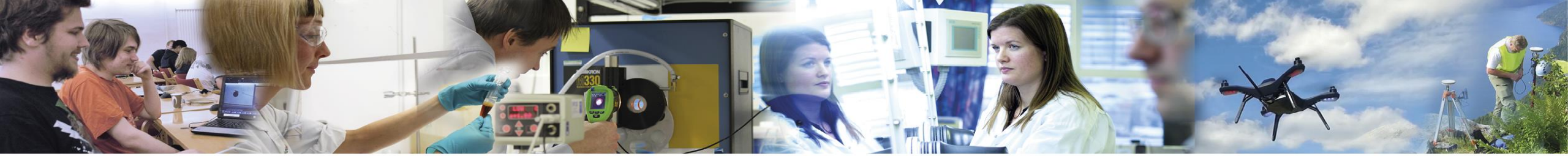


UiO : Institutt for teknologisystemer
Det matematisk-naturvitenskapelige fakultet

Introduction to master in Cybernetic and Autonomous Systems (CAS)

Ulysse Côté-Allard[1], Jonas Moen[2], Kaja Mosserud-Haavardsholm[3] , Pål Solheim[4] and Tønnes F. Nygaard[1]
[1]Associate professor, CAS coordinator
[2]Associate professor
[2]Head of studies, ITS administration
[3]Principal engineer, coordinator ITS robotics lab

Agenda

- Overview MSc Robotics and intelligent systems

- Cybernetics and automous systems (CAS) programme option
  - CAS research at ITS
  - CAS courses and thesis
  - «Årshjulet» - practical infomation

Overview MSc Informatics: Robotics and intelligent systems

2 programme options

- CAS: Cybernetics and Autonomous Systems (ITS – Kjeller)
- ROBIN: Robotics and Intelligent Systems (IFI – Blindern)

Duration of programme is 4 semesters (2 years) giving 120 credits

- Long thesis: 60 credits (thesis) and 60 credits (courses)
- Short thesis: 30 credits (thesis) and 90 credits (courses)

CAS vs. ROBIN: Key Focus Areas

CAS - Comprehensive Mobile Robotics & Human-Robot Interactions

- Emphasizes **practical applications** and **holistic system development**.
- Focuses on the **design** and **deployment** of **mobile robots**, including autonomous vehicles, aircraft, underwater vessels, and space systems.
- Targets application areas in **healthcare**, **energy**, and **environmental monitoring**.

ROBIN – Experimental Robotics & Basic Research

- Prioritizes **hardware design** and the development of **embedded systems**.
- Engages in **fundamental research** in machine learning and optimization algorithms.
- Aims to enhance the **intelligence** and **adaptability** of robotics, sensors, and embedded systems.

Cybernetics and autonomous systems - programme option

Disciplines

- Cybernetics
- Scene analysis
- Collaborative systems

Applications

- Healthcare
- Robotics
- Energy and environmental monitoring
- Space systems
- IoT and cyber-physical systems

Example of CAS research: Energy monitoring

Huanghe Hydropower Development of 2.2 GW

Energy monitoring as example of CAS research

How do you maintain an efficient PV park of this magnitude?

Energy monitoring as example of CAS research

How do you maintain an efficient PV park of this magnitude?

- Today, replace all panels after a certain life expectancy period

Energy monitoring as example of CAS research

How do you maintain an efficient PV park of this magnitude?

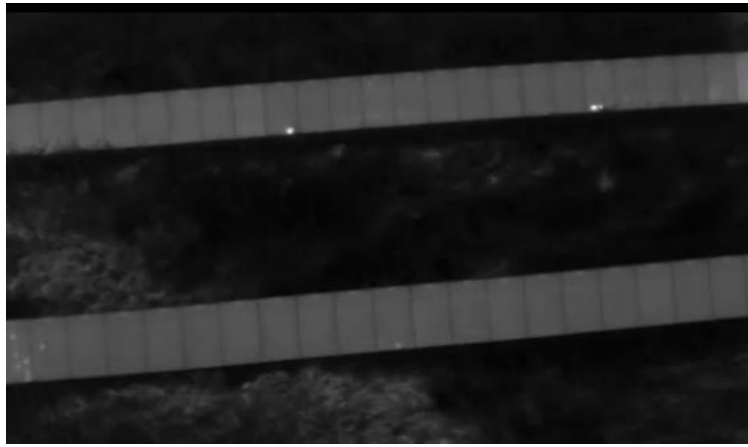
- Today, replace all panels after a certain life expectancy period
- Future, replace only damaged panels with updated technology

Energy monitoring as example of CAS research

How do you find and replace damaged panels?

