# School of Informatics Course Proposal Form (version: May 2021)

Please see Page 2 for instructions on which parts of this form to complete, whom to consult with to avoid unnecessary effort, and where to send the completed form.

**Proposer(s): Laura Sevilla-Lara** **Date: 12/11/2021**

## Cover page: Basic permanent course information

Unless otherwise noted, items in this section are entered into EUCLID and **cannot** be changed without creating an entirely new course.

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| **Course Name** | Computer Vision |
| **Is this an EPCC course?** | _X_ No (default)<br>__ Yes |
| **Course Acronym** *(used only School-internally)* | CV |
| **SCQF Credit Level and Normal Year Taken** | **Standard options for Informatics courses:**<br>__ Level 8/Year 1<br>__ Level 8/Year 2<br>__ Level 10/Year 3 (also available in Year 4).<br>_X_ Level 11/Year 4 (also available in Year 5 and MSc).<br>__ Level 11/PG (also available in Year 5).<br>__ Level 11/PG (only).<br>**Other options. Please provide justification if using:**<br>__ Level 9/Year 3<br>__ Level 10/Year 4<br>__ Other: |
| **SCQF Credit Points** | __10 _X_ 20 __40 __60 __80 __Other: |
| **Delivery Location** | _X_ Campus __On-line Distance Learning |
| **Course Type** | _X_ Standard (default) __Dissertation __Online Distance Learning<br>__Placement __Student Led Individually Created Course __Year Abroad |
| **Marking Scheme** | _X_ Standard (numerical) __Letter grade only<br>__Pass/Fail |

## Guidance for remaining sections:

**Before starting your proposal:** please contact the DDoLT (Curriculum) informally before starting to complete this form, with at least the following information:

- Tentative course title, level, year, and number of credits
- Who the target audience is, and why the course is needed.

The DDoLT (Curriculum) or delegate will schedule a meeting with you to discuss your plans and whether a full course proposal makes sense. If so, you will be provided with further instructions.

**Deadlines:** New courses must be approved by the December BoS meeting to ensure allocation of teaching staff for the following academic year. Since it may require considerable discussion and iteration to prepare the proposal, you should **contact the DDoLT (Curriculum) as early as possible, ideally in spring or summer**, and you should **plan on submitting your full proposal by November.**

**Submitting your proposal:** When your proposal is complete, please submit to **iss-bos@inf.ed.ac.uk**.

**Colour coding and item-by-item guidance:**
*Guidance is provided in italics for each item. Please also refer to the guidance for new course proposals at http://www.inf.ed.ac.uk/student-services/committees/board-of-studies/course-proposal-guidelines. Examples of previous course proposal submissions are available on the past meetings page http://web.inf.ed.ac.uk/infweb/admin/committees/bos/meetings-directory but note that the proposal form was updated in Apr 2021.*

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| **Sections in gold** are for student view and are required before a course can be entered into DRPS. |
| **Sections in orange** are for School use but are still required for all courses (even those that have already been approved based on other documentation). |
| **Sections in gray** are for consideration by the Board of Studies. They are normally required for all new course proposals but may be omitted in some cases, with permission (e.g., for invited proposals). |

**Glossary of terms:**

**(D)DoLT**: (Deputy) Director of Learning and Teaching.

**DRPS** (The Degree Regulations and Programmes of Study): Provides the University's official listing and descriptions of courses, degree programmes, and the regulations that govern them; updated annually in April. Course information in DRPS is considered a contract with students.

**DPT** (Degree Programme Table): Lays out the course requirements for each year of a degree. All UoE degrees have a DPT in the DRPS.

**Path**: A system that students use to help choose courses and view options in their DPT. The information feeds through from DRPS but has a more student-friendly interface (e.g., by highlighting courses that are not running or where the student hasn't satisfied prerequisites).

**SCQF** (The Scottish Credit Qualifications Framework): Lays out the requirements for courses at different levels and with different numbers of credits.

## 1. Course overview and case for support

Except as noted, all fields are required and will go into the DRPS (course catalogue) entry for students. Important: Text in DRPS is effectively a contract with students, so should not include details that are likely to change from year to year.

