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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.

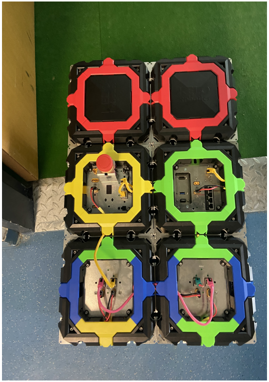
Robile platform of Freddy: Capabilities

- 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

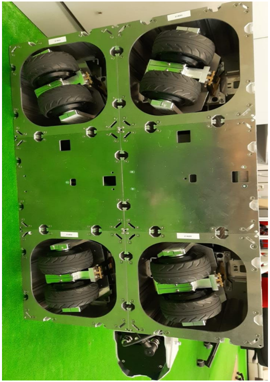
Robile platform of Freddy: User interface

- Control interface: velocity(power limited) and force(current controlled)
- Programming language: C

Robile platform



(a) Top view



(b) Bottom view

Figure 1: Top and bottom view of Robile platform

Problem definition

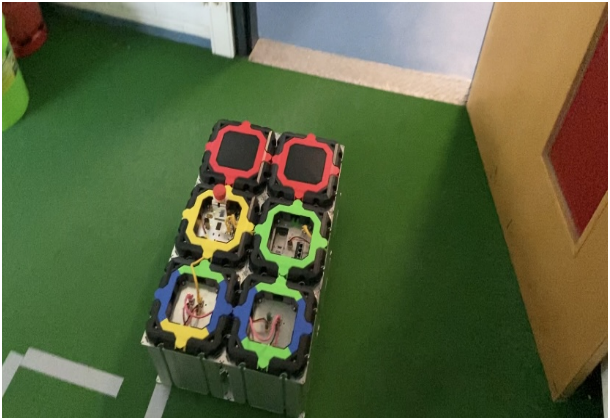
Controlled movement over the ramp using motion primitives for the Freddy robot

Project goal

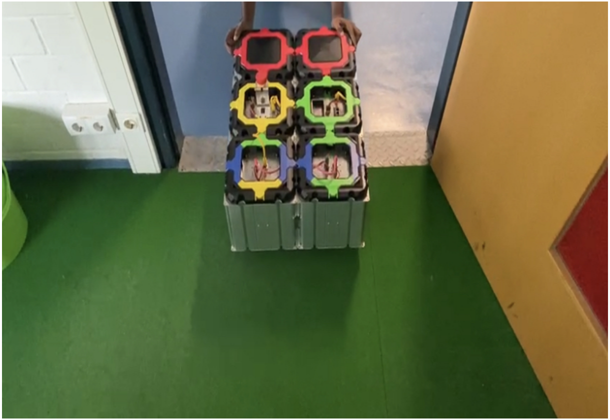
Develop a control interface for Freddy robot to perform a motion over the ramp [a]

[a] Considering environment is static

Velocity control - video



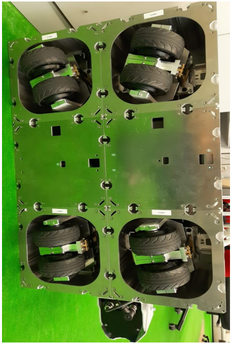
Safe ramping behaviour - video



Wheel configurations

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

(a) 2 active wheels and 2 castor wheels



(b) 4 active wheels

Required libraries

- Simple Open EtherCAT Master (SOEM) - communication between robot and the actuators.[2]
- robif2b - robot control interface[3]
- GSL - GNU Scientific Library[4]
- WS21 SDP repository: Motion Control of the KELO 500[5]

[2] OpenEtherCATsociety 2022.

[3] Rosym-Project 2022.

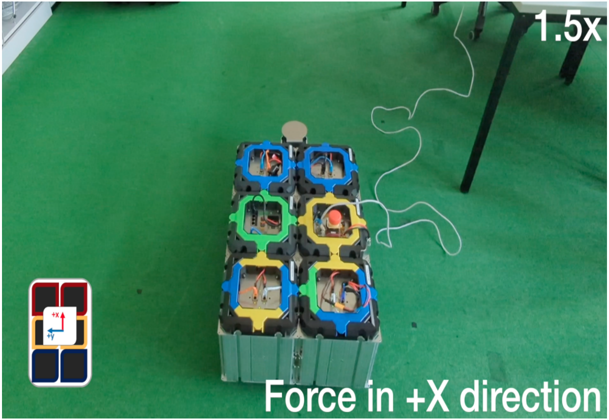
[4] Dr M. Galassi 2021.

[5] **ws21-kelo-500-motion-control** 2021.

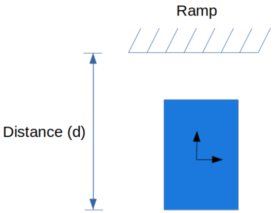
User story 1

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 :** 2 weeks

Acceptance criteria 1 - video



Robot distance w.r.t. ramp



Distance between robot and ramp

Robile platform

Acceptance criteria 2 (d=250cm) - video

Acceptance criteria 2 (d=125 cm) - video

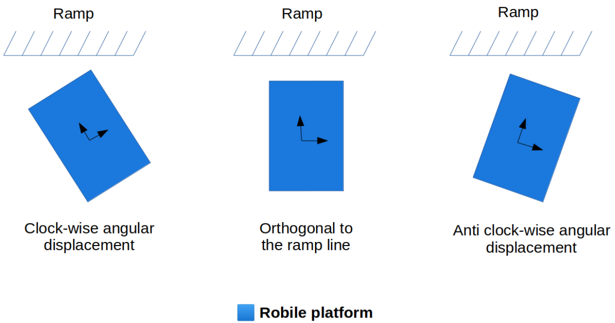
User story 2

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

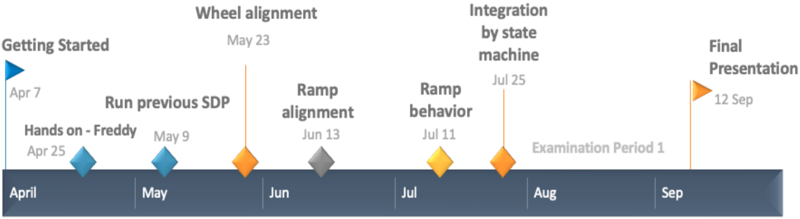


Figure 2: Project Roadmap

- GIT version control: Motion Primitive Freddy repository
- Communication medium: Slack
- Meeting frequency: internal meeting twice a week and with the advisor, every Thursday (in-person/online)

References

Bruyninckx, Herman (2022). **Building blocks for complicated and situational aware robotic and cyber-physical systems**. Accessed on 21.04.2022. URL: https://robmosys.pages.gitlab.kuleuven.be/composable-and-explainable-systems-of-systems.pdf.

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ws21-kelo-500-motion-control (2021). Accessed on 21.04.2022. URL: https://github.com/HBRS-SDP/ws21-kelo-500-motion-control.

Thank you for your attention!
Questions?