Board of Studies
Course Proposal Template

PROPOSED COURSE TITLE: Probabilistic Modelling and Reasoning

PROPOSER(S): Amos Storkey, Iain Murray (and the machine learning staff).

DATE: 11 Jan 2016

SUMMARY

This template contains the following sections, which should be prepared roughly in the order in which they appear (to avoid spending too much time on preparation of proposals that are unlikely to be approved):

1. Case for Support
– To be supplied by the proposer and shown to the BoS Academic Secretary prior to preparation of an in-depth course description

1a. Overall contribution to teaching portfolio

1b. Target audience and expected demand

1c. Relation to existing curriculum

1d. Resources

2. Course descriptor
- This is the official course documentation that will be published if the course is approved, ITO and the BoS Academic Secretary can assist in its preparation

3. Course materials
- These should be prepared once the Board meeting at which the proposal will be discussed has been specified

3a. Sample exam question

3b. Sample coursework specification

3c. Sample tutorial/lab sheet question

3d. Any other relevant materials

4. Course management

- This information can be compiled in parallel to the elicitation of comments for section 5.

4a. Course information and publicity

4b. Feedback

4c. Management of teaching delivery

5. Comments

- To be collected by the proposer in good time before the actual BoS meeting and included as received

5a. Year Organiser Comments

5b. Degree Programme Co-Ordinators

5c. BoS Academic Secretary

[Guidance in square brackets below 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://www.inf.ed.ac.uk/admin/committees/bos/meetings/*.]*

SECTION 1 – CASE FOR SUPPORT

[This section should summarise why the new course is needed, how it fits with the existing course portfolio, the curricula of our Degree Programmes, and delivery of teaching for the different years it would affect.]

1a. Overall contribution to teaching portfolio

[Explain what motivates the course proposal, e.g. an emergent or maturing research area, a previous course having become outdated or inappropriate in other ways, novel research activity or newly acquired expertise in the School, offerings of our competitors.]

This is a change of the number of points for the course. We have made a case for this in the cover letter. But in summary, PMR (along with MLPR) is considered to be one of the hardest MSc courses we offer, with students routinely spending more than twice as much time on it than other courses, and *even given that* having failure rates between 25% and 40%. On reflection, student are often very positive about what they learn from the course, but emphasise the exorbitant time cost it takes. Furthermore as a lecturer, I routinely spend 30 minutes answering questions after each lecture (to the benefit of a few, and the loss of those who have to go on to other lectures). The course content cannot reasonably be reduced – much of the difficulty is the problems some students have in getting their head round the basic concepts of PMR, especially probabilistic graphical models. Furthermore changes in MLPR mean PMR will need to inherit additional material (e.g. approximate inference, MCMC). The material belongs in PMR and will make it more coherent and less MLPR dependent.

Changing it to 20 points will allow us to provide more contact time, Q&A sessions, review and recap sessions, as well as better reflecting the real time this course takes and the commitment involved.

1b. Target audience and expected demand

[Describe the type of student the course would appeal to in terms of background, level of ability, and interests, and the expected class size for the course based on anticipated demand. A good justification would include some evidence, e.g. by referring to projects in an area, class sizes in similar courses, employer demand for the skills taught in the course, etc.]

The target audience is the same as the current PMR, but explicitly making it 20 points to ensure that those taking it are properly aware of the time commitment involved.

1c. Relation to existing curriculum

[This section should describe how the proposed course relates to existing courses, programmes, years of study, and specialisms. Every new course should make an important contribution to the delivery of our Degree Programmes, which are described at http://www.drps.ed.ac.uk/15-16/dpt/drps_inf.htm.

Please name the Programmes the course will contribute to, and justify its contribution in relation to courses already available within those programmes. For courses available to MSc students, describe which specialism(s) the course should be listed under (see http://web.inf.ed.ac.uk/infweb/student-services/ito/students/taught-msc-2015/programme-guide/specialist-areas*), and what its significance for the specialism would be. Comment on the fit of the proposed course with the structure of academic years for which it should be offered. This is described in the Year Guides linked from* http://web.inf.ed.ac.uk/infweb/student-services/ito/students*.]*

No change here. This is not a new course. However moving it to 20 points will affect selections. We have provided typical pathways for certain student interest groups to show how the change to this (and MLPR) affects choice.