Energy monitoring as example of CAS research

How do you find and replace damaged panels?

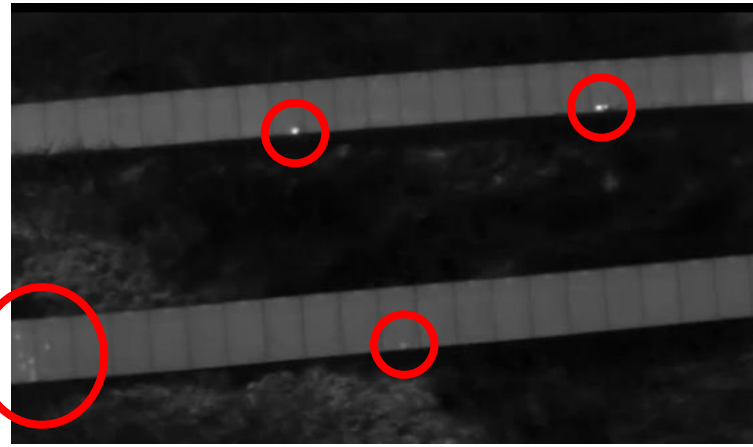


1. Infrared cameras with AI based fault detection

Energy monitoring as example of CAS research

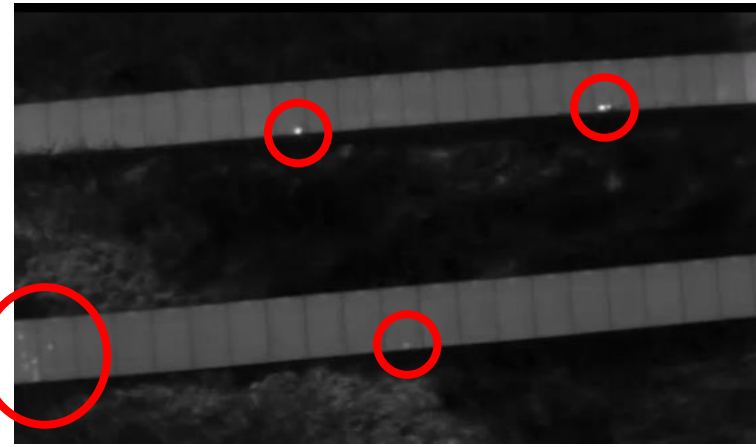
How do you find and replace damaged panels?

1. Infrared cameras with AI based fault detection



Energy monitoring as example of CAS research

How do you find and replace damaged panels?

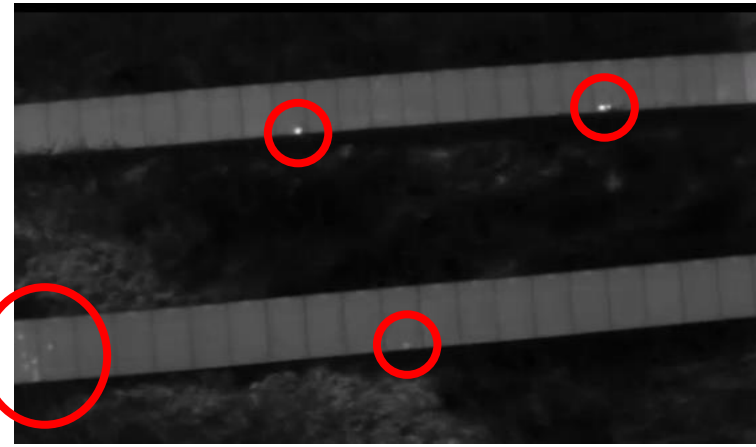


1. Infrared cameras with AI based fault detection

2. UAV swarm for efficient survey of PV parks

Energy monitoring as example of CAS research

How do you find and replace damaged panels?



