PhD Proposal in Computer Science 2013

Learning environment for interactive proof in geometry

Lab: ICube (former LSIIT) (http://icube.unistra.fr/icube/index.php/Accueil)
Team: IGG (http://icube-igg.unistra.fr/en/index.php/Main_Page)
City: Strasbourg, France
PhD advisors: Pascal Schreck (schreck@unistra.fr) and Julien Narboux (narboux@unistra.fr)
Keywords: Automated Theorem Proving, Interactive Theorem Proving, Logical Reasoning, Math Education, Formal Proofs, Coq, GeoGebra

Abstract: In the proposal, we aim at developing a computer based learning environment for interactive proof in geometry based on technologies for interactive and automated theorem proving and dynamic geometry.

Context: Technological tools are widely used to teach mathematics in schools. Dynamic Geometry Software (D.G.S.) and Computer Algebra Software (C.A.S) are the two families of software that are well represented. On the one hand, these tools are widely used to explore, experiment, visualize, calculate, measure, find counter examples, conjecture. In one word, they make mathematics more experimental, but they fail as tools assisting the student to really build a *proof*. However, we believe that reasoning and the concept of proof should also have a crucial role in mathematical teaching. On the other hand, proof systems such as Coq and Isabelle are way too general and complicated for direct use in science and mathematics education. In this proposal, we propose to use both the Coq proof assistant and Geogebra dynamic geometry software together in order to build a computer based learning environment for interactive proof in geometry. Hence we will have to develop tools and libraries for formal proof in geometry adapted to the context of education.
The work will be based on our previous work about formalization and automation of geometry within Coq [DDS01,GNS11,JNQ10,MNS09,Nar07] and the work of Frédérique Guilhot [Gui05] who developed a library of formal proofs in geometry and Tuan Minh Pham [PB10] who improved this library and developed a prototype of a user interface based on GeoGebra.

Objectives: The candidate will develop the tools and libraries for formal proof in geometry, this involves:

1. Defining geometric universes adapted to different education levels (sets of standard lemmas and theorems) as well as tactics to translate statements and proofs from a given geometric universe to another one. For instance, we could consider the transformation of a statement in analytic geometry involving points, lines and circles into a statement involving only points and vectors.
2. Providing tools and libraries of proofs to help build solid foundations for the different geometric universes, proving that different geometric universes are coherent.

3. Studying, formalizing and extending techniques for automation of proof in geometry and generation of readable proof. In particular, we will focus on the automatic treatment and simplification of non-degeneracy conditions.
4. Guidance: base on automated deduction techniques, we will study how to provide automatic next step guidance in proof or construction exercises.
5. User interface: extending the prototype of Tuan Minh Pham based on Coq and GeoGebra [PB10]

Bibliography:

[DDS01] Dehlinger C., Dufourd J-F. and P. Schreck, Higher-order intuitionistic formalization and proofs in Hilbert's elementary geometry, 3rd Int. Workshop on Automated Deduction in Geometry, Zürich, Switzerland, 2000, LNAI 2061, Springer-Verlag, 306-323, 2001.

[GNS11] Formalization of Wu's simple method in Coq Genevaux J.-D., Narboux J., Schreck P. Dans CPP 2011 First International Conference on Certified Programs and Proofs, 2011.

[Gui05] Formalisation en Coq et visualisation d'un cours de géométrie pour le lycée,Guilhot., F., Technique et Science Informatiques, Volume 24, Langages applicatifs, pages 1113 à 1138, Hermes Science, 2005

[JNQ10] The Area Method: a Recapitulation Janicic P., Narboux J., Quaresma P. Journal of Automated Reasoning (2010)

[MNS09] Formalizing Desargues' theorem in Coq using ranks in Coq, Magaud N., Narboux J., Schreck P. Dans 24th Annual ACM Symposium on Applied Computing (2009) 1110-1115

[Nar07] A Graphical User Interface for Formal Proofs in Geometry.. Narboux J. Journal of Automated Reasoning 39, 2 (2007) 161-180

[PB10] A combination of a dynamic geometry software with a proof assistant for interactive formal proofs, Pham T.M. and Bertot Y., 9th International Workshop On User Interfaces for Theorem Provers FLOC'10 Satellite Workshop 2010.

Funding: The candidate will be funded for three years by an '*allocation ministérielle, bourse fléchée*' (State-funded doctoral grants provided by the French ministry of Higher Education and Research) (income 1684.93€ gross per month)

Closing date: June 2013 but contact us as soon as possible, the PhD will start in September 2013.

How to apply: Interested candidates are invited to send a Curriculum Vitae and name of references to Julien Narboux (narboux@unistra.fr) and Pascal Schreck (schreck@unistra.fr).

Academic Criteria: The candidate should hold a master degree in computer science. Skills in logic, automated and/or interactive theorem proving is desirable asset. Good working knowledge of the English language is necessary, but French is not a requisite.