FSUmath
THE FLORIDA STATE UNIVERSITY COLLEGE OF ARTS & SCIENCES
FALL 2009

Mathematics Leads in 'Shaping' the Future

The next time a student faced with hours of grueling mathematics homework complains that such study is irrelevant in the real world, point them in the direction of the Imaging Sciences Lab (ISL) at Florida State University. Here, Department of Mathematics professor Washington Mio and an interdisciplinary team of faculty and students arre demonstrating new ways that mathematical research can help us understand challenging problems biological science.

Model of the shape of the hippocampus

Established in 2004 and run by Mio and Xiuwen Liu, associate professor of computer science, the Imaging Sciences Lab conducts research in pattern analysis, computer vision and their various applications. The ISL team consists of Florida State faculty and students from several units – mathematics, computer science and engineering – who are involved in several projects funded by the National Science Foundation (NSF). The collaborative

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FSU-Teach Preparing Next Generation of Math Educators

Florida schools may soon see a wave of new highly-qualified teachers. FSU-Teach, a recently launched initiative at The Florida State University, aims to give a major boost to math and science education in Florida.

A declining number of qualified teachers for science and mathematics in K-12 schools has opened the door for the innovative program. The joint program between the College of Education and the College of Arts & Sciences offers undergraduates a unique route to becoming math or science teachers.

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In This Issue

Letter from the Chair

Welcome to the Fall 2009 issue of FSUmath. The past year has been one of challenge and opportunity. Many of you know that the general state of the economy, and particularly of Florida's economy, has brought to the State University System significant economic challenges. Florida State University experienced a significant cut in its operating budget, in excess of 12% this academic year, this on top of roughly 10% in the preceding two years. This has had an extraordinary and lasting impact on the university. Several departments have been reorganized and with reorganization has come, for the first time at FSU, the firing of tenured and tenure-earning faculty, as well as support faculty and staff. Departmental operating budgets have been cut and a hiring freeze has been enacted.

Though there are challenges within our department posed by budget cuts, hiring freezes, and loss of faculty, we find ourselves well-positioned to endure the downturn. As reported in last year's newsletter, "we have made significant investments in infrastructure over the past year with purchases of major computing equipment that should sustain us through the next three years. We have saved for this rainy day and have funds to support research and travel, and we have more than sufficient budget to support our 100 or so teaching and research assistants. When hiring returns, we will be well-positioned to argue for hires in all four areas." And indeed, the department finds itself blessed with a more than sufficient pool of resources to support research and teaching, and the resourcefulness and hard work of the faculty and staff has provided for us some major successes reported in this newsletter.

Our faculty continue to produce excellent world-class research in pure and applied mathematics, including in bio- and financial mathematics. We generally highlight the research program of one of our faculty in each newsletter, and in the present one you may read about Washington Mio's pioneering work with an interdisciplinary team of faculty and students in their Imaging Sciences Lab at FSU. You may also read about a couple of new ventures that the department inaugurated this year. First, FSU has adopted a new model for training secondary school science and mathematics teachers that is modeled after a program at the University of Texas-Austin called UTeach. Our program is FSU-Teach and is a new major within mathematics where a student graduates with a bachelor's in mathematics as well as secondary school teaching credentials. In this first year the program has attracted over 40 majors. A second initiative is the beginnings of an enhancement to the undergraduate mathematics degree. The idea is to offer courses that will provide the prospective mathematics graduate student with better training for his or her graduate work. Yours truly taught the first course in this enhancement with an Advanced Calculus III offering that develops vector calculus rigorously. Planned for the future is a new course in linear algebra that presents higher level material than our current course, and with much more rigor.

All in all, doctoral training is going full steam ahead in the department. During the past year, the department awarded 7 doctoral degrees, and we look to award another 10 or so in the next year. Though the budget that supports teaching assistants has been cut, we have been able to sustain the program at the same level as last year. Our hope is that we can continue next year at the current levels.

Cheers until the next newsletter!

Philip Bowers

News from Actuarial Science

The Florida State Actuarial Science Program enjoyed another great year. Our undergraduate actuarial club, the Florida State Student Actuarial Society (FSSAS) hosted over a dozen companies that came to campus to give presentations and interview students. We had the 5th Annual FSSAS Tailgate Party on November 11, 2008, prior to the Florida State-Clemson game. (See picture.) The party was sponsored by Watson Wyatt & Company. The game was very enjoyable with Florida State coming out on top by the score 41-27.