1. Infrared cameras with AI based fault detection

2. UAV swarm for efficient survey of PV parks

3. Autonomous robots for PV panel change

Example of CAS research: Energy monitoring*

*Tor Atle Solend and Victoria Lofstad-Lie

Example of CAS research: Energy monitoring*

Energy monitoring as example of CAS research

Site	Production	Panels	Survey 1 UAV	Survey 4 UAVs	Survey 100 UAVs
Arvika	1 MW	~4000	20 mins	5 mins	
Huanghe	2.2 GW	~10 mill	30 days	7.5 days	7 hours

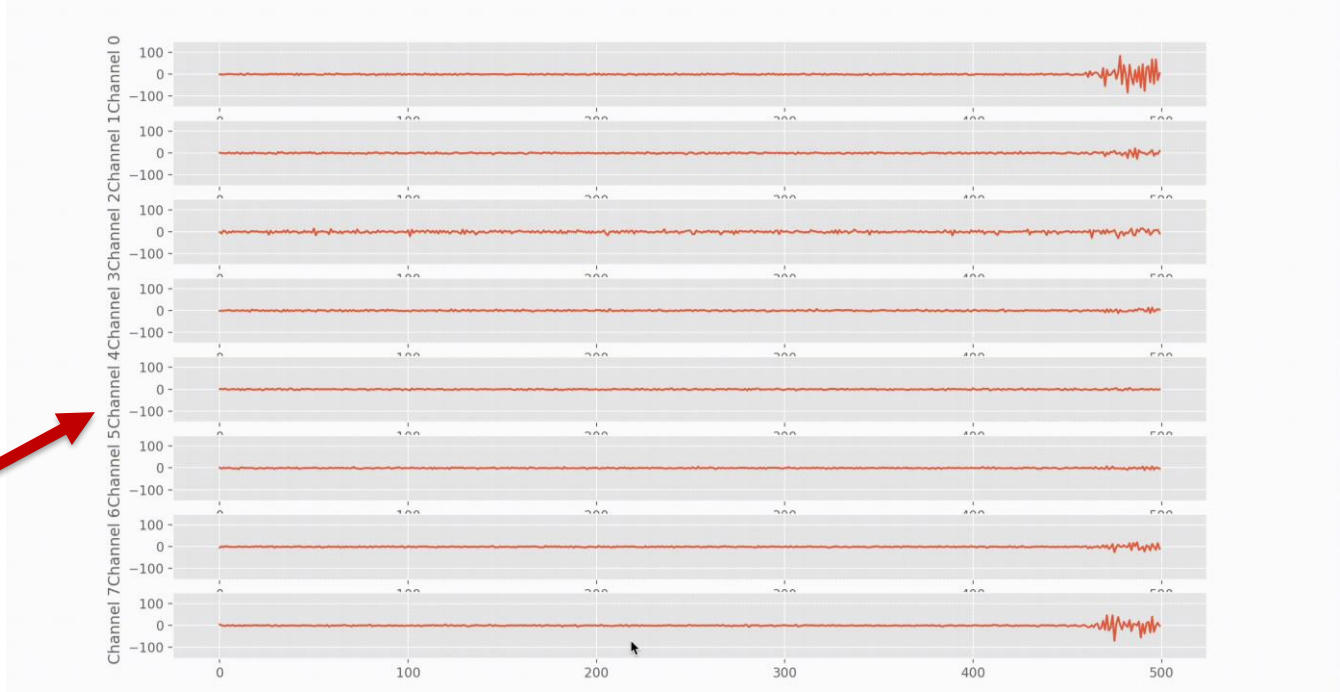
Example of CAS research: Biomedical Engineering

Human-Machine Interaction: Enhancing Human Potential Through biosignals-based control