Core ML:
- MLPR+{2 of MLP, IAML, EXC, TTDS, NC, IQC, IJP}; PMR+DME+RL

ML+Vison: MLPR+MLP+{IAML, EXC, CG}, PMR+IVR+AV

ML+Robotics: MLPR+RSS;PMR+IVR+RLSC

ML+Language:
Ex 1: MLPR+ANLP, PMR+{2 of MT,NLU,TNLP}
Ex 2: MLPR+TTDS+EX, PMR+{2 of MT,NLU,TNLP}

Of course there are other combinations (ML+comp neuro, ML+bioinf, etc) which I think we can work out too.

Note none of the people in these areas have to choose both MLPR and PMR. But apart from the NLP people who might currently choose all of PMR,MT,NLU, and TNLP (which seems quite a heavy load for anyone), most subject combinations are catered for. At the end of the day we are only asking people with a ML focus to dedicate 50% of their course choice to ML. That is not too tall an ask. It allows for concepts of joint-major, major-minor, and single subject specialisms.

1d. Resources

[While course approvals do not anticipate the School's decision that a course will actually be taught in any given year, it is important to describe what resources would be required if it

were run. Please describe how much lecturing, tutoring, exam preparation and marking effort will be required in steady state, and any additional resources that will be required to set the course up for the first time. Please make sure that you provide estimates relative to class size if there are natural limits to its scalability (e.g. due to equipment or space requirements). Describe the profile of the course team, including lecturer, tutors, markers, and their required background. Where possible, identify a set of specific lecturers who have confirmed that they would either like to teach this course apart from the proposer, or who could teach the course in principle. It is useful to include ideas and suggestions for potential teaching duty re-allocation (e.g. through course sharing, discontinuation of an existing course, voluntary teaching over and above normal teaching duties) to be taken into account when resourcing decisions are made.]

This requires extra 10 points resource of lecturer time. Given the size of this course (over 120 this year), that does not seem like a major extra commitment. Note that this reduces the demand on other courses (the total points doesn't change) so there is no actual real change in resourcing per student. No other specific additional resources are required over PMR.

SECTION 2 – COURSE DESCRIPTOR

[This is the official course descriptor that will be published by the University and serves as the authoritative source of information about the course for student via DRPS and PATH. Current course descriptions in the EUCLID Course Catalogue are available at www.euclid.ed.ac.uk under 'DPTs and Courses', searching for courses beginning 'INFR'*]*

2a. Course Title *[Name of the course.]* :

Probabilistic Modelling and Reasoning

2b. SCQF Credit Points:

[The Scottish Credit and Qualifications Framework specifies where each training component provided by educational institutions fits into the national education system. Credit points per course are normally 10 or 20, and a student normally enrols for 60 credits per semester. For those familiar with the ECTS system, one ECTS credit is equivalent to 2 SCQF credits. See also http://www.scqf.org.uk/The%20Framework/Credit%20Points*.]*

20

SCQF Credit Level:

[These levels correspond to different levels of skills and outcomes, see http://www.sqa.org.uk/files_ccc/SCQF-LevelDescriptors.pdf. *At University level, Year 1/2 courses are normally level 8, Year 3 can be level 9 or 10, Year 4 10 or 11, and Year 5/MSc have to be level 11. MSc programmes may permit a small number (up to 30 credits overall) of level 9 or 10 courses.]*

11

Normal Year Taken: 1/2/3/4/5/MSc

[While a course may be available for more than one year, this should specify when it is normally taken by a student. "5" here indicates the fifth year of undergraduate Masters programmes such as MInf.]

MSc

Also available in years: 1/2/3/4/5/MSc

Different options are possible depending on the choice of SCQF Credit Level above: for level 9, you should specify if the course is for 3rd year undergraduates only, or also open to MSc students (default); for level 10, you should specify if the course is available to 3rd year and 4th year undergraduates (default), 4th year undergraduates only, and whether it should be open to MSc students; for level 11, a course can be available to 4th and 5th year undergraduates and MSc students (default), to 5th year undergraduates and MSc students, or to MSc students only]

2c. Subject Area and Specialism Classification:

[Any combination of Computer Science, Artificial Intelligence, Software Engineering and/or Cognitive Science as appropriate. For courses available to MSc students, please also specify the relevant MSc specialist area (to be found in the online MSc Year Guide at http://web.inf.ed.ac.uk/infweb/student-services/ito/students/taught-msc-2015/programme-guide/specialist-areas), distinguishing between whether the course should be considered as "core" or "optional" for the respective specialist area.]

Artificial Intelligence. Machine Learning Specialism Major. No change from current.