**Summary Description (for DRPS)**

*Provide a brief official description of the course, around 100 words. This should be student-friendly, as it is the part of the descriptor a student is most likely to read. If this course replaces another course, please say so in this summary.*

**This course replaces Image and Vision Computing (INFR11140) and Advanced Vision (INFR11031)**

Computer Vision is the field of study that teaches computers how to "see". This means, how to go from the pixels in an image to the information that a human can describe when they see a picture, much like self-driving cars, autonomous robots, or social media apps that recommend images or videos based on your preferences. This course is an in-depth introduction to the field of Computer Vision.

The course is structured around different problems in computer vision, such as object recognition and video classification, and covers both classical and deep learning approaches.

The course can be taken without any prior knowledge of computer vision or deep learning, but it does assume some familiarity with machine learning concepts, and relevant mathematics and programming skills (see details under "Other requirements"). The course delivers both theoretical and practical knowledge, and by the end you should be able to understand, design, and implement computer vision techniques for many real-world problems.

**Contribution to curriculum; target audience and expected demand; consultation (for BoS only)**

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| Why is this course needed and how does it relate to existing courses and degree programmes (including any prerequisite courses)? | This course aims to update the two existing courses "Advanced Vision" and "Image and Vision Computing" in a more integrated and coherent manner.<br>It also aims to relieve the related course "Machine Learning Practical" (MLP), which often has too many students. There is a strong interest among the students to learn modern computer vision techniques based on deep learning. While MLP provides an intro to deep learning and its applications in some example problems, it cannot cover most vision problems in detail because of its breadth. We expect that our course will attract MLP students who are primarily interested in deep computer vision and reduce the load of MLP. |
| What is the target audience, in terms of background and interests, and what is the expected demand (class size) for the course?<br>*State what your estimate is based on: e.g. by referring to projects in an area, sizes of similar courses, employer demand, etc. A survey of students may be requested once the main descriptor information is ready.* | The target audience is final year undergraduates and also graduate (e.g. MSc) students that have no/little previous experience with vision and want to get a solid introduction. For example, an undergrad or masters student who wants to get a job in a company that does vision, a first-year PhD student in a related field (eg, robotics or NLP) who wants to use vision in their research.<br>The hope is to partially relieve the load on MLP. Currently IVC/AV have around 50-100 students. We hope the class size would be 100-200. |

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| Has this proposal been discussed with the DDoLT (Curriculum) or DoLT prior to BoS submission? | _X_ Yes<br>__ No |
| Who else has been consulted?<br>*Proposals should typically be discussed with relevant colleagues, including the programme director (for MSc courses). Summarize their comments if needed.* | IPAB staff, and more in depth with Hakan Bilen, Bob Fisher and Tim Hospedales. |

**Course Description (for DRPS)**

This course teaches the principles and methodologies of computer vision, both from a theoretical and a practical perspective.

The content includes first the basics of image formation, image processing and classic computer vision principles and methods. In the second part, we will study one vision problem per week including object recognition, object segmentation, video classification, optical flow, pose estimation, learning from limited data, learning from biased data and its ethical and social implications, etc. For each of these problems we will discuss several seminal methods in the field, spanning both classical vision and deep learning methods.

The course will be taught as a live lecture. It will also have lab sessions to help with the coursework project. The coursework will be structured as a series of small non-assessed practice sessions, which will build up the skills for the assessed mini-project at the end of the course.

A tentative syllabus would be:

Week 1 -- Introduction
Week 2 -- Image formation (Camera types, projection, light)
Week 3 -- Image processing (convolution, filtering, effects)
Week 4 -- Traditional pipeline (interest points, descriptors, matching)
Week 5 -- Break
Week 6 -- Deep Learning I: MLP, ConvNets, training and testing
Week 7 -- Object Classification (1 classic approach, 1 established modern approach, 1 state-of-the-art)
Week 8 -- Object Segmentation (1 classic approach, 1 established modern approach, 1 state-of-the-art)
Week 9 -- Optical flow (1 classic approach, 1 established modern approach, 1 state-of-the-art)

Week 1 -- Depth Estimation (1 classic approach, 1 established modern approach, 1 state-of-the-art)
Week 2 -- Humans (pose and shape estimation) (1 classic approach, 1 established modern approach, 1 state-of-the-art)
Week 3 -- Video Classification (1 classic approach, 1 established modern approach, 1 state-of-the-art)
Week 4 -- Object Tracking (1 classic approach, 1 established modern approach, 1 state-of-the-art)
Week 5 -- Break
Week 6 -- Ethical and social impact (dataset bias, explainability)
Week 7 -- Learning from limited data (weak supervision, noisy data, self-supervision)
Week 8 -- Learning from limited data (few-shot, zero-shot)
Week 9 -- Vision and Language (Captioning, Grounding)

