Projects in Automatic Control FRTN40, fall 2017

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http://www.control.lth.se/course/FRTN40

LUNDS UNIVERSITET
Lunds Tekniska Högskola

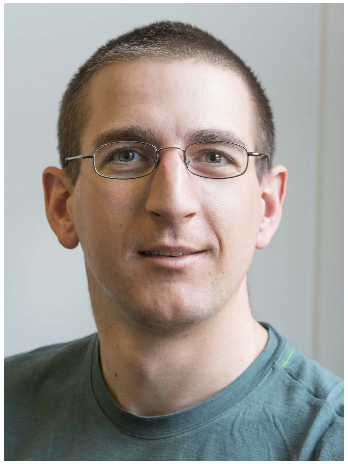
Projects in Automatic Control

- Team effort
  - Collaborative problem solving
- Get practical experience
- Apply course knowledge
  - Modeling
  - Identification
  - Design
  - Implementation
- Interdisciplinary
  - Control, programming, electronics, mechanics, image processing, ...

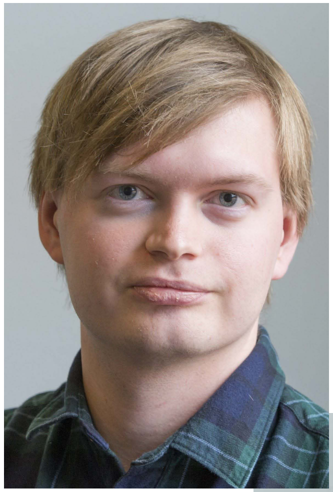
Who are we?

Anton

Kristian



Tommi



Olof

Anders N

Pontus

Macrus

Mika

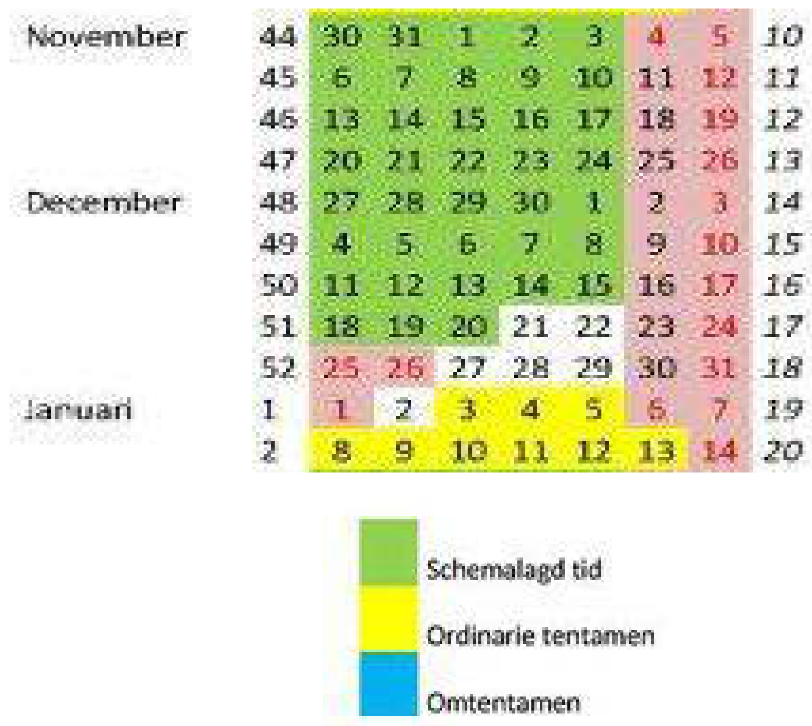
Timeline

HT 2017 study period 2 starts 2017-10-30

Project presentations: Friday 2018-01-12 (details TBA)

Note: Exchange students may present before X-mas

- whole project group
- specify this when applying for project



Course plan

Forming groups and planning

Mon Oct 16: Introductory meeting (this!)

Thu Oct 19: Mail wish-list with four projects in prio order
(and possibly list of group members) to anton@control.lth.se

Mon Oct 30: Official course start and git tutorial 10:15-12:00 in M:D.

