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UBIQUITY INTERVIEWS USC'S DR. ALICE PARKER

Alice Parker is a Professor in the electrical engineering department at the University of Southern California, where she has also served as Division Director for Computer Engineering, Dean of Graduate Studies, and Vice Provost for Research. Among numerous other honors, she has received an NSF Faculty Award for Women Scientists and Engineers and is a fellow of IEEE.

UBIQUITY: What are you mainly focusing on these days?

PARKER: I have many diverse research interests, including automatic synthesis of networked systems, network-on-chip architectures, and autonomous vehicles, but I've put all these projects on hold indefinitely, and am only focusing on just one research problem these days, and am trying to answer only one question: When are we going to be able to construct a synthetic cortex of reasonable size? It turns out that this question has many dimensions, and we are looking at a lot of them. We're interested in electronic circuits that model neurons in a biomimetic fashion, sometimes called neuromorphic.

UBIQUITY: And so you're modeling the cortex?

PARKER: Yes, because that's the most complex region of the brain -- but we are also looking at sensory inputs that involve the cortex, especially the visual cortex. Many researchers in the past have modeled neurons with software, or with simplified models such as the perceptron. A few are modeling neural behavior quite accurately, and we are following that research. We are looking at models of the neuron that take into account complex aspects of neural behavior, in the interest of producing accurate models, and models that are flexible enough to model changes in neural behavior under different circumstances.

UBIQUITY: Where is your research leading you?

PARKER: The basic premise is that if the model is accurate enough, the behavior elicited should approximate that of a biological brain, at least in certain aspects. We are even modeling the effects of neurotransmitter concentration, so that a cortex being modeled to exhibit a good night’s sleep might behave differently from one that has certain transmitter deficits.

UBIQUITY: How did you get interested in this problem?

PARKER: I’ve been interested in it since my first days as a graduate student, inspired by Michael Arbib and Bernie Widrow. Carver Mead at CalTech revitalized the field in the late 80s, and he and his former students, especially Kwabena Boahen, have been active in this area since. Now, the technology has matured to the point that transistor densities are sufficient to consider brain models -- large enough neural networks to model portions of an entire brain. Our predictions show that sufficient space to house all the neurons in a human cortex could by provided by the free floor space in my office by the year 2021. However, the problem is not the neurons themselves, but their interconnections. The average neuron in the cortex connects to around 10,000 other distinct neurons, and, over time, transistor density is predicted to increase much more rapidly than interconnection technology. So what we are looking at is a diverse field of technologies for interconnection, including networks on chip, photonics, stacked CMOS dies, spin waves, carbon nanotubes and nanowires. A further complication is the somewhat recent understanding of the plasticity of the brain, with structural changes occurring even in mature brains.

UBIQUITY: That's fascinating. What' the history of your project?

PARKER: This project began in April of 2005, but was essentially on hold until after the second DARPA Grand Challenge, where I competed on Team Tormenta. We have begun to look for funding for the synthetic cortex and are collaborating with researchers at UCLA as well as other engineering and neuroscience faculty at USC and Stanford. At any one point, I have about 20 graduate students busy on the diverse research problems that have arisen from our single question, including a half-dozen Ph.D. students, and even two undergraduate students.

UBIQUITY: Have you gotten any outside support for the project?

PARKER: Not yet, but that has not been the initial priority. We just started in April 2005, and since we took time out for the DARPA Grand Challenge, the project effectively got off the ground in Jan., 2006. I took a hiatus from research for quite awhile, doing administrative work for the university and some other things with my personal life. And when I came back to research I wanted to start in a different direction. And what started intriguing me was the notion of how much processing it was going to take to build a synthetic cortex, and when it was going to be economically viable. Technology is moving very rapidly, and nanotechnology holds a lot of promise as an implementation technology for a synthetic cortex, especially carbon nanotubes. We recently simulated a carbon nanotube synapse (an input portion of a neuron that responds to “firing” of other neurons) that allows us to adjust certain parameters like neurotransmitter reuptake and ion potentials in order to display a variety of synaptic behaviors

UBIQUITY: Talk a bit about your career. How did it develop?

