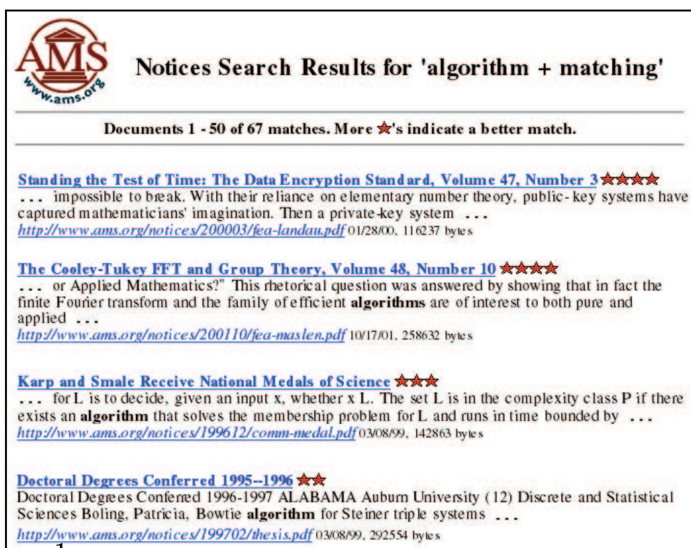
Getting Results on the Web

Imagine trying to find the right information quickly in a library where billions of pages are randomly piled in a heap, instead of being in books shelved in order. That's what Web search engines do, millions of times a day. First-generation search engines often found useful pages, but those pages may have been too far down the list to be of any practical use. Current search engines rank pages by using mathematics—probability, graph theory, and linear algebra—so that sites most relevant to a query are listed at the top, where the user can most easily see them.

The vast number of pages and links on the Web can be represented as a graph in which the nodes are Web pages and the directed edges are links. Today's search engines determine the relevance of a page to a query by incorporating the importance of pages pointing to and from that page. Thus, when it comes to a search, a page's links can be just as important as its content. The final ranking comes from techniques in linear algebra and probability that help formulate and solve equations which, according to the founders of one search engine, involve millions of variables and billions of terms. In the future, search engines may use artificial intelligence and information on past searches to discern the actual intent of a query.

For more information: David Voss, "Better Searching Through Science," *Science*, 14 Sept. 2001



Notices Search Results for 'algorithm + matching'

Documents 1 - 50 of 67 matches. More ★'s indicate a better match.

Standing the Test of Time: The Data Encryption Standard, Volume 47, Number 3 ★★★★
... impossible to break. With their reliance on elementary number theory, public-key systems have captured mathematicians' imagination. Then a private-key system ...
http://www.ams.org/notices/200003/fea-landau.pdf 01/28/00, 116237 bytes

The Cooley-Tukey FFT and Group Theory, Volume 48, Number 10 ★★★★
... or Applied Mathematics?" This rhetorical question was answered by showing that in fact the finite Fourier transform and the family of efficient **algorithms** are of interest to both pure and applied ...
http://www.ams.org/notices/200110/fea-maslen.pdf 10/17/01, 258632 bytes

Karp and Smale Receive National Medals of Science ★★★
... for L is to decide, given an input x, whether x L. The set L is in the complexity class P if there exists an **algorithm** that solves the membership problem for L and runs in time bounded by ...
http://www.ams.org/notices/199612/comm-medal.pdf 03/08/99, 142863 bytes

Doctoral Degrees Conferred 1995--1996 ★★
Doctoral Degrees Conferred 1996-1997 ALABAMA Auburn University (12) Discrete and Statistical Sciences Boling, Patricia, Bowtie **algorithm** for Steiner triple systems ...
http://www.ams.org/notices/199702/thesis.pdf 03/08/99, 292554 bytes

1

AMS
AMERICAN MATHEMATICAL SOCIETY

*The **Mathematical Moments** program promotes appreciation and understanding of the role mathematics plays in science, nature, technology, and human culture.*

MATHEMATICAL MOMENTS

Seeing More Clearly

Twinkling stars are fun for songs but frustrating for astronomers. Current technology uses *adaptive optics* to adjust for turbulence in the atmosphere and deliver an accurate image of stars, planets, and satellites. Correcting for atmospheric distortion involves linear algebra, geometry, and statistics to determine the extent of the distortion and continually adjust deformable mirrors which refocus light waves back along their true paths.