*This student-facing description should normally include **(a)** a more in-depth description of the learning aims, nature and context of the course, **(b)** a rough outline of the content, and **(c)** a description of how the course will be taught, and how students are expected to engage with it and to demonstrate their achievement of the learning outcomes.*
***Note:** Please keep this section general enough to avoid the need for yearly updates, and keep in mind that you should have only around 15 lecture hours of examinable material per 10pts of a course. (10pt courses may have 18-20 lecture hours, but the rest should be used for guest lectures, revision sessions, assignment feedforward/feedback, etc.)*

## Assessment Weightings (for DRPS)

*These should correspond approximately to the proportion of learning outcomes (below) that each component assesses. Note that assessed coursework is typically more time-consuming than exams for both students and staff. A typical course is based no more than 30% on coursework and doing so requires justification.*

Written Exam __50__%
Practical Exam _____% (*for courses with programming exams)*
Coursework __50__%

## Additional Information, Assessment (for DRPS)

Coursework will involve implementing some of the methods discussed, or modifying existing publicly available ones.

## Learning Outcomes (MAXIMUM OF 5; for DRPS)

*List the learning outcomes (LOs) of the course. These must be assessable (i.e., observable), so must specify what the student should be able to do concretely, not simply what they should "understand". Use concrete verbs that indicate (a) what type of assessment would be appropriate, and (b) what level of knowledge/thinking is expected (from recall to analysis to novel creation).* ***Example verbs:*** *define, explain, implement, compare, justify. Assessments (described later) should be tied to the LOs.*

*LOs should focus more on the types of thinking/skills developed than on the detailed course content, and should be appropriate to the level of the course: e.g., LOs at Level 11 should include more higher-level thinking skills than at Level 8. See how to write good learning outcomes and the descriptors of the SCQF Levels. Also, please consider including LOs related to* ***social or ethical implications*** *or* ***meta-skills*** *as well as technically-focussed LOs.*

On completion of this course, the student will be able to

1) Define and explain principles underpinning computer vision methods
2) Describe current vision problem settings and their current solutions
3) Implement, train and debug computer vision models
4) Design, explain, analyze, and compare the behavior of computer vision models under different settings
5) Identify social and ethical implications of computer vision methods in the real world

## Graduate Attributes, Personal & Professional Skills (for DRPS)

*Please list the generic transferrable skills that this course will develop, as aligned with the UoE's Graduate Attributes framework. Examples from the four skills categories in the framework include:*

**Research and enquiry:**

- Problem-solving, debugging and understanding the behavior of systems under different scenarios
- Critical/analytical thinking of methods, their advantages and disadvantages
- Describing partial evidence or results, and reasoning under uncertainty

**Personal effectiveness:**

- Planning and organizing own time, to achieve milestones at particular deadlines

**Personal responsibility and autonomy:**

- Learning independently, researching how others have addressed the same issue
- Develop creativity to address problems in existing methods

**Communication:**

- Work is done in pairs, so interpersonal/teamwork skills will be developed
- The coursework involves writing a report, so verbal and written communication will be developed

## 2. Additional information on course design and resourcing (for BoS only, except where noted)

**Breakdown of Learning and Teaching Activities (for DRPS)**

*Please fill in the number of timetabled hours per student for each type of activity. Do not include non-timetabled hours.*

***A typical 10pt Informatics course** has:*

- *18-20 lecture slots (2/wk), but only ~15h should be examinable lectures, with the rest used for guest lectures, revision sessions, assignment feedforward/ feedback, etc. If unsure of plans, count these under 'lecture hours' but please explain tentative plans in the free text below.*
- *No more than 4-5 lab or tutorial hours. Please consider whether fewer can be used, e.g. by using some lecture hours for whole-class discussion/feedforward.*

***A typical 20pt course** has 30 lecture slots (3/wk) and no more than 8 lab/tutorial hours.*

| Timetabled Hours | Type |
|---|---|
| **35** | Lecture Hours |
| **0** | Seminar/Tutorial Hours |
| **0** | Dissertation Project Supervision Hours |
| **8** | Supervised Lab/Workshop/Studio Hours |
| **0** | Feedback/Feedforward hours |
| **2** | Summative assessment hours *[Normally 2h if using an exam; otherwise 0]* |
| **5** | Revision Session Hours |

*(Note for ISS: Remaining hours should be allocated to Directed and Undirected Learning Activities.)*

**Use of timetabled activities (not to be included in DRPS)**

Labs are meant as support for assessed coursework.