Same week: Meet your supervisors, start working

Mon Nov 6: Deadline for submitting project plans (using git)

Project work includes

Mon Nov 13: Feedback seminar 1 (modelling and design)

Mon Dec 4: Feedback seminar 2 (design and implementation)

Project presentations in exam week

Fri Jan 12: Presentation and demonstration

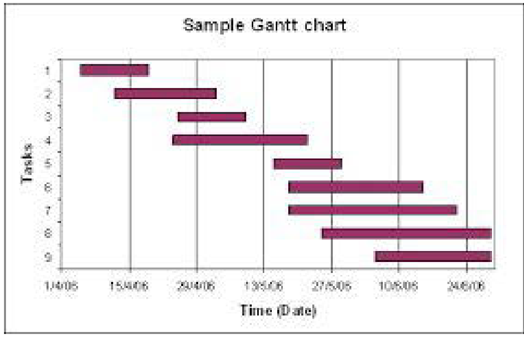
Project infrastructure

- Version control system – Git
  - Distributed version control
  - Collaborative development
  - Git repo @ Automatic Control maintained by Anders Nilsson

- Instructions for file structure, reports, presentations, etc., available on the course homepage

Project plan

- An overview of the project.
- Descriptions of the key parts of the project, including materials and methods to be used.
- A decomposition of the project into subtasks and a suggested allocation of the project resources to key tasks.
- A time plan (e.g., Gantt diagram)



Hints for project planning

- Break project into manageable subtasks
- Establish dependencies between subtasks
- Estimate time required each subtask (person hours/days)
- For each week estimate how many hours every member of the group will work
- Plan deadlines for each subtask using the estimates above
- Put any spare time you might have in the end of the schedule, not the beginning!
- Every week follow up on your progress **compared to your time plan**, and reschedule if you are falling behind. This is to be discussed with your project supervisor at regular meetings.

Feedback seminars

- Two mandatory feedback seminars with different themes
  - 1: Modeling and design
  - 2: Design and implementation
- Peer review of reports before second seminar
- All groups prepare presentations
  - Choices of methods
  - Results
  - Lessons learnt
- Split of groups for presentations in parallel rooms
  - (everyone prepared to present)
- Emphasis on **feedback between groups** and knowledge transfer

Examination

Requirements for the grade Pass:

- Complete project task
- Active participation in feedback seminars
- Write own + review other group's report
- Oral project presentation
- Participation in demo session
- Written report
- Commented code and documentation in git repo
- All equipment and tools returned

Student representatives

Student feedback

- Ongoing during course
- Reporting
- CEQs from previous years available at http://www.ceq.lth.se/, see e.g.,

http://www.ceq.lth.se/rapporter/2016_HT/LP2/FRT090_2016_HT_LP2_slutrapport_en.html

Choose two student representatives from the course

Please, help us to close the loop for better performance.

Project awards

The teachers and supervisors form a jury, which will reward outstanding projects in two categories:

- Best engineering effort
- Best report & documentation

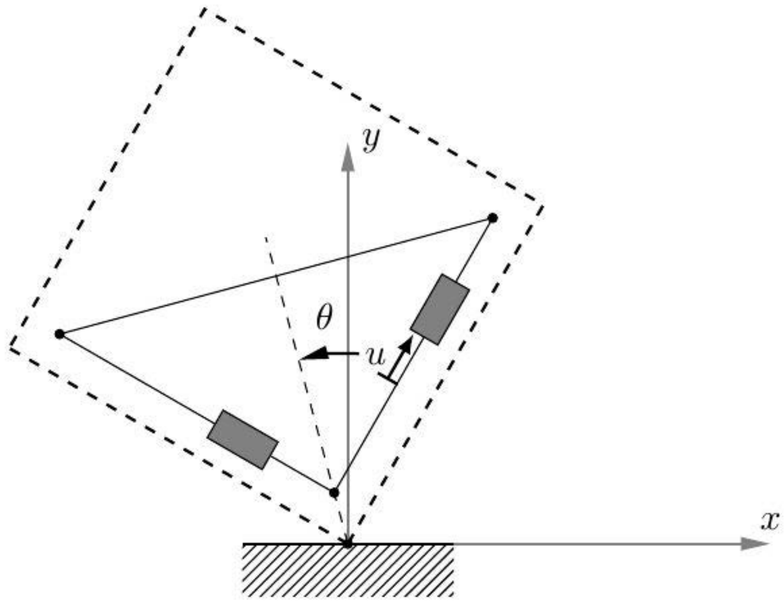
Each winning group receives a prize during the final presentations.

