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# How to make a robot that will build your Ikea furniture

By SEAN GREENE APR 20, 2018 | 10:05 AM

Watch this robot, a combination of industrial robot arms, parallel grippers, force-detecting sensors and a 3-D camera, assemble an IKEA chair in about 20 minutes. (Suárez-Ruiz, Zhou, Pham, *Sci. Robot.* 3, eaat6385 (2018))

Here's one way to tackle the dreaded task of assembling your Ikea furniture: Get a robot to do it for you.

With some off-the-shelf robotics hardware and a substantial amount of programming, researchers at Nanyang Technological University in Singapore built a machine capable of assembling the Swedish megastore's Stefan chair in just over 20 minutes.

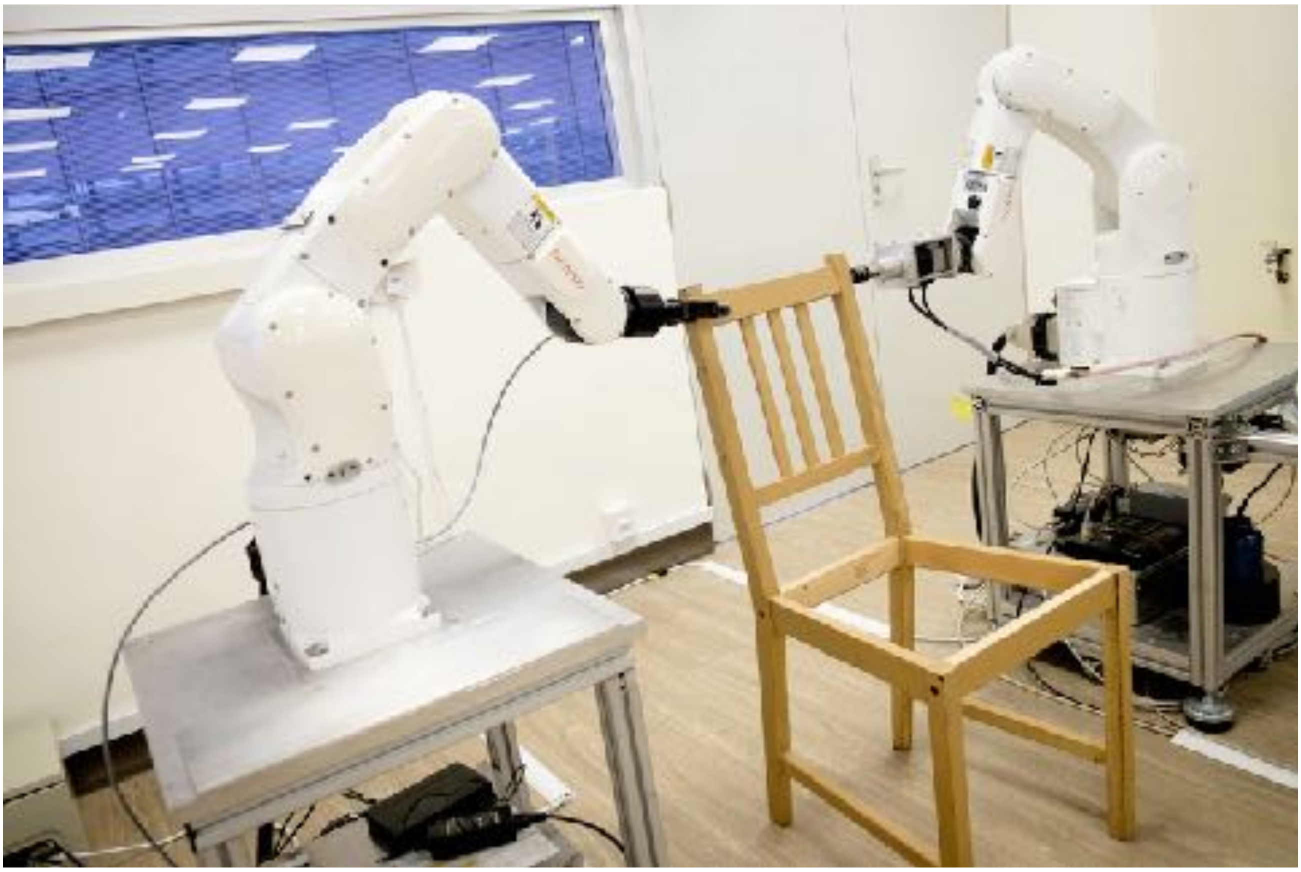
By putting their creation through the ultimate test of robo-dexterity, mechatronics engineer Francisco Suarez-Ruiz and colleagues hoped to assess how close robots have come to reproducing key human skills — in this case, motor movement.

