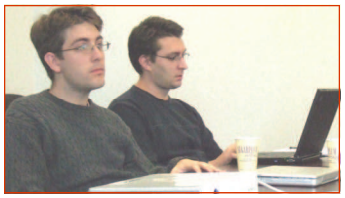
FEniCS 2005– SUCCESS

Anders Logg organized the first FEniCS workshop to date at TTI-C October 19th and 20th. The FEniCS workshop provided the opportunity to get an introduction to the use of FEniCS components. Participants learned how to contribute to the development of FEniCS, which will ultimately influence future directions for FEniCS. The latest developments of software components FFC, FIAT, DOLFIN and the new mesh component Sieve were also featured.

The vision of FEniCS is to set a new standard in Computational Mathematical Modeling (CMM), which is the Automation of CMM (ACMM), towards the goals of generality, efficiency and simplicity,



concerning mathematical methodology, implementation and application.

In a recent interview, Logg explained the background of this project:

"ACMM means the Automation of Computational Mathematical Modeling, so to explain what ACMM is, we need to explain each of the terms Automation, Computational, Mathematical and Modeling.

Starting from the back, Modeling is to create a description of a natural process that captures the essence of that natural process.

With a good model of Nature, one can make predictions of the outcomes of natural processes. Modeling is the backbone of science and is used all the time in science and engineering to make predictions: the weather forecast, designing and building bridges, cars, airplanes, the expansion of the universe, black holes, the big bang, the evolution of our solar system etc. Every prediction we make about Nature is based on some model.

The models we create of Nature

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INSIDE STUDENTS' HEADS

Since September, we have some new faces in our spaces here at TTI-C; four new students, to be exact. Matthew Hammer, Irvin Hwang, Hector Villafuerte, and Nobuaki Sasaki. So- to get to know them a little better, I asked our new students some questions, so we can get a feel for who they are.

Q- Before you came to TTI-C, what were you up to, and what did you like about it?

Matt- I was an undergraduate student at UW Madison for 3 years, and worked each summer in San Jose for IBM.

Irvin- I was a student at U of Texas at Austin, and I liked being in Austin, and liked the friends I met there. (It's a great city to live in!)

Hector- I did telecommunications fraud management for the biggest operator in Guatemala. What I liked the most about it was the first time it was done there~ so it was like researching.

Nobuaki– I was taking Masters courses at TTI in Japan.

Q- Why do you think you're going to like TTI-C?

Matt- Because I'm finally a grad student. As a result, I intend to do some interesting research of my own while working in an environment of peers and faculty also working on equally interesting topics.

Irvin- There seems to be a lot of freedom to research what you want.

Hector- Because of its dynamic academic environment: the reading groups, the show & tell, and the visiting-faulty talks, just to name a few.

Nobuaki– I wanted to go abroad.

Q- What is your impression of Chicago?

Matt- My impression is that it is a really big place, full of a variety of interesting neighborhoods and communities. The parts of Chicago that I like the most are the ones that remind me of Madison. Although Hyde Park exists in isolation, it's been a very pleasant place to be thus far.

Hector- It's an amazing city with pretty crazy weather!

Nobuaki– There is a variety of people in Chicago! And I was impressed at U of C's traditional buildings.

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FEniCS 2005– SUCCESS *Cont'd.*

come in the form of Mathematical Models, that is, as equations. Most of these equations are differential equations and there are numerous famous examples of such equations that are important models of Nature: Einstein's equation of general relativity, the Schrödinger equation of quantum mechanics, Maxwell's equations of electromagnetics, the Navier-Stokes equations of fluid mechanics, Newton's equation of classical mechanics.

Now, to make predictions, we need to solve all these equations and since it can't be done using pen and paper, we have to compute the solution using a computer. This is what we refer to as Computational Mathematical Modeling; solving mathematical models of Nature using the computer as our basic tool.

Computational Mathematical Modeling has been a reality ever since the advent of the first computer. In fact, it was a reality even before then when the head engineers of some big projects could actually use human computers consisting of large groups of assistants sitting in a big room passing sheets of paper with results of simple calculations around in one massively parallel human computation effort.

The problem today is that even if we can solve very many differential equations using the computer, each differential equation is solved by a different program and it takes years and a lot of effort to develop a program for the solution of one particular differential equation.

With the FEniCS project, we want to change this. We want to automate Computational Mathematical Modeling, that is, create a machine (a computer program) that can solve any differential equation. This is a grand challenge, but we have a new approach that I think will make us succeed: Instead of writing one big computer program that solves everything, we are developing a computer program that is able to create other computer programs. So, for each differential equation given to the machine, it creates a new machine that can be used to solve that differential equation...

This is what we mean by the Automation of Computational Mathematical Modeling, to automate one of the most important processes of science and enginering: solving equations."