Project proposals

- A number of different projects are suggested
  - More details are available in the project abstracts
- Some projects have recommended prerequisites
  - Find team members that complement your own competences!
- The normal group size is **four students**
- We aim for **ten** project groups in total

1. Balancing suitcase

An impressive and portable demonstration of automatic control.



- Reaction wheel or pulley system with weights

2. Balanduino on rocky road

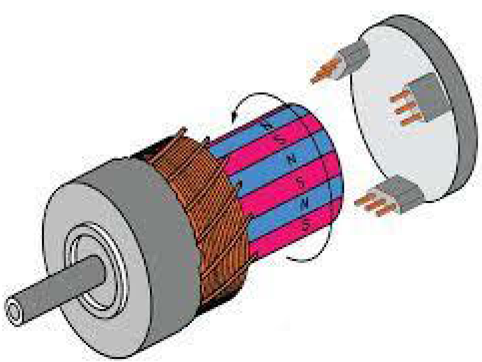
Train the Balanduino self-balancing robot to drive along a non-flat route

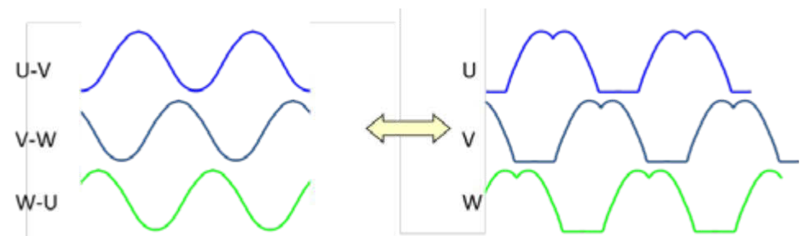
Use learning or optimization algorithms, e.g.

- Iterative learning control
- Optimization using JModelica

3. Brushless DC motor control

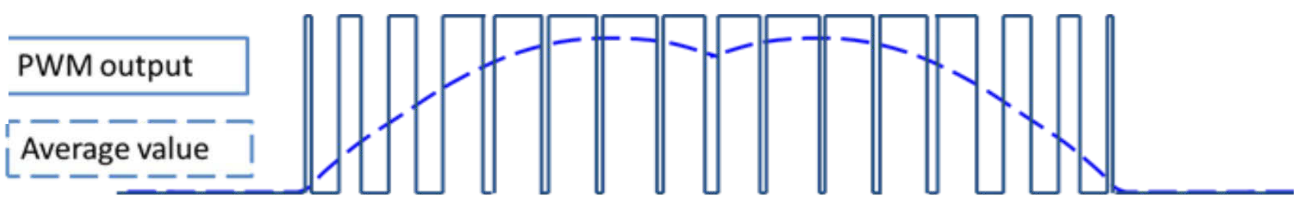
Design an embedded feedback control system to control the motion of a brushless DC motor. Getting a motor to spin, how hard can it be?





Sinusoidal Voltage from Phase to Phase

Sinusoidal Voltage fromPhase to GND
With 3rd Order Harmonics



PWM Encoded Phase Output and the Average Value

Prerequisite: A background in electronics is preferable.

4. Continuous control of batch tank

The batch tank is a multivariable lab process with two pumps, heating, cooling, and mixing capabilities.