Mathematical algorithms make possible the many real-time calculations required to clarify views both beyond earth and under the microscope. In fact, adaptive optics allowed researchers their first views of individual cells in a living eye. This has brought about the potential for better diagnostics and more accurate surgery, so that a science created to help some people see a few things more clearly may help millions see everything better.

For More Information: *Adaptive Optics in Astronomy,* François Roddier.

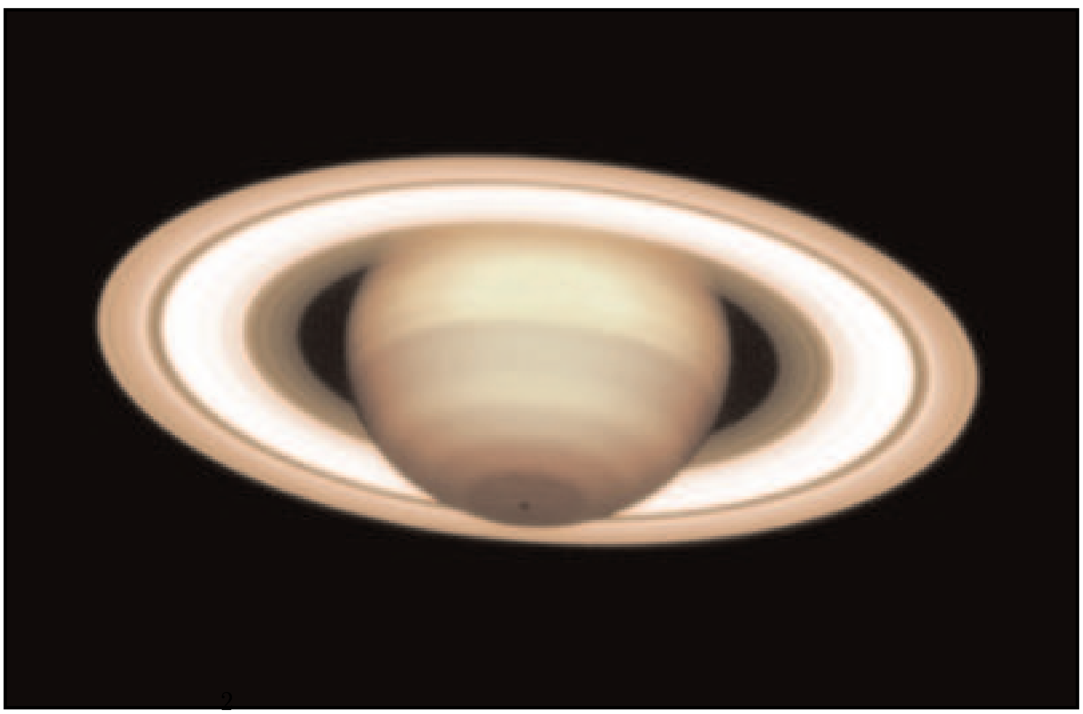


Image courtesy of the European Southern Observatory.

AMS
AMERICAN MATHEMATICAL SOCIETY

*The **Mathematical Moments** program promotes appreciation and understanding of the role mathematics plays in science, nature, technology, and human culture.*

www.ams.org/mathmoments

MM/35

MATHEMATICAL MOMENTS

Cutting the Cord

A cellular phone's size disguises the considerable amount of activity going on inside. In a digital phone, your voice is converted by the phone's processor into a stream of 0's and 1's that are transmitted to a base station, received, relayed, and reconverted back to the original sound (actually, an extremely good approximation of that sound) by the receiving phone. Along with sending your words, your phone transmits an identifying code and determines the nearest base station. Hand-off algorithms are employed to help maintain a continuous conversation as the phone's location changes. (Note that E.T. didn't phone home until **after** landing.)