The program once again enjoyed the generosity of D.W. Simpson & Company in the form of a $1000 scholarship for deserving upper-class undergraduate actuarial science majors. This year's first place winner was Ms. Kristin Longenecker and the second place winner was Ms. Katie Puterbaugh.

Finally, through generous cash donations from Southeastern Actuaries Conference, Towers-Perrin, and several actuarial science alumni, partial exam fee reimbursements were given to 7 students who successfully completed Exam P/1, 16 students who successfully completed Exam FM/2, and 1 student who successfully completed Exam MLC. It is the program's goal to be able to fully reimburse students who successfully complete actuarial exams. If you would like to contribute to this worthy cause, please contact the coordinator of the program, Dr. Steve Paris, at paris@math.fsu.edu. Any contribution amount will be greatly appreciated.

Math Plus for Undergraduates Preparing for Graduate Study

What do Math majors need to best prepare themselves for the step up to rigorous graduate study in mathematics?

The Department has been working on ways to ensure that math majors contemplating a Ph.D. in Mathematics get the best possible preparation during their undergraduate years. We are working on a set of course recommendations for such students that we unofficially call "Math Plus".

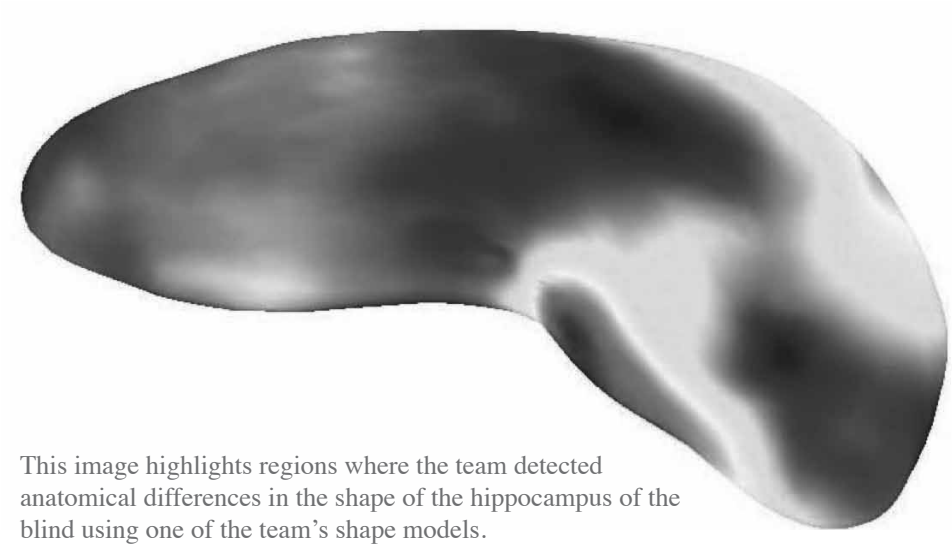
A student in any of the four current Math majors (Pure, Applied, Bio, FSU-Teach) will follow the Math Plus recommendations by taking the following courses:

1. both semesters of Advanced Calculus (MAA 4226/7)
2. both semesters of Abstract Algebra (MAS 4302/3)
3. a newly developed Advanced Calculus III, now being offered for the first time in Fall 2009,
4. a planned new second course on linear algebra: Linear Algebra II
5. selected graduate courses as advised, if time permits

The two new courses are intended to fill in critical topics that American undergraduates commonly fail to have upon entering graduate school, and often must then learn on their own.

This year's highlight is Advanced Calculus III, taught first by Professor Phil Bowers. It aims to cover the multivariable analysis usually omitted by the first year of rigorous undergraduate analysis. Topics include the Frechet derivative, the inverse and implicit function theorems, smooth manifolds, integration on chains and manifolds, the Morse-Sard theorem, and an introduction to smooth manifold topology.

Those familiar with these topics will appreciate the superb classic texts chosen for the course: Rudin's Principles of Mathematical Analysis, Spivak's Calculus on Manifolds, and Milnor's Topology from a Differentiable Viewpoint. Math majors: bon appetit!



