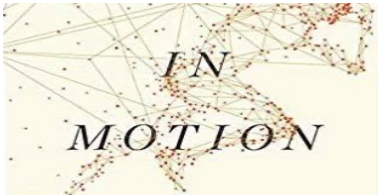




SYDE673

Video Processing & Analysis

Lectures: Tuesdays 9:30–11 am and Thursday(s), 9:30 to 11:00 am online



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Office EC4-2017

Office Hours: tbd

(519) 888-4567 x32567

Teaching Assistant: NA

TA office hours tbd

This syllabus may be slightly updated during the course of the term.

Course Description: This course introduces methods to acquire state (both spatial and temporal) estimations from video streams. Video streams are analyzed as dynamic systems, linear and non-linear. If the system can be approximated as linear and Gaussian in terms of the dynamic noise in the process and measurement, then Kalman filter techniques are used. This refers to sequential state estimation. For nonlinear dynamical systems, the EKF (Extended Kalman filter) can be used by a liberalization of the state space model. Particle filters are used to address state estimation problems where the systems are non-linear and non-Gaussian. Particle Filters are rooted in Bayesian estimation and Monte Carlo procedures. The course builds upon these techniques in studying visual tracking and the components of Visual SLAM (Simultaneous Localization and Mapping) procedures. Pre-requisites:: SYDE 671, a Deep Learning course

Credit Hours: 0.5 academic units

Required Text(s): note: (1) can be purchased at the UW book store or amazon. (2) and (3) will be provided via learn for this course only.

1. Szeliski, R. (2020). Computer vision: algorithms and applications. Springer Science. Free pdf available at <https://szeliski.org/Book/>
2. Timothy D. Barfoot, "State Estimation for Robotics", July 2017, Cambridge University Press Free pdf available: http://asrl.utias.utoronto.ca/~tdb/bib/barfoot_ser17.pdf

Other Recommended Text(s): I would recommend getting a hold of 1 and 2 and doing 3 as an online courses on your own.

1. Multiple View Geometry in Computer Vision, Second Edition, Richard Hartley and Andrew Zisserman, Cambridge University Press, March 2004. <https://www.robots.ox.ac.uk/vgg/hzbook/>

2. Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y. (2016). Deep learning (Vol. 1, No. 2). Cambridge: MIT press. <https://www.deeplearningbook.org>
3. Forsyth, D. A., & Ponce, J. (2002). Computer vision: a modern approach. Prentice Hall Professional Technical Reference.
4. Yan Lecun Deep Learning course: <https://atcold.github.io/pytorch-Deep-Learning>

Course Objectives:

At the completion of this course, students will be able to:

1. have a fundamental knowledge of the tools to use for video motion processing,
2. be able to identify what aspects of fundamental computer vision is required for deep learning processing of motion data,
3. be able to understand and evaluate video processing papers,
4. be up to date on the state of the art in this field

Format:

Course website: Available through <http://learn.uwaterloo.ca> for the purpose of distributing slides, videos, assignments and announcements. Please ensure your email settings are up to date so that you receive messages sent to the class. **Lecture slides/notes will be uploaded on Learn each week, which will cover the material of the two lectures. Videos to explain the main points will be posted as well.** We will use either the Tuesday or Thursday to meet virtually using Microsoft Teams to either discuss the assignment(s) or other material. We will use the course Microsoft Teams page for all of our synchronized meetings.

Software: Students are required to use OpenCV and either Pytorch or Tensorflow via Javascript and upload this to a website for evaluating their software. The actual software needs to also be uploaded to learn. One tool to facilitate this include ONNX models and OpenCV JS. There are other references online to help you with this.

Course Discussions: On Learn, there is a discussion site blog to post questions for the prof. This is to be shared by the class.

Assignments: On Learn, Under the heading "Submit", under the heading of "Dropbox". is where you will find all assignments to be completed. Most assignments will also be uploaded here by the deadline posted.

Readings:

by Week 6 - Come up to speed on all material that is covered in 671 and LeCun's Deep Learning online course..

by Week 3 - Select Project topic.

Outline:

1. Week 1
 - Introduction
 - Background
2. Week 2

- Introduction
- Background

3. Week 3

- Optical flow
- Scene Flow
- Motion flow

4. Week 4

- Optical flow ctn.

5. Week 5

- 2d Visual Tracking, single, multiple
- 3d Tracking

6. Week 6

- Kalman Filter
- Particle Filter
- Time Series tools

7. Week 7

- Human Body Pose tracking

8. Week 8

- Autonomous Vehicles
- EgoMotion

9. Week 9

- Visual Odometry

10. Week 10

- Visual SLAM

11. Week 11

- Projects

12. Week 12

- Projects

Grade Distribution:

- Individual

- Programming Assignment 1 (optical flow) 20%
- Programming Assignment 2 (tracking) 20%.
- Programming Assignment 3 (visual odometry) 20%
- Project - Problem definition 5%
- Project - lit review - 5%
- Project - innovative contribution in the area (presentation, code, paper) - 30%

Important Dates:

various assignments will be posted on Learn in the dropbox
 Final Exam: none.

Collaboration Rule:

Students are encouraged to discuss individual assignment exercises with each other and the course instructor. Any assistance must be limited to discussion of the problem and sketching general approaches to a solution. Each student must write their own individual solutions, including codes and text. Consulting another student's solution is prohibited and submitted solutions may not be copies from any source. In particular, submitting solutions copied in whole or in part from an assignment submission or solution key from any offering of a similar course is prohibited, even if the student is resubmitting their own work. These and any other forms of collaboration on assignments constitute cheating.

