>	<b>Acceptance Criteria :</b> <ul style="list-style-type: none"><li>The robot should be aligned with the baseline of the ramp from different starting orientations:<ul style="list-style-type: none"><li>-&gt; w.r.t. to the baseline of the ramp,</li><li>1) positive slope,</li><li>2) negative slope, and</li><li>3) parallel to the line.</li></ul></li></ul>
<b>Risk :</b>	<b>Real Effort :</b>



# Robot alignment w.r.t. ramp



# User story 4

<b>Unique Identifier :</b> D4	<b>Estimate :</b> 4 weeks
<b>Task Description :</b> <ul style="list-style-type: none"><li>Understand the ramp-up behaviour for the Freddy robot.</li><li>Implement ramping behaviour on the robot.</li></ul>	<b>Acceptance Criteria :</b> <ul style="list-style-type: none"><li>The robot should be able to complete the ramp slope.</li><li>The robot should be able to safely stop after finishing the ramp.</li><li>The robot should also be able to run over a small bump (ramp up and down).</li></ul>
<b>Risk :</b>	<b>Real Effort :</b>



# User story 5

<b>Unique Identifier :</b> D5	<b>Estimate :</b> 2 weeks
<b>Task Description :</b> <ul style="list-style-type: none"><li>Integrate all sub-modules as a complete state machine.</li></ul>	<b>Acceptance Criteria :</b> <ul style="list-style-type: none"><li>The robot should be able to autonomously drive over the ramp.</li><li>The robot should be stopped after the finishing ramp behaviour.</li></ul>
<b>Risk :</b>	<b>Real Effort :</b>



# Collaboration plans

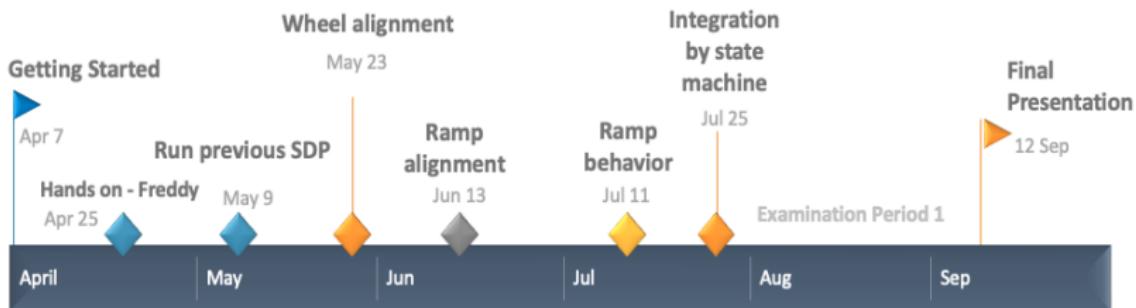


Figure 2: Project Roadmap

Version Control : GIT: Motion Primitive Freddy repository

Communication medium: Slack

Meeting frequency : Internal meeting twice a week and with the Advisor, every Monday (in-person/online)