This image highlights regions where the team detected anatomical differences in the shape of the hippocampus of the blind using one of the team's shape models.

'Shaping' continued from Page 1

effort seeks to develop computational models and algorithmic approaches to shape, image analysis and other pattern recognition problems that can then be used to enhance a myriad of fields, from law enforcement to biomedical research and genetics.

Perception is Everything

The lab's work is based on the study of how images are perceived and visual information conveyed. According to Mio there are two essential elements of any image that allow the human eye to immediately and effortlessly extract information. These elements – appearance and shape – are interpreted and categorized by the brain allowing for the identification of objects and interpretation of scenes. The challenge posed by current advances in technology is whether or not a machine (computer) can be equipped with similar capabilities, an area of study known as pattern analysis and computer vision.

Mio explains that "The goal is to discover whether or not a computer can isolate the most important components of an image and then integrate them to effectively interpret the content of the image."

The answer is 'yes.' Through an NSF grant, completed in June 2009, Mio and his team have successfully demonstrated ways of automatically identifying texture patterns in two-dimensional images. They have also achieved promising results in image categorization, a process in which images from sizeable databases are retrieved and categorized. These findings have potential application in the biomedical community where large libraries of digital images are kept.

Another aspect of the project involves extracting elements from images of the human face and matching the isolated features to images of individuals. This process, known as facial recognition, could play an essential role in the area of law enforcement.

Adding Another Dimension

Though the above findings are important, the study of two-dimensional images is somewhat limited. Two-dimensional representations can change in appearance when viewed from different angles, making them relatively unstable. This has led Mio and Liu to expand their research to the third dimension where images do not vary with vantage point.

"The natural progression of research [with two-dimensional images] is to move to three-dimensional images," said Mio. "Though more challenging, they offer better stability for categorizing shapes because of their visual consistency."

Mio and Liu are working on another NSF funded project studying three-dimensional shapes and forms, which will offer expanded indications for pattern recognition in the biomedical field. They have teamed with researchers from UCLA to explore applications of the models to neuroimaging.

According to Mio, "one of the most important motivation for analysis of patterns in 3D images is for biomedical imaging- particularly mapping the brain."

In this study the brains of approximately 500 Alzheimer's patients are scanned (via MRI) every six months. Shapes from images of the hippocampus are extracted and the progression of tissue loss is analyzed. Mio and Liu are working to develop mathematical models that help keep track of the disease's effect on the brain with the hopes of providing a vehicle for understanding, predicting and preventing

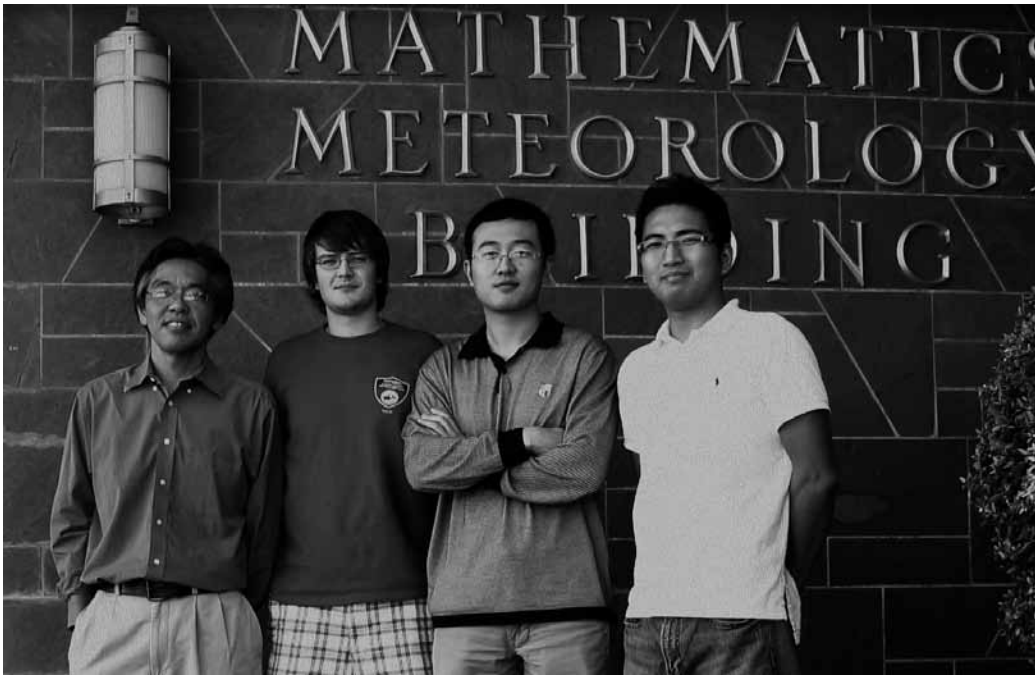
further advancement.

