Robotic surgeons – a huge leap forward

Last week scientists at the Children's National Medical Center in Washington, DC, announced a pretty important breakthrough – they've developed a robot that can operate by itself on soft tissue. The robot is called the Smart Tissue Autonomous Robot.

This is highly significant. Not just because it's another step towards even more precise and safe surgery, which is good for everyone, but because the robot can do this with a level of independence not previously seen.

Robotics and surgery go back a long way. In 1985, doctors used the Puma 560 to assist them in delicate operations, and that's how robotic surgery has developed – as a way of assisting human doctors. It's not hard to see why: a robot may be able to make more precise movements than a person, and it won't get tired or feel the strain of a long operation in the way a surgeon might.

But that's now all changing. It's a change that was foreseen in a TED Talk robotics expert Ken Goldberg gave in 2012.

"The last project also has to do with medical robotics. And this is something that's grown out of a system called the da Vinci surgical robot, and this is a commercially available device. It's being used in over 2,000 hospitals around the world, and the idea is it allows the surgeon to operate comfortably in his own coordinate frame, but many of the subtasks in surgery are very routine and tedious, like suturing, and currently, all of these are performed under the specific and immediate control of the surgeon, so the surgeon becomes fatigued over time.

"And we've been wondering, what if we
could program the robot to perform some of these subtasks, and thereby free the surgeons to focus on the more complicated parts of the surgery, and also cut down on the time that the surgery would take if we could get the robot to do them a little bit faster?"

That was the plan: to develop a way of allowing the robot to perform tasks without so much human input. And – given the announcement last week – that seems to be something that's becoming a reality. CNET had the story:

"Designed and programmed by Azad Shademan, Peter Kim and their team, the Smart Tissue Autonomous Robot proved even more adept at soft-tissue surgery than experienced human surgeons, at least in this particular test surgery, according to a paper published today in Science Translational Medicine.

“To improve on current technology to a point where this was possible, the team worked on improving the robot’s vision.

“To make what the robot sees more in line with what a human sees, they gave the robot a panoptic camera that allows it to determine where things are in three-dimensional space, and added a similar near-infrared night-vision technology to what the military uses. With the added use of fluorescent markers, this allows the robot to see and follow the movement of soft tissue, which previously was too unpredictable for a robot to work with.

“Tweaking the robot’s dexterity, equipping it with the best and least invasive tools, and programming it with the best surgical techniques based on consensus, allows the robot to effectively conduct surgery. There is no AI involved, although that might come in the future.

“The test case was what is known as an anastomotic surgery, connecting two structures together. In this case, it was two pieces of pig intestine. This is actually fairly difficult to perform, since it involves precisely guiding tools through delicate tissue. To accomplish such a complex task, the robot has seven degrees of freedom and an articulated suturing tool, as well as a sensor that can gauge suture tension. This combines with the vision system to accurately place sutures.”

The most important – if understated – part of that story is the fact that the robot is “even more adept at surgery than experienced human surgeons”.

Keep in mind the way technology works. Once a new piece of technology – whether software or hardware – has been developed and can do what we need it to, we can replicate it. Sometimes that’s highly expensive (generally hardware); other times, it’s not (software). Either way, it means what is now a singular piece of technology in a lab in America can very quickly explode onto the global scene.

This is something we’ve been exploring for a while. In fact, a while ago we spoke to a robotics expert at King’s College London, Kaspar Althoefer, about this very subject. He had several interesting things to say:

Q: Professor Althoefer, you were recently in the news because a team of roboticists, engineers and surgeons from King’s College – including you – operated for the first time on a human body using a soft surgical robot. Can you speak about this breakthrough?

A: These results came about through the work we did over the last four years on a new project called “Stiff-Flop”. The project, as the name implies, is about creating new robots that can change their stiffness. They can be really stiff if required, then change

to another state where they're more floppy.

The idea is to create new robotic devices which are very different from traditional robotic systems, with their very rigid and hard links. The aim is to create something that, when required, is very soft, and can interact in a very natural way with the human body – as is required for minimally invasive surgery.

Our robotic devices are made of silicon. They have inside chambers that can be pneumatically activated. Through this pneumatic activation, we are able to move the robots in different directions – very much like the octopus moves its tentacles about. We take inspiration from biology, from the octopus: that is a really important part of this project. We try to recreate that in an artificial system with the aim of creating tools that can be used in the surgical environment.

Q: You used the robot to operate on human cadavers and medical mannequins. Can you explain what the procedure involved?

A: We managed to create a new prototype – another of these soft robotic systems. This particular prototype was small enough to be used on a human body. In Dundee, at the Insight Institute there, we were then able to carry out experiments where we used our robotic devices, our soft robot arms, and inserted them into human beings. These were human cadavers, and we were supported by clinicians who were part of the project, in particular Professor Alberto Arezzo from the University of Turin. We were able to conduct a standard operation using our robotic device.

Professor Althoefer went on to describe the challenges his team face in developing this new form of robotic surgeon... and the problem he seeks to solve:

The main issue we can see with existing robots is that they are based very much on the traditional type of robots – robots in the manufacturing environment, for example as used in the car industry. There are very rigid links used there, and these are potentially dangerous for the patient: if a wrong movement is done, these things are extremely robust and very strong, so tissue could be damaged.

We want to draw a line and move radically away from that. That is our vision – to create soft robots which are inherently safe when used on a human being.

Q: You have said that one day these procedures will become entirely automated. Isn't that a scary prospect?

A: There is a certain reluctance from the public to embrace these technologies. I think the main reason is that this approach is something new, and not tried and tested yet. We are very used to humans operating on humans. That has been happening for

centuries. Suddenly coming up with this new idea could be a daunting thing.

Once these new systems are introduced and the process is happening, once people understand that it is safe and possibly even safer than having a human in the room, they will embrace them.

Q: How many years until we get to that point?

A: That is always the difficult question! Let me put it this way: there will be more and more robotic systems used in the operating theatre, but they will remain tailor-operated for quite some time, or at least with a human in the loop to oversee certain aspects of the operation.

To move to a completely autonomous system, we have to wait quite some time. The intelligence needed for these totally autonomous systems is not available yet.

Q: By quite some time, what do you mean?

A: Twenty years.

Q: As you've explained in the past, this is not just about moving joysticks. A decision has to be made about where to cut, where to move the instrument to.

A: That is a very important point. What is usually done nowadays is to use camera images to guide the surgeon – whether a laparoscopic surgeon or a robot-assisted surgeon – to the areas of interest, and to inform the surgeon where to cut and carry out the operation. Just interpreting these images is extremely difficult.

I'm personally not a surgeon, so I look at these images and don't understand anything. However, surgeons, through years of training, can interpret those images and carry out the right task. Automating that process is a challenge.

Q: You need artificial intelligence at a very sophisticated level?

A: Exactly.

How will we get to that level of AI? Will we see it in our lifetimes? Who out there could develop it?

More on that in a future issue...

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