COMPUTER SCIENCE

Program Proves That Checkers, Perfectly Played, Is a No-Win Situation

If two players face off at checkers and neither makes a wrong move, then the game will inevitably end in a draw. That's the result of a proof executed by hundreds of computers over nearly 2 decades and reported online by *Science* this week (www.sciencemag.org/cgi/content/abstract/1144079). The finding guarantees that an appropriately programmed machine will never lose to a human. It also marks a personal victory for Jonathan Schaeffer, a computer scientist at the University of Alberta in Edmonton, Canada, who set out to "solve" checkers in 1989.

Hopeless. Unable to beat the computer program, a human will eventually make a mistake that leads to a win for the machine.

"It's a huge accomplishment," says David Levy, president of the International Computer Games Association in London and an expert on chess-playing machines. "It's by far the most complex game ever solved." The tools and strategies developed for the problem might prove useful for analyzing genetic code or computerized translation, he says.

The point of checkers, or draughts as the game is also known, is to get the jump on your opponent. The game is played on an eight-by-eight grid of red and black squares. The checkers are black and red disks that can slide forward diagonally from black square to black square. The players, call them Bob and Rita, start with 12 checkers each in the rows closest to their sides of the board. Players move in turn, and Bob can capture one of Rita's checkers by hopping over it into an empty space just beyond, and vice versa. Checkers that cross the board become "kings" that can move backward. The game continues until one player captures all of the other's pieces.

Schaeffer and his team have shown that if Bob and Rita have perfect foresight, they will always reach a stalemate in which neither can finish the other off. So checkers resembles tick-tack-toe (known as "noughts and crosses" in Britain), the game in which players fill a three-by-three grid with X's and O's in hopes of getting three in a row. Given that there are roughly 500 billion billion possible arrangements of checkers on the board, proving checkers is a guaranteed draw is far harder than proving that tick-tack-toe can't be won.

The researchers began by constructing a database of all 39,000 billion arrangements with 10 or fewer pieces on the board. In the process, they determined whether each one led to a win for black, a win for red, or a draw. They then considered the very beginning of the game, opened with a move by black, and then used a specialized search algorithm to trace out subsequent moves and show that, as the two players try to maximize their advantage, they inevitably steer the game to one of the 10-checker configurations that leads to a draw.

Schaeffer credits improvements in computers for making the result possible. In fact, he suspended work from 1997 to 2001 to wait for a particular technology—the 64-bit processor—to mature. But Murray Campbell, a computer scientist at IBM's Thomas J. Watson Research Center in Hawthorne, New York, says that the researchers' ingenuity was key, too. "Without a lot of the clever ideas behind what they did, I think it would have been a number of years before technology alone could have solved checkers," says ▶

U.S. SCIENCE FUNDING

Pentagon Is Looking for a Few Good Scientists

Topflight researchers at U.S. universities, the nation needs you.

This fall, the U.S. Department of Defense (DOD) will launch a grants program to fund researchers with innovative ideas for tackling important security challenges. It will be modeled on the National Institutes of Health Director's Pioneer Awards, which support blue-sky, interdisciplinary research in biomedicine. DOD plans to make about 10 awards, each good for $3 million over 5 years. Applicants for the National Security Science and Engineering Faculty Fellowships must be U.S. citizens, and preference will be given to early-career researchers.

Agency officials hope the program will foster research outside the bounds of predetermined research questions. "We do not have specific areas in mind; rather, we have challenges that cut across several disciplines," says William Rees, DOD's deputy under secretary of defense for laboratories and basic science. Although the research performed under the program would be unclassified, awardees would need a security clearance to be briefed on the challenges they are supposed to address.

The challenges, not yet chosen, are likely to be similar to those identified last year by DOD's Quadrennial Defense Review. Its list of priorities includes biometrics; social, cultural, and behavioral modeling; tracking of enemy targets; countering improvised explosive devices; and extracting information about suspicious activities and events from large data sets. Agency officials plan to invite about 20 applicants who survive an initial cut to make presentations at the Pentagon. The first class of winners will be announced next spring.

V. S. Subrahmanian, a computer scientist at the University of Maryland, College Park, whose research is partly funded by DOD, says allowing researchers to come up with proposals in response to agency-designated challenges is an "outstanding" idea. "We are used to having research topics defined top-down by DOD," says Subrahmanian, who plans to apply. "While that usually works well, researchers know best what their field has to offer." He also thinks the fellowships will create a "corps of academic researchers dedicated to defense and national security."

If the first round goes well, DOD officials hope to eventually support as many as 50 researchers.

–YUDHIJIT BHATTACHARJEE

CREDIT: ALYSSA GROEN

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Campbell, who co-wrote the Deep Blue program that defeated chess champion Garry Kasparov in 1997.

Most experts expected that checkers would eventually be proved a draw, says Jaap van den Herik, a computer scientist at Maastricht University in the Netherlands, if only because grandmaster players routinely play each other to a draw. But, he says, "if you have not proved the result, then every expectation is worth nothing."

Schaeffer says he feels vindicated by the proof. In 1994, a program he developed called Chinook played the then-reigning world champion, Marion Tinsley, to a series of draws before Tinsley withdrew because of health problems and conceded. Tinsley, who is considered the best player ever and who lost only three tournament games from 1951 to 1991, died of cancer 8 months later. Some players scorned Schaeffer, he says, and even charged that the stress of the special title match had killed Tinsley. Chinook defended its crown in two subsequent matches against the next-highest-ranked player. "To this day, I still get people saying that you would never have beaten Tinsley," Schaeffer says. "The program today would never lose to Tinsley or anyone else, period." And because humans eventually make mistakes, the program should inevitably prevail in a series of games against any person, even Tinsley, for whom Schaeffer says he has "great respect."

