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# Force Feedback Control System Dedicated for Robin Heart Surgical Robot

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**Abstract**

3D contact force sensors were developed and integrated in a demonstration system for testing the feasibility of their application in minimal invasive surgery (MIS). Piezoresistive MEMS based vectorial force sensors were designed and fabricated by 3D silicon micromachining technology and packaged according to their proposed transducer and sensor applications. In this work we demonstrated the integrability and functional applicability of the 3D force sensors in MIS robotic systems to improve their flexibility and reliability by providing real-time force and tactile information during the operation.
The final goal is to integrate the new subsystems in the Robin Heart surgery robot of FRK. [1] Three different functions are targeted: 1. ***Micro-joystick actuator*** to be integrated in the hilt of the laparoscope to easily control robotic movement during operation. 2. ***Force sensor*** inside the laparoscopic jaw to provide feedback to the surgeon by measuring the grasping strength and 3. ***3D force/tactile sensor*** which facilitates palpation for tissue diagnostics during operation. In this paper we demonstrate a feasibility study regarding these proposed applications.


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*Keywords:* MEMS, 3D force sensor, piezoresistive, minimal invasive surgery, Robin Heart robot systems, real-time feedback

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## 1. Introduction

The lack of force feedback is one of the main barriers in the progress and widespread application of robotic surgery [2]. The main tasks of the surgical robot control (Fig. 1) are the mapping and analysis the movements of the surgeon operator (position/velocity and possibly other physical parameters), as well as facilitate arm movement by providing control signals to the actuators. Additionally desirable to reverse transfer the force/touch information to the person handling the tools. These signals can help the operator to make immediate correcting actions during the operation: cutting, separation, handle and move tissues, to care vascular clamping, to tie a knot, to recognize the type of tissue (pathology, calcification), to manipulate between different elements of internal organs without the risk of harming neighboring tissue, and also to sense collision of arms/or tools by automatic recognition.

Since the robot moves with 5 degrees of freedom (Fig. 1 right), activating the complex movement is available by the use of clutch switching control object. By choosing the appropriate mode the sensor provides the ability to control all the functions of the spherical robot: to lean forward or sideways or alternatively to penetrate or withdraw and to rotate of the tool axis. The feasibility of appropriate control system equipped with this novel sensor was investigated and compared with the classic remote control methods.

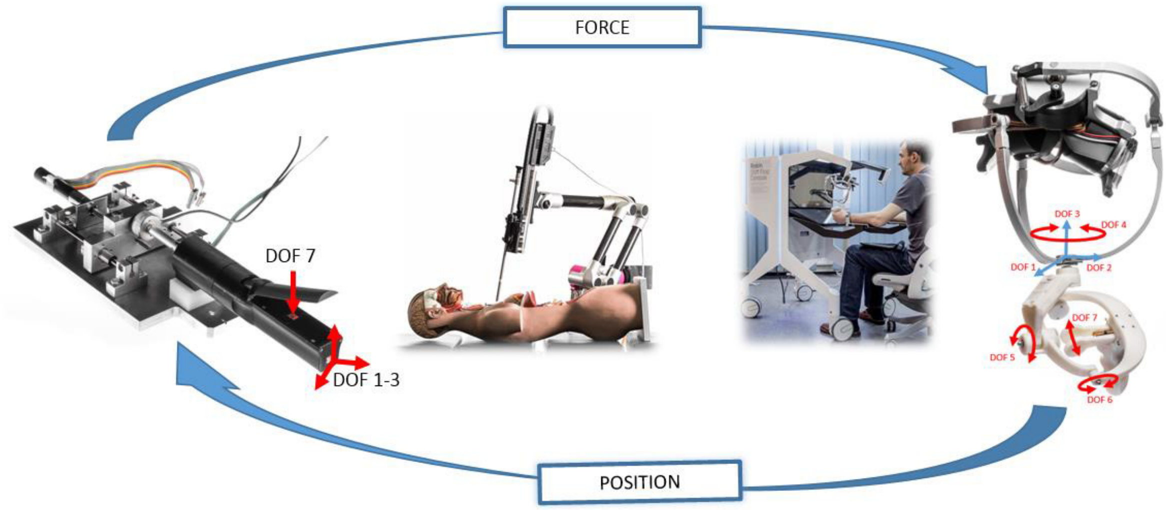


Fig. 1. Schematic representation of the master-slave systems with force-feedback and manipulation.

## 2. Force sensors in Robin Heart MIS robots

According to the preliminary results force sensors were designed and manufactured by 3D Silicon micromachining technology. The force sensor chip was mounted on a dedicated package and covered by a specially shaped flexible polydimethylsiloxane (PDMS) cap. The MEMS devices were integrated electronically and connected to the control system of the Robin Heart surgery robot. The functionality of the proposed MEMS sensors were simulated by FEM modelling and characterized experimentally.

### *2.1. Micro-joystick actuator*

The subject aim of this work is to investigate the applicability of 3D MEMS based force micro-sensors made by 3D MEMS micromachining technology and use it as micro-joystick to control the position of robot Robin Heart PVA (Port Vision Able). The force sensors were assembled on flexible PCB and their application for controlling Robin Heart Vision camera was proved (Fig. 2).