Appropriate/Important for the Following Degree Programmes:

[Please check against programmes from http://www.drps.ed.ac.uk/15-16/dpt/drps_inf.htm to determine any specific programmes for which the course would be relevant (in many cases, information about the Subject Area classification above will be sufficient and specific programmes do not have to be specified). Some courses may be specifically designed for non-Informatics students or with students with a specific profile as a potential audience, please describe this here if appropriate.]

As current PMR

Timetabling Information:

[Provide details on the semester the course should be offered in, specifying any timetabling constraints to be considered (e.g. overlap of popular combinations, other specialism courses, external courses etc).]

Semester 2.

2d. Summary Course Description:

[Provide a brief official description of the course, around 100 words. This should be worded in a student-friendly way, it is the part of the descriptor a student is most likely to read.]

When dealing with real world data, we often need to deal with uncertainty. For example, short segments of a speech signal are ambiguous, and we need to take into account context in order to make sense of an utterance. Probability theory provides a rigorous method for representing and reasoning with uncertain knowledge. The course covers two main areas (i) the process of inference in probabilistic reasoning systems and (ii) learning probabilistic models from data. Its aim is to provide a firm grounding in probabilistic modelling and reasoning, and to give a basis which will allow students to go on to develop their interests in more specific areas, such as data-intensive linguistics, automatic speech recognition, probabilistic expert systems, statistical theories of vision etc.

[Provide an academic description, an outline of the content covered by the course and a description of the learning experience students can expect to get. See guidance notes at: http://www.studentsystems.ed.ac.uk/Staff/Support/User_Guides/CCAM/CCAM_Information_Captured.html#AcademicDescription*].*

The course will cover the most important topics in probabilistic modelling and unsupervised learning, and provide a thorough basis for understanding other extensions developments and applications.

*Introduction
* Probability
o events, discrete variables
o joint, conditional probability
* Discrete belief networks, inference
* Continuous distributions, graphical Gaussian models
* Learning: Maximum Likelihood parameter estimation
* Decision theory
* Hidden variable models
o mixture models and the EM algorithm
o factor analysis
o ICA, non-linear factor analysis
* Dynamic hidden variable models
o Hidden Markov models
o Kalman filters (and extensions)
* Undirected graphical models
o Markov Random Fields
o Boltzmann machines
* Information theory
o entropy, mutual information
o source coding, Kullback-Leibler divergence
* Approximate Inference: MCMC, Variational Methods

* Bayesian methods for
o Inference on parameters
o Model comparison

Relevant QAA Computing Curriculum Sections: Artificial Intelligence

Pre-Requisite Courses:

[Specify any courses that a student must have taken to be permitted to take this course. Pre-requisites listed in this section can only be waived by special permission from the School's Curriculum Approval Officer, so they should be treated as "must-have". By default, you may assume that any student who will register for the course has taken those courses

compulsory for the degree for which the course is listed in previous years. Please include the FULL course name and course code].

None

Co-Requisite Courses:

[Specify any courses that should be taken in parallel with the existing course. Note that this leads to a timetabling constraint that should be mentioned elsewhere in the proposal. Please include the FULL course name and course code].

None

[Specify any courses that should not be taken in combination with the proposed course. Please include the FULL course name and course code].

Existing PMR course: INFR11050 Probabilistic Modelling and Reasoning

Other Requirements:

[Please list any further background students should have, including, for example, mathematical skills, programming ability, experimentation/lab experience, etc. It is important to consider that unless there are formal prerequisites for participation in a course, other Schools can register their students onto our courses, so it is important to be clear in this section. If you want to only permit this by special permission, a statement like "Successful completion of Year X of an Informatics Single or Combined Honours Degree, or equivalent by permission of the School." can be included.]

This course is open to all Informatics students including those on joint degrees. For external students where this course is not listed in your DPT, please seek special permission from the course organiser.

Mathematics prerequisites:

1 - Probability theory: Discrete and continuous univariate random variables. Expectation, variance. Joint and conditional distributions.

2 - Linear algebra: Vectors and matrices: definitions, addition. Matrix multiplication, matrix inversion. Eigenvectors, determinants, quadratic forms.

3 - Calculus: Functions of several variables. Partial differentiation. Multivariate maxima and minima. Integration: need to know definitions, including multivariate integration.

4 - Special functions: Log, exp are fundamental.