Investigate operating the process in continuous mode

- Model the system using system identification and/or mathematical modeling
- Design controller for regulating liquid level, temperature and (simulated) concentration

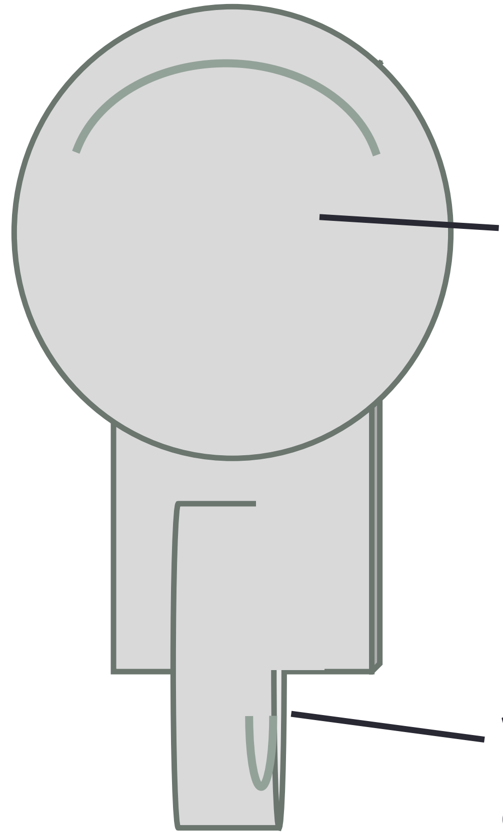
5. Industrial adaptive controller

- MC XC05 – an industrial adaptive controller from FirstControl
- Model and simulate nonlinear process using the Modelica language
- Run the controller against the model and then against the real process

6. Lego self-balancing unicycle

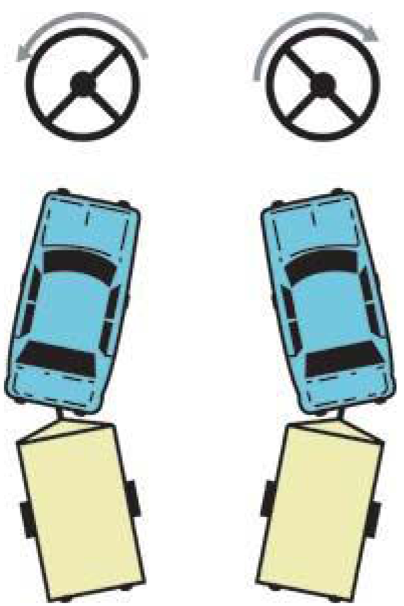
Build a self-balancing robot

- Balance in the forward direction with one wheel on the ground
- Lateral balance with an inertia wheel
- State estimation with gyros and/or accelerometers



7. Lego trailer system

Design and implement (multi-) trailer system with support for autonomous parallel parking and/or backing

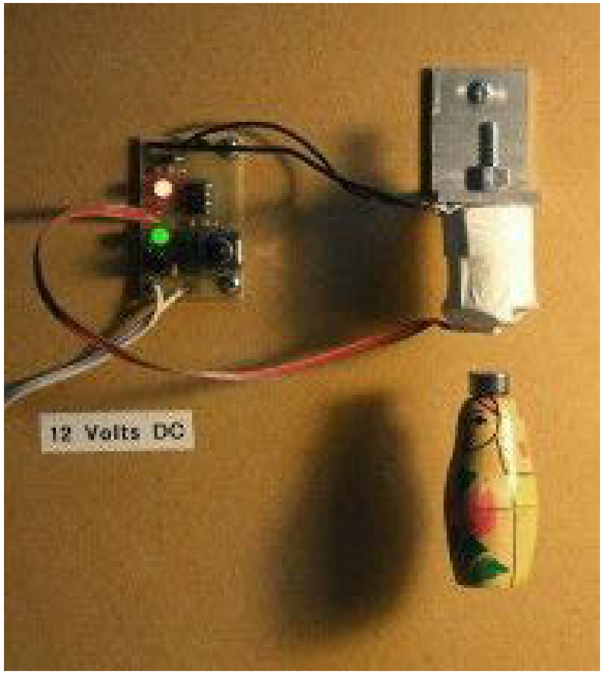


8. Magnetic levitation system

Design, construct, and control a magnetic levitation system.