Photo courtesy of Tiny Love.

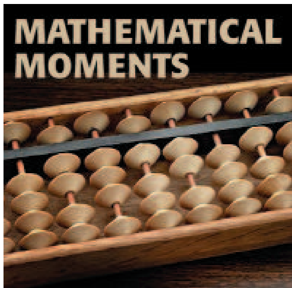
Even when a cell phone is stationary, obstacles such as buildings and trees, as well as other signals, interfere with transmission and reception. In a much simpler world with one cellular telephone and one antenna, one complex number can represent the resulting variation (in amplitude and phase) in a signal. With multiple phones and multiple antennas, a large matrix of numbers is needed to represent all the variations. The size of these matrices makes exact computation impractical, but they are being successfully modeled using random matrix theory. The modeling makes possible an analysis of system performance and a determination of limits on system capacity with the goal of optimizing the system design. An interesting new technology allows broadband service by having multiple antennas even on a single cellular phone.

For more information: *The Cell Phone Handbook*, by Penelope Stetz.

AMS
American Mathematical Society

*The **Mathematical Moments** program promotes appreciation and understanding of the role mathematics plays in science, nature, technology, and human culture.*

www.ams.org/mathmoments



Defeating Disease

From modeling microscopic genes and proteins to tracing the progression of an epidemic through a country, mathematics plays an important role in combating disease. For example, the basic model used to analyze the dynamics of infectious disease is a system of differential equations. A new field called "data mining", involving statistics and pattern recognition, helps locate significant information in the vast amounts of data collected from studies of diseases in populations. Mathematics also plays a key role in connecting changes in the human genome to specific diseases.

Mathematics has helped recent fights against foot-and-mouth disease in the United Kingdom and against Chagas disease—a disease affecting millions of people in Latin America. Epidemiologists studying the foot-and-mouth epidemic used mathematical models to conclude that early efforts were insufficient to stop what would become a calamitous spread of the disease. The government accepted the conclusions and took a course of action that, although drastic, did indeed arrest the outbreak. In Latin America, mathematicians computationally tested several courses of action against Chagas disease and found a surprisingly simple yet highly effective step (keeping dogs out of the bedroom) to greatly reduce the infection rate. These examples share three important characteristics: a mathematical model of the disease, modern computers to do calculations required by the model, and researchers with the insight to design the former so as to take advantage of the power of the latter.

For more information: *Infectious Diseases of Humans: Dynamics and Control*, R. M. Anderson and R. M. May.

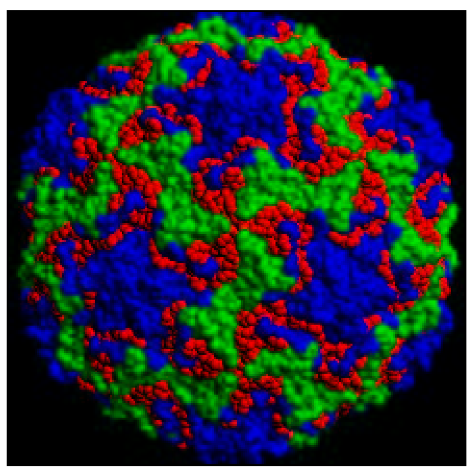


Image courtesy of: Jean-Yves Sgro, University of Wisconsin-Madison. Rhinovirus color-coded by protein, enhances display of icosahedral symmetry. ©1993

