PROGRESS REPORT: 2012-2013

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Research Description

My primary goal is to lead the effort to provide the mathematical and computational infrastructure that will transform the way we compute with partial differential equations by making Abelian functions and Riemann surfaces as computationally accessible as trigonometric and hyperbolic functions thereby providing to the scientific community an essential ingredient in finding large families of solutions to partial differential equations arising in a variety of fields including plasma physics, nonlinear optics, and water waves.

Research Update

During this academic year I continued to add to ABELFUNCTIONS, a Python library for computing with Abelian functions and Riemann surfaces. (`github.com/cswiercz/abelfunctions`) I used Deconinck and van Hoeij's ALGCURVES package as reference but added variations and improvements on algorithm components. The goal is to have the functionality of ALGCURVES implemented in ABELFUNCTIONS by next Winter. Such an implementation will bring an open-source, fully-documented computational Riemann surfaces software package to the mathematics community.

I was an invited speaker at North Carolina State University's Symbolic Computation seminar where I gave an extensive overview of ABELFUNCTIONS and theory behind the software. My discussions with faculty members at NCSU led to incorporating Smale's α-theory into my code — a technique for provably verifying the validity of Newton's method. I also gave a conference talk based on selected topics from the aforementioned lecture at the Eighth IMACS International Conference on Nonlinear Evolution Equations and Wave Phenomena for the "Symbolic and numerical aspects of nonlinear differential and difference equations" organized session.

Grady Williams, an undergraduate in the Mathematics Department, joined me during the summer in developing high-performance implementations of Riemann theta function evaluation. We wrote optimized C and CUDA code for computing Riemann theta on Graphics Processing Units (GPUs) — a specialized compute device for highly parallel calculations. We are currently developing an algorithm for efficiently computing Riemann theta in parallel over many choices of Riemann matrix by using the Siegel Transform to take advantage of the problem's symplectic geometry. If successful, we will submit a paper on this work.

This year I expanded my mathematical knowledge primarily by attending reading courses and seminars. I initiated personal reading courses on the topic of my research with my advisor, Bernard Deconinck. I also attend weekly group readings on linear analysis and perturbation theory; foundational topics within my general interests. I regularly attend the Applied Mathematics Special Topics Seminar and the Mathematical Methods Seminar as well as various other seminar sessions within the Mathematics and Applied Mathematics departments.

Expected Academic Schedule

I expect to complete my general examination by Winter 2014 and complete my degree at the end of 2015.