Mathematics

Ivars Peterson reports from Washington, D.C., at the International Conference on Industrial and Applied Mathematics

Calculating the Wright stuff

With the temperature just above freezing and winds blowing steadily at more than 20 miles per hour, the weather on Dec. 17, 1903, at Kitty Hawk, N.C., appeared decidedly unfavorable for flying – especially for attempting the first flight in a heavier-than-air, powered and manned plane. But Wilbur and Orville Wright decided to go ahead, and the rest is history.

The Wright brothers had every reason to expect that their flyer would get off the ground, contends mathematician Robert N. McCullough of Ferris State University in Big Rapids, Mich. "I believe that the main reason for their confidence was mathematics."

In developing their aircraft, the Wright brothers carried out extensive experimental work and a large number of calculations. To obtain the details, McCullough delved into the published edition of their collected papers. He found that by the time the two men were ready to test their aircraft, they had all the necessary mathematical formulas and data on aerodynamic forces to calculate in advance that flight was possible. In many cases, that information came from their own wind-tunnel tests.

Whether the Wright brothers actually made the necessary calculation on that day at Kitty Hawk isn't known, McCullough says. But the numerous calculations they had performed in the months preceding the historic flight certainly would have told them that they had a reasonable chance of success.

Computing with real arithmetic

Computers and calculators generally have a fixed, limited number of slots in which to stuff the digits that make up a given number. This presents a problem when a computation involves a number that has more digits than the number of slots available. To overcome that difficulty, computer scientists in the 1950s developed the floating-point system of arithmetic, expressing each number in two parts. One set of digits gives the rounded-off number, and the other set represents, in effect, the position of the decimal point.

Although widely applied, the floating-point system still causes problems, especially when calculations using operations such as multiplication or subtraction yield answers that are extremely large or extremely small, falling outside the range of numbers that the system can represent. At that point, the system fails, and the computer produces the wrong answer or no answer at all.

To overcome this flaw, mathematician Peter R. Turner of the U.S. Naval Academy in Annapolis, Md., and others have been studying an alternative, logarithm-based method of representing numbers on a computer. For a given number, the idea is to find natural logarithms repeatedly until the result lies between 1 and 0. Thus, the original number is represented by the number of times the logarithm has been determined (the level) and the final logarithm (the index). The computer then uses this particular combination of digits in its calculations.

This "symmetric level-index" scheme avoids many of the problems the floating-point system encounters with numbers close to zero or approaching infinity. But it is slower, and if built into a computer, it requires more complicated circuitry than equivalent floating-point schemes. Nonetheless, says Turner, "I would maintain that useful information attained more slowly is better than getting no answer at all quickly."

Similar criticisms initially greeted the floating-point system, which was slower than whole-number arithmetic. Yet that method flourished because it allowed researchers to develop efficient ways of solving problems they couldn't tackle before. The same may yet happen for symmetric level-index arithmetic. Although individual operations are slower, simpler programs could result.

Science & Society

High-tech eyes check train 'fingerprints'

Sometime next month, a sophisticated scanner will begin helping a railroad company keep track of its freight cars. The system works by recognizing each car's distinctive features, says Robert Thibadeau, a computer scientist at Carnegie Mellon University in Pittsburgh.

Misplaced freight cars mean lost revenues, but cars do break down and get separated from their trains, so they don't always show up as scheduled. Railroad companies currently depend on employees to check car numbers as each train pulls into the yard. In addition, a small percentage of the 1.4 million freight cars in North America carry transponders that emit identifying radio signals.

But transponders break down, and ID numbers wear off as the cars undergo abuse from the elements. Moreover, updating the centralized database on car locations can take many hours. "People who are managing the flow of the trains . . . depend on the accuracy of the data," says Thibadeau.

Using machine-vision technology developed for industrial robots, Thibadeau has created a high-resolution image scanner that can identify a freight car, no matter how beat up. It notes physical traits as well as broken rivets, dents, rust, chipped paint or other types of damage that form a "fingerprint" unique to each car. The scanner's camera picks up details as small as a quarter of an inch, and its powerful computer anticipates degradation, taking those changes into account when identifying cars.

The system images a freight car as it passes into a railroad yard, picking up 9 megabits of data or more per car. If the fingerprint is not the one expected, the system checks through the fingerprints of all other cars expected in that train. If no match appears, then the system reads the identification number. If that fails, the program sorts through categories of cars and features to find the car's identity in the database. In theory, the computer can then instantly update a centralized database about the cars sighted.

The project's sponsor, CSX Corp., has set up one camera in Tampa, Fla., and may install others by November to assess the system's utility, says Percy F. Shadwell Jr. of CSX's Jacksonville, Fla., office. The company will evaluate how well the system holds up against foul weather and vandalism and whether it works fast enough to be practical.

"My personal opinion is that this technology as we're developing it may have a major impact on the whole transportation industry," says Shadwell. "The recognition technology we use could potentially be used to recognize anything." He also envisions adapting the system for safety inspections.

OTA: Highways need repair, not expansion

Hauling refrigerators from one side of New York City to the other can take more effort than sending them across the ocean. Airline travelers often spend more time getting to and from airports than in flight. Such is the sad state of the U.S. transportation system, concludes the congressional Office of Technology Assessment (OTA) in a report released last month.

OTA faults the decades-old federal policy that has focused on the construction of interstate highways, charging that it failed to keep up with the changing needs of society. Instead, the report suggests four options for Congress to consider, and it recommends improving highway maintenance and rehabilitation programs, working to make rural areas more accessible and urban areas less congested, and creating more efficient, less polluting transportation methods.

The report, titled "Moving Ahead: 1991 Surface Transportation Legislation," cites a need for more research and calls for closer ties between transportation and environmental administrators and between state and federal officials.