School of Informatics Teaching Course Proposal Form

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Proposal

Course Name: Automated Reasoning
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Course Year: 3
Names of any courses that this new course replaces :
Automated Reasoning

Course Outline

Course Level: 10
Course Points: 10
Subject area: Informatics
Programme Collections:
Computer Science, Artificial Intelligence.

Teaching / Assessment

Number of Lectures: 16
Number of Tutorials or Lab Sessions: 8
Identified Pre-requisite Courses: Informatics 2D, DMMR
Identified Co-requisite Courses: None
Identified Prohibited Combinations: None

Assessment Weightings:
Written Examination: 60%
Assessed Coursework: 40%
Oral Presentations: 0%

Description of Nature of Assessment:
The course will consist of 1 practical exercise (40%), assessing learning objectives 5 to 7. Students may be asked to represent and reason about particular domains (e.g. geometry or inductive proofs) in the Isabelle theorem prover. There will be a formative part to the assessment that will involve the students carrying out Natural Deduction proofs in propositional/first order logic in Isabelle and receiving early feedback on their effort. The students will submit their files, usually in the form of mechanized theories, electronically for marking.

The examination (60%) will then concentrate on assessing learning outcomes 1 to 4, which mainly involve theoretical aspects (e.g. important algorithms and techniques), problem solving (e.g. proofs using natural deduction) and discussing broader aspects such as the capabilities and limitations of various proof techniques.

Course Details

Brief Course Description:

The overall aim of the course is to describe how reasoning can be modelled using computer. Its more specific aim is to provide a route into more advanced uses of theorem proving in order to solve problems in mathematics and formal verification.

Major emphases are on: how knowledge can be represented using propositional, first-order and higher oder logic; how these representations can be used as the basis for reasoning, and how these reasoning processes can be guided to a successful conclusion through a variety of means ranging from fully-automated to interactive ones. Students will develop a thorough understanding of modern, interactive theorem proving via lectures, tutorials and an assignment.

Detailed list of Learning Objectives:

1. Represent mathematical and other less formal knowledge using logic.
2. Understand the role of mathematical proof processes.
3. Understand reasoning techniques and apply them to pen-and-paper proofs.
4. Compare precisely the tradeoffs between rival techniques for the same reasoning task.
5. Use sophisticated mechanisms available in theorem provers to represent problem.
6. Write interactive proof in procedural and declarative styles.
7. Use interactive and automated methods to carry out proofs in the theorem prover.
8. Organize their own study to manage project development.
9. Search and read the literature.
10. Conduct exploratory experiments.
11. Critically analyze and evaluate other people's work.
12. Be broadly up-to-date with current research in the field.

Syllabus Information:

The syllabus still needs to be worked out in detail but it will consist of a subset of the existing AR topics. Topics such as unification, higher-order logic, rewriting and proof style will be expanded. Model checking will be removed.

Recommended Reading List:

1. John Harrison. Handbook of Practical Logic and Automated Reasoning, CUP, 2009.
2. Tobias Nipkow and Gerwin Klein. Concrete Semantics with Isabelle/HOL, Springer, 2014.
3. T. Nipkow, L. C. Paulson, and M. Wenzel. Isabelle/HOL: A Proof Assistant for Higher-Order Logic , Springer, 2002.
4. M.Huth and M.Ryan. Logic in Computer Science, Modelling and and Reasoning about Systems, CUP, 2nd Edition, 2004

Any additional case for support information:

The current Automated Reasoning course is split into two distinct parts involving interactive theorem proving and model checking. While the students do manage to get hands-on experience with state-of-the-art tools such as Isabelle and NuSMV, the course is delivered at a fast pace and there are numerous topics that cannot be covered in much depth. This is especially problematic for the theorem proving part, where the first 5 lectures have to cover introductory material about propositional and first order logic to ensure that all students have the appropriate background. This leaves very little room when it comes to providing the students with an understanding of topics such as rewriting, higher-order unification, proof style (e.g. procedural vs declarative proofs) and the interplay between interactive and fully automatic theorem provers, which are important aspects of modern automated reasoning.

Another issue with the current AR course is that it is delivered as a 4th year course, which I believe has led to a reduction in the number of third year students selecting theorem proving/AR-related individual projects.

The aim of this proposal is to revamp the Automated Reasoning course to ensure a less-hurried delivery that i) will enable appropriate motivation and coverage of existing topics and ii) the introduction of new ones that provide a thorough understanding of modern, interactive theorem proving. The model checking

part would then move to a more specialised, Level 11 Formal Verification course, which is being proposed (by Paul Jackson). Moreover, the proposal sets AR as Year 3 course (as it used to be in the past) to broaden the choice available to students when it comes to projects in the area. AR will also benefit from the foundations laid by courses such as Inf2D and DMMR, thereby ensuring that the time spent revisiting topics such as propositional and first order logic is kept to a minimum.