PRELIMINARY DESIGN OF AN ACTUATED PROBE FOR ENHANCE VISUALIZATION IN ROBOTIC SURGERIES

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Abstract

INTRODUCTION:

Robotic surgery allows minimally invasive procedures to be performed with greater precision, higher dexterity, and ergonomic comfort. The widely used daVinci surgical robot (Intuitive Surgical, California, USA) consists of a central stereoscopic camera and three robotic surgical arms controlled by the surgeon using a console. Though the stereoscopic camera provides superior visualization of the surgical site, it faces problems in certain surgical scenarios. These include visual problems with depth perception along view direction, occlusion by tissues, and low resolution at farther distance. One possible solution is to augment the understanding of the surgical site by addition of an extra visualization channel during the surgery. This could be achieved by inclusion of an additional camera probe. In this paper, we explore the preliminary design of an actuated probe with a camera alongside instruments to be used in a robotic surgery and demonstrate its functionality in three modes of operation.

DESIGN METHODOLOGY:

The probe consists of three tubular segments in tandem: telescopic arm, actuated spring, and camera (Figure-1). The probe is inserted along with the surgical instrument through a trocar. The design of the trocar is modified to have an additional insertion port alongside the instrument. Although this requires shifting of remote-centre-of-motion for the surgical-robot, it could be implemented in the robot control software as an additional feature without any change in the hardware. The telescopic arm allows insertion and retraction of the probe. The actuated spring is used to control the angulation of the probe. The angulation is achieved using a cable driven active system that combines pull and release action inside the spring. At the distal end of the probe, a camera is fixed to visualize the surgical site. Earlier prototypes used a straight camera that looked directly in front relative to the probe. This required two angulations in the spring: first to make the probe move away from the surgical instrument, and second to redirect the camera onto the surgical instrument. To simplify the mechanism while achieving the same results, we used an orthogonal camera in lieu of a straight camera. The video-stream captured through the camera is rendered to the surgeon’s console.

PRELIMINARY RESULTS:

The preliminary design of the probe was implemented in CAD software. The probe design exhibited two-degree of freedom resulting in three modes of operation during the surgery (Figure-2). Mode 1: The ‘insertion and retraction mode’ would be used to insert and retract the tool. Mode 2: The ‘endoscopic mode’ would allow close visualization of the tool-tip (Figure-3a). Since this mode increases the field-of-view of the tissue to be operated, it could be use for surgical subtasks requiring higher level of precision...