- Position measurement using Hall effect sensor
- Actuation using current to electromagnet

Prerequisite: At least one project participant knowledgeable in electronics design.

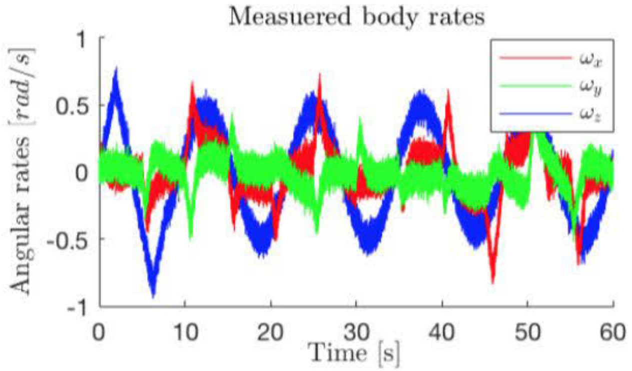


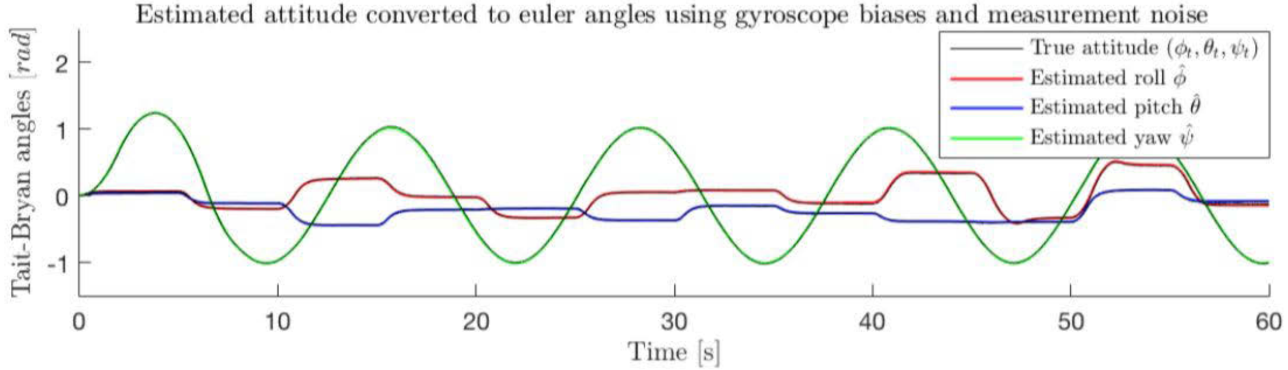
9. Quadcopter attitude estimation

This project explores modern methods of UAV attitude estimation using nonlinear complementary filters.

- Implementation and tests of the algorithm (in Matlab/Simulink/Julia)
- Real-time tests of an embedded implementation using the Crazyflie platform (in C)

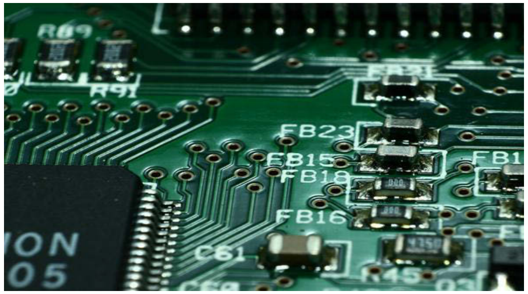
$$\hat{\mathbf{q}}_{\mathcal{BG}} = \hat{\mathbf{q}}_{\mathcal{BG}} z^{-1} + \Delta t \Big(\frac{1}{2} (\mathbf{q}_{\mathcal{BG}} z^{-1} \otimes \boldsymbol{\omega}^q) - \beta \frac{\nabla \mathbf{C}(\mathbf{q}_{\mathcal{BG}} z^{-1}, \mathbf{g}^q, \mathbf{a}^q)}{||\nabla \mathbf{C}(\mathbf{q}_{\mathcal{BG}} z^{-1}, \mathbf{g}^q, \mathbf{a}^q)||_2} \Big)$$