AMS
American Mathematical Society

*The **Mathematical Moments** program promotes appreciation and understanding of the role mathematics plays in science, nature, technology, and human culture.*

www.ams.org/mathmoments

MM/25

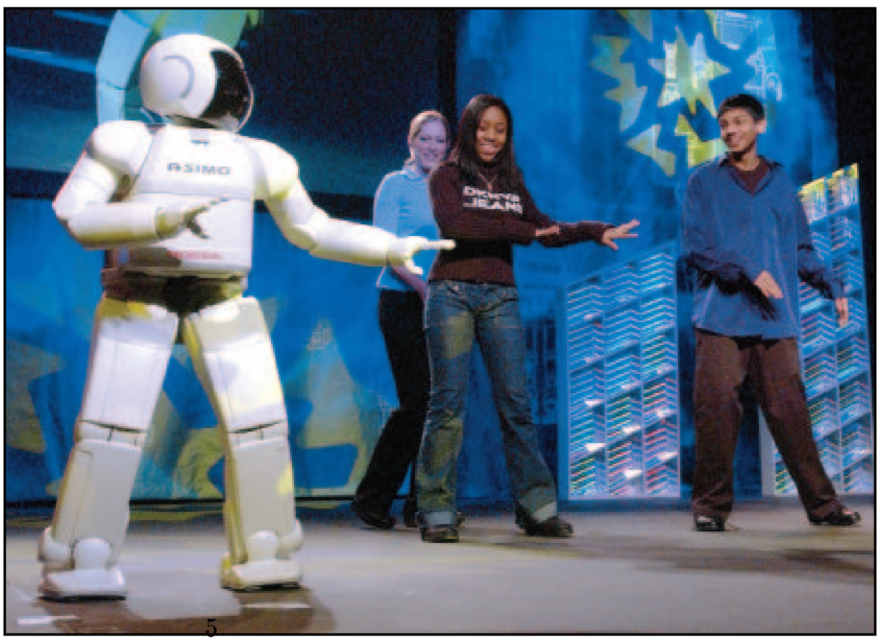
MATHEMATICAL MOMENTS

Bringing Robots to Life

Robots of all shapes and sizes now perform tasks as routine as vacuuming the living room floor and as remarkable as discovering a hydrothermal vent on the ocean floor. Geometry, statistics, graph theory, differential equations, and linear algebra are some of the areas of mathematics that allow navigation and decision making so that robots can function autonomously and do things we either can't, or would rather not, do.

The robot pictured below not only dances but also greets visitors and escorts them to their destinations, providing news and weather updates along the way. Abilities like these require algorithms for vision, pattern recognition, speech recognition, and dealing with uncertainty so that accumulated error doesn't render the robot ineffective. Most researchers think that we are a long way from creating machines that behave like humans, but improving algorithms will improve the capabilities of robots, which have already served in space, in rescues at disaster areas, and in the operating room, where physicians use robotic arms that allow for more precise, less invasive surgery.

For more information: *Robots,* Ruth Aylett



Getty Images

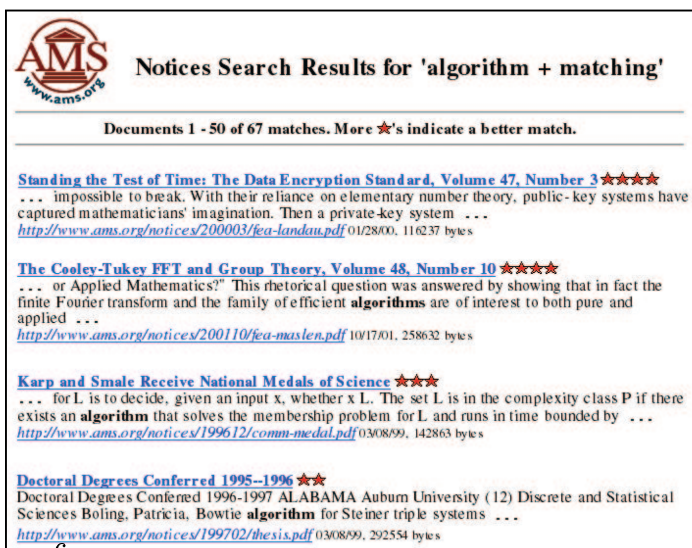
MM/29

Getting Results on the Web

Imagine trying to find the right information quickly in a library where billions of pages are randomly piled in a heap, instead of being in books shelved in order. That's what Web search engines do, millions of times a day. First-generation search engines often found useful pages, but those pages may have been too far down the list to be of any practical use. Current search engines rank pages by using mathematics—probability, graph theory, and linear algebra—so that sites most relevant to a query are listed at the top, where the user can most easily see them.