"If you can track the changes and identify where there are commonalities," said Mio, "you may be able to predict future deterioration and pick up something significant that will help manage or fight the disease."

Wing Formation

In a related project Mio and his team are expanding their collaboration to biological sciences. David Houle, professor of evolutionary biology at Florida State, is principal investigator on a study that seeks to identify how genetic variation changes the external morphology of fruit flies. Mio and Liu are using the tools of image and pattern analysis developed in their other work to create three-dimensional reconstructions of flies that will make variation easier to detect. As part of this intricate and meticulous effort, a microscope is used to take hundreds of pictures of tiny sections, or bands, of a fruit fly. The individual bands are then fit together to create a three-dimensional image. Though the focus is currently on the head and wings, the project will eventually aim to create three-dimensional reconstructions of the entire fly.

Below: The fruit fly is the first subject to be explored by the biological science group.



Above: Professor Washington Mio and his students. From left to right. Mio, Jonathan Bates, Xinyang Liu, Yu Fan

Similar to brain mapping, visual processing of this kind of data can lead scientists to discover patterns and commonalities in phenotype. The goal is to understand the genetic causes for phenotypic variations. If successful, the tools used to identify these patterns may be applied more broadly to the field of biology.

Room to Grow

Through involvement with projects of this nature, the Department of Mathematics has identified itself as a leader in ground-breaking research. Computer vision and pattern analysis are disciplines still in the early stages of development and Mio's team is at the forefront of their growth. The promise of contributing to such noble efforts as disease prevention and genetics has become an important calling for many established and aspiring researchers at Florida State. Through the Imaging Sciences Lab faculty and students have taken up the cause by devoting their unique talents – as mathematicians, computer scientists and engineers – to research that will shape the future of biomedical technology and impact the lives of individuals for generations to come.

'FSU-TEACH' continued from page 1

In addition to mathematics, FSU-Teach recruits current students from the fields of biology, chemistry, geosciences and physics. The program's two introductory courses are free of charge for in-state students and allow them to experience teaching in local K-12 schools in the first two semesters of the program. This immediate classroom immersion has kindled a passion for teaching that many students had not realized before joining the program.

According to Alec Kercheval, Mathematics Professor and FSU-Teach affiliate faculty member, the initiative represents a new partnership between the College of Arts and Sciences and the College of Education in the training of prospective secondary math and science teachers, who must now complete a full major in their math or science discipline.

Part of the new FSU-Teach math major is a new course called Functions and Modeling, aimed at drawing connections between various topics in secondary and college math, and giving students practice in active exploration and learning.

"The program not only gets away from the traditional lecture-style class, but students take more of an ownership in their education because they are more directly involved early on."

Upon graduating, students will have earned a degree with two majors, one in the content area and one in education. The unique nature of the program allows them to complete all required courses and graduate in four years. With a double major students are qualified for a number of positions both in education and their content field, providing them more professional opportunities in today's extremely competitive market.

Beyond graduation, FSU-Teach provides continued assistance to its graduates by offering face-to-face and/ or online support through regularly scheduled professional development to help them overcome challenges in their first years in the classroom.

FSU-Teach was established through a $2.4 million grant over a five year period from the National Math and Science Initiative (NMSI), an innovative not-for- profit organization launched by ExxonMobil in 2007 to address one of the nation's greatest economic and intellectual threats, the declining number of teachers qualified to effectively teach science, mathematics and computer sciences to K-12

students.

The Helios Foundation helped augment the cost of the new initiative with a $1 million donation; NMSI will also donate $1 million to the program's endowment at the end of its grant period. With matching funds from the State of Florida Legislature, the financial support for FSU-Teach exceeds $5 million.

