

Computer Vision

Programme course

12 credits

Datorseende

TSBB15

Valid from: 2022 Spring semester

Determined by

Board of Studies for Electrical Engineering,
Physics and Mathematics

Date determined

2021-09-01

Main field of study

Computer Science and Engineering, Electrical Engineering

Course level

Second cycle

Advancement level

A1X

Course offered for

- Master of Science in Computer Science and Engineering
- Master of Science in Information Technology
- Master of Science in Biomedical Engineering
- Master of Science in Computer Science and Software Engineering
- Master of Science in Applied Physics and Electrical Engineering
- Master of Science in Applied Physics and Electrical Engineering - International

Specific information

Exchange students may apply for the course after arrival to LiTH but before it starts. The Faculty coordinators for exchange studies must be contacted before applying.

Prerequisites

Probability theory, estimation theory, the least-squares-method, partial differential equations, 1D & 2D linear system theory (deterministic and stochastic).

From for example Multidimensional Signal Analysis: projective spaces, homogeneous representations of 2D and 3D geometry, perspective imaging, camera calibration, epipolar geometry, and frame theory.

Basic image processing: thresholding, segmentation, edge detection.

Use of Python or Matlab.

As half the course consists of a programming project, experience of programming is also recommended.

Intended learning outcomes

After having passed this course, the student is expected to be able to describe problems and algorithms for the following basic computer vision and image processing tasks:

- tracking of image regions
- structure from motion estimation
- estimation of optical flow
- detection and matching of local image features
- structure from motion and bundle adjustment
- generative image models
- segmentation of image regions
- enhancement of images
- debugging and visualisation

These are relevant for applications 3D reconstruction, camera pose estimation, object detection, motion estimation, visualization, and quality control within the areas of 3D vision, object tracking, scientific and industrial image analysis.

Course content

Computational methods related to the various applications mentioned in the learning outcomes above. For each application, a number of standard methods are being presented. Necessary mathematics is being introduced. Alternative methods and related research areas are mentioned.

Teaching and working methods

The course consists of two parts that are presented in parallel. One part is more theoretical and is based on a larger number of lectures and computer exercises that present and illustrate basic methods in computer vision. This part concludes with a written examination. The other part is more practical and begins with an introduction to two application areas: 3D-reconstruction and tracking of objects in image sequences. After that follows focused work in small projects and with guidance. The course participants are divided into small groups, and each group carries out both these applied projects, which shall demonstrate a number of methods presented in the theoretical part of the course. The results from each project group are presented orally at seminars and are documented in reports. Guidance for the projects is only given during the course semester. Each project is concluded by an analysis and reflection of the project work.

Examination

LAB1	Laboratory Work	U, G	3 credits
KTR1	Optional Written Test	U, G	0 credits
TEN1	Written Examination	U, 3, 4, 5	3 credits
PRA3	Project Assignment 1	U, G	3 credits
PRA4	Project Assignment 2	U, G	3 credits

The course has a written examination that covers theory and methods introduced in the lectures. Each of the two projects requires implementation, report writing, and an oral presentation in order to pass. The projects are graded with 4 if passed directly. If initially failed, they may be passed with grade 3 after meeting the stipulated requirements. Attaining grade 5 for a project requires, beyond this, an individual or group based work as described on the course web page. The total course grade is a weighted average of the grades from the written examination and the two projects. The voluntary mid-term examination covers the first half of the course. Passing the mid-term examination gives credit points in the written examination TEN1 and allows the student to skip the first half of the TEN1 exam. A passed mid-term examination is valid one year from the date it was written.

Grades

Four-grade scale, LiU, U, 3, 4, 5

Course literature

R. Szeliski: Computer Vision, Algorithms and Applications

Klas Nordberg: Introduction to Representations and Estimation in Geometry. ISY printed manuscript.

Additional material will be handed out or made available on the course web page.

Other information

Supplementary courses: Images and Graphics - Project Course CDIO, Thesis work

About teaching and examination language

The teaching language is presented in the Overview tab for each course. The examination language relates to the teaching language as follows:

- If teaching language is “Swedish”, the course as a whole could be given in Swedish, or partly in English. Examination language is Swedish, but parts of the examination can be in English.
- If teaching language is “English”, the course as a whole is taught in English. Examination language is English.

- If teaching language is “Swedish/English”, the course as a whole will be taught in English if students without prior knowledge of the Swedish language participate. Examination language is Swedish or English depending on teaching language.

Other

The course is conducted in a manner where both men's and women's experience and knowledge are made visible and developed.

The planning and implementation of a course should correspond to the course syllabus. The course evaluation should therefore be conducted with the course syllabus as a starting point.

If special circumstances prevail, the vice-chancellor may in a special decision specify the preconditions for temporary deviations from this course syllabus, and delegate the right to take such decisions.

