Overcoming distance

Expanding the potential for minimally invasive surgeries, **RESEARCHERS AT TIANJIN UNIVERSITY HAVE PRIORITIZED PRECISION AND FLEXIBILITY** in their surgical robots.

This robotic system's capacity was demonstrated via a remote operation to stitch up an eggshell membrane.

In a TV programme broadcast live in China early this year, a surgeon in Beijing, via the 5G network, manoeuvred a surgical robotic system, 700 km away in Qingdao, to sew a raw egg's shell membrane, measuring only 0.07mm thick. An audience of millions witnessed the surgical robot completing this delicate task, which requires high precision and dexterity.

The robot is designed for minimally invasive laparoscopic surgery. "When we started developing our robotic systems, the MicroHand series, we aimed for precision, flexibility, and compactness," said Shuxin Wang, vice president and professor of Tianjin University. His team collaborated with Wego Group, a large medical equipment producer, and China's top-tier hospitals to transfer the lab-based research into clinical applications.

Minimally invasive surgery (MIS) typically involves using keyhole incisions (about 1cm) to conduct complex operations, with the aid of an endoscope. Compared with open surgery, it causes less trauma and enables a speedier recovery, thus, becoming an increasingly favoured procedure. However, a small keyhole incision means that the surgeon cannot observe tissues directly, so an endoscope is essential. "This is where a robotic system can help, by allowing more flexible movements, and a clearer view," said Wang.

Wang's team has been working on minimally invasive surgical robots since the early 2000s. "First, we want to make sure that our system is compact, so that the surgical instruments can get into small incisions," said Wang. "More importantly, the instruments need to move flexibly within a confined space."

The team's breakthrough in complex cable-driven instruments allows the decoupling of four degrees of freedom movement and improved motion transmission efficiency. The novel instruments extend the surgeon's operational skills, enabling accomplishing tasks with even greater dexterity.

Additionally, an innovative passive mechanism is in place to make sure that the force applied is within the safe range, avoiding tissue damage, while maintaining the necessary grabbing strength.

A high-definition stereoscopic laparoscopic endoscope system designed by the team also helps ensure precision. "It makes all the details clearly visible," said Wang. Surgeons can zoom in on the lesion areas, view them in greater clarity, and adjust the operation accordingly. The distal flexible ends of the endoscope offer expanded and adjustable viewing angles, solving problems of limited field of view and image distortion, while enabling reproduction of the scene.

Another challenge for a master-slave robotic system is correct mapping of the surgeon's movement with the slave manipulator. Wang's team has developed customized algorithms to enable accurate mapping between the master and slave ends, with enhanced synchronicity. Their technology has improved real-time implementation and precision, reducing safety risks.

Remote operation is further enhanced by the 5G network, which reduces time delay. Based on 5G technology, Wang's team proposed a master-slave communication algorithm, enabling continuous and precise movement mapping for remote operations. "Our technology has improved stability and safety of remote operation," said Wang. "The demonstration in the TV programme has already shown our capability of precise control over long distances."

As network speed continues to improve, Wang hopes that the teleoperation system will help increase the accessibility of MIS. To achieve this, he has established extensive partnerships with clinical and industrial collaborators. Clinical trials are in progress and show bright prospects. ■

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