Science Ama Series: We're Josh Bongard and Mark Wagy, and we just published a paper about crowdsourcing robotics. Ask Us Anything!

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Abstract

Hello reddit! We are... Josh Bongard, an associate professor in Computer Science at the University of Vermont, Mark Wagy, a PhD student working with Josh, and The DotBot, a robot collectively designed by 209 of your fellow redditors! We're interested in how people and computers can work together to create complex technology, like robots. We just published a paper in which we demonstrate that teams of people can actually design better robots than 'teams' of computers, if the humans work together. Here is a summary video of this work. Better yet: try it yourself! Since we wrote that paper, we have also discovered that a combined team can do even better: intuitions from the crowd can be boiled down into models that then guide computers, allowing them to design more robots than people on their own could ever do. Ask us anything! Edit: (5:30pm EST) JB: Signing off for the day. Thanks for all your great comments and your interest in our work! Follow me here to keep abreast of new crowdsourcing results from our group.

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REDDIT

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JOSH_BONGARD R/SCIENCE

ABSTRACT

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We are…
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The DotBot, a robot collectively designed by 209 of your fellow redditors!
We're interested in how people and computers can work together to create complex technology, like robots.
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Hi guys, I feel it's important the work that you are doing, keep it up! Now the question: how are profits from your crowd sourced projects distributed, who owns the IP, and how do you keep human nature from fucking up the team? Thanks for pushing the science envelope!

yeomanpharmer

JB: Thanks very much!

how are profits from your crowd sourced projects distributed,

JB: Profits? Why was I not told about this! :) No, there were no profits derived from this study, for participants or investigators. The participants chose to participate for fun or interest, not a financial reward. In fact, we have conducted a number of crowdsourcing projects now and we've found that large numbers of people were willing to participate if they were able to:

- **see how** their participation contributed to the science,
- learn something about **the topic**,
- learn something about **themselves**, or
- just because they felt **it was a fun thing to do**.

who owns the IP,

JB: No one. This work was published in PLoS ONE, an open publishing journal.

how do you keep human nature from fucking up the team?

MW: Define “human nature” :) In some sense, basic human behavior contributed to the positive outcome of the experiment. For example, many of the robots that we saw people design had four legs -- resembling familiar animals. We believe that because we each have decades of experience observing the behavior of legged animals, together, the participants were able to design robots that walked well, even though most participants probably did not have robotics experience.

This is completely awesome, and uplifting too. Thanks for sharing your work!

What is the most surprising thing that you've learned during your research, and what could it mean for our future?...

Ruruchops

JB: Glad to hear you found the results uplifting; so did we!

What is the most surprising thing that you've learned during your research?

JB: Oh boy. The most surprising thing for me in terms of our crowdsourcing research is the overwhelming positive response we have received from our participants. In **this paper** on the crowdsourcing of surveys, thousands of people participated; they generated hundreds of useful survey questions; and they supplied over a quarter-million survey responses… all without any expectation of financial reward! From what we could tell, most people participated sheerly for the joy of helping to move science forward and to learn something new about themselves or their community.

Similarly, we launched a new crowdsourcing experiment about language **here** just last week, and have had over 1000 participants in that time.

In **this paper**, I was particularly surprised to find that whatever intuition non-experts do have about robots, it’s very difficult to boil that intuition down into an understandable equation. We can produce such equations, but we have not yet been able to understand them. (If you’d like to try, the equations can be found in Table 2.)

what could it mean for our future?...

JB: I think that the willingness of people to participate and collaboration in online games and research efforts bodes well for the future of education. Instead of sitting in a classroom, students and teachers will mix virtual and physical reality to create hard-to-imagine environments in which to learn. As just one (admittedly biased) example, a recent **spinoff company from my lab** is beginning to create educational **games** built around young peoples’ fascination with robots.

That’s education; how about society as a whole? Many fear that technology in general---and AI and robotics in particular---will marginalize most of humanity. Personally, I believe that this will not be the case. (**Here** is a recent set of essays about thinking machines.) Given our species’ experience with tool use, new tools enable people to interact in new ways, accomplish tasks that were difficult or impossible to perform before, and pave the way to the development of more powerful tools; robots are just our most recently-devised tool. The Internet itself is a great example: it allows anyone with a browser to share their opinions, ideas, designs, and products. My long-term hope is that robots will likewise help to unlock people’s creative potential: I think people will not just use robots, but participate in their design, just like the Internet is the aggregate creation of millions of participants, not all of whom are tech savvy.

