MASTER'S THESIS PROPOSAL

CODE: 1687

2021/10/11

Master's Thesis Proposals

Mechatronics Team

ABB

CODE: 1687

Master's Thesis Proposals

Real-time local positioning of mobile robot

Scope

Research topics:

How to fast and accurately position mobile platform at a chosen point

Goal(s):

1. Find cost efficient sensory system with required accuracy and speed to be part of low-level control loop
2. Develop control for the "last inch" motion to point

Description

In many use-cases involving mobile robots it is important that the robot can be accurately positioned. Large-scale localization of the robot is usually made using either 2D LIDAR sensors or visual sensors (e.g. VSLAM). These systems can usually achieve an accuracy in the centimeter range.

The present MSc project targets to find complementary sensory system that can locally reach millimeter accuracy of a goal point, given a starting-point few centimeters from the goal point. This sensory system should be high speed and robust enough such that it can be part of vehicle motion control loop.

Approach

The work will address the following points:

- Review sensory systems and their feasibility
- Build HW PoC set-up using selected sensory system
- Develop algorithm for generation of motion reference based on sensory input
- Make PoC for mobile robot

Required background

- Suitable for one student with interest in mobile robotics in general and sensors and embedded systems in particular
- Embedded systems, SW, MATLAB Simulink
- (ROS-knowledge is a plus)

Timeline

- Start: between Jan. 2022 and June 2021
- Duration: 6 months
- Place: ABB CRC (Västerås)
- ABB will cover the accommodation in Västerås if necessary

Supervisor contact: **Jonatan Blom**
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Master's Thesis Proposals

Automatic and accurate determination of sensor position/orientation on mobile platform

Scope

Research topics:

How to fast and accurately calibrate sensors position on-board a mobile platform

Goal(s):

1. Develop procedure to in a flexible way be able to accurately determine sensors position on a mobile platform
2. Strategy to simultaneously manage positioning of sensors of different types such as LIDARs and 3D cameras.

Approach

The work will address the following points:

- Review state-of-art for feasible automatic calibration algorithms and their requirements
- Select and implement algorithm for required motion and optimization of sensors positions
- Evaluate results based on data collected in ABB lab with available mobile robot

Description

In many use-cases involving mobile robots it is important that the robot can be accurately positioned. Large-scale localization of the robot is usually made using either 2D LIDAR sensors or visual sensors (e.g. VSLAM). These systems can usually achieve an accuracy in the centimeter range. If we would like to combine/fuse results of both these systems, it is crucial to have the best possible positioning of these sensors on the robot and relative to each other. In addition, if a sensor is replaced due to e.g. maintenance it is important to be able to easily re-calibrate.

The present MSc project targets to find an efficient procedure that can be used to accurately determine position and orientation of sensors so data can be fused.

Required background

- Suitable for one student with interest in mobile robotics in general and optimization in particular
- Required skills: SW programming (C and/or Python)
- (ROS-knowledge is a plus)

Timeline

- Start: between Jan. 2022 and June 2021
- Duration: 6 months
- Place: ABB CRC (Västerås)
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Supervisor contact: **Jonas Larsson**
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Master's Thesis Proposals

Charging station design for mobile robot

Scope

Research topics:

How to find method for fast charging mobile robots considering cost, safety and reliability

Goal(s):

1. Develop overview of recommended charging solutions for different power ratings
2. Proof-of-Concept prototype for mobile robot charging station

Description

For mobile robots an solution for autonomous charging of its batteries is a must.

The solution has to be safe, both for equipment and persons (electrical and physical/squeezing). Also, it has to meet requirements in reliability considering mechanical accuracy of robot-to-charging-station tolerances as well as the electrical interface, allowing many cycles of charging at high current. Finally, it has to be energy- and cost efficient.

The present MSc project targets to in a systematic way find an optimal design solution for charging of mobile robot with omni-motion capability.