The vast number of pages and links on the Web can be represented as a graph in which the nodes are Web pages and the directed edges are links. Today's search engines determine the relevance of a page to a query by incorporating the importance of pages pointing to and from that page. Thus, when it comes to a search, a page's links can be just as important as its content. The final ranking comes from techniques in linear algebra and probability that help formulate and solve equations which, according to the founders of one search engine, involve millions of variables and billions of terms. In the future, search engines may use artificial intelligence and information on past searches to discern the actual intent of a query.

For more information: David Voss, "Better Searching Through Science," *Science*, 14 Sept. 2001


Notices Search Results for 'algorithm + matching'

Documents 1 - 50 of 67 matches. More ★'s indicate a better match.

Standing the Test of Time: The Data Encryption Standard, Volume 47, Number 3 ★★★★
... impossible to break. With their reliance on elementary number theory, public-key systems have captured mathematicians' imagination. Then a private-key system ...
http://www.ams.org/notices/200003/fea-landau.pdf 01/28/00, 116237 bytes

The Cooley-Tukey FFT and Group Theory, Volume 48, Number 10 ★★★★
... or Applied Mathematics?" This rhetorical question was answered by showing that in fact the finite Fourier transform and the family of efficient **algorithms** are of interest to both pure and applied ...
http://www.ams.org/notices/200110/fea-maslen.pdf 10/17/01, 258632 bytes

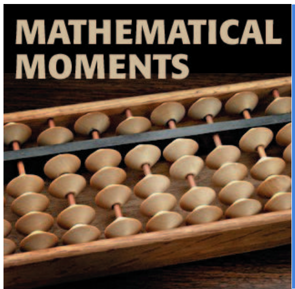
Karp and Smale Receive National Medals of Science ★★★
... for L is to decide, given an input x, whether x L. The set L is in the complexity class P if there exists an **algorithm** that solves the membership problem for L and runs in time bounded by ...
http://www.ams.org/notices/199612/comm-medal.pdf 03/08/99, 142863 bytes

Doctoral Degrees Conferred 1995--1996 ★★
Doctoral Degrees Conferred 1996-1997 ALABAMA Auburn University (12) Discrete and Statistical Sciences Boling, Patricia, Bowtie **algorithm** for Steiner triple systems ...
http://www.ams.org/notices/199702/thesis.pdf 03/08/99, 292554 bytes

AMERICAN MATHEMATICAL SOCIETY

*The **Mathematical Moments** program promotes appreciation and understanding of the role mathematics plays in science, nature, technology, and human culture.*

www.ams.org/mathmoments

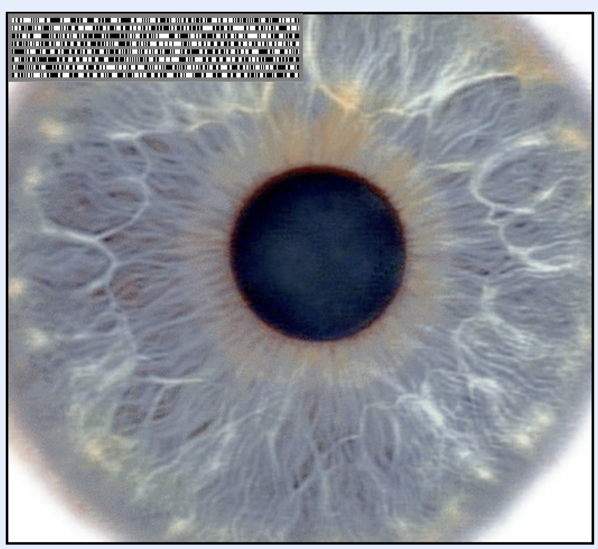


Eye-dentifying Yourself

Iris recognition may allow us to live in a world without PIN numbers—identifying ourselves just by looking at the ATM. Identification by iris recognition is based on pattern recognition, wavelets and statistics. The first two fields are used to translate the patterns in your iris into a string of 0's and 1's, while statistics establishes that the scanned iris is yours.