PARKER: I think I stumbled into computing, coming from electrical engineering. I got involved in computing for a variety of reasons, some of which weren't that good. I was kind of surprised at what happened and how computing took off, but once it took off -- which was, I think, the point where HP was starting to make hand calculators -- that was when I said, OK, computing is going to be something interesting. I was fascinated by what can you build in an integrated circuit and how you can build it. So I went to Carnegie Mellon as an assistant professor, and there were already a couple of people there working on a project called Synthesis, that had been inspired by Gordon Bell, who had asked the question, "Can you generate hardware automatically to do any instruction set that you want for a computer?" And so, I got very interested in synthesis and we pushed it further and said, "Can you generate hardware that does any function, whether it's a computer or any other digital system? Can you generate the hardware automatically from a high-level description of what the hardware should do, an algorithmic description?" So we started out in 1975 trying to do that. And the students that started working on it got results very quickly, maybe three years later. We had software that could design a computer called a PDP-8.

UBIQUITY: Gordon Bell had designed that, right?

PARKER: Right. Gordon Bell had designed it, and so we were thrilled that we were able to synthesize it automatically. At CMU, we started an area called high-level synthesis or behavioral synthesis. And we were well before our time because people didn't need to synthesize our target systems, application-specific circuits. There wasn't a demand for them. There wasn't a market until years after we had perfected the research so that it could be developed into an application technology, i.e, to a technology that people actually use. So, it was a technology that was anticipatory. At one point in the early 90’s we showed that we could synthesize a complex signal processing chip from the algorithmic specification in under 48 hours. At the end of about a decade and a half of doing work in that area I said to myself, "OK, we can build chips now, but we really need to build systems." And so, I started looking to see whether we could synthesize systems automatically -- multiprocessors, again -- systems that might be used for specific applications. A digital system to control an autonomous vehicle is a good example of an application-specific system. And it took about a decade to figure out how to generate systems from very high-level specifications and how to specify them, how to represent them, how to optimize them, how to determine the number of processors I need, which tasks go to which processors, how much memory space or disk space do I need, and so forth. And so that took about a decade.

UBIQUITY: What then?

PARKER: And then I realized that people were using a lot of networks but nobody had a formal methodology to design the physical networks. It was very *ad hoc*. So we started looking at the following problem: If you're going to network a lot of people together in a single enterprise, how do you decide where to put the bridges and the routers and what kind of networking strategy should you use? Will you use ATM switches? Will you use Ethernet? Will you use gigabyte Ethernet, whatever? Where do you put the file servers? How many of them? Which files go in which servers? So, we started looking at that problem and spent about a decade on that one. I've anticipated three different stages of needing CAD tools for technologies that people didn't think they needed CAD tools for when we started -- yet had decided at the end that they did. Now we are at the end of that, and I'm asking myself a different question. Now we're trying to look at where technology's going for a very sophisticated application, the synthetic cortex, and figure out when it's going to be there -- or is it going to be a case of the basic core technology's still not here to support what we need to do? So, it's going full circle back to my initial interest, which was in trying to build neural chips and neural network chips. The technology wasn't there in the early '70s, and so research progressed slowly. And then it came back in the '90s because now the technology was there to build neural chips. So now my question is: ***when*** will we be able to build a synthetic cortex in the future?.

UBIQUITY: You're also working on a robotic car project under US and California government sponsorship, right? Tell us a bit about that.

PARKER: We participated in the 2005 DARPA Grand Challenge Qualification Trials with a team composed mostly of USC faculty and students, including my son Joe Bebel, who's an undergraduate at USC in Computer Science, Physics and Electrical Engineering. We spent less than $20,000, over a period of 9 months, to produce an operational vehicle. That's roughly .1% to 1% of what most of the teams spent. I wanted to show DARPA that the basics could be executed in a simple, inexpensive, straightforward manner. The vehicle, a Jeep Cherokee, followed GPS points around an obstacle course designed by DARPA. The vehicle used laser rangefinders and stereo cameras to avoid obstacles. A tunnel that resulted in a GPS outage planned by DARPA caused problems for us, as well as other vehicles, and we did not qualify for the final challenge. As an outgrowth of that research, we have funding now to look at automating the vehicles used in major ports, like the Port of Los Angeles, with machine processing of a video camera stream.

UBIQUITY: You mentioned earlier that the students are interested in these applications. What's your assessment of today's students?

