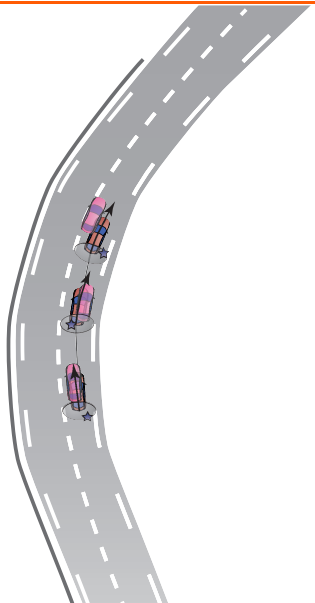
Course introduction

Sensor fusion & nonlinear filtering

Lars Hammarstrand

Sensor fusion and (nonlinear) filtering

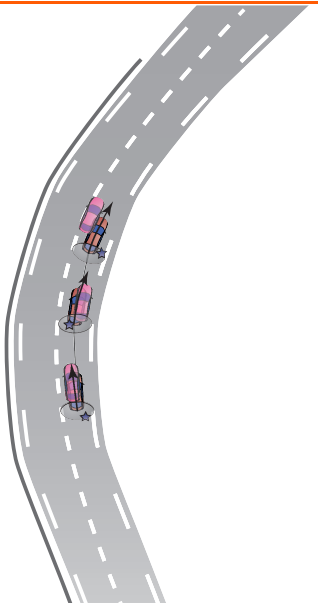
- Use a sequence of noisy observations from one or more sensors to better estimate some unknown quantity of interest (state) and associated uncertainty measures at the current time instance.



LECTURE CONTENTS AND LEARNING OBJECTIVES

The content of this course divided into 8 sections:

1. Course introduction and a primer in statistics
2. Bayesian statistics
3. State space models and optimal filters
4. The Kalman filter and its properties
5. Motion and measurement models
6. Nonlinear Gaussian filters
7. Gaussian smoothing
8. Particle filters
9. Application in industry (Guest lecture)



TEACHERS

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- **Teaching assistants**:
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- **Student representatives:**

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MPCOM	Vaidyanathan Kumar
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TEACHING STRATEGY

- We will make use of the flipped classroom model in this course.
- Idea: basic knowledge about a topic is obtained at home.
  $\Rightarrow$ In class we devote our time to active learning for improved understand and learning.
- To make the in-class sessions effective it is important that you have some understanding regarding the topic before class.

	At home	In class
Traditional lecture	**Solve** problems	**Listen** to lecture
Flipped classroom	**Watch** videos	**Solve** problems

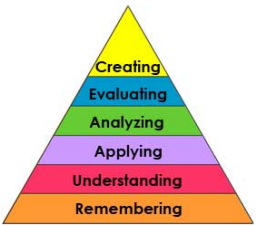
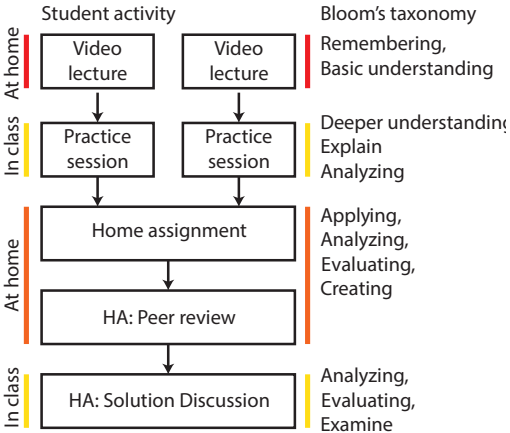


Figure 1: Bloom's taxonomy of learning objectives.

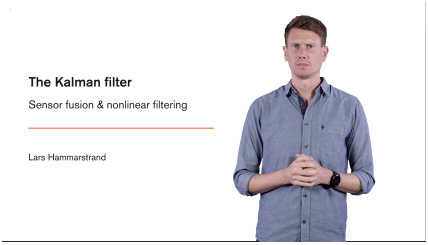
LEARNING SEQUENCES IN OUR COURSE

- The course comprises 8 lectures, taught in four learning sequences.
- Each learning sequence is continuously examinated using a set of Home Assignments.
- You are also expected to do a project and attend a final oral examination.



VIDEO LECTURES

- Shorter videos discussing a specific concept.
- Self-assessment questions to help reflect and stay active (do not count towards final grade).
- Watch and answer the self-assessment questions day before corresponding practice session not to lose late days.
- Possible to ask questions on canvas discussion forum.



PRACTICE SESSIONS (PS)

- Work in breakout groups to actively discuss the concepts in the course.
- Mix of so called Peer instructions and group problem solving.
- *Tip:* One in each group share the problem description on which you can annotate.
- Half-class:
  - Group 1 13:15 – 15:00
  - Group 2 15:15 – 17:00
- Mandatory, if you can not attend you lose one "late day" and need to submit written solutions to the problems within a week.

HOME ASSIGNMENTS (HA)

- Each home assignment consist of three mandatory parts
  - **Implementation**
    Build your own filtering toolbox in Matlab which is automatically tested and graded.
  - **Analysis**
    Apply the methods in relevant problems and analyse their behaviour in a small report with well-annotated figures and short answers to related questions.
  - **Quiz**
    Mainly multiple-choice questions related to the material in the learning sequence.

