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OCTOBER 25, 2011

Q&A: University of Vermont Robotics Researcher Josh Bongard

POSTED BY KEN PICARD ON OCTOBER 25, 2011 AT 11:33 AM IN HIGHER ED, NEWS, SCIENCE, UNIVERSITY OF VERMONT, WEB/TECH | PERMALINK

How and why did life on earth evolve in the myriad ways it did? Would creatures evolve in the same ways, and with the same anatomical structures, if we could rewind time and replay evolution over and over again? And, can humans create robots that not only evolve and learn but eventually become sentient?

These are just a few of the heady questions that University of Vermont robotics researcher **Josh Bongard** wrestles with every day. Little wonder, then, that on October 14, Bongard was one of 94 winners of the Presidential Early Career Award for Scientists and Engineers. The White House honor came with a $500,000 research grant. (And in case you're wondering, no, that's not Bongard's Lamborghini parked outside of Votey Hall.)

This week, the 37-year-old Toronto native took a short break from his research in UVM's **Morphology, Evolution and Cognition Lab** to talk about his work and the

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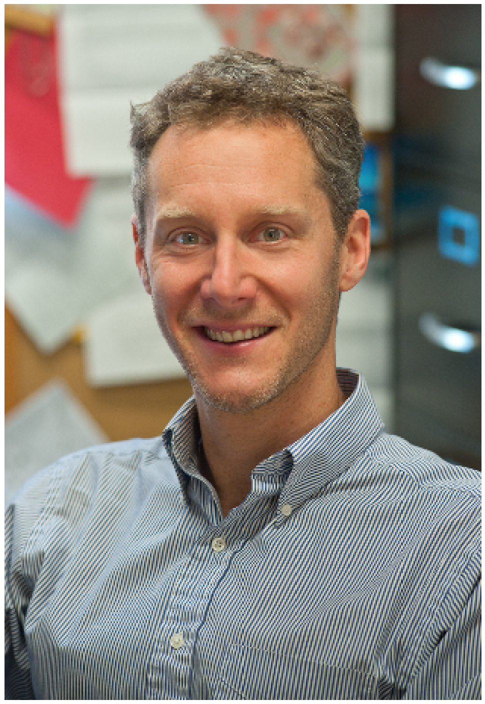
future of "computational evolution." (For visual depictions of Bongard's work, check out the **media link** on his site.)



Bongard is one of 11 speakers at this Friday's **TEDxUVM** event. Registration for the Oct. 28 event is full but the seminars will be streaming live from the TEDxUVM website.

SEVEN DAYS: Did President Obama recognize you for one specific scientific breakthrough or discovery, or was it your entire body of work thus far?

JOSH BONGARD: It's both, actually. This half-million dollars is for a specific research project we proposed and have started research on. But this project is, obviously, built on a lot of other projects we've done in the past. The PECASE [Presidential Early Career Award for Scientists and Engineers] Awards are given for basic science. So, part of the idea is that, by doing this work, there will be a discovery in an area where there hasn't been one before. And then the other part of it is, in your proposal, you have an idea for how to make that basic science, as it's happening, available to everyone. So, there's the basic research side and the educational side that people can peer in and contribute to as it moves forward.

SD: Did you begin your research from a biology background and then move into robotics, vice versa or did you pursue both paths simultaneously?

JB: I have four degrees under my belt. Some of them are biological and some of them are computer science. So, it's a mixture.

SD: What's the nature of the robotic devices you build?

JB: Most of the work we do in my lab is not necessarily on the hardware side. Instead of making robots, what we like to do in our group is to build virtual worlds where robots evolve. We make robot-evolving systems, rather than the robots themselves... My interest in robotics has been conceptual: How did Mother Nature go about creating complex machines, which are animals and plants, and can we borrow some of her ideas to do the same thing in simulation? So, very much how ancient humans bred dogs from wolves, can we breed robots in simulation to do useful tasks in a virtual world? And if evolution succeeds, if we can produce a useful robot in simulation, we could then send a blueprint of that robot to someone else to build a physical version of the robot.

SD: Conceptually, what are some of the hardest challenges for robotics developers to overcome?

JB: We're often borrowing a lot of ideas from biology and obviously, biology is a vast field. And a lot is known about how evolution works. So, what we're looking for are processes that are not tied to the specifics of biology. So they're things that are not specific to carbon-based life forms. They're general design principles. And it's often hard to tell that this is the way Mother Nature did it because this was the only way she could do it given the materials at hand, or this is just the *best* way to do it. It's those latter processes that we're looking for and that's what we want to build into our computer systems.

SD: So, you're literally reinventing the wheel with each experiment.