5 - Geometry: Basics of lines, planes and hyperplanes. Coordinate geometry of circle, sphere, ellipse, ellipsoid and n-dimensional generalizations.

6 - Graph theory: Basic concepts and definitions: vertices and edges, directed and undirected graphs, trees, paths and cycles, cliques.

Programming prerequisite: A basic level of programming is assumed and not covered in lectures. The assessed assignment will involve some programming.

Previously taking and being happy with MLPR is highly recommended for this course. There will be some assumption that people are familiar with machine learning concepts such as those taught on MLPR or an equivalent course.

Available to Visiting Students: Yes/No

[Provide a justification if the answer is No.]

YES

2e. Summary of Intended Learning Outcomes (MAXIMUM OF 5):

[List the learning outcomes of the course, emphasising what the impact of the course will be on an individual who successfully completes it, rather than the activity that will lead to this outcome. Further guidance is available from https://canvas.instructure.com/courses/801386/files/24062695]

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

1 - Define the joint distribution implied by directed and undirected probabilistic graphical models, and vice versa.
2 - Carry out inference in graphical models from first principles by hand, and convert between different graphical models.
3 - Demonstrate understanding of maximum likelihood and Bayesian methods for parameter estimation by hand derivation of estimation equations for specific problems.

Assessment Information

[Provide a description of all types of assessment that will be used in the course (e.g. written exam, oral presentation, essay, programming practical, etc) and how each of them will assess the intended learning outcomes listed above. Where coursework involves group work, it is important to remember that every student has to be assessed individually for their contribution to any jointly produced piece of work. Please include any minimum requirements for assessment components e.g. student must pass all individual pieces of assessment as well as course overall].

Coursework 20%, Exam 80%

Assessment Weightings:

Written Examination: 80%

Practical Examination: 0%

Coursework: 20%

Time spend on assignments:

[Weightings up to a 70/30 split between exam and coursework are considered standard, any higher coursework percentage requires a specific justification. The general expectation is that a 10-point course will have an 80/20 split and include the equivalent of one 20-hour coursework assignment (although this can be split into several smaller pieces of coursework. The Practical Examination category should be used for courses with programming exams. You should not expect that during term time a student will have more than 2-4 hours to spend on a single assignment for a course per week. Please note that it is possible, and in many cases desirable, to include formative assignments which are not formally assessed but submitted for feedback, often in combination with peer assessment.]

40 hours worth of coursework, which is a mixture of practical (building and using graphical models) and tests of understanding.

Academic description:

[A more technical summary of the course aims and contents. May include terminology and technical content that might be more relevant to colleagues and administrators than to students.]

See the main summary and course outline.

[Provide a more detailed description of the contents of the course, e.g. a list of bullet points roughly corresponding to the topics covered in each individual lecture/tutorial/coursework. The description should not exceed 500 words but should be detailed enough to allow a student to have a good idea of what material will be covered in the course. Please keep in mind that this needs to be flexible enough to allow for minor changes from year to year without requiring new course approval each time.]

See the main summary and course outline.

Relevant QAA Computing Curriculum Sections:

[Please see http://www.qaa.ac.uk/en/Publications/Documents/Subject-benchmark-statement-Computing.aspx.pdf *to check which section the course fits into.]*

Artificial Intelligence

Graduate Attributes, Personal and Professional skills:

[This field should be used to describe the contribution made to the development of a student's personal and professional attributes and skills as a result of studying this course – i.e. the generic and transferable skills beyond the subject of study itself. Reference in particular should be made to SCQF learning characteristics at the correct level http://www.sqa.org.uk/files_ccc/SCQF-LevelDescriptors.pdf *].*

The student will be able to reason about uncertainty, an important transferable skill. In addition the student will be able to Undertake critical evaluations of a wide range of numerical and graphical data. Apply critical analysis, evaluation and synthesis to forefront issues, or issues that are informed by forefront developments in the subject/discipline/sector. Identify, conceptualise and define new and abstract problems and issues. Develop original and creative responses to problems and issues. Critically review, consolidate and extend knowledge, skills, practices and thinking in a subject/discipline/sector. Deal with complex issues and make informed judgements in situations in the absence of complete or consistent data/information.

the students; everything else should be accounted for in the Directed Learning and Independent Learning hours.