10. Reflow oven control

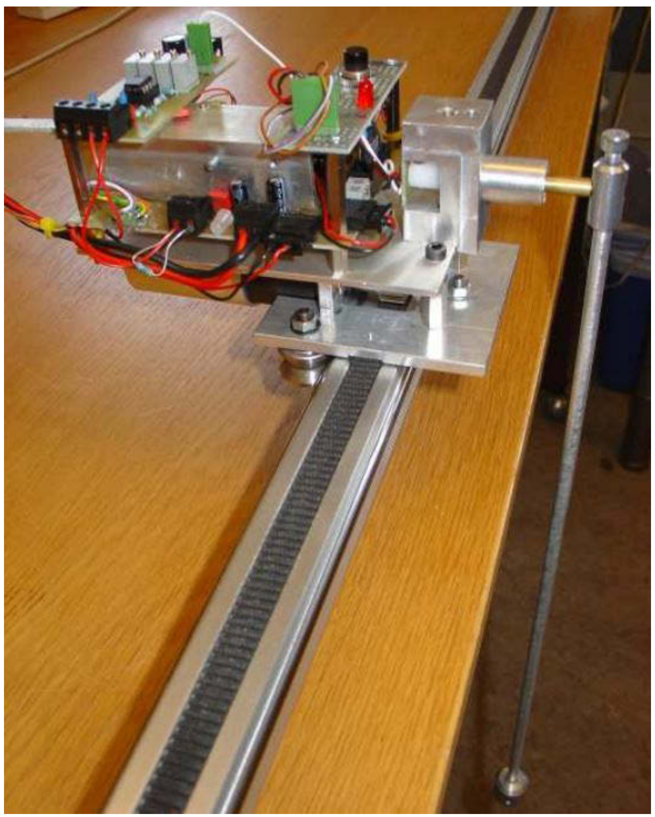
Modify a hot air oven to follow a pre-programmed temperature trajectory by measuring temperature and actuating the heater and fan speed.
(The oven can then be used for soldering surface mounted electronics.)

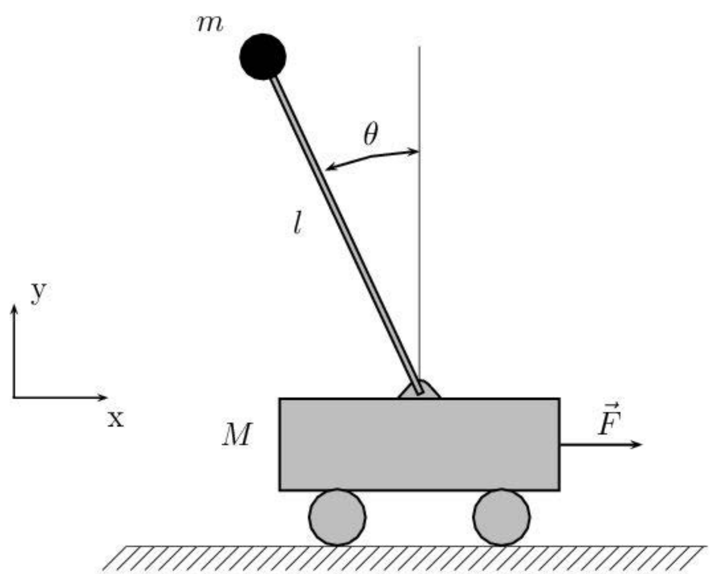


Prerequisites: Basic control and some experience with programming (of embedded systems).