The iris is a good physical feature to use for identification because of the tremendous variability in iris patterns, even between twins. This variability guarantees that a correct identification is made when the code for a scanned iris matches a stored code in at least two-thirds of the bits. Furthermore, the eye and iris are easy for a scanner to find, due to their shape and placement. Once the iris is located, wavelets are used to translate the pattern of the sampled portion of the iris into two bits. These bits reflect the agreement between that portion of the iris and specific wavelets. The entire iris is encoded in about 2000 bits. Finding a relative match between this bit pattern and one of the thousands of iris codes in the database completes the identification. This comparison is done in parallel, so that the whole process takes place in about the blink of an eye.

For more information: "Iris Recognition," *American Scientist*, John Daugman



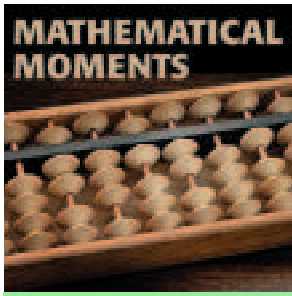
Photograph courtesy of John Daugman.

AMS
American Mathematical Society

*The **Mathematical Moments** program promotes appreciation and understanding of the role mathematics plays in science, nature, technology, and human culture.*

www.ams.org/mathmoments

MM/17



Folding for Fun and Function

Origami—paper-folding—may not seem like a subject for mathematical investigation or one with sophisticated applications, yet anyone who has tried to fold a road map or wrap a present knows that origami is no trivial matter. Mathematicians, computer scientists, and engineers have recently discovered that this centuries-old subject can be used to solve many modern problems. The methods of origami are now used to fold objects such as automobile air bags and huge space telescopes efficiently, and may be related to how proteins fold.

Manufacturers often want to make a product out of a single piece of material. The manufacturing problem then becomes one of deciding whether a shape can be folded and if so, is there an efficient way to find a good fold? Thus, many origami research problems have to do with algorithm complexity and optimization theory. A testament to the diversity of origami, as well as the power of mathematics, is its applicability to problems at the molecular level, in manufacturing, and in outer space.

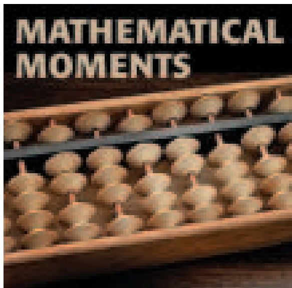
For More Information: http://db.uwaterloo.ca/~eddemain/papers/MapFolding/

Model designed by Thomas Hull (Merrimack College) and Francis Ow, folded by Papajoe (Joe Gilardi)

AMS
American Mathematical Society

*The **Mathematical Moments** program promotes appreciation and understanding of the role mathematics plays in science, nature, technology, and human culture.*

www.ams.org/mathmoments



Tracing Your Routes

The *Traveling Salesman Problem* entails finding the shortest route that passes through each assigned town exactly once. (The route below visits over 13,000 towns.) The problem is noteworthy for its complexity, which grows exponentially with the number of towns, and for its applications, which range from wiring a chip to scheduling airline crews. Researchers use graph theory and linear programming to solve the problem when feasible and to find near-optimal solutions in other instances, saving industry time and money.

There may never be a workable general solution to the *Traveling Salesman Problem*. Yet even without knowing the best answer, mathematicians still can estimate how close to optimal a given route is. Perhaps even more surprising: Operating on a map of 25,000 towns, current algorithms design paths whose lengths are within 0.01% of that of a shortest path.

For More Information: *The Traveling Salesman Problem: A Guided Tour of Combinatorial Optimization,* Lawler, Lenstra, Rinnooy Kan, and Shmoys.