The FEniCS project was initiated in 2003 in cooperation between the TTI-C, the University of Chicago and Chalmers University of Technology in Göteborg. Since then, the project has grown to include developers from the Royal Institute of Technology in Stockholm, Argonne National Laboratory, Simula Research Laboratory in Oslo and Delft University of Technology.

The project began in the offices here at TTI when Claes Johnson, Johan Hoffman and myself visited Ridgway Scott and Robert Kirby at the University of Chicago. Since then, we have expanded considerably and made great progress both on the methodology side and the implementation side. In addition to TTI, we now have people from six different institutions committed to the FEniCS project.

Our goal is to create a new standard in Computational Mathematical Modeling and ultimately the Automation of Computational Mathematical Modeling. Time will tell if we succeed, but we are making good progress."

FEniCS is organized as a collection of software components, including the form compiler FFC, the finite element tabulator FIAT and the programming environment DOLFIN, all freely available on the FEniCS web page.

Future workshops are on the horizon. Perhaps there will be a FEniCS'06 or it will be a biannual event. Other than that, the collaborators are trying to be visible at the major conferences. Already, Johan Hoffman and Anders Logg have been invited by SINTEF (The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology) to give next year's lecture series at the Winter School in Computational Mathematics in Geilo in March 2006. The topic of the lecture series will, of course, be FEniCS and the Automation of Computational Mathematical Modeling.

The FEniCS'05 workshop at TTI-C provided a great opportunity for this group of people who have been working together from great distances around the world to collaborate in one place. Over the last year, the group has made significant progress on one key aspect which is the automation of discretization. Everyone who visited had a really nice time. Not only did they enjoy Chicago with soccer and late night discussions at Chicago blues clubs, but we also had two days of very interesting talks and some concrete results to take home from the meeting.

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WINTER WONDERLAND IN CHICAGO

If you enjoy the fall and winter and all those holidays and celebrations that go with it, Chicago is the perfect place for you! This is what is happening around the city up through the 2006 New Year!

Magnificent Mile Lights Festival and Parade-
Oak Street to Michigan Avenue and continues south on Michigan Avenue until East Wacker Drive. Nov 19th
The annual Lights Festival is a weekend full of holiday fun. Entertainment includes Disney stage shows with master of ceremonies, Mickey Mouse, gingerbread decorating, live music, ice-carving and more. But the main event is the Saturday evening lighting of more than one million white lights that bring 200 trees brilliantly to life. The procession begins at 6pm on Saturday at Rush and Oak Streets; it heads down to end at the Chicago River and fireworks cap off the event at 6:55pm. Don't fret if you don't make it to the lighting festival–the lights and decorations remain up throughout the holiday season. Free.

Zoo Lights-
Lincoln Park Zoo Dec. 16th- Jan 1st 5-9pm nightly
See the zoo in a different light, when all the grounds and areas of habitat are lit with over 1 million Christmas lights. Admission is free.

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FEniCS 2005– SUCCESS *Cont'd.*

Participants in the 2005 FEniCS Workshop:

UNIVERSITY OF CHICAGO
Flavio Cunha, Todd Dupont, Robert C. Kirby, Ridgway Scott and Andy R. Terrel
CHALMERS UNIVERSITY of TECHNOLOGY, GÖTEBORG
Claes Johnson
ARGONNE NATIONAL LABORATORY
Dmitry Karpeev , Matthew Knepley and Boyana Norris
ROYAL INSTITUTE of TECHNOLOGY, STOCKHOLM
Johan Hoffman
SIMULA RESEARCH LABORATORY, OSLO
Hans Petter Langtangen, and Ola Skavhaug
SANDIA NATIONAL LABORATORIES, LIVERMORE
Kevin Long
STILLWATER SUPERCOMPUTING SOLUTIONS
Theodore Omtzigt
DEFLT UNIVERSITY of TECHNOLOGY
Garth N. Wells
UNIVERSITY of WISCONSIN-MILWAUKEE
Dexuan Xie

Program Highlights:

Wednesday October 19
Robert C. Kirby
Complexity-reducing relations for optimizing finite element matrix evaluation
Dmitry Karpeev
Computational Mesh Abstractions
Garth N. Wells
Mechanical Modelling with FEniCS: A Wish List
Andy R. Terrel
A Novice Uses FEniCS
Johan Hoffman
Automation of Turbulence Simulation
Dexuan Xie
Minimization Protocols for Solving Mortar Finite Element Equations of Nonlinear Poisson-Boltzmann Equation

Thursday October 20
Hans Petter Langtangen
Tools for Multi-Physics Simulations
Matthew Knepley
Build Systems and Code Generation
Theodore Omtzigt
Personal Supercomputing
Kevin Long
Symbolic Algorithms for Numerical PDEs
Anders Logg
Extending and Optimizing the FEniCS Form Compiler
Ola Skavhaug, Swiginac
Extending Python with Symbolic Mathematics

By Katherine Cumming