Students restore motion to five-year-old boy's arms

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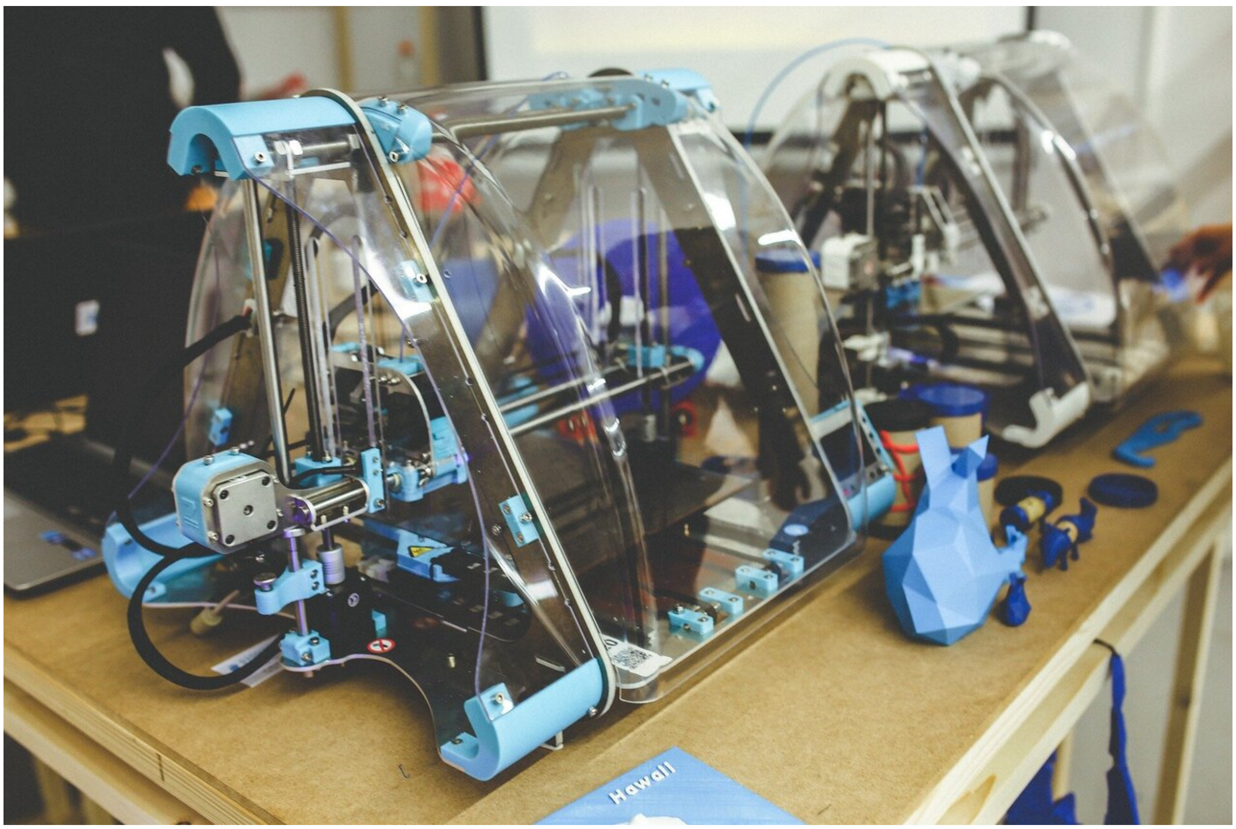

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His arms paralyzed by a rare virus three years ago, Max Ng has struggled to push, pull and poke his way through the world with the gleeful ease that most 5 year olds enjoy.

But a device built by four clever UC San Diego engineering students delivers just the help he needs to reach out and touch the world in ways that have long been out of reach.

Cameras watching Friday morning at Rady Children's Hospital, Max was strapped into a pair of motor-assisted orthotic braces, his fingers sliding into sensor-loaded gloves.

Once the contraption was in place, tilting his wrist up caused his arm to raise, bending at the elbow. Tilting down accomplished the opposite motion, and Max was quick to start roughhousing with his father, Dr. Ted Ng, landing a few light punches before reaching up and grabbing his dad's nose.

While that kind of play drew laughs, Ted Ng said he has been looking forward to a slightly different maneuver that has been difficult for his boy to accomplish.

"One of the things I missed the most is him just grabbing me for a hug," Ng said. "It just feels nice, you know, to have him wrap his arms around you."

Max is one of more than 500 kids nationwide who have experienced such devastating symptoms since 2014. His condition, called acute flaccid myelitis, is thought to be caused by infection from viruses in the same family as the germ that causes polio.