Principles for our SYDE-BME Community (faculty, staff, and students):

- 1) Be compassionate. 2) Be accountable. 3) Be patient. 4) Be safe and healthy.

Compassionate and respectful communication: Most online communication between the Department and students will be done through LEARN and/or email. Students are reminded that they should now use their email account name@uwaterloo.ca. Include an academic signature with your full name, program, student ID. We encourage you to include your preferred pronouns (he/him; she/her; they/them).

Scheduling of Synchronous (live) online course events: Due to the COVID-19 pandemic, all University of Waterloo courses components will be delivered online, until further notice. To maintain build supportive teaching environments, instructors may use the time slots (EDT) scheduled ?in-class? hours to hold ?live-stream? events such as lectures, tutorial help sessions, group activities, and open office hours. To accommodate different time zones, different working/studying conditions and limitations in internet access, all critical course components, including lectures and student support must be made available in asynchronous formats. Any timed component (for example: a test or quiz) must take time zone and internet availability into account.

SYDE-BME COMMENT ON ACCOMMODATION: We respect that our SYDE-BME students are independent adult decision-makers, with many opportunities to partake in activities that might be in time conflict with academic deadlines and deliverables. Along with the right to make adult decisions comes the responsibility and accountability for those decisions and any outcomes. The University of Waterloo's policy on accommodation for missed deliverables pertains to verifiable health matters, and highly unfortunate events (for example: family tragedies). The Department of

Systems Design Engineering follows University of Waterloo's general policy: students who self-elect to forgo a deliverable receive a 0% for that deliverable. It is preferred practice so that fairness is maintained for members of the same class/course by avoiding preferential treatment, and so that instructors are not burdened with having to create extra quizzes, deliverables, etc. It also reflects professional practice, as failing to show up to work and missing deadlines can be very costly to the company and individual (for example: not submitting a contract proposal, or design review on time). Please read the policy here: [Link: Accommodation due to illness](#)]

SYDE-BME Academic Priorities over Co-op Interviews: With asynchronous schedules, students should be able to arrange co-op interviews that do not conflict with major deliverables (for example: timed course midterms, final exams). For deliverables with longer time windows (for example: 24-48 hours or more), students must manage their time for deliverables and co-op interviews accordingly. If a co-op interview conflicts with a short deliverable time window (for example: 1-3 hours), then students MUST follow the CECA procedure for rescheduling the interview: [[Link CECA rescheduling co-op interviews](#)]

Compassionate Accommodation: If you are facing challenges that are affecting more than one course contact the Associate Chair Undergraduate (A.C.U.G. email: sydeunde@uwaterloo.ca) or the Director of BME (email: sdbmedir@uwaterloo.ca). They will review your case and coordinate a reasonable and fair plan in consultation with appropriate others (for example: instructors, Department Undergraduate Studies Committee, Chair, AccessAbility Services, Engineering Counselling services, Registrar's Office).

FACULTY OF ENGINEERING: MORE FINE PRINT

Faculty of Engineering website: [[Link Academic Support and Policies](#)].

Academic Integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect, and responsibility. [[Check Academic Integrity website for more information. Link Office of Academic Integrity](#)].

Discipline: A student is expected to know what constitutes academic integrity (see link above) to avoid committing an academic offence, and to take responsibility for their actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (for example: plagiarism, cheating) or about expectations for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. Relevant documents include:

- University of Waterloo Policy 71 [[Link Policy 71 Student Discipline](#)].
- Academic Penalty Guidelines [[Link Policy 71 Penalty Guidelines](#)].
- Assessment of Unauthorized Collaboration: [[Link Assessment of Unauthorized Collaboration](#)].

Grievance: A student who believes that a decision affecting some aspect of their university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student

Petitions and Grievances, Section 4. When in doubt please be certain to contact the **Associate Chair Undergraduate or Academic Advisor** who will provide further assistance. [Link Policy 70 Petitions & Grievance].

Appeals: A decision made, or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes they have a ground for an appeal should refer to Policy 72 (Student Appeals) [Link Policy 72 Student Appeals].

bf Note: We are facing unusual and challenging times. The instructor reserves the right to modify course topics and/or assessments with due notice. In the event of further challenges, the instructor will work with the Department to find reasonable and fair solutions. Writing and Communication Centre.

The Writing and Communication Centre works with students in all Faculties to help you consider your audience, clarify your ideas, develop your voice, and write in the style appropriate to your discipline. We offer one-on-one support for writing papers, delivering presentations, integrating research, and revising for clarity and coherence. Group appointments for team-based projects, presentations, and papers are also available.

All of our services are available virtually: booked appointments, drop-ins, resources, and writing groups. Check out our website for other ways to interact with us, such as open online forums and online ?Question and Answers?. Visit us at www.uwaterloo.ca/wcc.

Please note that communication specialists guide you to see your work as readers would. We can teach you revising skills and strategies, but will not change or correct your work for you. Please bring your assignment instructions and any notes or drafts to your appointment.

[Link Writing and Communication Centre].

AccessAbility Services: AccessAbility Services (A.A.S.) is the University's centralized office for the provision of academic accommodations for students with a known or unknown disability, illness, or condition. Even if students are unsure of whether they qualify for A.A.S. support, an A.A.S. consultant can talk them through next steps, and refer them elsewhere if appropriate. [Link AccessAbility Services].