Approach

The work will address the following points:

1. Develop overview of different charging solutions
2. Systematically evaluate charging solutions based on requirements
3. Develop design and build PoC prototype

Required background

- Suitable for one student with interest in mobile robotics and mechanical design
- Required skills: Mechanical design and (some) electronics

Timeline

- Start: between Jan. 2022 and June 2021
- Duration: 6 months
- Place: ABB CRC (Västerås)
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Supervisor contact: **Jonas Larsson**
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Master's Thesis Proposals

Modelling and simulation for PMSM controlled by wide-bandgap semiconductors

Scope

Research topics:

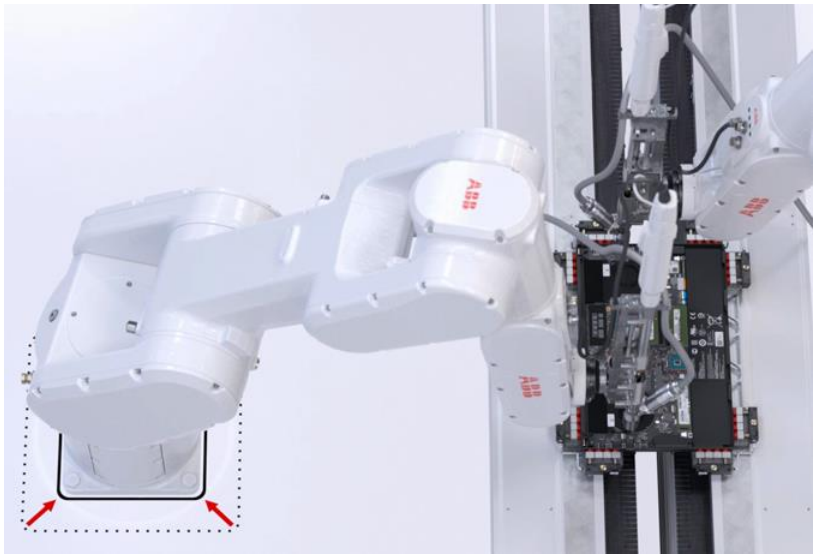
Developing high frequency PMSM model and analyzing system performance by simulation and experiment.

Goal(s):

1. To study modelling approaches on high frequency PMSM model controlled by wide-bandgap semiconductors;
2. To conduct simulation and experiment verification and analyzing system performance.

Description

The recent development of wide-bandgap semiconductor technology reached the market stage, where many of such devices can be found at affordable prices and with an acceptable reliability level. The key for the development of next generation robotics drivetrains may lie in the exploitation of wide-bandgap semiconductors. This could lead to an even more efficient utilization of electric energy, as well as enabling a smaller drivetrain size with potential for integration of power electronics and machines, a lower weight and improved thermal performances.



Approach

The work will address the following points:

- To study different modelling approaches on high frequency PMSM model;
- To conduct simulation and experiment verification and analyzing system performance.

Required background

- Knowledge on electrical machinery
- Knowledge on power electronics

Timeline

- Start: between Jan. 2022 and March 2022
- Duration: 6 months
- Place: ABB CRC (Västerås)
- ABB will cover the accommodation in Västerås

Supervisor contact: **Bin Liu** bin.liu@se.abb.com **LucaPeretti** lucap@kth.se

Master's Thesis Proposals

Speech-enabled learning of Behavior Trees from human demonstrations

Scope

Research topics:

Learning Behavior Trees (BT) from demonstration (LfD) [1] using verbal interaction with human users (HRI).

Goal(s):

1. Extension of the LfD framework with an existing verbal-HRI module.
2. Investigate the possibility of improving the existing speech recognition framework.
3. Validation of the extended framework with thorough experiments.

Approach

The work will address the following points:

- Integrate and extend the verbal HRI module in the learning framework.
- Adapt and improve the speech recognition module.
- Deploy the system on robot in real environments and test the verbal interaction in diverse tasks.