HOME ASSIGNMENTS (HA) – GRADING

- To get a passing grade you need to, before the deadline,

Impl.: pass all implementation assignments.

Analysis: submit your concise analysis report (pdf) as well as your well commented Matlab-code (txt-file).

Analysis: collect 5 points out of 14 on your analysis report.

Quiz: correctly answered the all home assignment quizzes (unlimited number of attempts).

- To get a higher grade you can collect POE by
  - collect even more points on the analysis report (1 p = 1 POE).
  - give constructive feedback (peer-review) on a fellow student's analysis report (max 2 POE).
- Deadlines are listed on the course homepage.

HOME ASSIGNMENTS (HA) – COMMENTS

- You are encouraged to discuss the problems with other students but not to share your solutions. That is, you have to produce your own solutions, implementations, report, etc.
- You need to understand what you have done and be able to argue for your solution!
- You should make an effort to illustrate all your results as well as possible! Are the results reasonable? Reflect!
- Note:
  - It is better to have the correct argument to the wrong results then trying to motivate results that are not reasonable.
  - We will award less points for analysis reports that are diffucult to understand (unclear figures and captions or missing explanations).

HOME ASSIGNMENTS (HA) – CONSULTATION

- On canvas we have a discussion forum for each home assignment.
- Support will mainly be through discussion forums and the consultation hours (see schedule).
- If you have any question, look though the discussion forum and
  1. Find your answer! Great!
  2. Someone has asked your question already but there is no answer. Give the question a like and it will be prioritised
  3. Post your question as a new question.

- Note: Keep all discussions polite, civil and constructive!

HOME ASSIGNMENTS (HA) – PEER-REVISION

- For each of the homework assignments you will be asked to review another student's solution. We expect you to spend at most one hour on it and complete it within 48 hours.
- You should provide feedback to your peers regarding:
  1. Content and accuracy. Is the solution correct and complete?
  2. Presentation/clarity. Is the solution presented in a clear manner?
- We have included peer-reviewing for two reasons:
  1. you can learn from your peers.
  2. receive fast and detailed feedback on your solutions.
- Note: the solutions are graded by a teacher, but the teacher is likely to only provide brief feedback.

SOLUTION DISCUSSIONS (SD)

- Conclude and summaries your insigts from the home assignments.
- Work in groups to actively discuss and share with your peers.
- Mix of so called Peer instructions and group problem solving.
- Half-class / one-hour:
  - Group 1 13:15 – 14:00
  - Group 2 14:15 – 15:00
- Mandatory, if you can not attend you lose one "late day" but no need to submit anything.

CODE OF HONOUR

We would like to emphasise on a certain "code of honour" that you are expected to follow:

- I will respect my classmates and contribute to the learning of the group.
- I will participate in class discussions, while showing consideration for other members of the class who wish to make contributions.
- When my view differs from one offered by another in the class, I will present my view in a way which is respectful of the thoughts and feelings of others.
- I will consider any constructive criticism from my instructor or classmates, on the understanding that we all have room for improvement.
- Even though we are encouraged to collaborate with the home assignments and projects, I understand that the work is still governed by the rules of plagiarism. For instance, sharing or making use of existing solutions to these assignments, if such exist, is both unethical and considered an academic misconduct (cheating).
- I also understand that the honour code violations are not limited to the actions mentioned in the guidelines above, but also includes, e.g., other sorts of dishonesty and behaviour that do not contribute to the learning of the group.
- Finally, I will also do my best to help my classmates to follow the above honour code.

PROJECT AND ORAL EXAMINATIONS

- Project about orientation estimation of a smartphone.
  - You will do the project in groups of two.
  - Submit a written report.
  - Peer-review another group's report.

- There is a final oral examination:
  - Covers both the project and summary of the whole course.
  - Given during the exam week.
  - Sign up on course homepage.

MANDATORY COURSE ELEMENTS

There is no written exam but several other mandatory elements.

- There are 8 on-line video lectures. You should
  - watch the videos and complete the quizzes before midnight the day before the practice session.
  - attend the in-class practice sessions.
- There are four home assignments. For each, you have to
  - pass the implementation, quiz and analysis parts.
  - participate in classes where we discuss your solutions.
- There is one project and one oral exam:
  - get a passing grade on your group project report.
  - attend the oral examination.

You are allowed 8 “late-days” if you cannot make a deadline or attend a mandetory session.

GRADES

- To pass the course you need to fulfil the mandatory parts mentioned above.
- For higher grade, you can collect points of excellence (POE).
- For each of the four sets of home assignments (analysis report):
  - for your solution, up to 14 POE.
  - for a well performed peer-review 2 POE.
- Up to 14 POE for the project + 2 POE for peer-review
- Up to 20 POE for the oral examination.
- If you submit your solution late or you need to revise, the maximum number of POE is divided by 2.

In total, it is possible to obtain **100 POE**. The grading system:
50-69 POE: **grade 4** and $\geq$ 70 POE: **grade 5**.

COURSE LITERATURE AND HOMEPAGE

- **Literature:** We mainly use
  Simo Srkk, Bayesian Filtering and Smoothing, Cambridge University Press, 2013.
  which is available online:
  `becs.aalto.fi/~ssarkka/pub/cup_book_online_20131111.pdf`

- **Course homepage:** our main homepage is
  `https://chalmers.instructure.com/courses/18216`
  where you can find useful information about the schedule, learning objectives, download lecture slides, etc.