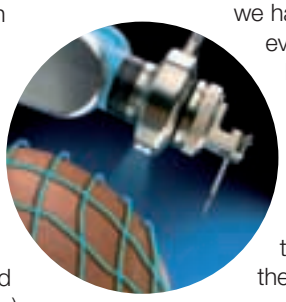
Hospital robots

Surgical precision is being redefined, as robot arms are adapted for use in hospital operating theatres. Brian Tinham talks to one of the sector's leading lights

The robot revolution is underway and will be happening in a hospital near you very soon. So says Dr Patrick Finlay, director of Prosurgics, the company he founded back in 1995 to build medical robots. And he adds: "Within the next 20 years, medical students will think it highly amusing that surgeons used to put their hands inside patients to carry out significant procedures."

Speaking last month at the SOE-sponsored EEESTA (East of England Engineering, Science & Technology Association) Prestige seminar, he predicted huge benefits. "Calibrated robots have much smaller corridors of uncertainty than humans, so operations are less invasive, safer and faster. That means less pain, scarring and recuperation time, and savings on beds and operating theatre capacity. It also means that some currently difficult or dangerous procedures will become run of the mill."



So what's behind all this? Finlay explains that advances with CT (computed tomography) and MR (magnetic resonance) scanners mean they can now routinely reveal abnormalities to within a millimetre. "Medical robots can use these as 3D maps, following surgeons' instructions on the scans for the entry point, trajectory and target – and with vastly reduced potential for collateral damage," he says.

Pinpoint precision

Orthopaedics and brain surgery are the major beneficiaries. For the former, Finlay's company offers two robot types: one image-guided that essentially facilitates joining and pinning of broken bones, tracking X ray images; the other acting as the surgeon's third (camera) hand in laparoscopic procedures, responding to his or her head movements to pan, tilt and zoom the target picture.

Meanwhile, for neurosurgery, it's about providing pinpoint precision, primarily either for destroying tumours by injecting micro doses of genetically modified viruses at key locations or for repairing functional disorders by carefully inserting electrodes – in all cases mindful of the proximity of important brain structures. "There are few experiences more rewarding than watching the robot reach its target and seeing the patient stop trembling – able to drink from a glass of water, without spilling it, for the first time in years," comments Finlay.

So to the engineering, which he explains falls into two camps – calibration and safety. Calibration is complicated by the fact that it's not only about the mechanical aspects of the robot – joints, linkages, dc servo drive outputs etc – but the optics of its camera. Beyond that, there's also registration of the scan to the real patient – achieved by automatically comparing images and finding best fits, using reference points and/or anatomical landmarks.

"What matters is accuracy – quite the opposite to most robotic applications, such as in automotive production, where the goal is repeatability," observes Finlay. "For us, every patient is different, so we have to produce a different programme every time, with sub-millimetre precision. For the robot arm, that means calibrating it, using laser projection to track hundreds of positions. Then we calibrate the camera optics, so the image centre is also precisely known."

As for safety, this industry is subject to stringent regulations. "For example, there must be no single points of failure, so we modify our bought-in arms, duplicating the joint encoders, so they track each other and, if they find a discernible error, force a stop. Depending on the application, we also introduce active constraints that define a cone in space, narrowing to the target, outside which the robot can't move."

Then there's electrical safety, which ranges from mechanical testing to simulating faults, such as reverse polarity, and ensuring not only that there can be no damage to the patient, but that the arm fails to safety and that instruments can be recovered.

For Finlay, robots performing procedures in hospitals represents the culmination of nearly 20 years of development. Expect widespread commissioning of robotic surgeons over the coming years. PE

Pointers

- Medical robots are already helping with orthopaedics and brain surgery
- Units are engineered for sub-millimetre precision
- Calibration techniques include laser projection and tracking for the robot arm
- Camera registration is automatic, using body feature reference points
- All critical components are duplicated and designed to fail to safety
- Electrical testing is designed for the rigours of the operating theatre