The program is modeled after UTeach, the highly successful parent program at the University of Texas at Austin. In 2007 NMSI issued a request for proposals for the replication of UTeach. Fifty- two institutions of higher education from around the United States submitted proposals; of those, 29 were invited to issue full proposals. Florida State was one of 12 colleges and universities selected to receive the grant awards.

FSU-Teach is already well on its way to success. Enrollment continues to see dramatic increases each semester not only in mathematics, but all disciplines, and students are brimming with excitement.

According to Florida State University President T.K. Wetherell, "FSU-Teach represents an important step in helping Florida – and the nation – to remain competitive in an increasingly challenging global economy."

Kelly Gover, a mathematics and FSU-Teach student, is enjoying the new program.

"I would recommend this to anybody and everybody that even thought about teaching," says Gover. "Not only do they prepare you and teach you so well, but they have such a passion, it makes you love it and have a passion for it as well."

Graduate Student Seminar

by Bettye Anne Case and Juan B. Gutierrez

The picture above - midwinter 2009 near the Dirac Library - includes seven recent Graduate Student Seminar organizers: top l-r Rana Parshad (Fin; now postdoc, Clarkson, University), Juan Gutierrez (Bio), Debbie Smith Striegel (Bio); bottom l-r Edwin Jimenez (ACM), Fei (Neil) Hua (ACM; now postdoc, Courant IMS), Emin Tatar (Pure), Ahmet Goncu (Fin; now Shandong University, China). Missing from the picture was Hoa Nguyen (ACM) who, on that cold January day, was in New Orleans - already 6 months into her postdoc at Tulane; we are sure she is honored to have Professor Dirac agree to stand in for her in the picture!

MAP 6939 - THE GRADUATE STUDENT SEMINAR (GSS). In addition to being competent in some specialized area of mathematics, there are soft skills needed to make a mathematician successful. The ability to communicate problems and results to a non-expert audience in an articulate manner probably tops the list. However, as important as this skill is, graduate students have traditionally paid little attention to it and professors are not schooled in helping them improve. Since these skills are gained over a period of time, there is a need for venues beyond the specialized area seminars in which graduate students can exercise their communicative prowess in a professional environment. That particular need is served in the Department of Mathematics with the Graduate Student Seminar (GSS) - no faculty allowed.

The GSS is organized and attended entirely by doctoral students. Students participate together from all the department's Ph.D. program areas; the pictured co-organizers for 2007-2008 and 2008-2009 represent all four areas (Pure, Applied and Computational, Bio, and Financial). The GSS encourages graduate students to talk about their own research and topics of interest. Talks are conducted in a casual atmosphere in which speakers talk in free format and audiences traditionally ask questions and/or suggest improvements to the fellow speaker.

EARLY DAYS. When was this activity, as a registered class, first set up, and who was the first student organizer? It has been in existence over a dozen years, launched by Penelope Kirby (Pure Ph.D. 1999/Bryant, now the Coordinator of Teaching Assistant Training and Supervision in the department). Several from the newly-forming "Bio" group followed her - Jeffrey K. Denny (Bio Ph.D. 2000/Quine, now Associate Professor and Associate Dean of Arts and Sciences, Mercer University) was the second seminar organizer and then Ivo Dinov (Bio Ph.D. 1998/Sumners, Associate Professor, UCLA) and Stacey McNiel. Jennifer Mann, (Bio Ph.D. 2007/ Sumners, postdoc UTexas) was the principal organizer and dependable energy for several years. The current organizers (jarmstro@math.fsu.edu; jstryker@math.fsu.edu; case@math.fsu.edu) would find it helpful to hear what activities were especially useful to the earlier students since a page from experience may give fresh new ideas.

(Reporter's note: As a numbered course the GSS has an Instructor of Record who functions as a non-attending "sponsor" or "advisor". I advised the restructuring two years ago so that a fresh pair of co-organizers bring new ideas each semester, and then arrange their successor organizers from enthusiastic volunteers so there is

informal rotation from the four areas. It is a pleasure to listen to the co-organizers planning each term. bac)

PROFESSIONAL DEVELOPMENT. In some terms there are talks by experts - the only time non-students attend. In this recent cycle, e.g., Graduate Dean Nancy Marcus spoke about professional ethics; experience about aspects of preparation for college and university professorial careers was sought from the current mathematics chair, Phil Bowers, and alumnus Jeff Denny.