PARKER: The masters students we're seeing are generally more focused, they're much more career-oriented, much more strategic in how they target where they want to be and how they want to market themselves as engineers. Many students are less motivated by wanting to solve a real problem that they've seen ("I think I can really solve this and contribute somehow") and more likely to ask themselves: "Let's see, where's the job market going and how can I focus on it?" I don't want to be critical about the students because they're very bright and well-prepared. But with doctoral students, and with our own undergraduates, I see more of that spark, the thing that drives an inventor forward -- the idea that she or he wants to solve a problem, to make the world a better place by contributing to technology -- that kind of motivation a select set of students have who are just delighting in the technology and in what they can accomplish with it. As I say, that's a very select set. And I have some opinions on why that is the case.

UBIQUITY: And those opinions are -- ?

PARKER: Well, it has to do with how these young people are educated K through 12 and what happens to them when they get to college. What has happened is that these students have been told what they should take, what they should study. There is so little choice in how students plot their educational course K through 12 that they are used to having all the decisions made for them. That is a generalization and is not true of all students; still, it is very hard for them to even know what they're interested in because they are so caught up in doing what they think they should be doing -- what people tell them they are supposed to do, what they're supposed to study, that if they do this, this and this the odds of getting into Stanford or Harvard will be greater. And so, they don't develop that ability to think independently. The natural curiosity that kids have disappears. And so we don't see these students being self-motivated or being able to say, "This is what I really want to do with my life." Instead, we see students saying, "Well, if I take this course can I get a better job?"

UBIQUITY: Contrast that with your own education and early background.

PARKER: Actually, I think that my own experience was very similar. I think I didn't really learn how to do research until even past my Ph.D. because I was so programmed to do whatever I was supposed to do. Tell me what to do and I'll do it. Tell me which chapter to read and I'll read it. Tell me which references are good for my thesis and I'll go read them. And I think especially for some students who are very good students, they're good students because they do whatever they're told to do. And it's very hard to break out of that mold and say, "What do I really want to do? What am I really interested in? What do I find fascinating?" And when I hit the ground running going to Carnegie Mellon as an assistant professor, I looked around at the projects that were going on and, for the first time, I could do what I wanted to do, it changed my world. And so one of my goals with my students is always to try to have them develop an interest in something that they can say this is really what they themselves want to do. I let the students kind of lead me along sometimes into directions that I may not personally be interested in -- like the smart home project -- because they're excited, they're interested and they can develop a sense of purpose, which is good for them.

UBIQUITY: So just becoming an assistant professor at CMU was like turning on a light switch -- because you could do what you wanted to?

PARKER: Yes. I had spent a year at Stanford on the Master's program. I was exposed to a lot of material, a lot of solid coursework and a little bit of research, but not enough to say, "OK, I want to think about what I really like doing," in a way that I was able to do at Carnegie Mellon as a professor, because then you're on your own and have a lot of freedom. Then looking back at my own education I thought: the way I was educated just wasn't the best.

UBIQUITY: But isn't it the case that assistant professors in a tenure track have very rigid hoops to jump through?

PARKER: I suppose so. I didn't look at it that way because I wasn't focused on getting tenure at Carnegie Mellon because I had this dream in my mind to be in California, so I just said, OK, "What am I interested in? What am I going to do?" And I looked at a lot of different, exciting things like electronic music, which was a lot of fun. And it was only when I came to the University of Southern California that I said, "OK, now I think I'll focus." And I focused on design automation at that point. But I think what I learned from the experience -- and what I try to instill in my students -- is this ability to identify what they really want to do in life and redevelop the natural curiosity they had as kids so that they're motivated from inside and not by some boss telling them you need to do this or you'll be fired. Because I think self-motivation will carry them through not one, not two, but three different careers, because you have to be self-motivated to be able to transition all the changes that are happening in technology. You can't just do it because you're being forced to. It doesn't work that way. People get old and tired and they don't want to learn something new. You have to be motivated to learn and to have that curiosity. And so that's what I'm trying to instill in the students.

UBIQUITY: What about when you were an administrator?

PARKER: Well, I had two hats. And one of the hats was dean and then vice provost for graduate studies. And there I had very little influence over graduate students because we were more concerned with the day-to-day operations to make sure that Ph.D. students were getting treated fairly, that dissertation progress was occurring, and all the nuts-and-bolts things. The other hat I wore was vice provost for research, where one of my main charters was to try to highlight interdisciplinary research in the university, and one of the areas I picked to focus on was the study of violence. That was very rewarding, and I guess I spent more time working with faculty than with graduate students, because the problem to be solved was how to get some interdisciplinary research projects underway to study violence from multiple points of view.

