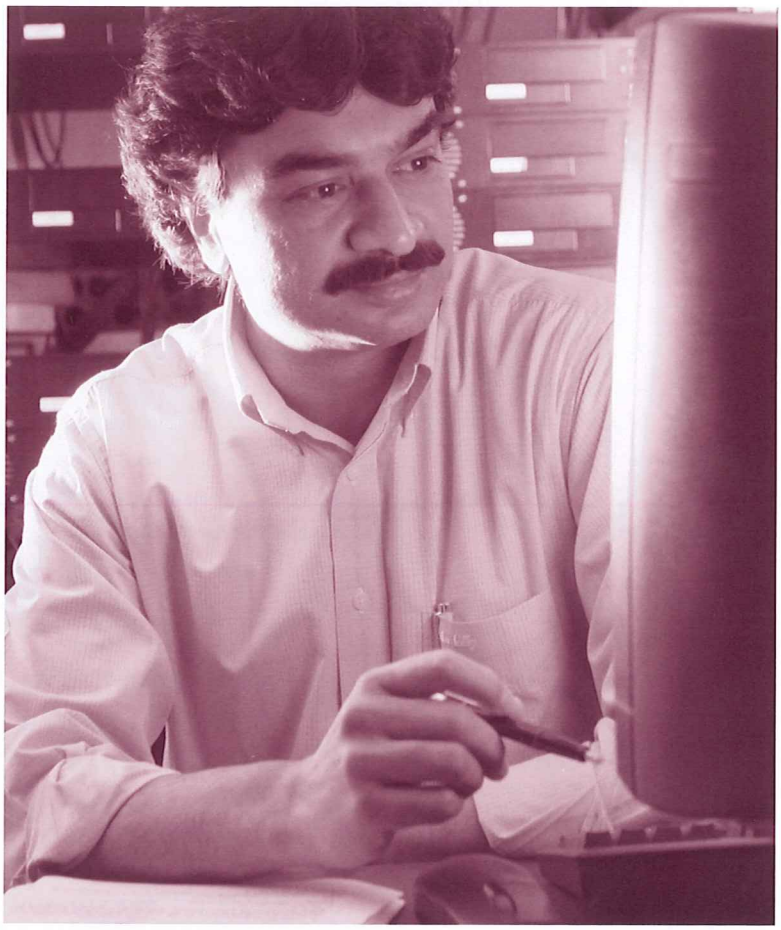
Tooling in technology

Anil Shende leads students in decoding a digital world

"Snakes" and "Hypercubes" — they're not exactly what you'd expect to be uppermost in the mind of the average college student, but Aleah Dillon is far from average. She's a Roanoke College senior with double majors in math and computer science and lots of intellectual curiosity.



Working under the supervision of Dr. Anil Shende, associate professor of computer science, Aleah spent the summer of 2004 as a Summer Scholar researching error-detecting codes. Her paper, *Maximal and Longest Snakes in d-Dimensional Hypercubes*, was underwritten by a National Science Foundation grant that was awarded to Shende and Dr. Abdulnasser Barghouty, associate professor of math, computer science and physics.

Besides helping underwrite student research, the NSF grant also helped Roanoke College obtain a 64-processor cluster. It has 32 computers, each with dual processors, which enables the user to take a complex problem and break it into pieces to work on. Because different processors are working on different parts of a problem, processing is immensely faster.

"It's highly unusual for a college our size to have such equipment," Shende says.

Aleah used that processor cluster for her project and had the added advantage of working with Shende, whose specialties include parallel and distributed computing and algorithms and who has long been researching hypercubes. Hypercubes are mathematical structures that are arbitrary dimensional cubes (arbitrary in the sense that they have no limit). A snake is a path in a hypercube in which no two non-adjacent vertices in the path are adjacent in the hypercube. Shende holds the record for finding one of the longest known snakes in an 8-dimensional hypercube.

Aleah says the research may improve error detection in digital communications. "Hypercubes are used in designing error-checking and detecting codes," she says. "By suitably labeling vertices of hypercubes, you can find a longest snake, enabling such a design. The ultimate goal is to find a pattern among the proof techniques because a limit to this pattern would help improve what we currently know about the lower bound on the length of a longest snake."