Prosthetic control

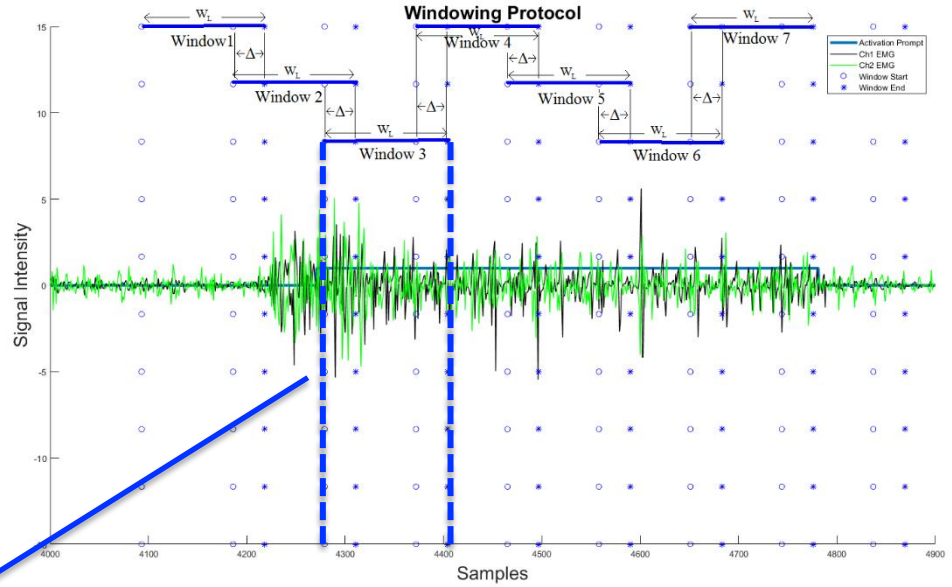
*Image from Johns Hopkins Applied Physics Laboratory

Human-Machine Interaction as example of CAS research

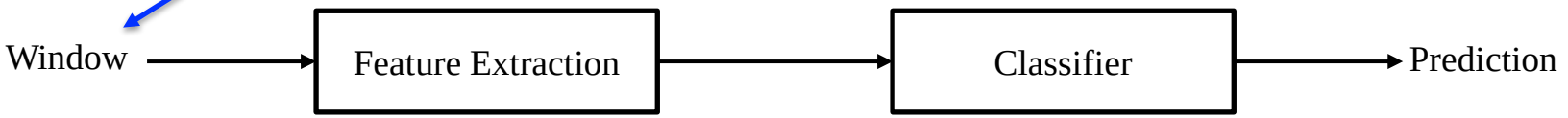


Muscle activity as a control modality

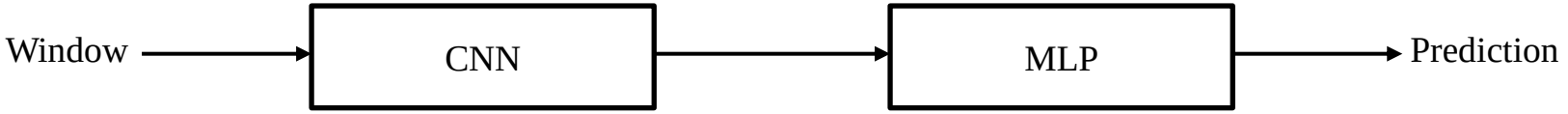
Biomedical Engineering as example of CAS research



Handcrafted Feature Pipeline



Deep Learning Pipeline



Biomedical Engineering as example of CAS research

This framework has shown a lot of promise from papers where offline analyses provide **90%+ accuracy**.

Amputees still report unsatisfactory device performance (50%, Salminger et al. 2020)

- Leads to abandonment of the device (44%)

Offline Performance vs. Online Performance

- Analyz
- Directly

Biomedical Engineering as example of CAS research

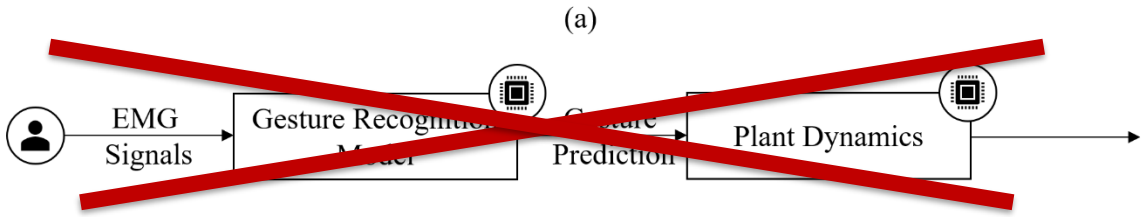
- Myoelectric control suffers in the real world (not post-hoc analysis) two linked concepts:
  - **Behavioural inconsistencies**
  - **Indirect optimization**