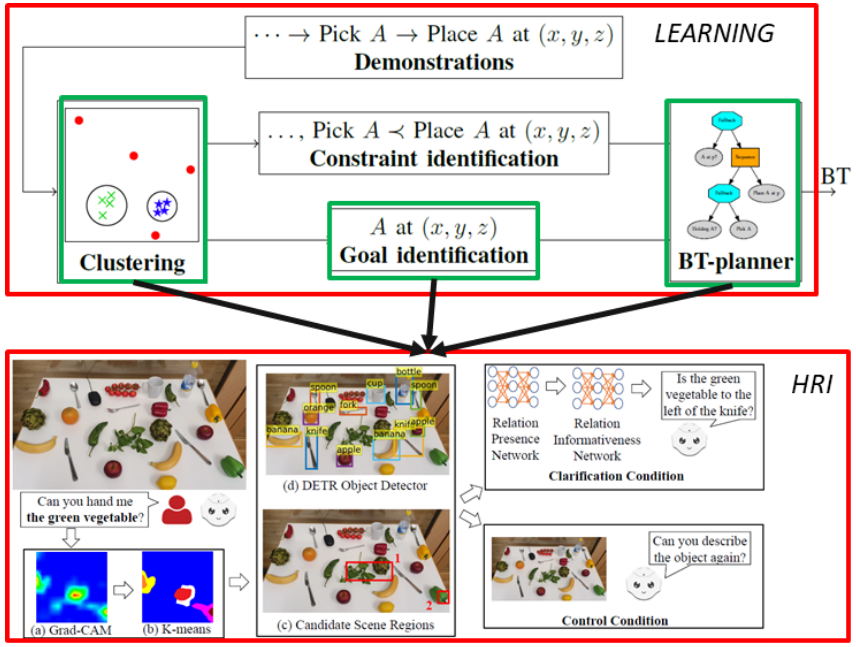
Description

Behavior Trees are a reactive task switching policy representation, used to control robotic agents. LfD can be used to teach the robot a task and BTs can be generated out of human demonstrations. However, ambiguities might rise if the target object for the task is similar to other objects in the environment. Thus, verbal-HRI can be used to disambiguate the task, both during the learning step and the execution step. The objective of the project is then to build a framework for continuous interaction between human and robot, from learning a task to execute it.

Required background

- System integration with ROS (ROS2 is a plus)
- Software: Python3.
- Familiarity with machine learning methods.
- Experience with computer vision and dialogue systems is a plus.

[1] https://arxiv.org/abs/2109.07133



Timeline

- Start: between Jan. 2022 and June 2022
- Duration: 6 months
- Place: ABB CRC (Västerås)
- ABB will cover the accommodation in Västerås

Supervisor contact: **Pietro Falco,** pietro.falco@se.abb.com
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Master's Thesis Proposals

Market requirement for hygienic robot in Healthcare/Pharma/Hospital segments

Scope

Research topics:

Understand market requirement for hygienic robot in the sector of Healthcare/Pharma/Hospital.

Goal(s):

1. Understand regulation/standards in Healthcare/Pharma Hospital
2. Understand market requirement (customer requirement) for hygienic robot in this sector

Description

Healthcare/Pharma/Hospital is relatively a new market for ABB Robotics and have a high business potential. The requirement for hygienic robot is different compared to Food and Beverage, Foodservice, etc. Without a good understanding, it is not easy to design the right robot product. Questions need to be answered including what should be the right robot structure material, should it be collaborative robot, what is the best way to clean the robot, etc.

Approach

The work will address the following points:

- Regulation/standard study
- Requirement understanding from customer contact
- Workshop with external experts and documentation
- Propose robot concept for this segment

Required background

- Robot hardware or material background
- Good communication skills to external partners
- Good documentation skills

Timeline

- Start: between Jan. 2022 and June 2022
- Duration: 6 months
- Place: ABB CRC (Västerås)
- ABB will cover the accommodation in Västerås

Supervisor contact: Shanghua Li (shanghua.li@se.abb.com)

Master's Thesis Proposals

Motion Planning of Mobile Manipulators over Wireless Communication

Scope

Research topics:

Control and motion planning of mobile manipulators via wireless communication

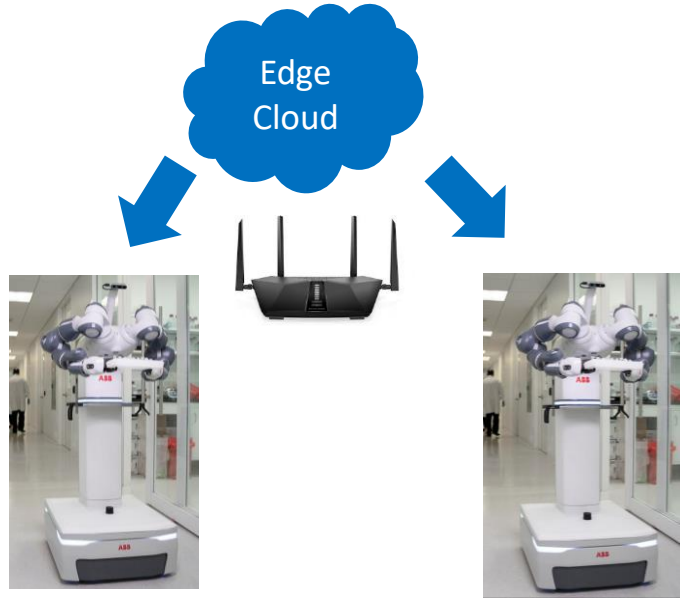
Goal(s):