Department

Institutionen för systemteknik

Director of Studies or equivalent

Lasse Alfredsson

Examiner

Per-Erik Forssén

Course website and other links

<http://www.cvl.isy.liu.se/education/undergraduate/tsbb15>

Education components

Preliminary scheduled hours: 96 h

Recommended self-study hours: 224 h

Course literature

Books

Richard Szeliski, (2011) *Computer Vision: Algorithms and Applications* Springer
ISBN: 978-1-84882-935-0
<http://szeliski.org/Book/>

Compendiums

Klas Nordberg, Introduction to Representations and Estimation in Geometry

Other

Additional material will be handed out or made available on the course web page.

Common rules

Course syllabus

A syllabus must be established for each course. The syllabus specifies the aim and contents of the course, and the prior knowledge that a student must have in order to be able to benefit from the course.

Timetabling

Courses are timetabled after a decision has been made for this course concerning its assignment to a timetable module.

Interruption in and deregistration from a course

The LiU decision, Guidelines concerning confirmation of participation in education (Dnr LiU-2020-02256), states that interruptions in study are to be recorded in Ladok. Thus, all students who do not participate in a course for which they have registered must record the interruption, such that the registration on the course can be removed. Deregistration from or interrupting a course is carried out using a web-based form: <https://www.lith.liu.se/for-studenter/kurskomplettering?f=en>.

Cancelled courses and changes to the course syllabus

Courses with few participants (fewer than 10) may be cancelled or organised in a manner that differs from that stated in the course syllabus. The Dean is to deliberate and decide whether a course is to be cancelled or changed from the course syllabus.

Guidelines relating to examinations and examiners

For details, see Guidelines for education and examination for first-cycle and second-cycle education at Linköping University, Dnr LiU-2020-04501 (<http://styrdokument.liu.se/Regelsamling/VisaBeslut/917592>).

An examiner must be employed as a teacher at LiU according to the LiU Regulations for Appointments, Dnr LiU-2021-01204 (<https://styrdokument.liu.se/Regelsamling/VisaBeslut/622784>). For courses in second-cycle, the following teachers can be appointed as examiner: Professor (including Adjunct and Visiting Professor), Associate Professor (including Adjunct), Senior Lecturer (including Adjunct and Visiting Senior Lecturer), Research Fellow, or Postdoc. For courses in first-cycle, Assistant Lecturer (including Adjunct and Visiting Assistant Lecturer) can also be appointed as examiner in addition to those listed for second-cycle courses. In exceptional cases, a Part-time Lecturer can also be appointed as an examiner at both first- and second cycle, see Delegation of authority for the Board of Faculty of Science and Engineering.

Forms of examination

Principles for examination

Written and oral examinations and digital and computer-based examinations are held at least three times a year: once immediately after the end of the course, once in August, and once (usually) in one of the re-examination periods. Examinations held at other times are to follow a decision of the board of studies.

Principles for examination scheduling for courses that follow the study periods:

- courses given in VT1 are examined for the first time in March, with re-examination in June and August
- courses given in VT2 are examined for the first time in May, with re-examination in August and October
- courses given in HT1 are examined for the first time in October, with re-examination in January and August
- courses given in HT2 are examined for the first time in January, with re-examination in March and in August.

The examination schedule is based on the structure of timetable modules, but there may be deviations from this, mainly in the case of courses that are studied and examined for several programmes and in lower grades (i.e. 1 and 2).

Examinations for courses that the board of studies has decided are to be held in alternate years are held three times during the school year in which the course is given according to the principles stated above.

Examinations for courses that are cancelled or rescheduled such that they are not given in one or several years are held three times during the year that immediately follows the course, with examination scheduling that corresponds to the scheduling that was in force before the course was cancelled or rescheduled.

When a course is given for the last time, the regular examination and two re-examinations will be offered. Thereafter, examinations are phased out by offering three examinations during the following academic year at the same times as the examinations in any substitute course. If there is no substitute course, three examinations will be offered during re-examination periods during the following academic year. Other examination times are decided by the board of studies. In all cases above, the examination is also offered one more time during the academic year after the following, unless the board of studies decides otherwise. In total, 6 re-examinations are offered, of which 2 are regular re-examinations. In the examination registration system, the examinations given for the penultimate time and the last time are denoted.

If a course is given during several periods of the year (for programmes, or on different occasions for different programmes) the board or boards of studies determine together the scheduling and frequency of re-examination occasions.

Retakes of other forms of examination

Regulations concerning retakes of other forms of examination than written examinations and digital and computer-based examinations are given in the LiU guidelines for examinations and examiners,

<http://styrdokument.liu.se/Regelsamling/VisaBeslut/917592>.

Registration for examination

In order to take an written, digital or computer-based examination, registration in advance is mandatory, see decision in the university's rule book <https://styrdokument.liu.se/Regelsamling/VisaBeslut/622682>. An unregistered student can thus not be offered a place. The registration is done at the Student Portal or in the LiU-app during the registration period. The registration period opens 30 days before the date of the examination and closes 10 days before the date of the examination. Candidates are informed of the location of the examination by email, four days in advance.

