Symbolic AI teaching:      
proposed new and updated courses

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1 This document

This is a preliminary outline of changes and new courses that are expected to come to the next meeting of the Board of Studies. It follows discussions with various people in the context of CISA-related teaching: J. Cheney, J. Fleuriot, P. Jackson, E. Klein, D. Robertson, M. Rovatsos, A. Smaill. Comments from the Board will be helpful in taking these ideas forward.

2 Background

With changes in staff circumstances, courses have disappeared from the MSc offering (Advanced Planning and KMM); this has impacted badly on the MSc specialism Knowledge Management, Representation & Reasoning. On the other hand, there is an opportunity to introduce modern topics into the syllabus. This is an opportunity to strengthen the syllabus in this area.

The following courses are under consideration:

1. **Artificial Intelligence Foundations**: a new 10 point course at MSc level.

2. Changes to the teaching of Automated Reasoning: instead of the current **Artificial Intelligence Foundations** 4th year/MSc course, the material rearranged and extended in:

   (a) **Automated Reasoning**: 10 point course in year 3, and

   (b) **Formal Verification**: 10 point course at MSc level, available to year 4.

Comments on these proposed courses follow.

We propose to offer these courses as follows:

1. **Artificial Intelligence Foundations**: semester 1
2. **Automated Reasoning**: semester 1

3. **Formal Verification**: semester 2

Some changes to Agent-Based Systems and Multi-Agent Semantic Web Systems are also being considered.

## 3 Artificial Intelligence Foundations

We propose a new 10-point Level 11 MSc-only course to cover formal logic, heuristic search, constraint satisfaction, knowledge representation and automated planning as fundamental knowledge-based AI techniques. This course will be mandatory for the Knowledge Representation & Reasoning specialism, and will provide the necessary background for the other specialist courses in the area. It could also help remove a lot of redundancy in teaching some of this material in other courses. Finally, it would complement core courses in other areas of AI (Machine Learning, NLP, Robotics) to provide solid foundations in another core thematic area of the subject.

It may be possible to incorporate into the teaching some of the material being developed currently in a MOOC on Planning.

The textbook by Russell and Norvig has a plentiful supply of associated teaching materials, and it is possible to cover this material rapidly following the book. This would use about half the material in Russell and Norvig.

## 4 Automated Reasoning

This will be revamped as a Level 9 course to provide a more thorough grounding in interactive theorem proving and model checking. Currently, AR is a level 10/11 course, which has Informatics 2D as a prerequisite for undergraduates but assumes no pre-requisites for MSc students. This disparity forces a significant portion of its materials to cover basic logic (for the sake of MSc students), thereby preventing a more detailed (and unhurried) look at some of the existing topics, while excluding other relevant ones due to lack of time. The overhauled course, which will retain Inf2D as a prerequisite, will free up lecture slots and thus enable better coverage of concepts such as unification, rewriting, and sequent calculus and allow the addition of new topics such as declarative proof languages, SAT, and bounded model checking. We believe that the change will have a beneficial effect on the number of students taking final year projects in AR-related areas – this has plummeted since the course was changed to Level 10/11 about 6 years ago.
5 Formal Verification

This will be a new 10-point Level 10/11 course. One half of the course will focus on approaches and tools for formal verification of software, both sequential and concurrent. For example, it will look at assertion-based verification as exemplified in tools such as Why and Spec#, and software model checking in SLAM/SDV. The other half will look at formal reasoning techniques that are realised in SMT solvers, which are the core reasoning engines inside many formal verification tools. Topics will include decision procedures for linear arithmetic, equality and uninterpreted functions, and methods for combining these. Weaved in will be non-examinable lectures on cutting-edge topics in formal verification. This course will be suitable for inclusion in the Cyber Security CDT bid and other bids involving verification and correctness.

6 ABS and MASWS

Here the changes are relatively minor.

1. **Agent-Based Systems** Currently a mixed Level 9/10 course, the proposal would be to discontinue the level 9 version and offer the level 10 version to UG3, UG4, and MSc students alike. The difference between the existing two versions is that the level 9 version has no assessed coursework, which has proven counter-productive for UG3 student engagement with the course, and led to a number of students failing the exam. Adding the level 10 version to the AI course list for UG3 would avoid restricting (already limited) AI choices in third year. The level 10 version would also be open to MSc students, with Artificial Intelligence Foundations (or equivalent prior learning) as a prerequisite.

2. **Multi-Agent Semantic Web Systems** We propose to rename this course to Semantic Web Systems (SWS), and to replace intelligent agent related material from the syllabus by more technical material on description logics, ontological reasoning systems, and linked/open data material. The current syllabus involves too much overlap with ABS, and the two parts of the course have always been hard to combine from a teaching perspective. We also propose to discontinue the level 10 version of the course, and to list the level 11 version as a course routinely taken by UG4 students. The current difference between the two versions is only one final piece of coursework, which should be omitted so that the two other assignments can become more manageable and cover more in-depth learning objectives.