1. Investigate the feasibility and performance of motion planning from edge cloud over WiFi6 / 5G
2. Contribute to developing strategies for communication and control co-adaptation
3. Conduct experiments on the real system

Description

The objective of this work is to investigate the feasibility of control / motion planning of mobile manipulators on edge cloud over modern wireless communication such as WiFi6 and 5G.

Moreover, in order to effectively control the robot, strategies will be investigated to increase the robustness of the system to uncertainties typical of the communication channel such as variable latency, variation of bandwidth and packet loss.



Approach

The work will address the following points:

- Investigate experimentally the feasibility to control a mobile manipulator based on defined performance indexes
- Develop novel strategies to make the robot more robust to variations in the communication channels,

Required background

- Programming in C++ or Python
- Fundamentals of Robotics
- Experience in ROS or ROS2 is a plus
- Knowledge about wireless communication is a plus

Timeline

- Start: between Jan. 2022
- Duration: 6 months
- Place: ABB CRC (Västerås)
- ABB will cover the accommodation in Västerås

Supervisor contact: **Pietro Falco**
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CODE: 1687

Master's Thesis Proposals

Weariness Ropes Assessment with AI Camera

Scope

Research topics:

Development and field testing of AI algorithms enhancing images of machinery components.

Goal(s):

1. Develop on-line technique monitoring technique for assessing the weariness of mine hoist ropes.
2. Develop and test AI algorithms to enhance damage development

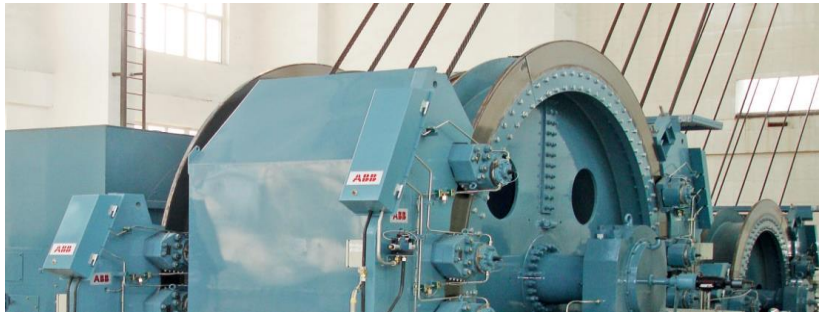
Approach

The project will be focus on:

- Review existing methods assessing ropes conditions
- Review image processing techniques to detect changes in the machinery components moving at high speed.
- Assess processing speed for embedded implementation
- Develop a prototype of on-line camera and test its performance

Description

Deterioration of the ropes is one of the critical issues in mining industry. There are needs to automized the process and develop more reliable solution than manual inspections. The focus is on machine vision capable of performing the ropes assessment during the hoist operation speed (up to 20 m/s). On-line image processing will use AI to optimize and enhance machine vision.



Required background

- May be suitable for one or two students having background in signal processing, ideally in the image processing.
- Mechatronics skills (sensors interfacing, MATLAB electronics design)

Timeline

- Start: between Feb. 2021 and May 2022
- Duration: 6 months
- Place: ABB CRC (Västerås)

Supervisor contact: **Krystof Kryniski (072) 2370240**
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CODE: XXXX

Master's Thesis Proposals

Manipulability measure maximization for whole-body controlled mobile robots

Scope

Research topics:

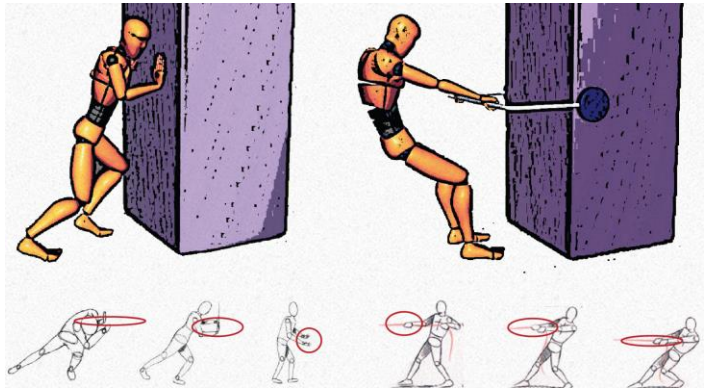
Automatic wheels reconfiguration via manipulability measure.

Goal(s):

1. Formulation of a manipulability-measure task
2. Replacement of inverse-kinematic task with manipulability-measure task in whole-body stack
3. Experimental validation

Description

Due to nonholonomic constraints, mobile robots are unable to instantaneously move in every directions. The objective of this project is to leverage on the manipulability concept to allow omni-directional navigation upon wheels reconfigurations. The maximization of the manipulability has to be integrated in the existing whole-body framework for a mobile robot. The final result is a demo where navigation with variable point of reference is deployed in physical experiment.



Source: Manipulability Learning, Tracking and Transfer

Approach

The work will address the following points:

- Derivation of the manipulability-measure Jacobian matrix for the whole-body framework
- Simulation of the whole-body control with manipulability maximization
- Testing of the designed control in experiments

Required background

- Knowledge of kinematic and dynamic models of robots
- Basic knowledge of Lyapunov-based control design for robots
- Linear algebra (Kernel and projection matrices)
- Programming skills (MATLAB & Simulink, ROS)

Timeline

- Start: between Jan. 2021 and June 2021
- Duration: 6 months
- Place: ABB CRC (Västerås)
- ABB will cover the accommodation in Västerås

Supervisor contact: **Gianluca Garofalo**
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ABB

CODE: 1687

Master's Thesis Proposals

Optimal design of steerable wheel mobile robot

Scope

Research topics:

Simulation to find optimized design of steerable wheel platforms

Goal(s):

1. Develop simulation model(s) to characterize duty loads for drive train and structural parts
2. Develop 'nominal' duty cycle for design of steerable wheel mobile robot
3. Formulate objectives and constraints for optimization (e.g. stability, (de-)acceleration, footprint, speed, vibrations, …)

Approach

The work will address the following points:

- Using existing dynamic model to create simulation environment for load analysis
- Cluster or classify loads w.r.t robot application space
- Formulate generic optimization problem for optimized design
- Propose design for specific case mobile YuMi

Description

Steerable wheels for mobile robots is an omni-directional drive concept that combines the flexibility of standard wheels with the maneuverability of omnidirectional wheels. The modular. compact drive modules can be used for all types of robot application, from household robots through to automated guided vehicles. To realize this flexibility into products, an approach to analyze different mobile robot applications to yield mechanical requirements for the actuation modules as well as a platform structure is needed.

The proposed project aims at exploring this problem and find a suitable approach and demonstrate on specific case of mobile YuMi.

Required background

- Suitable for one or two students with interest in mechanics and design optimization
- Design optimization skills. MATLAB knowledge.
- (ROS-knowledge is a plus)

Timeline

- Start: between Jan. 2021 and June 2021
- Duration: 6 months
- Place: ABB CRC (Västerås)
- ABB will cover the accommodation in Västerås

Supervisor contact: **Jonas Larsson**
jonas.larsson@se.abb.com

CODE: 1687

Master's Thesis Proposals

Navigation with variable point of reference for 3dof mobile robot

Scope

Research topics:

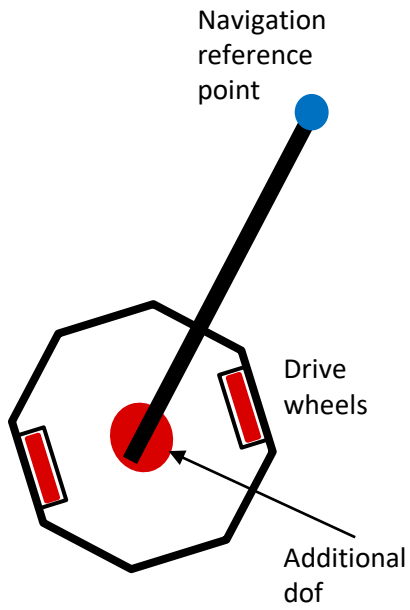
Navigation with variable point of reference

