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Software Development Project

Motion primitives for Freddy

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Definition

Motion primitives[1] , skill or behavioural building block:

- atomic unit of robotic behaviour
- configurable and hence reusable in different contexts
- composable with other motion primitives to build more complex behaviour

[1] **Kinematic constraints and motion primitives**. 2022. URL: http://sbpl.net/node/48.

Freddy(Robile platform) robot

2

- 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, IMU (Inertial Measurement Unit) - consists of gyroscope and accelerometer
- Control interface: velocity(power limited) and force(current controlled)
- Programming language: C

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[2] Herman Bruyninckx. **Building blocks for complicated and situational aware robotic and cyber-physical systems**. 2022. URL: https://robmosys.pages.gitlab.kuleuven.be/composable-and-explainable-systems-of-systems.pdf.

Freddy(Robile platform) robot

(a) Top view

(b) Bottom view

Figure 1: Top and bottom view of Robile platform

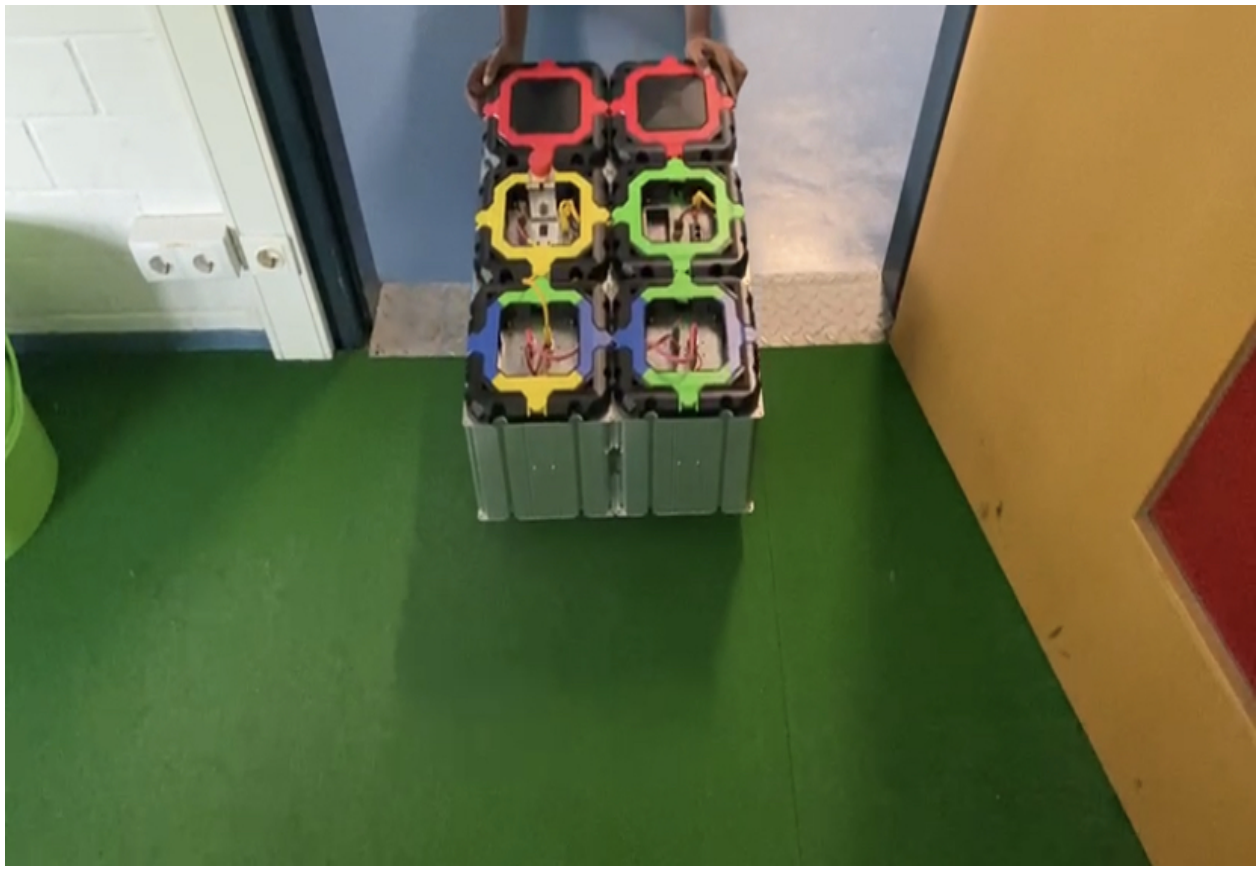
Problem definition

Safe movement over the ramp using motion primitives for the Freddy robot

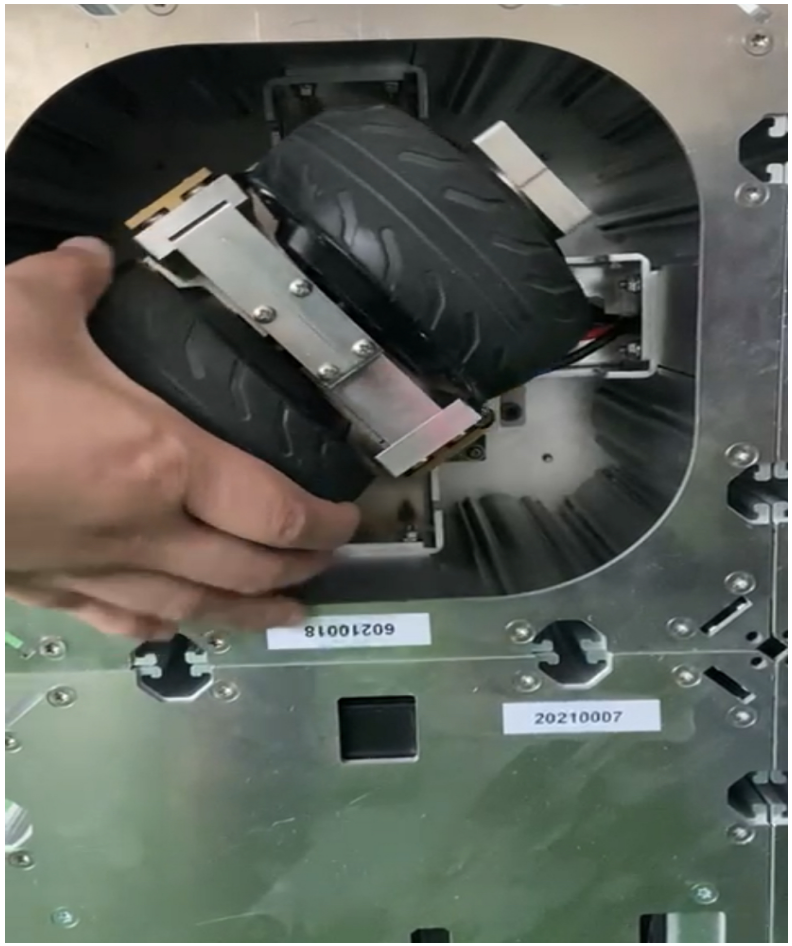
- Safe means the robot and the environment safety.
- Robot safety means moving the robot in a controlled manner.
- Environment safety means without colliding with the objects around the robot.

Velocity control - video

Safe ramping behaviour - video



Push/pull configuration - video



Wheel configurations

- Possible different configuration of the platform i.e., 4 wheeled , 2 wheels + 2 castors, tricycle etc.

Project goal

Develop a control interface for Freddy robot to perform a safe motion over the ramp

Required libraries

- Simple Open EtherCAT Master (SOEM) - communication between robot and the actuators.[3]
- robif2b - robot control interface[4]
- GSL - GNU Scientific Library[5]
- WS21 SDP repository: Motion Control of the KELO 500[6]

[3] OpenEtherCATsociety. **OpenEtherCATsociety/Soem: Simple Open Source ethercat master**. 2022. URL: https://github.com/OpenEtherCATsociety/SOEM.