The robot, described this week in Science Robotics, proved it was up to the task.

Here's how they did it.

## Materials

- 2 six-axis industrial robotic arms
- 2 parallel grippers
- 2 force detectors
- 1 3-D camera
- A ton (give or take) of computer code
- 1 Ikea Stefan chair



The robot plans a two-handed motion that is fast and collision-free. (NTU Singapore)

## Step 1: Assemble human-like robot arms

Our nimble fingers and hand-eye coordination make us masters of a wide variety of tasks. Putting together an Ikea chair is a tougher proposition for, say, a robot with poor vision (see Step 2), a limited range of motion and no sense of touch.

But don't let that discourage you.

Attach the parallel grippers at the end of each robotic arm. These will serve as robot "fingers" to pick up objects.

Mount the force sensors on the "wrists" to regulate the machine's grip. This enables the robot to vary how hard it pushes when it connects chair pieces.

"The way we have built our robot, from the parallel grippers to the force sensors on the wrists, all work towards manipulating objects in a way humans would," senior author Pham Quang Cuong said in a statement.

The robotic arm is equipped with parallel grippers to pick up objects, and has force sensors to determine how strongly the “fingers” are gripping. This makes the robot more human-like in its manipulation of objects. (NTU Singapore)

## Step 2: Maximize the robot’s hand-eye coordination

The study authors scattered the Stefan chair's five-piece frame within reach of the robot arms, along with a rack of wooden dowels. This setup mimicked the somewhat chaotic scene of humans assembling Ikea furniture.

The robot uses its 3-D camera to take images of the space around it. This gives it a quick-and-dirty idea of where all the parts are located. (The researchers' robot accomplished this in three seconds).

The camera, however, allows the machine to "see" accurately only within a few millimeters. It relies on its force sensors to do the rest of the work.