11. Time-optimal control of inverted pendulum

Develop new hardware and control software for the most popular lab at the department! (Nonlinear Control lab 3 [Video])

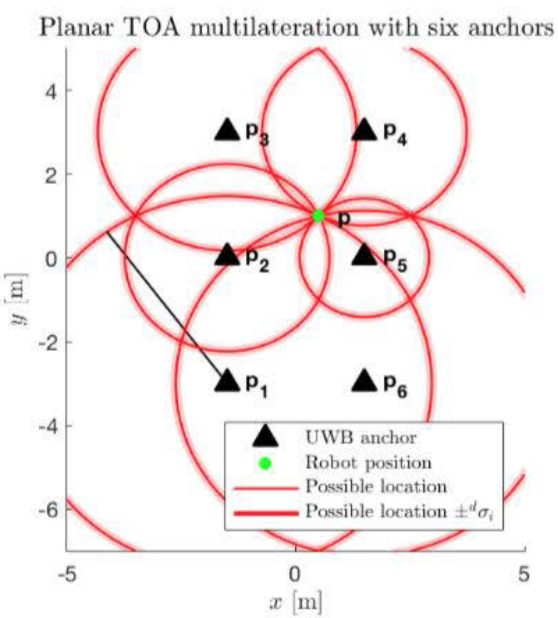


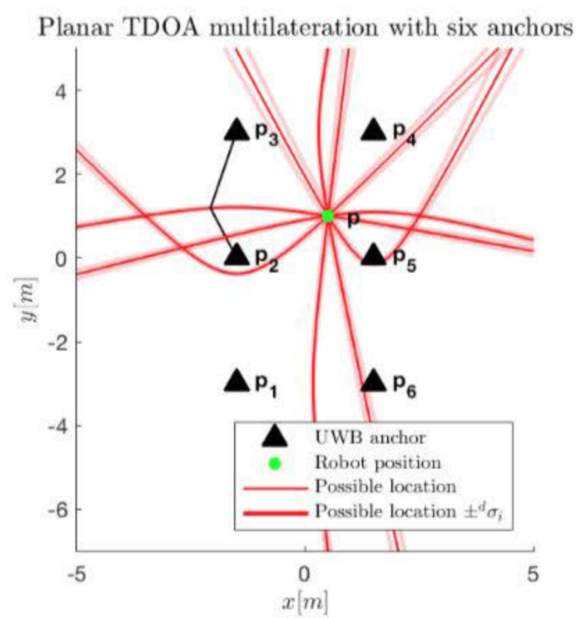


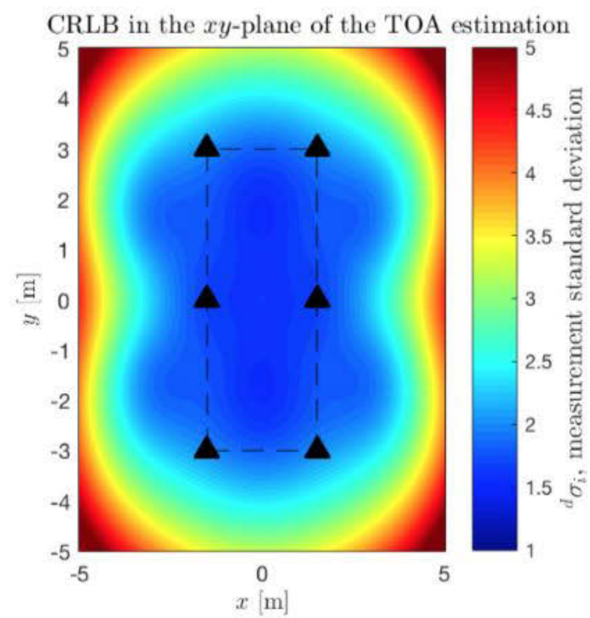
12. Static ultra wideband positioning

This project explores modern methods of static UWB positioning in the plane on an embedded platform.

- Implementation and tests of the algorithm (in Matlab/Simulink/Julia)
- Real-time tests of an embedded implementation using the Decawave platform (in C).







Your own ideas

You are very welcome to suggest your own ideas for projects.

Project selection and allocation

- Email wish-list with four projects in prio order (and possibly list of group members) to anton@control.lth.se by Thursday Oct 19.
- We will form the project groups, assign supervisors, and notify you by email a.s.a.p.