

Endo-PathController: a simulator device for investigating control skills for steerable minimally invasive surgical instruments

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In the last decade, new minimally invasive procedures are carried out through natural openings in the human body by following anatomical pathways (such as NOTES: Natural Orifice Transluminal Endoscopic Surgery). In this type of surgery, the instrument manipulation is limited because the incision point reduces the instrument's Degrees of Freedom (DOFs) and the anatomical pathway restricts the instrument's motion. In order to compensate instrument's limited DOFs, surgical instruments with a steerable tip are under development, in which the tip may include either single steering segment or multiple steering segments. However, so far, few knowledge is known about manual control skills for steerable surgical instruments, and it is unclear which control method is more intuitive for a dexterous performance.

We developed a simulator device, called the Endo-PathController, to investigate manual control skills for steerable MIS instruments. The Endo-PathController consists of a mechanism that mimics the shaft and handle of a steerable surgical instrument, and is electronically connected to a laptop computer by a USB data acquisition unit LabJack-U3 (LabJack Corporation, U.S.). Endo-PathController measures manual control motions in 5DOFs: 2DOFs rotation at the instrument incision point (left/right $\pm 90^\circ$; up/down 0-60°), 2DOFs rotation at the instrument steering unit (up/down and left/right, $\pm 40^\circ$) and 1DOF shaft translation along its axis (0-100mm). Endo-PathController has the standard surgical instrument dimension, and can accommodate various control methods (such as, thumb control or wrist control). A custom designed software was employed for simulating the tip steering and evaluating the control skills.

The system accuracy and sensitivity of Endo-pathcontroller will be investigated throughout the validation phase. Subsequently, Endo-pathcontroller will be utilized in different forms of manual control methods and different simulated surgical tasks (such as path following tasks or target orientated tasks). In the future, a universal simulator facility, Endo-pathcontroller, for the development of steerable MIS instruments control technology will be presented.