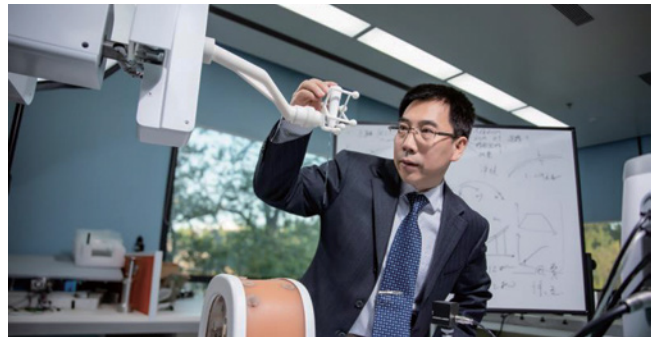
Putting a grand vision into practice

Integrating engineering and medical technologies **HELPS DEVELOP ROBOTIC APPLICATIONS** that maximize surgical efficiency.



BIT professor Xingguang Duan incorporates the strengths of robots and surgeons.

Medical robotics is an increasingly promising field, and for robots to become trusted assistants for surgeons, enhanced accuracy, safety, and flexibility are needed to meet diverse clinical needs. Such improvements need cross-disciplinary collaborations. Promoting closer integration between medicine and engineering to support the Healthy China initiative, the Beijing Institute of Technology (BIT), in 2018, teamed up with top tertiary hospitals to establish the Institute of Engineering Medicine (IEM). Earlier, an advanced innovation centre for intelligent robots and systems was established at BIT, focusing on service robotics.

Research and development of medical robotic technologies and systems, led by BIT professor, Xingguang Duan, is integral to IEM's emphasis on medical-engineering synergy to accelerate clinical application. Through years of interdisciplinary work, Duan's team has forged ahead with robotic technologies, specializing in puncture robots, human-machine collaborative surgical systems, and other novel surgical robots.

Driven by the demand for more precise biopsy, and more efficient ablation therapy, robot-assisted needle insertion systems, with ultrasound, CT, or MRI guidance, are gaining more use. Yet, limited visibility and complex structures of organs and soft tissues have challenged these puncture procedures, demanding high reliance on surgeon expertise to ensure safety and accuracy.

Duan's team has worked on puncture robots' intelligence to solve the issue. Over the years, they have investigated interactions between puncture needles and soft tissues to optimize puncture path planning. They have also studied information transparency for mid-surgery guidance, enabling easier operation for surgeons, while solving the issues of transparency, precision, and safety, for complicated procedures.

For Duan, surgical robots can be placed into three categories, based on the required technologies: 'active' robots with surgical planning capabilities, 'passive' master-slave robotic systems, and human-machine collaborative systems. The former two, exemplified by stereotactic surgical robots, and the da Vinci surgical system, have already seen successful clinical applications. Yet, for complex operations such as open-skull surgeries (craniotomy) and spinal lamina grinding (laminectomy), combining surgeon experience and flexibility, with robotic stability, becomes paramount, said Duan. He aims to incorporate the strengths of surgeons and robots to achieve collaborative intelligence.

In craniotomy, Duan's team has applied different techniques, including virtual constraints, compliant interaction, and hybrid intelligent servo control, to achieve collaborative interaction for the complex human-machine-environment interactive system. These technologies help promote robotic intelligence, and complement surgeon experience.

Applying these technologies, Duan's team has also developed robots for cranio-maxillofacial surgeries, which have been used clinically for fine-needle aspiration.

"With improved robotic intelligence and enhanced human-machine integration, we hope surgeries will no longer be difficult to perform," Duan said. "By working with researchers from academia, industry and hospitals, we seek to improve theories and technologies for medical robots and maximize benefits brought by medical-engineering integration." ■

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