Viktor Kuncak: Teaching Statement

I view teaching as an important part of any scientific or engineering activity. During my doctoral program, I have enjoyed communicating ideas both to my junior colleagues and to students in a class. I am looking forward to new opportunities for educating young scientists and engineers by teaching and supervising my own students.

Supervising Experience

In the course of my doctoral studies, I informally advised (with my advisor, Professor Martin Rinard) several undergraduate and graduate students.

- I advised Cristian Cadar (now a doctoral student at Stanford University) and Tudor Leu (now at Google) on an MIT Undergraduate Research Opportunity Project (UROP) whose goal was to develop a prototype for the NASA's *Direct-To* air-traffic advisory tool. As part of this development, we used object models to express structural invariants on the data structures of the system.
- I advised Mihai Pătraşcu on an MIT UROP on verifying purely functional implementations of data structures using the Isabelle interactive theorem prover.
- I advised Suhabe Bugrara (now a doctoral student at Stanford University) on an MIT UROP on implementing a programming language based on manipulating relations, as well as on an Advanced Undergraduate Project (AUP) on verifying the buffer cache implementation of a file system using the Jahob data structure verification system.
- I advised Peter Schmitt, an undergraduate student from the Freiburg University, Germany, on implementation, annotation, and verification of a turn-based strategy game using Jahob.
- I advised Bruno Marnette, a visiting master's student from ÉNS de Cachan, Paris, France, on development of polynomial-time constraints for reasoning about sets with cardinality constraints [5]. (With Jean Goubault-Larrecq, we subsequently wrote a grant proposal to the MIT-France Seed Fund to continue this collaboration.)

I am particularly pleased about an ongoing collaboration with Thomas Wies, now a doctoral student of Professor Andreas Podelski at the Max-Planck-Institute for Computer Science in Saarbrücken, Germany. Through discussions with Professor Andreas Podelski, I have contributed to the formulation of Thomas's master's thesis topic [7]. We continued this collaboration, leading to the concept and the implementation of field constraint analysis [8] and, more recently, results in the context of the Jahob project.

I have found the collaboration with junior colleagues to be a thrilling experience. I am excited about the possibility of establishing my own research group, where I will introduce young people into the field and share with them the excitement of scientific discovery.

During these collaborations I have realized that, although the motivation of a researcher is the primary factor for a successful result, their background is also very important. Through my teaching activities I would like to help students maintain their motivation and gain the appropriate background. My goal is to help students develop reasoning skills for doing research, as well as skills for constructing reliable software in any environment in which they choose to continue their careers.

Teaching Experience

In Spring 2002 I was a teaching assistant for the MIT graduate course *Principles of Computer Systems*, taught by Professor Butler Lampson and Professor Martin Rinard. I developed problem sets for the class, graded problem sets and student projects, helped students grade their own problems, held office hours, and presented one lecture in the class (*Concurrent Transactions*). I enjoyed helping students understand the material through office hours and email exchanges. Subsequently, in Spring 2003, I led recitations in an MIT undegraduate course, *Computer System Engineering*.

Approach to Teaching

I believe that the key to successful teaching is the right choice of the material, as well as the ability to demonstrate to students the beauty and the relevance of the subject. My higher education experience comes from MIT as well as from the University of Novi Sad; I would like to use my observations from both of these schools when developing my own teaching approach. What I like about MIT classes is their ability to engage students through challenging problem sets and the ability to connect the material to recent research in the field. What I like about the University of Novi Sad is the choice of the material that enables students to fully understand the assumptions used in certain problem area and to use the appropriate mathematical tools in order to derive conclusions from these assumptions. I expect to draw on the positive sides of both of these environments when organizing my classes.

Teaching Interests

At the graduate level, I would particularly enjoy teaching a class on Automated reasoning about software systems. After establishing common ground on logic and semantics, I will focus on techniques for constructing program verification and analysis tools using static analyses, decision procedures, and theorem provers. As class material I will use lecture notes, research papers, as well as thesis and book chapters. Through problem sets and projects I will encourage students to gain experience in using existing tools and to develop their own variations of reasoning techniques. As a unified platform for experimenting with these techniques I will use the Hob [3] and Jahob [4] systems that I have developed with my collaborators. These systems are suitable for use in class projects because they are constructed to facilitate the combination of different reasoning techniques, and the existing infrastructure allows students to focus on the most creative parts of the their problems.

At the undergraduate level, I would be happy to teach a course in Programming Languages, Compilers, Software Engineering, Mathematics for Computer Science, and Theory of Computation. I would enjoy either adapting an existing course or developing a new course, making sure that the course integrates well into the undergraduate curriculum. I will make the subject relevant to students by appealing to current issues in software development, in particular software reliability.

I enjoy developing systematic expositions of areas of my interest. After my freshman year at the University of Novi Sad I turned the lecture notes I took in the class *Mathematical Logic and Algebra* into a complete textbook [6] which was printed and is still being used as the textbook for this course. In the future, I am interested in writing a self-contained textbook about techniques for reasoning about software systems. The textbook will make it easier for future computer scientists to develop new techniques, as well as to use and adapt the existing ones. I hope to make the book available electronically to everyone, ideally in a form that allows contributions and improvements by the readers of the book itself.

Technology in Education

I believe that teaching practice can greatly benefit from the results of computing research. Computers and the Internet are offering new ways of communicating information, enabling it to reach a broader community, as witnessed, for example, by the MIT OpenCourseWare initiative [2]. Moreover, it is possible to give unified semantic foundations for the educational materials, as in the CMU CourseCapsules Project [1], increasing the possibilities for automated manipulation and reuse. While I believe that there is no substitute for the well-established interaction between the teacher and the students in a class, I am excited about the possibility of creating adaptive and interactive educational materials that would allow students to test their understanding on running computational models, expand their knowledge in the direction driven by their interests, and allow them to improve the contents of the material. These possibilities allow us to develop high-quality educational materials and increase the impact of universities in the society, and can also inspire new research ideas.

References

[1] The Course Capsules Project. `http://aiki.ccaps.cs.cmu.edu/`.

[2] MIT OpenCourseWare. `http://ocw.mit.edu/`.

[3] Viktor Kuncak, Patrick Lam, Karen Zee, and Martin Rinard. Implications of a data structure consistency checking system. In *Int. conf. on Verified Software: Theories, Tools, Experiments (VSTTE, IFIP Working Group 2.3 Conference)*, Zürich, October 2005.

[4] Viktor Kuncak, Hai Huu Nguyen, and Martin Rinard. An algorithm for deciding BAPA: Boolean Algebra with Presburger Arithmetic. In *20th International Conference on Automated Deduction, CADE-20*, Tallinn, Estonia, July 2005.

[5] Bruno Marnette, Viktor Kuncak, and Martin Rinard. On algorithms and complexity for sets with cardinality constraints. Technical report, MIT CSAIL, August 2005.

[6] Gradimir Vojvodić. *Lectures on Mathematical Logic and Algebra*. University of Novi Sad, 1998. 383 pages, in Serbian.

[7] Thomas Wies. Symbolic shape analysis. Master's thesis, Universität des Saarlandes, Saarbrücken, Germany, September 2004.

[8] Thomas Wies, Viktor Kuncak, Patrick Lam, Andreas Podelski, and Martin Rinard. Field constraint analysis. In *Proc. Int. Conf. Verification, Model Checking, and Abstract Interpratation*, 2006.