Behavioural Inconsistencies

Train

Biomedical Engineering as example of CAS research

- Myoelectric control suffers in the real world (not post-hoc analysis) two linked concepts:
  - **Behavioural inconsistencies**
  - **Indirect optimization**



Biomedical Engineering as example of CAS research

Simultaneous learning: “Human in the Loop” Approach

- How can we effectively incorporate the "human in the loop" to facilitate mutual learning between the person and the AI model?

Real-life Learning: Learning from the End-Environment

- How can we extract and leverage a learning signal directly from the end-environment to improve real-world efficacy of our AI models?

Cybernetics and autonomous systems (Programme Option)

Opportunity to choose specialization in the fields of:

1. **Cybernetics**
   - Control and management of mobile robots, robotic arms
   - Biomedical engineering
2. **Scene analysis**
   - Machine intelligence for understanding and navigating complex environments
3. **Collaborative systems**
   - The system perspective with multi-agent systems and
   - Network analysis

Long vs short master thesis

- Short thesis example

4. semester	Master thesis	Master thesis	Master thesis
3. semester	Master course	Master course	Master course
2. semester	Master course	Master course	Master course
1. semester	Master course	Master course	Master course
	10 credits	10 credits	10 credits

- Industry-oriented

- Long thesis example

4. semester	Master thesis	Master thesis	Master thesis
3. semester	Master thesis	Master thesis	Master thesis
2. semester	Master course	Master course	Master course
1. semester	Master course	Master course	Master course
	10 credits	10 credits	10 credits

-Research-oriented

Example the long thesis work starts earlier

- Long thesis example (1 – 2 – 3 model is recommended)

4. semester	Master thesis	Master thesis	Master thesis	<- No courses last semester
3. semester	Master thesis	Master thesis	Master course	<- Flexible
2. semester	Master thesis	Master course	Master course	
1. semester	Master course	Master course	Master course	
	10 credits	10 credits	10 credits	

- You need to start soon to find a master thesis topic and a supervisor
- Selecting long thesis vs short, depends on:
  - Your interests (research-oriented vs industry-oriented)
  - Your ability to work independently for a long time with progression
  - Most short MSc master topics can be extended into a long one, and many long ones can be scoded down into a short one. Just ask the supervisor proposing the topic.

Core courses

- At least half of your credits must be chosen from the list of core courses.
  - See web page for complete list

- Two of the core courses are recommended for all cybernetics students but can be replaced with other core courses if your thesis requires it.
  - TEK 4040 Mathematical modeling (Fall)
  - TEK 4050 Stochastic systems (Spring)

Courses CAS (programme option)

Tønnes F. Nygaard

Cybernetics

Mobile robotics & Manipulator

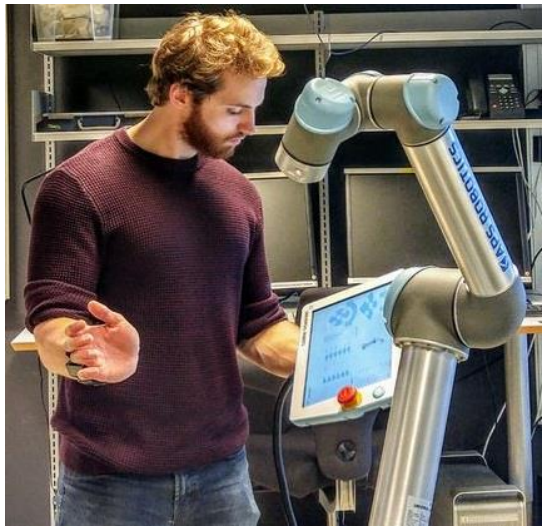
TEK4040 – Mathematical Modelling of Dynamic Systems