Code of conduct for students during examinations

Details are given in a decision in the university's rule book:

<http://styrdokument.liu.se/Regelsamling/VisaBeslut/622682>.

Retakes for higher grade

Students at the Institute of Technology at LiU have the right to retake written examinations and digital and computer-based examinations in an attempt to achieve a higher grade. This is valid for all examination components with code "TEN", "DIT" and "DAT". The same right may not be exercised for other examination components, unless otherwise specified in the course syllabus.

A retake is not possible on courses that are included in an issued degree diploma.

Grades

The grades that are preferably to be used are Fail (U), Pass (3), Pass not without distinction (4) and Pass with distinction (5).

- Grades U, 3, 4, 5 are to be awarded for courses that have written or digital examinations.
- Grades Fail (U) and Pass (G) may be awarded for courses with a large degree of practical components such as laboratory work, project work and group work.
- Grades Fail (U) and Pass (G) are to be used for degree projects and other independent work.

Examination components

The following examination components and associated module codes are used at the Faculty of Science and Engineering:

- Grades U, 3, 4, 5 are to be awarded for written examinations (TEN) and digital examinations (DIT).
- Examination components for which the grades Fail (U) and Pass (G) may be awarded are laboratory work (LAB), project work (PRA), preparatory written examination (KTR), digital preparatory written examination (DIK), oral examination (MUN), computer-based examination (DAT), home assignment (HEM), and assignment (UPG).

- Students receive grades either Fail (U) or Pass (G) for other examination components in which the examination criteria are satisfied principally through active attendance such as tutorial group (BAS) or examination item (MOM).
- Grades Fail (U) and Pass (G) are to be used for the examination components Opposition (OPPO) and Attendance at thesis presentation (AUSK) (i.e. part of the degree project).

In general, the following applies:

- Mandatory course components must be scored and given a module code.
- Examination components that are not scored, cannot be mandatory. Hence, it is voluntary to participate in these examinations, and the voluntariness must be clearly stated. Additionally, if there are any associated conditions to the examination component, these must be clearly stated as well.
- For courses with more than one examination component with grades U,3,4,5, it shall be clearly stated how the final grade is weighted.

For mandatory components, the following applies (in accordance with the LiU Guidelines for education and examination for first-cycle and second-cycle education at Linköping University, <http://styrdokument.liu.se/Regelsamling/VisaBeslut/917592>):

- If special circumstances prevail, and if it is possible with consideration of the nature of the compulsory component, the examiner may decide to replace the compulsory component with another equivalent component.

For possibilities to alternative forms of examinations, the following applies (in accordance with the LiU Guidelines for education and examination for first-cycle and second-cycle education at Linköping University, <http://styrdokument.liu.se/Regelsamling/VisaBeslut/917592>):

- If the LiU coordinator for students with disabilities has granted a student the right to an adapted examination for a written examination in an examination hall, the student has the right to it.
- If the coordinator has recommended for the student an adapted examination or alternative form of examination, the examiner may grant this if the examiner assesses that it is possible, based on consideration of the course objectives.
- An examiner may also decide that an adapted examination or alternative form of examination if the examiner assessed that special circumstances prevail, and the examiner assesses that it is possible while maintaining the objectives of the course.

Reporting of examination results

The examination results for a student are reported at the relevant department.

Plagiarism

For examinations that involve the writing of reports, in cases in which it can be assumed that the student has had access to other sources (such as during project work, writing essays, etc.), the material submitted must be prepared in accordance with principles for acceptable practice when referring to sources (references or quotations for which the source is specified) when the text, images, ideas, data, etc. of other people are used. It is also to be made clear whether the author has reused his or her own text, images, ideas, data, etc. from previous examinations, such as degree projects, project reports, etc. (this is sometimes known as “self-plagiarism”).

A failure to specify such sources may be regarded as attempted deception during examination.

Attempts to cheat

In the event of a suspected attempt by a student to cheat during an examination, or when study performance is to be assessed as specified in Chapter 10 of the Higher Education Ordinance, the examiner is to report this to the disciplinary board of the university. Possible consequences for the student are suspension from study and a formal warning. More information is available at

<https://www.student.liu.se/studenttjanster/lagar-regler-rattigheter?f=en>.

Regulations (apply to LiU in its entirety)

The university is a government agency whose operations are regulated by legislation and ordinances, which include the Higher Education Act and the Higher Education Ordinance. In addition to legislation and ordinances, operations are subject to several policy documents. The Linköping University rule book collects currently valid decisions of a regulatory nature taken by the university board, the vice-chancellor and faculty/department boards.

LiU's rule book for education at first-cycle and second-cycle levels is available at http://styrdokument.liu.se/Regelsamling/Innehall/Utbildning_pa_grund-_och_avancerad_niva.

