"First steps towards robotic assistance to reconstructive microsurgery"

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Abstract

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FIRST STEPS TOWARDS ROBOTIC ASSISTANCE TO RECONSTRUCTIVE MICROSURGERY

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Abstract
Reconstructive microsurgery enables extraordinary procedures such as face allograft, breast reconstruction, or torn member saving. However, several gestures require a precision that goes beyond human dexterity. An ergonomic robotic assistant is currently being developed to increase safety and reliability of microsurgery, and scale it down to the submillimeter scale of so-called super-microsurgery.

Keyword(s): Robotics, Microsurgery.

1. Introduction

In 2012, 19,500 women with breast cancer were treated by mastectomy in Belgium. The breast reconstruction technique that offers the best esthetic results is DIEP (Deep Inferior Epigastric Perforator). This procedure consists in removing a flap of skin with underlying fat tissue and a pair of blood vessels, and to graft it in place of the removed breast. However, only very experienced microsurgeons can achieve this complex operation during which vessels with ~1 mm outer diameter must be anastomosed. Indeed required precision is higher than the average magnitude of hand tremor. We aim at providing a robotic assistance that would make super-microsurgery gestures easier in order to perform free-flaps more safely and to reduce their invasiveness.

2. Instruments Motion Quantification

To quantify the workspace that our robot should have, a preliminary experiment was carried out. Two microsurgeons performed a microanastomose on rat adrenal aorta (1.7 mm outer diameter) with micro-instruments provided with sensors to record position and orientation of their end effector. Results are depicted in figure 1.

3. Topology and Optimization

The proposed system will be based on a master-slave teleoperation architecture to enable adaptive motion scaling. Robot needs at least 7 degrees of freedom: Six to have sufficient dexterity and the seventh to open/close manipulated tools. Tool tip position and orientation should be decoupled since accuracy requirements are very high in position but low in orientation, where human dexterity is already sufficient. So we chose a XYZ Cartesian structure that carries a spherical wrist with concurrent axes crossing at tool tip. This kinematics was already implemented in the Robotol system [1] devoted to middle-ear microsurgery, and seems to be a good starting point for the design of our own system.

4. Conclusion and Future Work

We selected a solution and we now work on the design of a prototype and its control modes.

References