**Summative assessment and time spent on assignments (not to be included in DRPS)**

The assessment will be:

- a written exam: this will assess learning outcomes 1, 2, 5
- a report of the programming assignment: this will assess learning outcomes 3-4 (perhaps 5)

I expect the 6 hours a week to be distributed roughly as:

- 2 contact hours
- 2 hours of self-study
- 2 hours of coursework

*Please describe your plans for summative assessment, in more detail than in the student-facing description: How many and what types of assessment are planned (oral presentation, report, programming, etc)? For each piece of assessment, please indicate **(a)** which learning outcome(s) it assesses; and **(b)** how many hours students are expected to spend on it.*

*Please minimize the time spent on summative assessments (for both students and markers) while robustly assessing the learning outcomes. See the School policy on Workload and Assessment, which places limits on the number of summative courseworks and time expectations: to ensure a 35-40h working week, we must limit time asked of students to **6-7h/wk in total per 10 credits, including contact hours, self-study, and coursework.***

**Tentative plans for feedback/formative assessment (not to be included in DRPS)**

Feedback will be based on:

- Formative online quizzes (Weekly at most)
- 1 written formative coursework (2h weekly, half of the semester)
- 1 written assessed coursework (2h weekly, half of the semester)

*Please describe your current plans for providing feedback to students: e.g. oral feedback during labs/tutorials, automarked solutions to in-lecture or online quizzes, peer feedback, etc. We also encourage submission of at least one piece of (individual or group) written work, with formative feedback emphasizing how students can improve.*

*Some useful guides for planning effective and efficient feedback:*

- *Two short IAD web pages: Five basic principles for feedback and Tips for improving feedback*
- *EngagED in... assessment and feedback. This flyer from IAD discusses assessment **of**, **for**, and **as** learning, and includes examples of innovative approaches that could help both with scaling to large courses and with causing students to reflect on and become engaged with their own assessment.*
- *Considerable further reading is available at the University pages on Enhancing Feedback.*

**Decolonisation and Inclusivity (not to be included in DRPS)**

*What actions are you taking towards making your course inclusive for all students, in terms of both **content** and **delivery**? Please be as specific as possible. If you are not taking any action, please justify. See suggestions and guidance here.*

Content: We will include content on social and ethical consequences of computer vision in the real world.

Delivery:

**Anticipated Resource Requirements**

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| If tutorials are needed, how many students per tutors? (*Please provide your desired number, and the maximum feasible number.)* | **NA** |
| If labs are needed, how many students per demonstrator? (*Please provide your desired number, and the maximum feasible number.)* | **20-30 students per lab session would be good.** |
| Please estimate the number of hours required for marking, per student. | **1-2 hours / student (for coursework)**<br>**20-30 min / student (for written exam)** |
| If any other teaching support resource will be requested in order to **develop** or **maintain** the course, please provide an estimate of that here. | |
| Do you anticipate any difficulty recruiting enough teaching support? *(For example if the course is very large or very specialized.)* | **Perhaps this could be an issue if the class grows a lot, as it is already hard to find suitable TAs.** |
| Does the course have any scaling limits due to available space or equipment? | **Perhaps in terms of both GPU access and TA.** |
| If equipment is required, please state how it will be procured and maintained. | **Access to GPU.** |
| Does the course have any external funding? *(Typically only for CPD courses)* | **No.** |
| Does the course need any special arrangements such as quotas, agreements with other schools, or registration arrangements? Does it have any | **No.** |

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| atypical characteristics that may affect finance or student registration? Please specify if so. | |

## 3. Further information for BoS consideration

A full proposal for a new course must include examples of exercises and assessment. Please provide these below, along with publicity information.

**Course information and publicity**

N/A.