Van den Herik worries that Schaeffer's solution will accelerate the decades-long decline of tournament checkers. Meanwhile, Schaeffer is turning his computers to poker. In principle, that game can't be solved—but it can make you a lot of money. **–ADRIAN CHO**

U.S. WEATHER FORECASTING

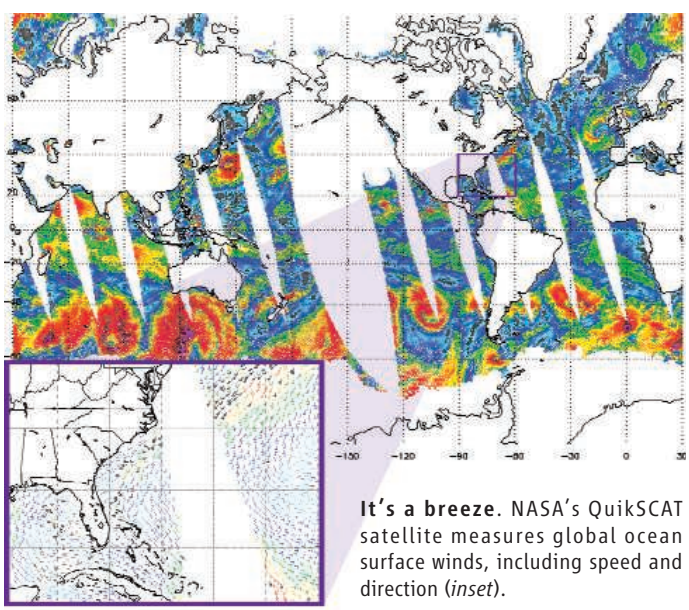
Satellite Kicks Up a Storm Looking Out for Hurricanes

An 8-year-old NASA weather satellite sits improbably at the center of the latest scientific storm raging in Washington, D.C.

In the last 2 weeks, two congressional panels have held hearings on events surrounding the ouster of William Proenza as director of the National Hurricane Center (NHC) on 9 July. Proenza had repeatedly criticized his employer, the National Oceanic and Atmospheric Administration (NOAA), for failing to plan for the impending failure of QuikSCAT, a satellite launched in 1999 and 3 years past its design life. Proenza, a 35-year NOAA forecaster who became NHC head in January, says loss of the craft's sensors could degrade 3-day hurricane track forecasts by 16%, citing a study in press that analyzed forecasts for six 2003 storms. Scientists familiar with QuikSCAT's capabilities say Proenza was both "right and wrong" in his acerbic charges.

To predict coming hurricanes, forecasters rely most heavily on radar or visual cloud data from satellites, typically NOAA's Geostationary Operational Environmental Satellite. Its information is bolstered by a network of buoys, hurricane-hunting planes, and coastal radar units to help modelers make computer simulations of developing storms. QuikSCAT added to that ensemble by bouncing microwave signals off ocean waters over a 1800-kilometer swath, reporting surface wind speeds by analyzing the reflections. By following a polar orbit, QuikSCAT covers 90% of the oceans, in many areas twice a day.

NOAA researchers have lauded its data, which is particularly useful for detecting tropical Atlantic storms early and providing vital coverage over colder waters, including the Pacific. A Hawaii-based U.S. Navy official said last year it plays a "critical role" in Pacific forecasting. NHC forecasters most treasure the craft's ability to see developing tropical depressions long before they're otherwise detected. Last year, NOAA forecaster Hugh Cobb called QuikSCAT, now operating on its backup transmitter, "our bread and butter."



It's a breeze. NASA's QuikSCAT satellite measures global ocean surface winds, including speed and direction (*inset*).

CREDIT: NOAA/NESDIS/CENTER FOR SATELLITE APPLICATIONS AND RESEARCH

But forecasters don't live on bread alone. Last week, at a Senate hearing in which NOAA officials were lambasted for not preparing adequately for QuikSCAT's demise, NOAA satellite branch chief Mary Ellen Kicza tried to poke holes in Proenza's arguments. The satellite's sensors don't quantify hurricane wind speeds greater than 105 km, can't see well through rain, and its polar orbit means QuikSCAT "may not be at the right place at the right time," she said. European and U.S. Navy satellites provide data "not quite as good" as QuikSCAT but could plug holes if the NASA craft fails, she said, adding that NOAA's other tools pick up storms once they seem headed for a landfall. "We are not blind" if QuikSCAT dies, Kicza asserted.

Meteorologist and respected weather blogger Jeff Masters agrees, noting that the unpublished study Proenza cited involved only one of roughly seven active forecasting models. Folding in all the simulations, plus the rest of the data sources, creates a "global system" of which QuikSCAT is but one element, says hurricane expert Greg Holland of the National Center for Atmospheric Research in Boulder, Colorado. So Proenza "was right and wrong," Holland explains.

A joint NASA-NOAA study, due next year, will spell out the next options. But lawmakers want to push NOAA along. In May, Representative Ron Klein (D–FL) and co-sponsors proposed a bill to authorize $375 million to build a QuikSCAT replacement. "The loss of this data—whether minute or significant—could cause dire consequences," Klein told the committee. Those funds, however, have not been included in appropriations bills moving through Congress that otherwise provide generous increases to NOAA's 2008 budget.

–ELI KINTISCH

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