[4] Rosym-Project. **ROSYM-project/ROBIF2B: Building blocks for robot interfaces**. 2022. URL: https://github.com/rosym-project/robif2b.

[5] Dr J. Theiler Dr M. Galassi. **GSL - GNU Scientific Library**. 1996. URL: https://www.gnu.org/software/gsl/.

[6] **ws21-kelo-500-motion-control**. 2021. URL: https://github.com/HBRS-SDP/ws21-kelo-500-motion-control.

User story 1

Unique Identifier : D1	**Estimate :** 2 weeks
Task Description : • Understand force control distribution on Freddy robot. • Test previous SDP code on Freddy. • Evaluate overlap between previous SDP and ramping behaviour. • Refactoring the existing code.	**Acceptance Criteria :** • 1. Move robot in translational forward/backward and left/right as well as rotational clockwise/ anticlockwise manner. • 2. Drive up the ramp with the different platform-level force setpoints.
Risk : Low	**Real Effort :**

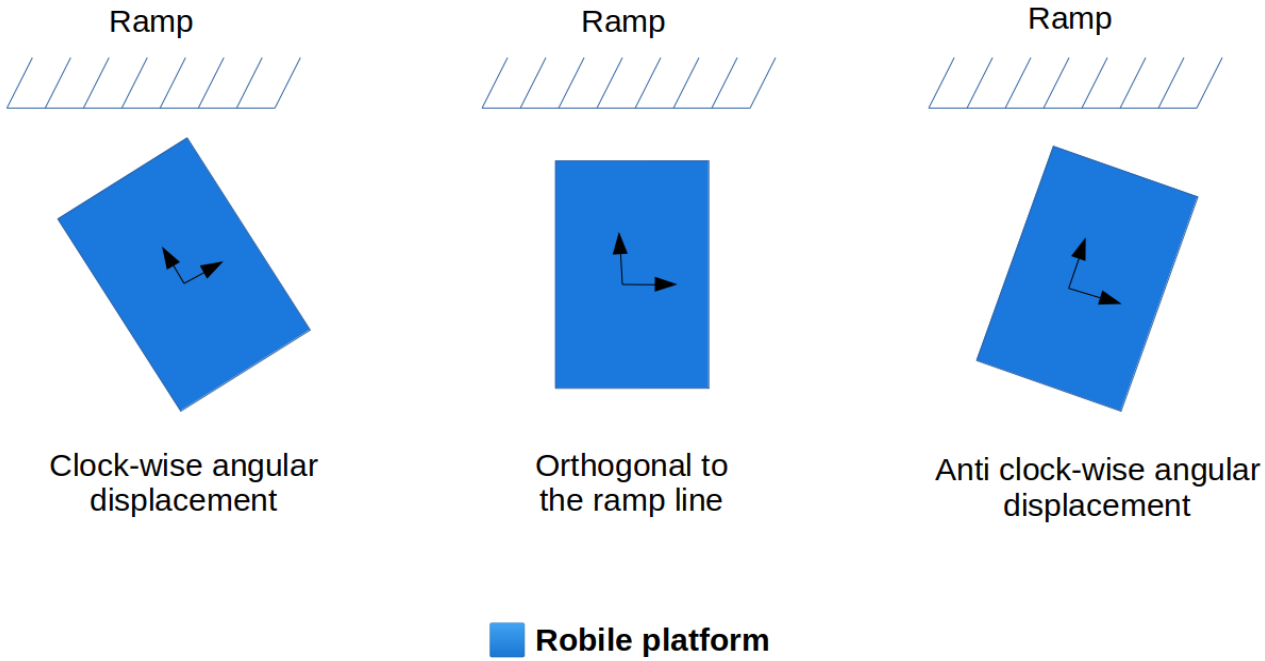
User story 2

Unique Identifier : D2	**Estimate :** 2 weeks
Task Description : • Orient wheel units to the desired configuration w.r.t. base of the robot.	**Acceptance Criteria :** • Bring the wheels to 0, 90, 180 and 270 degrees.
Risk : High	**Real Effort :**

