Fireside Chat with Robotics Engineer Hod Lipson: Man’s Next Best Friends may be Self-Aware Robots, Self-Replicating Robots, Robotic Scientist Eureqa, and 3D Printing

On June 16, 2012, in 3D Printing, Cathy Tao, China Business Forum, Chinnovation, Eureqa, Robots, by Tan Yinglan
Cathy, as usual, adds her perceptive lens to two emerging trends: robotic automation and 3D printing, and talks to much acclaimed Hod Lipson. Imagine a day when 3D printers are as common as inkjet printers and allow university students to tinker – won’t that open the realm of innovation. Add mechanics and motors to the mix and you have live robots to assist you in tasks in everyday life. We have already seen a shift with devices like Roomba (mentioned in article), Jawbone, Fitbit, Withings (I own all of these devices) becoming mainstream. Will there be a day when robots replaces our maids? yinglan

By Cathy Tao

At Chinnovate.com, timely articles about business innovation are featured to help readers incorporate and invent creative approaches for improving their business fundamentals. Cornell professor and robotics engineer Hod Lipson is fascinated by a different type of innovation. He is preoccupied with the question: Can computers augment or replace human invention? In other words, can computers be as creative and innovative as humans? Since humans and other biological life forms excel at designing, adapting, breeding, and evolving, Lipson uses a biologically inspired approach in his design of robots. With a background in mechanical engineering, he is performing cutting edge research at Cornell University in evolutionary robotics, design automation, rapid prototyping, artificial life, and robotic self assembly. According to Forbes, Professor Lipson was identified by Tim O’Reilly as one of the world’s seven most powerful data scientists. He is the developer of Eureqa, the automated scientist which mined data from a swinging pendulum to derive Newton’s second law of motion in just a few hours, beating Newton’s own efforts by several years. Too bad Eureqa as a software program won’t qualify for the Nobel Prize. Even you and I can use Eureqa for free to analyze our own data. Maybe we will be able to produce Einstein-like revelations and elegant equations with Eureqa’s help. Read and enjoy the Fireside Chat below to see what Professor Lipson and his research team have been working on. Be sure to watch the two videos included below about his work; they will surely inspire and amaze you.
Hod Lipson on Programmable Matter: Shape of Things to Come

Hod Lipson on The Robot Scientist: Mining Experimental Data

CT: You have been developing these self-aware robots. What exactly does that mean for the uninitiated? How did you program them and what type of data did they have to work with? I’ve seen the videos where you showed those starfish-like robots moving forward. Did they learn to do that by themselves?

HL: Self-aware robots are machines which can create simulations of themselves. They can plan and predict what is going to happen in different circumstances, and adapt according to their circumstances. They collect their experiences from the environment, learn from them, and gradually develop a simulation or self-image of themselves which allows them to master and interact successfully with their environment. This is similar to the way humans learn from their experiences. For instance, we are confronted with a tree that we have to climb. If we have previously climbed a tree before, we use the self-image we have developed of our body’s capabilities and how we are able to perform relative to our environment from our past tree climbing experiences and most likely, we will be able to climb this new tree more successfully. Self-aware robots have many practical applications in the real world. A robot could be designed consisting of software connected to a physical structure, say a building. The robot could be self-taught to diagnose problems with the building and take corrective measures without human intervention.

With the starfish-like robots we built, they were very different from traditional robots in that they were not pre-programmed as to how to behave in a given situation. They did not know what they were supposed to do next, and their only instruction was to get from Point A to B. By learning to simulate themselves (develop self-awareness) and adapt to their environment, they learned to move forward and “walk” from one end to the other. They learned by themselves how to change their behavior to adapt to their environment.

CT: Can you explain your project where the robots “replicated” themselves? Did you program them to do this, or did they choose to do this themselves, of their own free will?

HL: We also built robotic cubes that learned how to replicate themselves. They were not pre-programmed to do this. These four cubes were given the necessary building blocks and they correctly reassembled these blocks in the right order to create another four identical cubes, essentially replicating themselves. They learned to replicate themselves by changing their “bodies” to adapt to the given environment. This is an example of machines making other machines.

CT: Do you think that in the foreseeable future, we will have affordable robots that act as our assistants, like help us with housework or take care of the elderly and disabled? Will this be possible within the next 20 years?

HL: No, this will not be possible within the next 20 years. Of course, progress will happen in incremental stages. For example, when the
vacuuming robot Roomba was first introduced, it was very slow. The Roombas as specialized robots have come a long way since then. They do a very good job of what they are designed to do – I myself own 5 of them.

**CT:** Will there ever be a day where robots will co-exist side by side with humans, and act independently, with their own personalities and emotions? I have seen a video of a guy in Canada who has built a robot that serves as his girlfriend. Will robots always be dependent on some human input or supervision, or can they be totally self-reliant, and capable of surviving and reproducing on their own, like a separate living species?

**HL:** That is a tough question. You mean as autonomous as your pet? I think it will take a few hundred years for us to get there, maybe 100 years. The tricky part of building fully autonomous robots is how they will engage in self-repair.

**CT:** You developed Eureqa, the automated scientist. Can you explain in simple terms what Eureqa does? Can anyone use it?