A NEW IDEA. In Fall 2008 the new organizers, Rana Parshad (Fin/X.Wang Ph.D. 2009) and Emin Tatar (Pure), innovated a shift in the format of the student talks. Speakers would be each judged by a panel of their peers, with the modest budget of the seminar used to give a prize in cold cash to the best speakers, instead of a pizza-lure. How would the judges be selected? Parshad and Tatar thought advanced students, one from each area - would volunteer the significant time commitment of hearing and evaluating every talk and the difficult job of making comparisons over a semester's time.

This dose of competition and reward was just the antidote needed to defeat shyness or apathy. Suddenly, for the first time in the history of the seminar, there were more speakers than days available. Before a student presented their "Advanced Topics Exam" to become a doctoral candidate - or gave a talk at a conference - this opportunity to practice before peers including nonspecialists in their own area was spiced by a dash of competition! In the spring semester of 2009, the GSS was conducted in a similar way, with a twist. During that semester CAVIIAR, The Advanced Research Center in Artificial Intelligence, a non-profit scientific corporation based in Tallahassee, matched funds. Prize winners during the 2008-2009 year were John George (Pure), Juan Gutierrez (Bio), Rana Parshad (Fin), Debbie Smith Striegel (Bio), and Matthew Willyard (Fin).

FALL 2009. The organizers, Jay Stryker and Kyle Armstrong, both Pure Mathematics, recently invited second-year and higher Ph.D. students to join the seminar (whether or not registered) and describe the seminar emphasis as "talks given by fellow graduate students in Applied, Bio, Financial, and Pure mathematics" with some invited talks by experts: professors do not attend unless they are invited as a speaker. "Some graduate students find the GSS ... helpful for the interesting research topics ... useful to prepare for an upcoming seminar, ATE, or dissertation talk by speaking to peers first ... a nice place to learn about mathematics [beyond one's own niche] and nice to discuss these ideas with fellow graduate students."

LOOKING AHEAD. We hope readers who know details about the Graduate Student Seminar prior to 2006 will share the information (case@math.fsu.edu). It would be great if there were some "contest angels" who remember their own GSS and would be willing to help fund GSS prizes ... and always for "department angels" who might make general contributions... Regular or one-time gifts to the departmental Foundation funds are always needed.

The reporters: Case is the department's Associate Chair for Graduate Studies; Gutierrez completed his Ph.D. defense in September 2009 and is now a postdoc at the University of Miami; he was a seminar co-organizer in 2008-2009. The photo was snapped on Gutierrez's camera by an anonymous bystander.

Congratulations Ph.D. Graduates!

Ahmet Goncu, *Monte Carlo and Quasi-Monte Carlo methods in Pricing Financial Derivatives,* Summer 2009. Goncu is Assistant Professor at the Center for Economic Research, Shandong University, Jinan, China.

Fei Hua, *Modeling, analysis, and simulation of the Stokes-Darcy system with Beavers-Joseph interface condition,* Summer 2009. Hua is a Postdoctoral researcher, Courant Institute of Mathematical Sciences, New York University.

Yuri Lebedev, *Open math library for computing Riemann surfaces,* Fall 2008.

Konstantinos Mavroudis, *Constant Proportions Portfolio Strategies in an Evolutionary Context under a Dividend Factor Model,* Fall 2008.

Rana Parshad, *Asymptotic Behavior of Convection in Porous Media,* Summer 2009. Parshad is a Post-Doctoral Research Associate at Clarkson University.

Emmanuel Salta, *Variance Reduction Techniques in Pricing Financial Derivatives,* Fall 2008. Emmanuel Salta is currently at Wilson Associates in Los Angeles, California.

Milena Tzigantcheva, *Stochastic Volatility Extensions of the Swap Market Model*, Fall 2008. Tzigantcheva is the Director of Risk Management, Investment Policy and Economics in Florida.

Student Research

J. Bates, **Y. Wang, X. Liu, W. Mio**, *Registration of Contours of Brain Structures Through a Heat-Kernel Representation of Shape*, 2009 IEEE International Symposium on Biomedical Imaging (ISBI), Boston, MA.