UBIQUITY: What was the gist of the project?

PARKER: It was focused on young people in terms of the violence studies -- gangs, students in high schools, even younger children subject to domestic violence -- and on what the side effects of that are. But there was also a focus on whether we can take what people learn in the social sciences about violence and use it to draw inferences and build predictive models that tell us what works and doesn't work in terms of interventions. I started talking to some of the engineers and mathematicians who had an interest in predictive modeling, and there were several individuals with the L.A. Police Department who were very interested in predictive models in violence and in trying to understand some of the activities that were going on in the brain when crimes were being committed, and interested in the criminal mind, the deceptive mind. So, trying to fold all that together was an interesting project. And there's a violence research group I started that is ongoing and has joint seminars and mailing lists. The project didn't become as large as I would like, or as broad-based, because I only spent a couple years on it, but it is an interesting group and they're making progress.

UBIQUITY: Was there much violence among the faculty? No, no, strike that!

PARKER: That's a different subject.

UBIQUITY: What impact has the Internet had on education at USC?

PARKER: Let's see. Well, I started using the Internet in 1975 when it was the ARPANET. It didn't have an impact on students for the first few years, but once they started, the ability to communicate with their colleagues at other institutions has just been invaluable. Students know what other students are doing at other universities -- the faculty not only know what each other are doing, but also the students do. So, just the collaborative potential is amazing! The other thing that's amazing is the ability to get research publications at your fingertips. You just search and, boom, you have what you need either from Google or Google Scholar or ACM or IEEE. You can get access to so much so quickly. Last fall I was teaching a PhD level class in computer-aided design and I said, "We're not going to use a textbook, we're just going to look at what's available on the Internet to us as a university and we're going to use it -- whatever the university's already paid for or whatever's free and is not copyright-protected, that's what we'll use." We were able to do an entire Ph.D.-level class with lots of reading without the students ever having to purchase a single item. It kind of changes the textbook model because the university's purchasing the access and then the students just have it available.

UBIQUITY: Now, is this kind of model likely to move in the foreseeable future to less elite institutions or to underdeveloped countries? What is the likely scale of the impact of what you're talking about?

PARKER: I think there's a big impact because institutions that can afford less in the way of print journals are certainly benefiting by the electronic subscriptions. They're still very expensive, but I think that as the prices come down that electronic subscriptions will be a big benefit to researchers working in an area where they might be the solitary researcher in their department. Everybody else is focused on teaching and they'll be able to have access to things they couldn't have access to before. And the individual cost for the electronic libraries are not that great, and I think electronic access to research journals has changed the world of research. We were able to jump onto the current topics as they came up and say, "OK, what's really happening here? What can we predict about the technology? What can we research?" It's just been an amazing change in ability to do research.

UBIQUITY: Beyond the question of document availability and research tools is the question of instruction. Is there anything in distance learning that particularly excites you?

PARKER: Well, distance learning brings to mind a lot of different things that are good. One of the things it brings to mind is these kids in K through 12 education who are exceptionally bright. And they might be in a school that has almost no resources. Before there were some correspondence courses that you could maybe get a student hooked up with, but now on the Internet there are so many more learning opportunities for these kids. For our undergraduates it's wonderful because I can just send out an e-mail and say, "Here's a link to something very interesting. Go look at it." And maybe only 10 percent of the students go look, but out of that 10 percent somebody's going to get really excited about what they see. And they wouldn't have otherwise if they were just looking at a print textbook. So, it's changed the world of education. With regard to distance education, I think the hardware technology's there, but the software and system technology's not there yet to be able to support ultimate interactive quality between distance students and on-campus students at a reasonable cost. That's not quite there yet.

UBIQUITY: But you see it coming?

PARKER: It's coming, it's definitely coming. Yes. And, of course, things improve week by week. New capabilities are available and prices drop, and so it's coming. The interaction with my distance students is very good through e-mail, instant messaging and message boards. They ask questions and I answer them and I get to know them through the e-mail correspondence sometimes better than I get to know the on-campus students, because the on-campus students tend to just ask a specific question, whereas the e-mail students use it as their little window into university life, and so sometimes they'll say, "By the way, I was wondering do you know about such-and-such class? Do you think that would be a good one for me to take?" So you start getting into dialogue with the student that is broadly more helpful to them.

