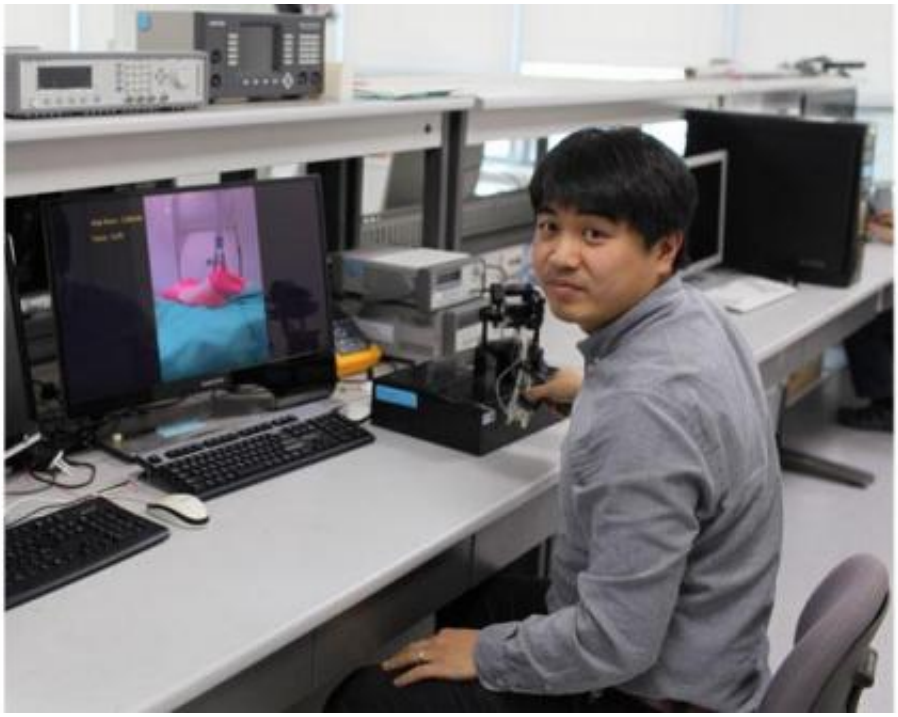
Force sensor integrated into surgical forceps

May 14 2014



Team member Dr Soo-Chul Lim in the lab at Samsung's Device and System Research Center

Samsung's Device and System Research Center present a force sensor integrated into surgical forceps to provide surgeons with a sense of touch in robotically-assisted procedures.

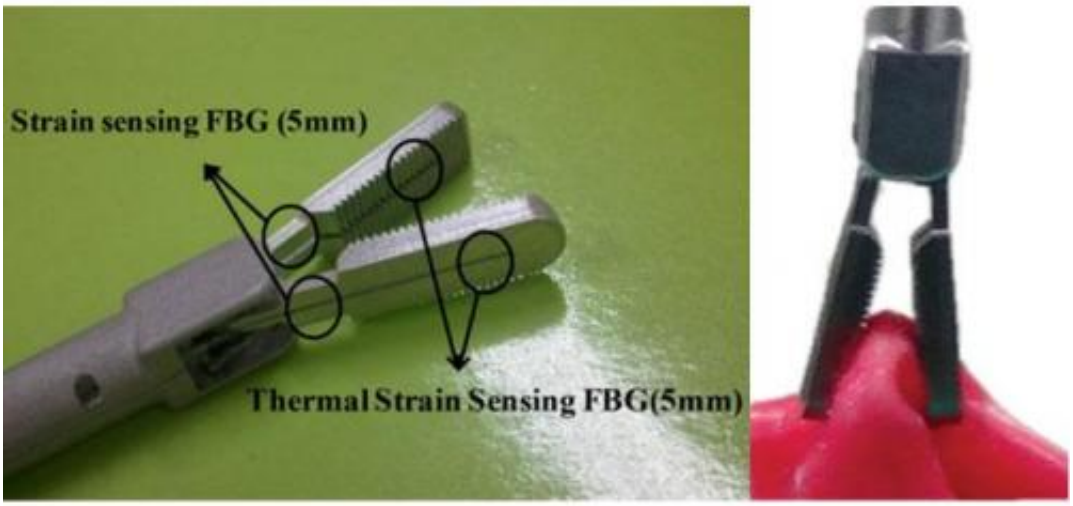
Sensory isolation

When performing open surgery, surgeons intuitively use their senses in

combination to capture the information they need to complete the procedure. Their sense of touch plays a very large part in this, providing information on the body tissues that they are interacting with, the materials they are using as part of the procedure and their interaction with both, including the amount of force they are applying.

In order to reduce the trauma associated with surgery, more and more procedures are now routinely performed not as open surgery, but using minimally invasive techniques such as 'keyhole' surgery. Increasingly then, the surgeon has to rely on imaging technologies to mediate their vision, and their sense of touch is entirely mediated by surgical implements, such as forceps. This can lead to insufficient control of pinch and pull forces, leading to use of too little or too much force, both of which can result in tissue damage, through slipping or crushing.

This difficulty is particularly present in robot-assisted minimally invasive surgery where there is no direct mechanical link between the surgeon's hand controls and the parts of the tools in contact with the tissue and surgical implements. In this context, accurate haptic feedback would be a significant boon to the surgeon. Such feedback first requires high fidelity measurement of the forces being generated at the tool tip.



A closer look at the grip force sensing forceps with their embedded FBGs (L) and in use, gripping a test material (R)

Unfortunately, attaching force and pressure sensors to surgical tools, including forceps, is far from straightforward. The application environments make packaging difficult. Tools designed to be minimally invasive are, perforce, small. They also have to be sterilised, so the sensors need to be robust to warm gas sterilisation. They will also be used in close proximity to EMI sources including electrocautery tools. The requirements have proved difficult to satisfy with force sensing resistors and capacitance type tactile sensors.

Sensory fibres

In their current Letter, the team from Samsung Advanced Institute of Technology's Device and System Research Center present a design of

force sensing forceps for surgical robot teleoperation that are robust to sterilisation and EMI with very compactly packaged sensors.

The Samsung team's design incorporates a pair of dual grating optic fibre Bragg grating (FBG) sensors that are sensitive to both tensile strain and thermal variations. By placing one FBG in the region of greatest strain of the forceps and one in an un-strained region, the grip force applied can be measured through the differences in the wavelength variation between the FBGs, removing the influence of temperature.

The team also believe this kind of FBG-based sensor could be used in other surgical applications such as in MRI-compatible biopsy needles to sense interaction forces at the tip of the needle's inner stylet and in radiofrequency catheter ablation.

Sensory fusion

"We are working on using the forceps for haptic feedback with a teleoperated surgical robot," explained team member Dr Soo-Chul Lim, but the team have plans far beyond this one dimensional haptic feedback. "We plan to develop three axis force sensible forceps. We expect that such force sensing forceps will enhance robot-assisted surgery by providing more stable feedback of interaction forces between the surgical tool and the tissue."

Over the next decade, the team believe it will be possible to incorporate grip and three-axis force sensing into same surgical tools using FBG sensors. It will also be necessary to combine this technology with advances from the wider world of robotics to create a truly intuitive haptic experience for the operator. "To use the developed haptic feedback system for performing real surgery, it will have to be implemented in a surgical robot that has a free motion generator at the robot wrist," said Lim.

More information: 'Grip force measurement of forceps with fibre Bragg grating sensors' digital-library.theiet.org/con … 10.1049/el.2013.4182

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