There are so many amazing demos of specialized "tricks" that are shown on the web, just amazing capabilities of specialized projects. Why have these capabilities not been consolidated into a general purpose robot with general usefulness? Is it just too hard a problem so far or is there a limitation of intellectual property and it'd be just too expensive. Or is there some key element the science has not found?

sammyo

JB: This is a really good question. Roboticists have long struggled with creating an autonomous machine that is capable of performing many tasks, rather than specializing to perform one task really well. These days, specialized systems like Siri and self-driving cars are collectively thought of as 'Artificial Intelligence' (AI), while the general-purpose machines that may be our intellectual equals (or betters!) are referred to as **Artificial General Intelligence** (AGI). We're just now starting to accomplish AI; we have not even made a dent in AGI.

Is it just too hard a problem so far or is there a limitation of intellectual property and it'd be just too expensive. Or is there some key element the science has not found?

JB: In my opinion, the roadblock is not technical but intellectual. In other words, creating very detailed simulations of human brains or building multi-million dollar robots won't help us much. We need to understand the basic principles of what enables *adaptivity*: the ability to change how you do things when the environment changes, or learn new things when your environment becomes more challenging. I feel there are three ways to make progress toward more adaptive robots:

- give them the ability to **recover from unanticipated situations**,
- make their brains more **modular**,
- scale up our ability to teach robots lots of tasks through **crowdsourcing**, and
- investigate how their **bodies** make them more adaptable.

Is there a limit to the number of people who can realistically work on one project?

davidmirkin

MW: There isn't a limit to how many people can participate in designing a robot. But whether or not there is a limit at which people can work together effectively might be a different question -- see, for example, **Dunbar's number**. Whether something like Dunbar's number holds for this type of experiment would be an interesting question to investigate.

This is truly uplifting to hear. Me and my team at Guaana have been building a challenge based scientific collaboration platform and this is exactly what we are building it for. What was the biggest obstacle for you during this collaborative research? How did you overcome it?

If you are willing to share your process and have a chat about it with our whole team then please let me know, I think we have a lot to learn from you.

markorussiver

JB: Thanks very much! Indeed, it is becoming increasingly clear that people from all sorts of backgrounds can contribute not just personal data or spare CPU cycles to scientific endeavors, but

involve themselves intellectually and creatively in the process itself. Some of my personal favorites so far are **FoldIt** and EyeWire.

In the long term, I think we will see a fundamental shift in the way science itself is carried out: instead of a professor and a few graduate students doing all the interesting stuff, we will see larger and more complex teams of computers, experts and non-experts formulating hypotheses, designing and conducting experiments, and creating models from the results. This idea already has its own name: **machine science**.

What was the biggest obstacle for you during this collaborative research? How did you overcome it?

MW: In addition to just building the platform itself, which wasn't easy, it was difficult to think of an appropriate means to enable a group of non-experts to design robots -- with no learning curve and little instruction -- and then communicate these design ideas to other members of the team. We solved the problem by utilizing the 'connect-the-dot' mechanism to draw robot morphologies as you can see in the paper and on **the video**. Many of us are familiar with this type of interface from our childhood, and the resulting designs can be easily communicated through two-dimensional visualizations.

If you are willing to share your process and have a chat about it with our whole team then please let me know, I think we have a lot to learn from you.

MW: We would love to chat. Please contact us directly using the website link above and we can arrange something. Guaana looks like an interesting project.

How would you apply this to more complicated systems? The systems you design consist of undirected unlabeled graphs, how would you apply this method to design systems that can only be represented as labeled and/or directed graphs?

newgenome

Thanks for your question.

How would you apply this to more complicated systems?

MW: It may be that non-experts are only able to build simple systems. However,**we have some evidence** that we can leverage intuition from the crowd to enable automated methods to design more complicated systems. Of course, it depends on what you mean by complicated systems.

The systems you design consist of undirected unlabeled graphs, how would you apply this method to design systems that can only be represented as labeled and/or directed graphs?

JB: We think your question is about altering the user interface. If that is what you meant, we could imagine altering the interface only slightly: for example, the user could click on an edge to change its direction or type in a label for it.