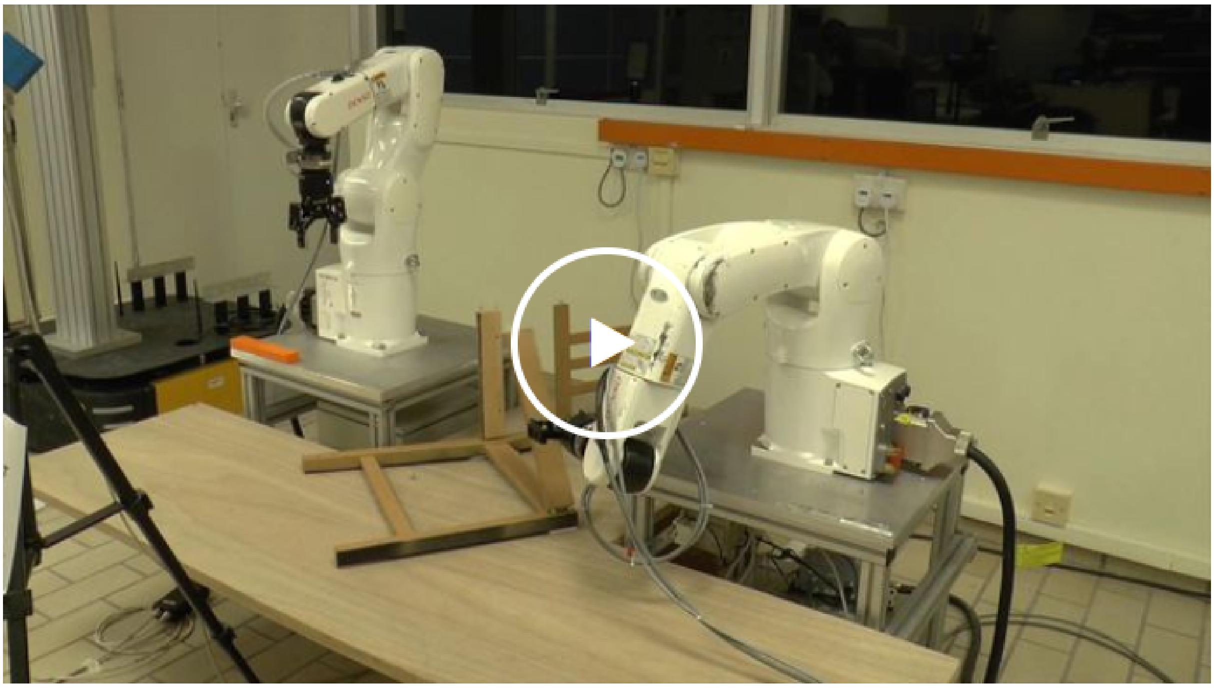
"To some extent," Suarez-Ruiz said, the robotic arms "are working in the dark and feeling their way around."

The pictographic assembly instructions that come with the Stefan chair indicate that 14 wooden pins must be inserted into holes around the frame.

The robot arms locate a hole by sliding a connector around in a spiral along the chair's surface. When the pin aligns, the pieces are pressed into place.

It took the Nanyang Technological University robot eight minutes and 55 seconds to assemble the chair's frame using the wooden pegs.

*Note: This process may sometimes fail.*



In a few cases, the robot failed to assemble an IKEA chair. (Francisco Suárez-Ruiz and Quang-Cuong Pham, Nanyang Technological University, Singapore)

## Step 3: Teach the robot how to build the chair

The Stefan chair is highly rated by humans for its ease of assembly. On the Ikea website, several buyers note they found the task "easy."

In all likelihood, they referred to the manual. Just as the researchers did, you will need to translate the Ikea assembly directions into computer code that the robot could use to plan and execute its task.

It took the machine 11 minutes and 21 seconds to devise its movements.

In this process, the robot needs to coordinate its two arms so they don't bump into each other. The so-called "motion pathway" also needs to accept visual and tactile feedback as it scans for parts and connects the pieces.

"In short, we tell the system 'what' to do, but it has to figure out the 'how,' " Suarez-Ruiz said. "We were interested in achieving the low-level capabilities, such as perception, planning, control, rather than in the high-level reasoning."

## Optional Step 4: Integrate AI for more autonomy

The robot described above, if properly equipped, could tackle other industrial tasks, such as drilling, glue dispensing and inspection, Suarez-Ruiz said. The research team is now trying to make the robot capable of bonding glass and drilling holes through metal — skills that could be useful in the automotive and aircraft industries.

But these tasks require some degree of training.

Artificial intelligence could allow your robot to learn the steps on its own by watching a human or studying the finished product. Another possibility: It could "read" the instructions itself, Suarez-Ruiz suggested.

For now, humans still outperform the robot when it comes to furniture assembly, Suarez-Ruiz said. Our "hardware" is much better than what the industrial robot has to work with.

"If human arms were rigid (such as our robot arms) and if human hands only had two fingers (such as our grippers), then humans would probably have a harder time than our robots assembling the chair," he said.

Pham Quang Cuong and Francisco Suarez-Ruiz with their robot and its chair. (NTU Singapore)

sean.greene@latimes.com

@seangreene89