Yongjae Cha co-authored *Liouvillian Solutions of Irreducible Linear Difference Equations* with Professor **Mark Van Hoeij**. The paper was accepted at ISSAC'2009 and was awarded Best Student Co-Authored Paper. ISSAC is the largest conference in computer algebra, and was held in Seoul, S. Korea, July 2009. (See *http://issac2009.kias.re.kr* for more details)

Fei (Neil) Hua, Ph.D. 2009 (joint with **Max Gunzburger**) had three accepted papers: 1) *Coupled Stokes-Darcy model with Beavers-Joseph interface boundary condition* with Yanzhao Cao, Max Gunzburger, and Xiaoming Wang, to appear in *Communications in Mathematical Sciences* (Majda special issue) 2) *Finite element approximation of the Stokes-Darcy system with Beavers-Joseph interface interface boundary condition*, with Yanzhao Cao, Bill Hu, Max Gunxburger, Xiaoming Wang and Weidong Zhao, to appear in *SIAM J. Num. Anal.* 3) *Laboratory Analog and Numerical Study of Groundwater Flow and Solute Transport in a Karst Aquifer with Conduit and Matrix Domains***,** J. Contam. Hydrol., in press, 2009. Hua was invited to talk at the SIAM Conference on Computational Science and Engineering March 2-6, 2009 in Miami, Florida Hua is currently at the Courant Institute, New York University Post-Doctoral

Xinyang Liu, **Y. Shi**, **J. Morra, X. Liu**, **P. Thompson**, **W. Mio**, *Mapping Hippocampal Atrophy with a Multi-Scale Model of Shape*, 2009 IEEE International Symposium on Biomedical Imaging (ISBI), Boston, MA.

Rana Parshad: Ph.D. 2009, Clarkson University Post-Doctoral. Parshad had a paper accepted by Discrete and Continuous Dynamical Systems, series A, entitled *Asymptotic behavior of the Darcy Bounssinesq system at large Darcy-Prandtl number*. Parshad was invited to talk at The 7th International Conference on Dynamical Systems, Differential Equations and Applications, Special session on Partial Differential Equation from Fluid Mechanics in Arlington, Texas, May 18-21, 2008. and contributed to a talk at the AMS annual meeting in DC in January 2009.

Fall 2009 Florida State Mathematics $100 Prize Problem

Below is a problem. If you think you can solve it, send in your answer to the address below.

Given a set S of n points in the plane, n > 2, with no three points on one line, one can form N(n)=n(n-1)(n-2)/6 triangles that have 3 of these points as vertices.

Let R(n) denote the largest possible number of acute triangles that can be formed out of n points, and let r(n)=R(n)/N(n) be the maximal possible ratio of acute triangles. (A triangle is acute when all its angles are strictly less than 90 degrees).

Compute as many as you can of the numbers r(3), r(4), r(5), r(6), ... before the deadline: FEB 14, 2010; send entries to Prof. Mark Van Hoeij, **hoeij@math.fsu.edu.**

ELIGIBILITY: Entries are limited to FSU students and alumni, excluding mathematics faculty. The prize goes to the best undergraduate solution; if none, then to the best graduate solution; if none, then to the best alumni solution.

Support tomorrow's students today

You can support the students and faculty of Florida State University's Department of Mathematics with a tax-deductible gift to enhance our teaching and research efforts.

Checks payable to FSU Foundation Mathematics Fund No. 0223 may be sent to:

Dr. Philip Bowers, Chair
FSU Department of Mathematics,
208 Love Building
1017 Academic Way
Tallahassee, FL 32306-4510

or

FSU Foundation
2010 Levy Avenue
P.O. Box 3062739
Tallahassee, Florida 32306-2739

Questions may be directed to Dr. Bowers by phone (850.645.3338) or email (**bowers@math.fsu.edu**).

Help us support the students who hope to follow in your footsteps.

Keep in touch!

Many of our graduates have kept in touch with the department and we invite all other alumni to do the same. In fact, we would like to add your name and contact information to our alumni database and include your information on our website. To be included, email **alumni@math.fsu.edu.**

Return this form to:

FSU Department of Mathematics,
208 Love Bldg., 1017 Academic Way,
Tallahassee, FL 32306-4510

Name _____ Maiden _____

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