*The course web page (typically the Learn landing page) will be linked from the Sortable Course List, and information such as timetables and assignment deadlines must be made available prior to the start of the academic year. Please specify here if any additional info/publicity is needed for your course, especially if it is aimed largely at non-SoI students.*

**Sample tutorial/lab sheet questions**

*Provide a list of tutorial questions and answers and/or samples of lab sheets. These need not be fully fleshed out but should indicate what sort of exercises will be provided to help students learn the material.*

We do not have tutorials or lab sheets. Some examples of questions for the online quizzes are:

- Why do you need to divide the values of a filter by their total sum?
- What is the number of weights in a network with X layers, and filter size Y ?
- What happens if we remove the regularizer in the optical flow method of Horn&Schunck?

**Sample assessment materials**

The exam style should be similar to the current IVC (https://exampapers.ed.ac.uk/bitstream/handle/20.500.12593/113088/2020169_INFR11140.pdf?sequence=1&isAllowed=y ) Around 50% of the content of IVC would transfer to the new computer vision course, so this exam is quite similar to what we expect.

An example of coursework would be:
"The seminal work of Mask-RCNN studied in class provided the first semantic segmentation method to work remarkably well in images. However, the results are not consistent when run on adjacent frames within a video. For example, in dataset X, the accuracy is Y. Given your knowledge of current vision methods, design and implement a well-motivated modification of Mask-RCNN for videos. Experiment with the accuracy of your novel method, and diagnose why it may be better or worse than the vanilla original method."

*If the course is primarily assessed by **exam**, provide a sample exam question with model answers. The online list of past exam papers gives an idea of typical and alternative exam formats.*
*If the course is largely or primarily assessed by **coursework**, provide a sketch of a possible assignment with an estimate of effort against each sub-task and a description of marking criteria.*

**Any other relevant materials**

*Include anything else that is relevant, possibly in the form of links. If you do not want to specify a set of concrete readings for the official course descriptor, please list examples here.*

## 4. Additional Course Details for DRPS

Except where otherwise noted, these fields are required for entry into EUCLID and will be visible to students in the DRPS entry.

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| **Planned Academic Year of Delivery**<br>*(The first year you anticipate the course running, e.g. AY 2019-20)* | AY 2022-2023 |
| **Keywords**<br>*Give a list of searchable keywords for the course.* | Computer vision, deep learning, image processing |
| **Course Organiser**<br>*(By default, the course proposer)* | Laura Sevilla |
| **Intended Delivery Period** | __Semester1<br>__Semester 2<br>_X_ Full Year<br>__Summer<br>__Other (please specify): |
| **Timetable considerations/conflicts**<br>*For School use. Please specify any constraints to be considered (e.g. overlap of popular combinations, other specialism courses, external courses etc). Include whether the semester delivery is constrained or could be flexible.* | The semester delivery could be flexible, and I wouldn't be opposed to a single semester delivery, in the second semester.<br>The course could overlap with MLP. |
| **Reading List/Learning Resources (for DRPS)**<br>*You are encouraged to create resource lists using LEGANTO* | Computer Vision (Rick Szeliski)<br>Deep Learning (Yoshua Bengio) |
| **Feedback Information**<br>*Provide a high-level description of how and what type of feedback will be provided to students, for inclusion in DRPS.* | Self-assessed online quizzes<br>Written feedback on coursework |
| **Is this course available to visiting students?** | _X_ Yes (default)<br>__No<br><br>**If no, please provide a justification here:** |
| **Required pre-requisite courses**<br>*Use sparingly: these are enforced in PATH and can only be waived by approval from the School's Curriculum Approval Officer. Note that cross-year required pre-requisites may prevent MSc students from registering; consider using recommended pre-requisites or "other requirements" instead.* | _X_ No<br>__Yes (please specify full course name(s) and code(s)): |