**HL:** Presently, Eureqa has about 30,000 users worldwide. Eureqa forms equations that summarizes massive amounts of data. It finds abnormalities and patterns among data. Eureqa is not just for scientists. It is free for anyone to use, and not just useful in the sciences such as particle physics or biology. It has been used for predicting the stock market, analyzing water quality, traffic in a neighborhood, and business sales patterns. Other practical uses include measuring and improving radon detection in basements, coming up with a formula for welding strength, making connections between quality of materials and productivity, and so on. Eureqa has even been used to measure that most elusive thing of all, happiness. What would make people happier? “Get more weekends!” Eureqa revealed.

In the next phase for Eureqa, we want it to be able to predict random processes. To what degree is it stochastic, or to what degree or rate are events more or less likely to happen? So we could then use Eureqa to predict the weather, like calculating the chance of rain at 80% Right now, Eureqa can only handle numerical data, but we want it to be able to handle text, video, and images as well.

**CT:** Can you describe the Fab@Home project? Can someone without technical knowledge build their own 3D printer? What kinds of objects can be made using a 3D printer? What kinds of raw materials can be used? What happens when you want to 3D print an object that needs to be comprised of disparate materials or separate parts in order to be functional?

**HL:** Fab@Home project is an open-source collaborative project where people share their skills and abilities to bring personal fabrication technology to the home. Personal fabrication devices like the 3D printer allow people to make real custom objects at home, like a toy or replacement part. When 3D printing becomes ubiquitous, it will totally change the way we live. Instead of buying off-the-shelf products, we can design and make our own highly customizable objects for our own consumption or even sell them. Evan Malone and myself at the Cornell University Computational Synthesis Laboratory began the Fab@Home project in 2006. The Fab@Home website received 17,000,000 hits within a year and the project received a Popular Mechanics Breakthrough Award.

People like hobbyists can even build their own 3D printer using instructions from the Fab@Home website. The printer can be made with easily available off-the-shelf parts and is designed to allow printing with almost anything that can be dispensed from a syringe, such as household silicone, rubber caulk, epoxy, ceramic clay, Play-Doh, cheese, cake frosting, or even chocolate!

Initially, we were 3D printing primarily with plastic. But definitely the challenge is in printing more complex objects made up of separate components with differing materials. Since then, we have used our 3D printers to print food, and even batteries, circuits, and other electronic parts, but they must be assembled by hand into the final complete object. Right now, I along with my colleagues, including Jonathan Butcher and Larry Bonassar, are experimenting with 3D printing of the ear using living tissue, and eventually we hope to be able to print heart valves, spinal discs, and cartilage like the meniscus. As you can imagine, the potential is enormous.

**CT:** Do you think a 3D printer will be as ubiquitous as the ink jet or laser printer within the next 5 years? Do you think the technology could be made sufficiently user-friendly, speedy, practical, and cost effective where people would actually be motivated to manufacture objects in their own home rather than just buy something online or at the neighborhood store (not everyone is a design genius or has a lot of spare time)?

**HL:** I think within the next 10 years, the 3D printer will be as common as household ink jet or laser printers. There will probably be different grades of 3D printers for different uses. I predict that 3D printers will be most popular in the areas of food, toys, and entertainment. Consumers will enjoy making customized cookies and cakes in their kitchen, and printing game oriented objects like chess pieces and action figurines. For those who are not good with design, they can go online and use open-source 3D software or download third party designs. They will be able to buy parts online too. The available software at present is not optimized for 3D printers and there is fertile ground for development. As more software and hardware become available, and the price points come down, consumers will enjoy limitless possibilities.

**CT:** What are some useful sites or resources for people interested in the possibilities of 3D printing?

**HL:** We put up a site called EndlessForms.com. In the same way that a rose is bred, the objects on EndlessForms can evolve. You can choose the objects you like and these objects become parents of the next generation of objects. Just like in the biological evolution of plants or animals, the offspring look similar, but are not identical, to their parents. Even with no artistic background, you can explore different design possibilities by combining objects you like which evolve into new designs. So, in the same way that people breed roses, you can breed designs.

Shapeways.com allows anyone to turn their idea for an object into reality. You can create a design using free 3D software available on that site, choose the material you wish, such as plastic, glass, or metal, and place an order for that object to be made. Shapeways will 3D print that object according to your specifications and ship it to you.
CT: There are many parents who want their kids to explore math or science as a future career option. Many kids have a hard time grasping math and science, and they become discouraged. What advice do you have for parents who want to help their kids excel in these areas? Do you think there is a better way for teaching math and science or improving education in the classroom?

HL: I think 3D printers create a new opportunity for education. There is too much emphasis in our educational system on science and math. There needs to be more emphasis on engineering and technology. This is where the economy is headed and where the future jobs will be. I did not do well in math at school. (I studied mechanical engineering and became a professor in that field without being good in math, so you don’t need to be good in math to become an engineer.) When I was young, I did make lots of things out of Lego pieces and wood. I also liked software programming. That’s where 3D printing may play an important role. It will enable kids to create something new out of building blocks. Instead of passive learning, kids will learn via experience how to make things. It will encourage creativity, which is lacking in our schools. Engineering, programming, and writing — these are some of the creative endeavors that should be cultivated.
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