User story 3

Unique Identifier : D3	**Estimate :** 3 weeks
Task Description : • Align the robot with a ramp baseline.	**Acceptance Criteria :** • The robot should be aligned with the baseline of the ramp from different starting orientations: –> w.r.t. to the baseline of the ramp, 1) clockwise angular displacement, 2) anti–clockwise angular displacement, and 3) orthogonal to the line.
Risk : High	**Real Effort :**

Robot alignment w.r.t. ramp



User story 4

Unique Identifier : D4	**Estimate :** 4 weeks
Task Description : • Understand the ramp-up behaviour for the Freddy robot. • Implement ramping behaviour on the robot.	**Acceptance Criteria :** • The robot should be able to complete the ramp slope. • The robot should be able to safely stop after finishing the ramp. • The robot should also be able to run over a small bump (ramp up and down).
Risk : High	**Real Effort :**

User story 5

Unique Identifier : D5	**Estimate :** 2 weeks
Task Description : • Integrate all sub–modules as a complete state machine.	**Acceptance Criteria :** • The robot should be able to autonomously drive over the ramp. • The robot should be stopped after the finishing ramp behaviour.
Risk : High	**Real Effort :**

Collaboration plans

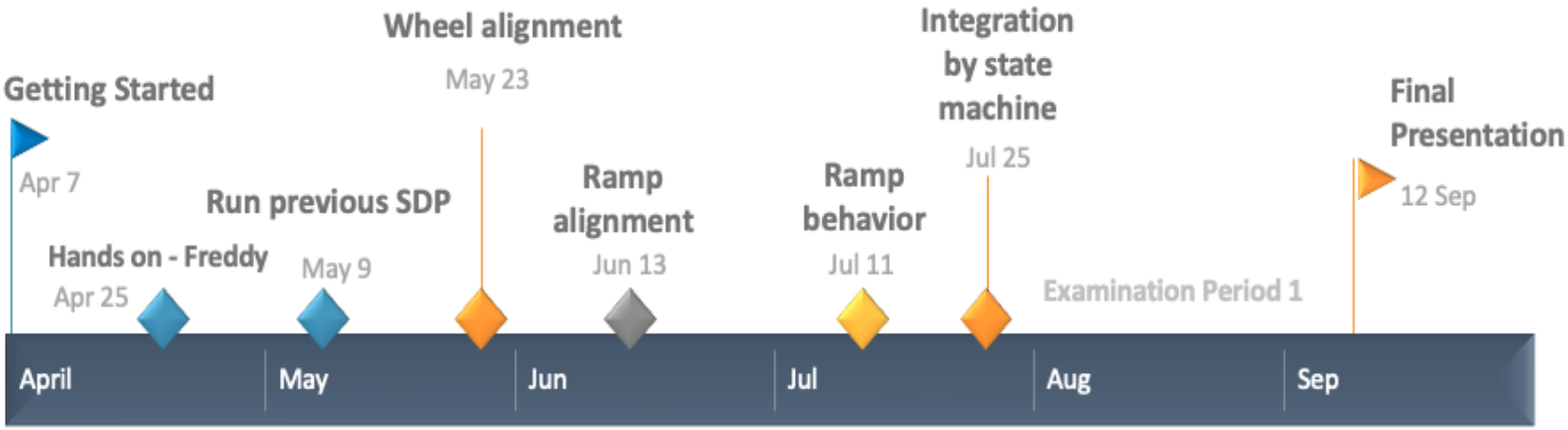


Figure 2: Project Roadmap

- 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)

Reference

[1] Herman Bruyninckx. **Building blocks for complicated and situational aware robotic and cyber-physical systems**. 2022. URL: https://robmosys.pages.gitlab.kuleuven.be/composable-and-explainable-systems-of-systems.pdf.

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[5] Rosym-Project. **ROSYM-project/ROBIF2B: Building blocks for robot interfaces**. 2022. URL: https://github.com/rosym-project/robif2b.

[6] **ws21-kelo-500-motion-control**. 2021. URL: https://github.com/HBRS-SDP/ws21-kelo-500-motion-control.

Thank you for your attention!
Questions?