Robot's gentle touch aids delicate cancer surgery

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New, delicate surgery techniques to hunt for tumours could benefit from a lighter touch - but from a robot, rather than from a human hand. Canadian researchers have created a touchy-feely robot that detects tougher tumour tissue in half the time, and with 40% more accuracy than a human. The technique also minimises tissue damage.

Surgeons have developed new minimally invasive surgery (MIS) techniques and instruments so that procedures that would previously have required a large incision can now be performed through a tiny 10mm cut. These new methods reduce tissue damage and infection compared with more traditional surgery, and can reduce recovery times and costs.

However, researchers from the University of Western Ontario and Canadian Surgical Technologies and Advanced Robotics (CSTAR) in London, Ontario identified an issue in MIS, and have come up with a robotic solution, which they detail in the *International Journal of Robotics Research*, published today by SAGE.

Malignant tissue is usually stiffer than the surrounding tissue. Oncologists use scanning techniques such as magnetic resonance imaging (MRI) and computed tomography (CT) scanning pre-operatively to identify lesions. But tissues may shift during surgery, making it hard to rely on the position identified by the scan.

So instead surgeons use gentle pressure (palpation) to confirm where the tumour is, or to locate further tumours not picked up through scanning. But in MIS this can be very tricky due to access difficulties - as the surgeon must attempt to feel for harder tissue using long, slim instruments via a very small incision.

An alternative is to relay touch (haptic) cues via an instrument. Haptic cues include kinaesthetic information, relating to movement, which helps determine the shape and stiffness of an object, and tactile cues about surface textures. A variety of handheld sensors and grasping instruments have been developed since the mid 1990s for use in surgery, but these have the drawback that they do not in themselves control the amount of pressure used, nor do they position themselves correctly. Many are also too large for use in MIS.

Enter the robot-controlled palpating device: With cows' livers standing in for human tissue and 10mm and 5mm blobs of glue wrapped in wire representing tumours, the researchers compared palpation by surgeons, non-surgeons and the robot in the blinded trials. The researchers used a torque sensor to measure the force of the palpations.

Using tactile MIS sensing instruments under robotic control reduces the maximum force applied to the tissue by over 35% compared to a human controlling the same instrument. Accuracy in detecting the tumours was also far greater with the robot - between 59 and 90% depending on the robot control method used for palpation.

Unlike humans, the robot applies consistent force in each step, and moves over the tissue systematically. This produces a complete map, equivalent to one large pad applying ideal levels of force to the whole sample. (Similar to tactile sensors that have been developed to detect breast tumours.)

Humans do not know from one palpation to the next exactly how much force they are applying. This means some features are only highlighted because the surgeon is applying more force, or because the human user has changed the angle slightly between the instrument and the tissue. It is also easier to miss a tumour due to applying slightly lower force.

In fact both surgeons and non-surgeons were more likely to cause tissue damage than the robot. When a subject observed increased pressure on the visual display, they tended to focus on the area and apply even more force to see if what they had observed was a tumour. In the case of MIS, only a very small area can be palpated, which makes it challenging to compare adjacent areas and search for a tumour manually.

If developed further, the authors suggest that this type of instrument would particularly benefit surgeons performing lung tumour resection, where tissue often shifts significantly.

To develop the prototype robot for use in real MIS, the researchers plan to incorporate a design upgrade to include a flexible rotating head and a remote centre of motion. They would also add an improved interface to help surgeons overcome any fears about using robots in this type of surgery, and to allow them to increase the number of palpations around a suspicious area.

This means using robots during MIS to detect tumours is "not only feasible, but results in reduced tissue trauma and increased tumour detection," according to lead author Analuisa Trejos.

With one in eight deaths worldwide due to cancer, rising to one in four in North America, robots with a gentle touch may one day routinely offer a helping hand in cancer surgery.

More information: Robot-assisted Tactile Sensing for Minimally Invasive Tumor Localization by A.L. Trejos, J. Jayender, M.T. Perri, M.D. Naish, R.V. Patel and R.A. Malthaner is published today (Friday 21st August 2009) in the *International Journal of Robotics Research*. The article will be free online for a limited period from ijr.sagepub.com/cgi/reprint/28/9/1118

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