Researchers have yet to determine why most kids are unaffected, but a very, very few end up with devastating nerve damage, quickly stealing away use of arms, legs or other body parts with a cruel randomness that is at once mystifying and potentially deadly.

Dr. Andrew Skalsky, a rehabilitation medicine physician at Rady, said that Max is rare among AMF patients. The boy retained full control of the muscles in his wrists and hands even as loss of the motor nerves attached to the major muscles in his arms and shoulders have atrophied, leaving both appendages hanging limp at his sides. Wrist and finger dexterity intact, Max has developed clever ways to raise his arms, pushing them up with his knees to bring his hands close to what he wants to grasp.

But certain tasks, such has hugging his parents or young sister, remain out of reach. Those kinds of tasks require lifting both arms simultaneously, a task that's difficult if you're using your knees to do the lifting.

Skalsky said using some sort of motorized brace to do the work Max's muscles can't has seemed like a great idea for some time. But existing braces, with beefy frames and large motors, have been too heavy to do the job.

"His shoulder girdle muscle isn't there anymore, and just the weight of the brace alone, even without the motors, would dislocate his arm pretty easily," Skalsky said.

Something much lighter, made to meet Max's exact set of challenges, would be necessary. But because no two AMF patients experience exactly the same issues, there was no real incentive for a company to invent the right product and start selling it on the open market.

A custom solution designed and built just for Max was what was needed, and Skalsky thought he knew just how to get the job done without breaking the bank.

In September, he submitted an application to UC San Diego's Jacobs School of Engineering, which requires all seniors in its mechanical and aerospace engineering program to complete a capstone course, teaming up to solve real-world problems posed by people in the community.

The challenge was accepted, and four students were assigned to spend just 10 weeks fabricating a solution.

The team quickly learned that they would need to come up with a way not just to minimize weight by using ultra-light components, but also would need a way to transfer that weight to Max's torso.

Through rapid prototyping, using 3-D printers and computer simulation, the team was able to make prototype after prototype, tweaking designs for a harness, arm braces and other critical components over and over again until they had something that worked well enough to be machined in lightweight aluminum and sewed together by a professional seamstress.

The team even sources ultralight motors called linear actuators capable of generating enough force to lift more than a pound while weighing only about as much as a ballpoint pen. Special sensors capable of being built into custom gloves were able to detect the motion of Max's wrists and a specially-programmed micro computer loaded with custom computer code was used to translate the data from the wrist sensors into smooth motion of the actuators.

Sourcing the right materials and writing the correct algorithms was just one piece of the challenge, said student Marcos Serrano. Bringing together disparate technical components around a growing boy was the real challenge. This design didn't just have to work; it had to be flexible enough to grow with a growing boy, durable enough to survive his many adventures and comfortable enough to be worn all day, every day.

"This is what is called human-centered design," Serrano said. "It was very important not just for it to work, but he had to be able to get it on and off easily, and he had to be able to actually use it."

That was no problem at all for a kid who has already figured out how to position his arms with his knees. Looking like Iron Man's little brother, Max showed off his new range of motion Friday, tilting his wrists up and down and getting an immediate response from the actuators at his elbows.

Asked by strangers what he intended to use his new motorized arms for, his response was non-verbal, feet running forward, torso twisting to deliver a solid punch with a sly smile.

Watching the show unfold, Kitty Cheung, Max's mom, marveled at how far her son has come over the past three years. The first sign of trouble came with a strange droop to one side of Max's face, almost like the then two-year-old had suffered a stroke.

"It was very sudden, and it was very scary. We didn't know what it was, but it came on so fast," Cheung said.

Not long after that, she said, the arm paralysis began followed by such weakness of the diaphragm that the toddler could not breathe on his own. Doctors were forced to keep him on a ventilator for a full year before he recovered enough for the breathing tube to be removed.

Skalsky explained that the amount of nerve damage caused by AFM varies wildly but generally comes all at once. Nerves either die or survive, and those that make it have an amazing ability to adapt, in some cases filling in for those that were lost.

"As long as some functional nerves remain, they can split and kind of enervate where the old nerve was. Of course, if you have no nerves left, there is nothing to branch," Skalsky said.

This year, there are about 100 senior engineering undergraduates in capstone classes, carrying out 24 different projects, said David Gillett, a professor in the Department of Mechanical and Aerospace Engineering at UCSD Jacobs.

The range of problems solved is truly eclectic, from creation of sensing equipment capable of detecting the inebriation level of lab mice being used in alcoholism research to an ultra-light exam table small enough to fit inside a backpack and designed to allow field gynecological exams by health care workers in rural India.

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