Claremont Center for the Mathematical Sciences

The 2018 Mathematical Problems in Industry Workshop

The 34th Annual MPI Workshop

June 25-29, 2018

Registration link:
https://goo.gl/forms/WAR87J5ujNg23WsF2

Questions about the workshop:
e-mail to An Do an.do@cgu.edu

Questions about an industrial problem submission:
e-mail to Ellis Cumberbatch ellis.cumberbatch@cgu.edu

List of the Industrial Problems:
http://net.cgu.edu/faculty/chugunom/MPI2018Problem1.pdf
http://net.cgu.edu/faculty/chugunom/MPI2018Problem2.pdf
http://net.cgu.edu/faculty/chugunom/MPI2018Problem3.pdf
http://net.cgu.edu/faculty/chugunom/MPI2018Problem4.pdf
http://net.cgu.edu/faculty/chugunom/MPI2018Problem5.pdf

Information about lodging options (Special offer for students until March 24!):
http://net.cgu.edu/faculty/chugunom/MPI2018Lodging.pdf

MPI is a problem solving workshop that attracts leading applied mathematicians, scientists and junior researchers (graduate students, postdocs and junior faculty) from universities, industry, and national laboratories. During the workshop, engineers and scientists from industry interact with the academic participants on problems of interest to their companies.

The workshop is a lively, 5-day interaction on the problems of interest to science and industry. On the first day, the industry representatives present their problems to the whole group. These problems vary widely in nature from those requiring basic physical modeling to those requiring significant simulation, computation or data analysis. For the rest of the week, the workshop participants break up into small working groups consisting of senior faculty and attending

scientists, graduate students, and the industrial representatives, to discuss and tackle the problems in an informal setting. On the last day of the workshop, an academic participant from each group presents the results obtained and discusses possible future directions. A written report detailing the progress made during the workshop is prepared subsequently and sent to the industry representatives.

The MPI Organizing Committee is committed to working with representatives from industry to strengthen academic-industrial ties on research challenges. The workshop also seeks to provide a stimulating and engaging collaborative environment for students and faculty to work together and explore innovative approaches to novel real-world problems.

Industry representatives who are interested in submitting a problem to the workshop should send their one page abstract of the problem to a member of MPI 2018 Organizing Committee (listed below) before February 28, 2018. The organizing committee will evaluate the suitability of the problem for the MPI workshop and, if the problem is accepted, will discuss a participation fee.

Local MPI 2018 organizers:

- Andrea Bertozzi, UCLA, (bertozzi@math.ucla.edu)
- Marina Chugunova, CGU, (marina.chugunova@cgu.edu)
- Ellis Cumberbatch, CGU, (ellis.cumberbatch@cgu.edu)
- Chiu-Yen Kao, CMC, (chiu-yen.kao@claremontmckenna.edu)
- Lisette de Pillis, HMC, (depillis@g.hmc.edu)

MPI Organizing committee

- **Thomas Witelski**, Duke
- **Donald Schwendeman**, RPI
- **David Edwards**, U-Delaware
- **Burt Tilley**, WPI
- **Linda Cummings**, NJIT
- **Richard Moore**, NJIT

Examples of past MPI abstracts of problems:

On characterizing and simulating porous media

W. L. Gore and Associates

May 26, 2017

Porous media are at the heart of many of the technology solutions that Gore offers. We have studied the performance of these media on macroscopic (~ cm) length scales and we would like to improve our understanding of the mechanistic details of processes that occur at the microscopic (~ μm) length scales within these media.

Modeling multi-layer membrane

A multi-layer membrane consists of a group of membranes with different properties, such as pore size and porosity, stacking on top of each other. Multi-layer membranes have been widely used in a variety of industrial applications, for example, filtration and separation. It has been demonstrated experimentally that well-designed multilayer structured membrane performs better than a homogeneous membrane. Mathematically characterize and model multi-layer membranes can certainly help understanding how membrane properties of each layer affect the performance of the membrane stack. Currently there are a number of models that aid in understanding filtration in a homogeneous membrane. Network model, for example, is a model that describes the microscopic structural features of a membrane. In the model, membrane pores are represented by a network of connected cylinders. The advantage of a network model is that it can generate performance data, such as flux and retention, for a broad sweep of filter geometries, based on membrane microstructure. Hence it provides useful information that relates performance of the membrane to its microscopic properties.