Shende has a knack for putting such esoteric subjects in layman's terms. He explains, "When you transmit data, you're really transmitting bit patterns because everything — text, images, sound — is stored as zeroes and ones. It's like a code.

"But when you transmit things, they go on wires, and there could be outside influences on the wires, and some bits may be changed in the process of transmission. So, for example, when

you receive the coded text I sent you, there may be changes in it. Instead of a capital 'A,' there could be an 'X.' A good coding scheme, where you can do one bit error checking, is one where no matter which bit of that 'A' changed, you could still tell it's not a correct code."

It's precisely the type of tough problem Shende challenges his students to tackle. His goal is not merely to give them technological tools but to teach them to think critically about their use, to analyze the "why" as well as the "what" of computing.

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— Aleah Dillon, senior

In the error-checking example, he says, you need to find a string of zeroes and ones, of "words," so that if you now pick alternate words in that string and use them as a coding mechanism, you're skipping middle words because they're not valid codes. "If you can arrange it so that one bit of change will put the word in the middle, which you're skipping, you can decide at the other end that that was an error. That's how you can get an error-detecting code, and the longer the string, the better the code. That's why you want the longer one because a snake satisfies this property you want from this string."

That all makes sense to Aleah. "Dr. Shende helped guide me," she explains. "I met with him almost daily, told him where I was in my research and what I had discovered. If I got stuck, he helped me figure out where I was going wrong. The research subject has been under study for some time, and once I told him I was interested, he gave me some papers to read about it. I wanted to involve both computer science and math, and this subject did that, and it was exciting."

Shende says the Roanoke College environment is very supportive of student research and that he enjoys working with the students and seeing their projects unfold. "Getting students interested in a problem, seeing how they immerse themselves in it and watching them experience the joy of discovering something new — all of that is very satisfying when you see that end result," he says.

Aleah's paper was presented twice last year, at a student conference at Sweet Briar College in October and at a November conference of the Consortium for Computing Sciences in College, a peer-reviewed conference. Shende requires all his students to submit their research papers to an outside peer-reviewed conference. "It's good experience for the students, very useful," he says. Three research papers were accepted for the CCSC conference, including another from one of Shende's students from India, who won the student research paper contest at the conference.

Shende spent his 2001-2002 sabbatical at the Birla Institute of Technology and Science (BITS) in Pilani, India, teaching a course on parallel computing and working with students on research projects. He earned his M.S. (Tech) in computer science at BITS and got his M.S. and Ph.D. in computer science at the State University of New York at Buffalo. He had taught at several institutions prior to joining Roanoke College in 1995.

In addition to external grants, Shende has received several research grants from Roanoke College. He also has long been active in CCSC-SE and regional and international computing conferences and has to his credit countless technical papers in prestigious publications. A forthcoming paper, completed with the aid of student research, will be published in the *Journal of Mobile Networks and Applications*. That paper and others were presented at international peer-reviewed research conferences.

"We get very bright students in computer science," Shende says, adding that such students tend to be self-motivated. "I had another Summer Scholar this past year, Mason Vines, who presented research on game theory, called 'The Prisoner's Dilemma.'" Another of his former Summer Scholars, Pam Armata, also worked on that game theory and was chosen to present her research at a highly competitive student research program called "Posters on the Hill," in Washington, D.C. "It's very much a plus to be included," he says.

In addition to Summer Scholars, Shende works with students who are doing Independent Studies during the year. "I want students to have the ability to learn new topics, and that's where research comes in," he says. "Computer science has grown so much that you can't possibly cover everything in four years. Some of it has to be learned by yourself, some in graduate school, which is almost a necessity at this point. My goal is to prepare students for graduate school."

Aleah says he has accomplished that goal. "Working with Dr. Shende I was able to see how research in graduate school would be, not just the teacher-student relationship but more like a mentor-mentee. Dr. Shende is demanding, but I like that. I'd rather have someone push me beyond my limits, and he did that, and I was able to achieve things I didn't realize I could."

One reason Aleah came to Roanoke College, she says, was that the math and computer science departments were so strong. "I'd been accepted at Virginia Tech, too, but I picked Roanoke College primarily because its computer science department was stronger. I was actually tutoring students in my sophomore year." ◆