Goal(s):

1. Simulation model in ROS including specific kinematics and navigation
2. Mechatronic integration of additional motor in a differential drive robot.
3. Demonstrate in physical experiment navigation with variable point of reference

Description

The objective of the project is to develop and demonstrate omni-directional navigation with navigation reference point located arbitrary with respect to robot. The robot concept is a differential drive robot with an additional rotational dof on top. Final result is a demo where navigation with variable point of reference is deployed in physical experiment.



Approach

The work will address the following points:

- Develop kinematics and simulation model for the robot in ROS and test/tune navigation
- Make mechatronics integration of extended differential platform concept based on an existing differential drive robot
- Deploy system on robot in real environments and obtain good performance

Required background

- May be suitable for two students (mechatronics and navigation/ROS)
- Mechatronics skills (basic mechanical design, MATLAB Simulink & control, basic electronics)
- ROS-knowledge and preferably experience with ROS navigation stack

Timeline

- Start: between Jan. 2021 and June 2021
- Duration: 6 months
- Place: ABB CRC (Västerås)
- ABB will cover the accommodation in Västerås

Supervisor contact: **Jonas Larsson**
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Master's Thesis Proposals

Learning fast and dynamically changing environments for mobile robot

Scope

Research topics:

Find a distributed design for classifying and monitor/predict real-time conditions in interface between robot and environment

Goal(s):

1. Propose an AI-based approach learn, classify and monitor/predict the friction conditions between wheel and ground of a mobile robot
2. Develop prototype and demonstrate on real robot or simulation environment as back-up

Description

For a mobile robot it is valuable to know the friction properties between wheels and ground, one reason being safety. Even for the same robot/installation, the friction may vary significantly around a facility. Also, friction as phenomenon requires very fast measurements to be characterized since it varies almost discontinuously e.g. in the transfer from stick to slip.

The objective of this project is to explore if AI-based approach can be used to cluster/classify friction in space and time and to monitor/predict changes.

Approach

The work will address the following points:

- Prior art review
- Propose an approach that is able to monitor fast (real-time) changes in frictional conditions
- Demonstrate and test using mobile YuMi, where different floor conditions are prepared

Required background

- Suitable for one or two students with interest in embedded systems and AI. The physics and modeling of friction, if required, can be supported from ABB
- Good implementation skills
- ROS-knowledge and experience is a plus

Timeline

- Start: between Jan. 2021 and June 2021
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Supervisor contact: **Jonas Larsson**
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Master's Thesis Proposals

Micro-ROS for mobile robotics systems

Scope

Research topics:

Explore the potential benefits of using ROS in the real-time system of mobile robot

Goal(s):

1. Deploy Micro-ROS for some real-time processes on an ARM32 microprocessor and evaluate performance and communication to a connected ROS computer
2. Develop prototype and demonstrate on test-setup or real robot or simulation environment as back-up

Approach

The work will address the following points:

- Analyze the real-time system of the ABB mobile robot and propose a plan how to apply Micro-ROS
- Demonstrate and test using test set-up or mobile YuMi, where real-time performance, computational cost and communication to external ROS processes are analyzed

Description

It is common to use ROS for the high-level control of mobile robots. This environment allows for fast prototyping through a standardized communication approach and availability of functionality that is continuously developing in a lively community.

The objective of this project is to explore the potential benefits of using ROS in the real-time part of mobile robot to 1) learn about benefits and limitations of Micro-ROS and having ROS running on both sides and 2) to become part of a community where new functionality is continuously made available

Required background

- Suitable for one or two students with interest in embedded systems
- Good implementation skills
- ROS-knowledge and experience

Timeline

- Start: between Jan. 2021 and June 2021
- Duration: 6 months
- Place: ABB CRC (Västerås)
- ABB will cover the accommodation in Västerås

Supervisor contact: **Jon Tjerngren**
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