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JB: That's right. And that, for us, actually counts as a success. We often see things evolving in our virtual world that have evolved before in nature. So, for example, we published a paper last year in which we had snake-like robots that eventually evolved legs. We didn't tell the computer that we wanted legs. We just wanted robots that could get from point A to point B as quickly as possible. So, as you say, we see computational evolution reinventing the wheel, something that biological evolution has already done.

SD: So, there's no fear that the human element somehow inadvertently imposed a bias toward what nature has already done?

JB: No, that's a very good point. We're always very vigilant for that sort of thing: Did we accidentally put something in there that deflected evolution toward a particular solution? So, a lot of our work is trying to prove that that is not the case and that it found that solution because that solution is a good solution.

SD: Have you ever gotten a chill from seeing your robotic creations do something unexpected or shocking — something that you wouldn't have predicted?

JB: Yes, definitely. And that's one of the reasons why I do what I do, that thrill of discovery. You often see something that no one has seen before. To give you one example: A few years ago we were evolving a robot that was to do an interesting task. And it did it without a centralized brain. It had a very, very simple brain and was able to do something more complex than we thought simple brains could do.

SD: Do you think we'll eventually reach a point where robots are as intelligent, or more intelligent, than humans?

JB: I don't think that's a question that science can answer, because it depends on what intelligence means ot you. It's actually very hard to define what we mean by intelligence. I tend to focus on robots because it's very easy to point to a machine or an animal and say it's doing something that looks intelligent. It's waiting, it's thinking, it's planning and then it's doing. So, for myself and others in my field, behavior is the hallmark of intelligence. If it's doing something that looks intelligent, then it is intelligent. There are others who would disagree with us. They would say that there's some magic stuff in biological brains that make us intelligent, and that's something that you'll never achieve in machines.

SD: Is there a holy grail in your research?

JB: The holy grail would be, if you look at nature, nature is continually producing diverse and ever-more-complex organisms. In our research, we can produce complex machines up to a point. And then there seems to be some glass ceiling. We can't seem to get beyond locomotion, carrying objects from point A to point B, very simple planning. But our evolutionary system seems to run out of gas after a while.

SD: And that's not limited by our computational abilities?

JB: No, it has nothing to do with the machines we run it on. We could run it on ten times as many machines and it still runs out of gas.

SD: So, there's something missing.

JB: There's *definitely* something missing. So, the holy grail would be to create one of these virtual worlds where robots of ever-greater variation and complexity continue to evolve without us having to do anything further. Biological evolution did it, and I think we can get computational to do it, too.

SD: Does your work ever take on a spiritual component? After all, you are trying to create a new form of intelligence.

JB: I get that. I don't know that I would use the term "spiritual." I would prefer the term "philosophical." Like the example I gave you where we saw a robot doing something complex, but when we looked at its brain it was much simpler than we expected. And that often reflects back on us. We observe other animals and other humans and we attribute intelligence or empathy or cognition to them. But is it really just the result of relatively simple electrical signals in the brain?

SD: Just like the part of the human brain that's programmed to recognize patterns that resemble human faces. So, when we look at the front grill of a car, we see two eyes and a mouth.

JB: Right. We project patterns.

SD: You're scheduled to speak at the TEDxUVM event. What will you be speaking about?

JB: I'm going to be talking about how big data applies to robotics. So, as I mentioned, if we have these evolving worlds with populations of robots, we have, in essence, a complete fossil record. We can go back and look at what evolved and why things evolved. We can rewind the evolutionary tape and then let it go forward again and see if we evolve the same kinds of things. So, we have these massive data sets where we have whole histories of life — robotic life, in this case — but they help us to ask questions about not just biology as it is, but life as it could be. How would evolution play out if we could do it again?

SD: Is there the potential for these things you're creating to eventually become self-aware?

JB: I think yes, in the literal sense of self-awareness, that I know where my body ends and the world begins. I know I'm capable of running at a certain speed and no faster... For some people, it has a spiritual or even religious connotation. I don't think so. But I think literal self-awareness can get you a long way. All of our behaviors, even up to the ones we're most proud of, like empathy, might be able to be explained by literal self-awareness. It doesn't remove any of the wonder of the things we're capable of doing. Shedding more understanding on human nature doesn't make it any less wonderful.

SD: Do you believe it's possible to build what Isaac Asimov once called the "positronic brain"?

JB: You mean build something of human-level intelligence? I do believe it's possible. I believe it's quite a long way into the future. I believe what we're more likely to see first in the coming decades are animal robots, simple robots that are fixing roads or operating on construction sites, things like that. I think we'll see ever-more-sophisticated robots that can do more for us. And, eventual something of human-level intelligence. But it'll be a long time coming.

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