UBIQUITY: Will distance learning be equally effective in developing countries?

PARKER: Most certainly. One of the most rewarding activities I have been involved with in recent years has been volunteering in a leadership role for the Josh Groban Foundation. (Josh Groban is a singer – www.joshgroban.com). The projects we take on would not have been possible without the Internet as a communication medium. Our project teams include volunteers from all over the world, including Europe, Africa and South America. We have raised funds and goods-in-kind for children in South Africa orphaned because of AIDS, high school and college students in New Orleans affected by hurricane Katrina, gifted college-bound students from south Los Angeles, children hospitalized throughout the United States, Tsunami victims, and other victims of disasters. I am following the efforts to develop a $100 computer with great interest because the educational needs of children, particularly African children, are so great, and Internet access could be life-changing for them.

UBIQUITY: Very interesting.

PARKER: E-mail is a great leveler for students. They will ask questions in e-mail they won't ask in person. They will challenge professors. They will express opinions. And it's almost as if they're shielded a little bit so that even if they get a stinging reply back at least it's a print correspondence, and so it's not embarrassing. And so they'll be more open.

UBIQUITY: You obviously enjoy interacting with students that way. Do you think you’re typical? Do some other faculty regard it as a burden?

PARKER: I don't want to generalize. I think many faculty really enjoy teaching, but personally about eight years ago when I decided I couldn't do the administrative work and take care of my personal life I started focusing on teaching. And I think that my view has always been radical. I've always been an advocate for students and for students' rights. I think the best thing that we can do for these students is to change the way they think about things rather than to give them specific knowledge. And that's radical in the sense that -- although of course we have a syllabus and we have certain materials to cover -- we have to figure out how best to prepare them for this world that is changing everyday. So, I'm looking at it from a different viewpoint than many faculty, I think. And I told the students I'm changing the way that their brains are organized. Because I want them to be able to think and reason and not just say, "Here's the equation to use." And, in fact, I don't have them memorize anything. We have open book, open note exams because I want them to be able to take what they know about a subject and reason about something new. And to do that you learn a different way. You learn the material a very different way.

UBIQUITY: What was your own high school and undergraduate education like?

PARKER: My high school education was in one of the top high schools in the country, very academically accelerated high school.

UBIQUITY: Public school?

PARKER: Yes, public school in Alabama, one of the top 10 in the country from a very wealthy neighborhood that I didn't live in. I lived on the fringes of. I came out with a very strong background into college and then I went north to North Carolina, and I spent my undergraduate years at North Carolina State, which is a very strong undergraduate school, and studied engineering because there was a scholarship available and I needed the money to go to college. And so, I said, "We did electrical circuits in physics and my physics teacher encouraged me." So I became an engineer, not knowing what that meant at the time, but I became one. And there were, I think, two women in electrical engineering in the department at that point, two women students. There were no female faculty at all. And so, I just sort of fell into it. But North Carolina State was a great undergraduate institution in engineering and is now strong at all levels.

UBIQUITY: Harvard President Larry Summers recently and famously gotten himself into trouble for his remarks about women in science and engineering. What are your thoughts on that general subject?

PARKER: The facts about the accomplishments of female scientists and engineers are speaking for themselves. Strong academic research has refuted his conclusions.

UBIQUITY: And that seems like a good place to end the interview. Is there anything else you might like to say to our readers?

PARKER: Well, I think the great frontier is software and applications at this point, and not technology, even though the technology is very exciting. I look at the demand for complex software systems that we're going to be required to produce, and I'm awestruck by how difficult it's going to be to produce these systems and have them be reliable and fail-safe and just generally safe. So, I think that's the looming frontier and one that technologists have often ignored. They've said, "Oh, yes, software -- that's over there somewhere." I think some of the technologists are going to need to focus on software and applications to figure out how can we best support the software enterprise, because it's a critical one and it's one that is very difficult to envision proceeding the same direction it's been going. Things are getting larger and more complex and harder and harder to construct so that they function in a fail-safe manner. That's the true frontier.

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Professor Parker's Bio: <http://ee.usc.edu/faculty_staff/faculty_directory/parker.htm>

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