TEK4050 – Stochastic systems

TEK4030 – Control of Manipulators and Mobile Robots

IN4140 – Introduction to Robotics

Courses CAS (programme option)



Ulysse Côté-Allard

Cybernetics

Biomedical Engineering

IN4050 – Introduction to Artificial Intelligence and Machine Learning

IN4190 – Digital Signal Processing
TEK5020 – Pattern Recognition

Courses CAS (programme option)

Collaborative systems

Jonas Moen

TEK5010 – Multi-Agent Systems

TEK5020 – Pattern Recognition

IN4050 – Introduction to Artificial Intelligence and Machine Learning

Courses CAS (programme option)

Scene analysis

Trym Haavardsholm

TEK5020 – Pattern Recognition
TEK5030 – Computer Vision
TEK5040 – Deep Learning for Autonomous Systems

IN4050 – Introduction to Artificial Intelligence and Machine Learning
IN5490 – Advanced Topics in AI for Intelligent Systems
IN5520 – Digital Image Analysis

Courses CAS (programme option)

Relevant for embedded systems:

IN4160 – Digital system design
IN5200 – Advanced Digital System Design

FYS4220 – Real Time and Embedded Data Systems


Alexander Wold (Robin)

Courses CAS (programme option)

Relevant for energy applications:

TEK5340 – Energy systems analysis: Modelling, methods and scenarios

TEK5330 – Solar Energy Systems

TEK5300 – Renewable Energy: Science and Technology

MENA3201 – Energy Materials

Sabrina Sartori

Courses CAS (programme option)

Relevant for IoT and cyber-physical systems:

Paal Engelstad

TEK5520 – Cyber Security of Industrial Systems
TEK5530 – Measurable Security for the Internet of Things
TEK5110 – Building Mobile and Wireless Networks
TEK4100 – Signal Processing in Wireless Communication Systems
TEK5130 – Satellittkommunikasjon
TEK5140 – Antennas and Radiowave Propagation

Courses CAS (programme option)

Relevant for sensors and space applications:

TEK5140 – Antennas and Radiowave Propagation

TEK5050 – Imaging and Detection of Optical and Infrared Radiation

TEK5160 – Radar Remote Sensing

IN5450 – Array Signal Processing

IN5340 – Statistical Signal Processing

IN4015 – Ultrasound Imaging

Torbjørn Skauli

ITS robotics labs

- **Motion-capture facility (basement of ITS)**
  - mm-precision tracking, indoors and outdoors
  - 20 Turtlebots, 25 Crazyflies
  - Robotics arms and manipulators
- **Makerspace and workshop (2nd floor of ITS)**
  - 3D printers
  - Laser-cutters and other machining tools

⇒ **Important for doing empirical master thesis!**

Pål Solheim

The structure provides a lot of flexibility

- In courses and thesis topics, also single courses at IFI, MAT or FYS
- Short thesis: flexibility in courses. Long thesis: flexibility in when to start thesis work
- Possible directions
  - Cybernetics
  - Scene analysis
  - Collaborative systems
  - Applications: Robotics, Biomedical Engineering, Energy & Environment, Space, IoT & Cyber Physical Systems,…

«Årshjulet» CAS

Kaja Haavardsholm

August deadlines: 17 aug registration for taking FYS, IFI, MAT courses in Student Web

- Welcome to new ITS/CAS-master students
- Student week/short introduction course in CAS
- Individual meetings with all new CAS students

September deadlines: 1 sept registration for TEK course and exam, payment of student fee

- Presentation: How to write a master thesis?

«Årshjulet» CAS

Kaja Haavardsholm

Oktober:

- Presentation of available CAS master thesis

December deadline: 1 dec for signing of master agreement

- Plan for the entire study (can be adjusted later)

«Årshjulet» CAS

Kaja Haavardsholm

Januar:

- Master week at IFI Blindern

June-august after 4th semester:

- Individual follow-up meeting with all graduated CAS students

CAS staff and contacts – we support you!

Head of studies
Kaja Haavardsholm

Robotics lab
Pål Solheim

Biomedical Engineering
Ulysse Côté-Allard

Mobile Robotics
Tønnes F. Nygaard

Collaborative systems
Jonas Moen