The total being 10 x course credits. Assume 10 weeks of lectures slots and 10 weeks of tutorials, though not all of these need to be filled with actual contact hours. As a guideline, if a 10-pt course has 20 lecture slots in principle, around 15 of these should be filled with

examinable material; the rest should be used for guest lectures, revision sessions, introductions to assignments, etc. Additional categories of learning and teaching activities are available, a full list can be found at:

http://www.euclid.ed.ac.uk/Staff/Support/User_Guides/CCAM/Teaching_Learning.htm*]*

Lecture Hours: _30___ hours

Seminar/Tutorial Hours: _10___ hours

Supervise practical/Workshop/Studio hours: ____ hours

Summative assessment hours: _40___ hours

Feedback/Feedforward hours: _2___ hours

Directed Learning and Independent Learning hours: __118__ hours

Total hours: __200__ hours

You may also find the guidance on 'Total Contact Teaching Hours' and 'Examination & Assessment Information' at:
http://www.studentsystems.ed.ac.uk/Staff/Support/User_Guides/CCAM/CCAM_Information_Captured.html

Keywords:

[A list of searchable keywords.]

Bayesian Statistics Unsupervised Learning Probabilistic Models	

ECTION 3 - COURSE MATERIALS

3a. Sample exam question(s)

[Sample exam questions with model answers to the individual questions are required for new courses. A justification of the exam format should be provided where the suggested format non-standard. The online list of past exam papers gives an idea of what exam formats are most commonly used and which alternative formats have been http://www.inf.ed.ac.uk/teaching/exam_papers/*.]*

See previous PMR exams (not new course)

3b. Sample coursework specification

[Provide a description of a possible assignment with an estimate of effort against each sub-task and a description of marking criteria.]

See previous PMR coursework (not new course)

3c. Sample tutorial/lab sheet questions

[Provide a list of tutorial questions and answers and/or samples of lab sheets.]

See previous tutorial/lab sheets (not new course)

specify a set of concrete readings for the official course descriptor, please list examples here.]

None

SECTION 4 - COURSE MANAGEMENT

4a. Course information and publicity

[Describe what information will be provided at the start of the academic year in which format, how and where the course will be advertised, what materials will be made available online and when they will be finalised. Please note that University and School policies require that all course information is available at the start of the academic year including all teaching materials and lecture slides.]

As currently.

4b. Feedback

[Provide details on feedback arrangements for the course. This includes when and how course feedback is solicited from the class and responded to, what feedback will be provided on assessment (coursework and exams) within what timeframe, and what opportunities students will be given to respond to feedback.

The University is committed to a baseline of principles regarding feedback that we have to implement at every level, these are described at http://www.docs.sasg.ed.ac.uk/AcademicServices/Policies/Feedback_Standards_Guiding_Principles.pdf*.*

Further guidance is available from http://www.enhancingfeedback.ed.ac.uk/staff.html*.]*

The extra time that a 20 point course provides will allow much more room for feedback, including online questions and feedback from those questions within core lecture time. This will enhance the current feedback arrangements. The marked assignment will provide additional feedback. Finally exam like questions will be provided for each lecture, or pair of lectures that help students see what they would need to do with what they have learnt in an exam setting. The coursework will be returned before the end of the lecture period allowing within lecture feedback.

ruit, train, and supervise other course staff, what forms of communication with the class will be used, how required equipment will be procured and maintained. Include information about what support will be required for this from other parties, e.g. colleagues or the Informatics Teaching Organisation.]

As currently

SECTION 5 - COMMENTS

[This section summarises comments received from relevant individuals prior to proposing the course. If you have not discussed this proposal with others please note this].

This course and the complementary proposal for MLPR has been discussed at length with the Machine Learning faculty and this proposal results from a regular review of the machine learning syllabus.This has also been discussed with staff in other institutes who teach course most likely to be impacted by this change. It has been discussed with previous PMR/MLPR students from a number of years.

Given the encouragement for more 20 point courses, the clear cost of this course to the students as it currently stands, the need to incorporate some extra material, and the increasing number of students taking PMR, this change is necessary.

5a. Year Organiser Comments

[Year Organisers are responsible for maintaining the official Year Guides for every year of study, which, among other things, provide guidance on available course choices and specialist areas. The Year Organisers of all years for which the course will be offered should be consulted on the appropriateness and relevance on the course. Issues to consider here include balance of course offerings across semesters, subject areas, and credit levels, timetabling implications, fit into the administrative structures used in delivering that year.]

5b. BoS Academic Secretary

[Any proposal has to be checked by the Secretary of the Board of Studies prior to discussion at the actual Board meeting. This is a placeholder for their comments, mainly on the formal quality of the content provided above.]