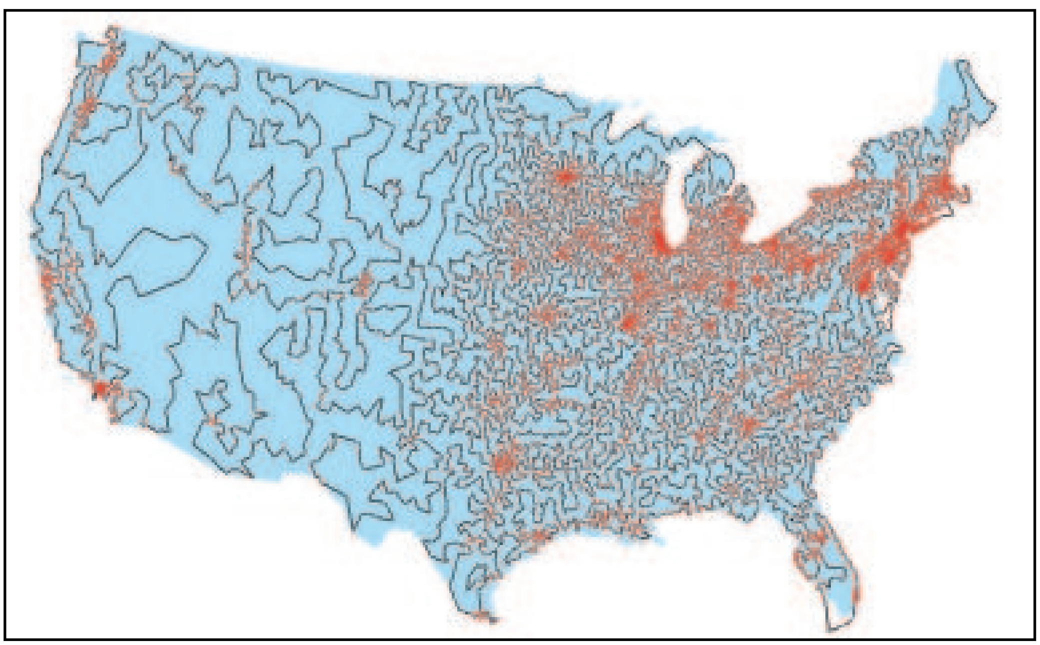
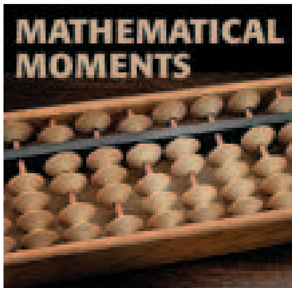


Image courtesy of D. Applegate, R. Bixby, V. Chvátal, and W. Cook; www.math.princeton.edu/tsp.

AMERICAN MATHEMATICAL SOCIETY

*The **Mathematical Moments** program promotes appreciation and understanding of the role mathematics plays in science, nature, technology, and human culture.*

www.ams.org/mathmoments



Beating Traffic

It's not your imagination; traffic **is** getting worse. In the last 30 years while the number of vehicle-miles traveled has more than doubled, physical road space has increased only six percent. Yet building new roads is no guarantee of relief: A counterintuitive result in traffic science is that a new road could actually increase the congestion in a network. Areas of mathematics like queuing theory and partial differential equations contribute to understanding traffic, which is a *backwards propagating wave*—cars move forward but the jam moves backward.

The mathematical study of traffic is relatively new, but a federal report concluded that the information revolution—that is, the combination of more powerful computers, telecommunications, and better numerical models—will affect transportation as much as the inventions of the automobile and jet engine. Analyzing traffic (like predicting weather) requires many variables (driver speed, length of trip, time of day, and origination point) and involves chaos theory (a small change down the road can drastically change travel conditions). Unlike weather, however, traffic can change in response to a forecast as alternative routes are chosen—today by drivers and, in the future, perhaps by the cars themselves.

For More Information: *What's Happening in the Mathematical Sciences,* Vol. 5, Barry Cipra

Image courtesy of Puget Sound Regional Council