When a network model is used to represent a multi-layer membrane, different networks represent membrane layers with different properties. It is not clear how to connect these networks properly. The goal is to build a robust and efficient network model for multi-layer membrane can aid in design and performance optimization. In other separation applications, it is important to understand the mass transfer of spices through the membrane. In particular, diffusion, convection and adsorption of spices

through multilayer membrane is of great interest. In this case, network model may be inefficient due to the scale and complexity of the structure. We would like to build a continuum model to study how microscopic properties of a multi-layer membrane stack affect mass transport.

Modeling and Optimization of Reach and Exposure in TV

Marco Montes de Oca,

CLYPD, Inc.

04/25/17

The “holy grail” of advertising is to convince people to take an action through a campaign. We have seen in past MIP editions that advertisers allocate a budget that will allow them to buy time (TV, radio) or insertions (printed media) in exchange for “impressions” (number of views of their advertisement).

Any campaign will reach a certain number of people at least once, but there will be a fraction of this population that will be reached twice, three times, etc. This gives rise to an “exposure distribution” There will be an ideal exposure distribution for a particular campaign, and therefore advertisers usually impose constraints on their campaign as an indirect way to control the resulting exposure distribution. For example, for the launch of a new product an advertiser might want to reach as many people as possible up to three times. This requirement is translated as a campaign with constraints in the number of times the advertiser’s ad is shown in the same show in the same channel, for instance, because it is expected that the same people will watch the same show week after week and the advertiser wants to limit the frequency of exposure of that audience. Likewise, a targeted campaign might want to increase the frequency of exposure of people who have expressed interest in buying a car by visiting online used car catalogues. In this case, the constraints on the campaign would be to buy more placements than usual on, for example, car-related shows.

Up until recently advertisers relied on their intuition, or on limited data, to establish the constraints that, they hope, will generate the desired exposure distribution. The problem we want to address during the workshop is 1) to mathematically model TV viewing behavior, 2) use real (or close to real

TV data) to validate and tune such models, and 3) automatically derive the constraints necessary to attain a particular exposure distribution.

Testimonials:

Jacqueline Ashmore

TIAX LLC

Cambridge, MA 02140

Over twelve academics from across the US and the UK worked on a problem related to TIAX's fluxgate sensors at the Math Problems in Industry workshop at Olin College. The group worked conscientiously and enthusiastically, often late into the evening and on some occasions into the early hours of the morning, to understand various different aspects of the problem. A TIAX representative was present for much of the workshop and was involved in many stimulating conversations that gave us useful ideas for different approaches to analyzing the fluxgate sensor output. The group has already written a substantial draft report for TIAX on their analysis and numerical work, which they will complete in the near future, and they also wrote Matlab programs to perform some of the analysis. Participating in the MPI workshop provided us with rapid results based on insights from multiple perspectives. The analytical and numerical results, the software programs, and the knowledge and understanding gained from the workshop will all be beneficial in directing TIAX's work to make improvements to our sensors.

John Skelton

Albany International Research Co

777 West St, Mansfield, MA 02048

Last year I had the opportunity to participate in MPI workshop for the first time. In fact it was not only the first time that I or anyone else from my company had participated, it was, I believe, the first time that any of us had even heard of the concept so we were truly uninitiated in the rituals. We were fairly confident that we had a problem (the hydrodynamics of a high speed roll press) that would stand up to the assault team, since we and a wide range of other workers had attacked parts of it over a span of several decades and the progress was not particularly impressive. We were much less confident that the workshop methodology would be conducive to a satisfactory solution, but in fact it turned out to be an excellent way to make progress.

My own training is as a physicist, and my physics is based on intuition rather than on mathematical rigor, so I was certainly stretched intellectually many times during the course of the week, but it was an amazing experience to see high level mathematical analysis being carried out on the run. We were quite fortunate that several of the professional participants had a great deal of experience with flow in porous media, so they were able to move very quickly to the heart of the problem, and to resolve some of the issues that had been blocking our progress. At the end of a hard week most of the

outstanding issues had been resolved, and the extensive general solution had been reduced to a number of quite tractable special cases, with a numerical solution completed for a typical roll press configuration. The week was a definite success both for me personally and for my company, and we will certainly be willing to repeat the experience as time and suitable problems present themselves.
