Ivars Peterson reports from Baltimore at the American Mathematical Society/Mathematical Association of America joint meeting

Bug traps in electric power networks

Monitoring the well-being of their extensive electric power networks presents utilities with a formidable task. Using a limited number of power-level measurements at various points scattered throughout a network, power engineers at a central control facility must have access to sufficient data to pinpoint problems and react appropriately.

But these elaborate networks, stretching from generating stations to distribution centers, substations and individual factories, businesses and homes, are often so large that engineers sometimes have trouble quickly locating faults, such as overloads or interruptions of electrical current in certain branches. Minor but frequent changes in the links between various parts of the network exacerbate the problem.

Mathematician Paul W. Davis and electrical engineer Kevin A. Clements of the Worcester (Mass.) Polytechnic Institute have now developed a mathematical tool, based on linear algebra, that allows power engineers to readily identify vulnerable links in their networks and blind spots in their monitoring programs. The researchers look at a set of equations representing the relationship between measured power levels and calculated voltages at various points in an electric power network. Expressed in the form of a grid of numbers, or matrix, these equations also include information on the network's connections. The idea is to use these equations, or equivalent matrix, to identify problems in the network.

Davis and Clements established a mathematical theorem involving these matrices, which enables them to propose a convenient method of identifying situations in which a failure in a certain branch or group of branches may not show up in a given set of power measurements, thereby making the fault undetectable at the control center. "We could immediately pinpoint vulnerable branches," Davis says.

Moreover, careful examination of the network geometry leads to useful ideas as to where within a given network to measure power levels to detect certain types of problems, Davis contends. It suggests how a utility could alter its measurement pattern – perhaps simply by shifting the locations of a few measuring devices – to detect more problems in more branches.

"This work is ready for implementation by power engineers," he adds. "What we've got to do now is run some test cases."

Pity the math grad student

Whatever the discipline, graduate students generally face lengthy, challenging regimens of research, coursework, teaching and exams. Often feeling overworked and underappreciated, they tend to grumble a lot, but those complaints are rarely taken seriously. It's all part of the grad-school experience, they are told, a legacy handed down from one generation of scholars to the next.

In the case of mathematics, however, someone is starting to pay attention to students' concerns. In a study sponsored by the Board on Mathematical Sciences for the National Research Council, a panel of mathematicians investigated doctoral and postdoctoral programs at 10 universities to get a sense of how successfully such programs prepare students for research mathematics and other pursuits beyond graduate school. Panel members found considerable discontent and uncovered evidence that too many talented students were failing to complete their degrees. They also identified program characteristics that appeared to increase the likelihood of success.

"This experience [of conducting the study] completely changed my perspective on graduate education," says panel member Karen Uhlenbeck of the University of Texas at Austin. She discovered that her own success many years earlier in a typical graduate program was the exception rather than the rule. "In most places, students are unhappy," she notes. "The actual percentage that succeed is quite small. It's a tremendous waste of a lot of talent."

Although the panel report comes at a time when mathematicians educated in the United States have an enviable international reputation, it reflects renewed concerns about the relatively small number of U.S. citizens, especially women and members of minority groups, who manage to earn a graduate degree in mathematics. The panel recommends that mathematics departments evaluate their graduate programs to identify shortcomings, keeping in mind that the "standard model" of graduate education, aimed at training research mathematicians for academia, may not be appropriate for every institution or student.

Successful programs, the panel suggests, tend to focus on realistic missions aimed at a variety of career paths for mathematicians with graduate degrees, including employment in industry and government. They also provide positive learning environments – for example, by encouraging group interactions instead of letting students work largely in isolation, or by providing "hands-on" experience with mathematical research early in a program.

"It sounds very simple and pretty obvious, but it often doesn't happen," says panel chairman Ronald G. Douglas of the State University of New York at Stony Brook.

"We are doing some things right; we're also doing some things wrong," Uhlenbeck says. "I'm very convinced it's worthwhile to think of creative ways to start changing things."

The National Research Council plans to publish the report, titled "Educating Mathematicians: Doctoral and Postdoctoral Study in the United States," next month.

Math for all seasons

When the American Association for the Advancement of Science announced with considerable fanfare last year the 1992 debut of THE ONLINE JOURNAL OF CURRENT CLINICAL TRIALS, it was billed as the world's first peer-reviewed science journal available to subscribers electronically. What the organizers of this effort didn't know was that several such electronic journals already existed. One of these concerns the application of mathematics to geography.

SOLSTICE: AN ELECTRONIC JOURNAL OF GEOGRAPHY AND MATHEMATICS – published by Sandra Lach Arlinghaus of the Institute of Mathematical Geography, a small, independent research organization in Ann Arbor, Mich. – first appeared in 1990. Its two issues per year, published appropriately on the dates of the summer and winter solstices, go to about 50 individuals, who receive the journal free. Transmission costs for distributing the journal electronically over a computer network to all subscribers amount to less than $5 per issue, with the cost of printing passed on to the user. Libraries and other institutions that prefer printed copies pay for each issue, and those copies are generated from computer files only when needed.

"It's all very cheap, all environmentally sound," Arlinghaus says.

But getting the journal going wasn't easy, she remarks. The biggest production problem involved photographs and figures, which can't be transmitted electronically in the same, compact way as letters, numbers or even mathematical notation. At present, individuals wishing to see particular illustrations must obtain photocopies directly from the Institute of Mathematical Geography. Arlinghaus also admits that she has had trouble obtaining manuscripts for publication in this still-unconventional medium. But individuals who might initially have been skeptics "become more receptive when they see the actual product," she says.