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| **Recommended pre-requisite courses** | _X_ No<br>__ Yes (please specify full course name(s) and code(s)): |
| **Required co-requisite courses**<br>*Specify any courses that must be taken in parallel with the existing course. Note that this leads to a timetabling constraint that should be mentioned elsewhere in the proposal.* | _X_ No<br>__ Yes (please specify full course name(s) and code(s)): |
| **Prohibited Combinations**<br>*Specify any courses that may not be taken in combination with the proposed course].* | _X No<br>__ Yes (please specify full course name(s) and code(s)): |
| **Other Requirements/Additional Information**<br>*This information is often used by MSc students and students from other Schools to see if they have appropriate background without having done our School's courses. So please avoid course titles, instead list specific knowledge and skills (such as mathematical concepts, programming ability or specific languages, etc).*<br><br>*Also list any other constraints on registration, for example: "Only available to 4th Year Informatics students including those on joint degrees." or "This course is open to all Informatics students including those on joint degrees, and to students in the School of Mathematics. Other external students whose DPT does not list this course should seek permission from the course organiser."* | __No<br>_X_ Yes (please specify):<br><br>Students should check these maths and programming requirements carefully, as the course assumes and builds on these foundations. Experience has shown that students without this background can struggle with the course.<br><br>Maths requirements:<br><br>1. Linear algebra: Vectors: scalar (dot) product, transpose, unit vectors, vector length, orthogonality. Matrices: addition, matrix multiplication, matrix inversion. Eigenvectors, determinants quadratic forms.<br><br>2. Special functions: properties and combination rules for logarithm and exponential.<br><br>3. Calculus: Rules for differentiation of standard functions. Functions of several variables. Partial differentiation. Multivariate maxima and minima.<br><br>4. Geometry: Basics of lines, planes and hyperplanes. Coordinate geometry of circle, sphere, ellipse, ellipsoid and n-dimensional generalizations.<br><br>5. Probability theory: Discrete and continuous univariate random variables. Expectation, variance. Univariate Gaussian distribution. Joint and conditional distributions.<br><br>Machine Learning requirements: This course assumes students are familiar with concepts from machine learning such as supervised training, feature selection, loss functions, and optimization. It is strongly recommended that students who register for this course have either taken a machine learning course previously or are registered for one in Semester 1.<br><br>Programming requirements: |

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| | Students should be familiar with programming in a modern object-oriented language, ideally Python which is the course language. |
| **Visiting Student Pre-requisites** | _X_ Same as “other requirements”<br>__ Different than “other requirements” (please specify): |

## 5. Placement in degree programme tables: for level 9-11 courses only (except EPCC)

This section is for consideration by the Board of Studies and will be used later by ITO to determine where the course will be added to existing degree programme tables.

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| **Is this course restricted to students on a specific degree?**<br>*E.g., some courses are only available to students on a specific CDT or MSc.* | _X_ No<br>__ Yes (please specify and provide justification): |
| **Is this course compulsory for students on any degree(s)?** | _X_ No<br>__ Yes (please specify and provide justification): |
| **Any issues for part-time students?**<br>*Normally, part-time students have access to the same courses as full-time students on the equivalent degree. If you anticipate any problems with this, please specify here.* | No |

**For optional courses:**

If this course is available but non-compulsory for students on various degrees (most courses), please fill in this section. The choices here determine where the course appears in degree programme tables (DPTs) and the 2-3 character tags are displayed in the Informatics sortable course list.

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| **Should this course be tagged as 'ML' (machine learning foundations and methods)?**<br>*Courses with the ML tag are typically very high-demand and most degrees limit the number of ML credits. If your course might appeal to a similar audience but draw off students from these large courses, please select 'no' and choose one of the tags below.* | _X_ No<br>__ Yes |
| **If you chose 'no', please choose at least one of the following tags…**<br>*Ideally, select exactly one, unless there is a good argument for more than one. These three are used in various combinations for many of our degrees.* | __ **FSS** (CS foundations, systems, and software)<br>_X_ **AIA** (artificial intelligence applications and paradigms)<br>__ **COG** (cognitive science: including HCI and NLP courses, but not most other AI courses. Please restrict to courses most relevant to natural cognition.) |
| **…and also tick if any of the following tags or categories apply.**<br>*Do not tick any of these if you selected 'ML' already.* | __ **SE** (software engineering: including courses that are highly relevant to SE degrees. All SE courses should also be FSS. This tag is mainly relevant for UG SE degrees.)<br>__ Databases and data management systems (used for Data Science MSc and MSc(R))<br>__ Unstructured data and applications (used for Data Science MSc and MSc(R))<br>__ Level 11 Security courses (used for Security MSc)<br>__ ATFC Optional courses (used for ATFC MSc) |

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| **If you are not sure which tags are most appropriate or have other questions about this section, please note any comments/issues here.** | |