

Physical Science

Elizabeth Pennisi reports from Irvine, Calif., at the National Academy of Sciences Frontiers of Science meeting

Mathematics aids fingerprint detection

Police stations all over the country may soon depend on a mathematical entity called wavelets to help them keep tabs on criminals. The FBI plans to use wavelets to improve the efficiency of fingerprint transmission, storage, and retrieval, thereby making print matching faster and more economical.

Mathematicians use wavelet analysis to process images. The procedure first divides an image into its basic constituents. It then pulls out and saves the constituents that define the image and ignores those that don't contribute information essential to the reconstruction of the image. "This method extracts the coherent parts from the garbage," explains M. Victor Wickerhauser, a mathematician at Washington University in St. Louis. Thus wavelets reduce the amount of data needed. Such "data compression" reduces the time and cost of processing.

The FBI encodes fingerprints with about 30 "minutia points," places where the finger's ridges end, split, or merge. Most data-compression techniques introduce distortions that are invisible to the eye but troublesome for a machine trying to match two fingerprints, says Wickerhauser. These techniques tend to add extra edges that can interfere with correct reading of minutiae. Wavelets do not create such distortions.

One type of wavelet procedure, called the Best-basis Algorithm, came out on top when the FBI tested it and two other technologies for transforming fingerprint images into compact data sets. For the test, the FBI asked experts trained in fingerprint matching to compare real and reconstructed prints.

The FBI was then able to simplify the algorithm further. "On a practical basis, it is almost the same quality, but the complexity is lower," says Wickerhauser, who thinks wavelets will prove valuable in many more applications.

Salt sandwiches boost opto-electronics

Although physicists figured out that some materials could respond to light in peculiar ways, it remained for chemists to create substances with these so-called nonlinear optical (NLO) properties, says Seth R. Marder, a chemist at the California Institute of Technology in Pasadena. Marder and his colleagues at NASA's Jet Propulsion Laboratory in Pasadena have made organic materials that, in electric fields, develop the uneven distribution of charges needed for NLO effects.

In 1989, they first produced the organic salt DAST, which they have now shown can work 20 times better than the NLO material lithium niobate as an electro-optic switch. It requires 1/350th the electric charge that lithium niobate needs to change the index of refraction and polarize the light passing through it, says Marder. Also, the material is stable, forms large crystals easily, and should cost about 10¢ a gram, he adds.

The group's X-ray diffraction studies have revealed that DAST's asymmetric polarity and its NLO properties arise because the salt's positive organic ions align parallel to one another in sheets, with sheets of negatively charged ions sandwiched in between the positive ones. "They find an orientation with respect to one another that makes them happy," says Marder. This configuration guarantees that like-charged ions do not face in opposite directions, which would cancel out the polarity.

In other work, Marder and his colleagues have synthesized organic molecules designed to optimize NLO properties. In these improved molecules, electrons readily shift between rings of carbon at each end of a carbon chain without disturbing the energy balance of the whole chain.

Science & Society

President signs energy bill

On Oct. 24, with a Maurice, La., oil rig for a backdrop, President Bush penned his name to the Energy Policy Act of 1992. By the year 2010, this bill to revamp U.S. energy strategy is expected to cut oil imports by one-third — up to 4.7 million barrels a day — and boost renewable energy use by 20 percent.

Congress scrapped the most contentious features in initial versions of the bill (SN: 7/6/91, p.8): so-called CAFE (corporate average fuel economy) standards to increase the mileage of U.S. cars, and the sale of leases in the Arctic National Wildlife Refuge and outer continental shelf for oil and gas drilling.

Highlights of what remains in the more than 800-page blueprint include:

- Incentives to encourage greater production of energy from renewable sources, such as a 1.5¢ per kilowatt subsidy to utilities for electricity derived from wind, solar-heated steam, photovoltaic power cells, geothermal heat, or biomass burning.

- One-step licensing for commercial nuclear plants. Like a court-contested Nuclear Regulatory Commission (NRC) rule issued in 1989, it requires one public hearing prior to construction of a reactor. NRC will waive a formerly standard second hearing before a plant starts up — unless petitioners show convincing evidence of a licensing violation that threatens public health or safety.

- Mandatory efficiency standards for lighting, electric motors, heating and cooling equipment, shower heads, toilets, and urinals. Six years ago, President Reagan vetoed a bill that would have instituted many such standards (SN: 11/15/86, p.316).

- Requirements to increase reliance on non-petroleum-based fuels. By 1999, for example, 75 percent of federally purchased cars and light-duty trucks must run on fuels such as natural gas, ethanol, methanol, propane, electricity, or hydrogen.

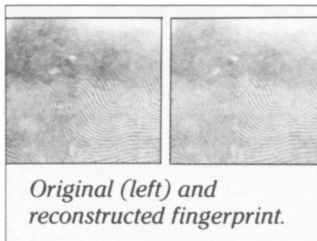
- Plans for new five-year research programs at the Department of Energy (DOE). Some will focus on increasing the energy efficiency of buildings, electric motors, and heat engines (including alternatively fueled gas turbines). Others aim to cut the volume and toxicity of wastes from civilian nuclear reactors, to design environmentally benign fuel cells, to demonstrate the viability of fusion-generated electric power, to standardize the design of advanced fission reactors, to produce high-temperature superconducting equipment (from wires to refrigeration systems), and to generate hydrogen from renewable resources. Two additional programs will work to commercialize advanced materials and manufacturing technologies.

- New programs to cope with greenhouse gases. Within one year, DOE must issue for each greenhouse gas a national inventory of emissions from 1987 through 1990. Six months later, it must publish guidelines not only for the voluntary industrial reporting of greenhouse-gas emissions, but also for the annual collection of data on reductions in those emissions — both intentional (such as through fuel switching and tree planting) and unintentional (such as through plant closings).

- A new interagency research program to investigate possible human-health effects of 60-hertz electromagnetic fields, directed by the Department of Health and Human Services.

New legislation revives WIPP

On Oct. 31, President Bush signed a law clearing away obstacles to tests of the Waste Isolation Pilot Plant (WIPP) near Carlsbad, N.M., a facility for storing nuclear-defense wastes. The bill transferred 10,240 acres of land — containing WIPP — from the Interior Department to the Energy Department. It also gives the Environmental Protection Agency 10 months to set standards characterizing the wastes that can be stored at WIPP during the initial five-year tests. DOE has been spending about \$14 million per month to maintain the \$1.1 billion facility in a standby mode since its completion in October of last year.



Wickerhauser/Washington Univ.