Robot for endovascular surgery

Degree programme: BSc in Micro- and Medical Technology | Specialisation: Robotics
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Minimally invasive surgery is a fast growing form of medical therapy, as the number of surgical operations using catheters inside or close to vessels is increasing. The standard procedure usually involves manual or remote controlled catheter insertion and a monitoring system, such as fluoroscopy or electromagnetic (EM) tracking. This thesis presents a tracking system based on sensor data fusion from an EM system and odometry feedback from a custom built insertion robot.

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Challenge

In a previous master thesis an implementation of a Monte Carlo particle filter was presented in order to track the tip of a catheter with an EM tracker. It postulates drastic improvement of the localization accuracy, if motion information of the catheter can be obtained and included into the tracking algorithm. The aim of this thesis is therefore to design and build a robot, capable of inserting a catheter into the vascular system, as well as extending the existing tracking algorithm to use the motion information provided by said robot.

Approach

Step 1: Building the robot

A custom catheter driver robot was designed and built. It allows to navigate the catheter in two independent and unlimited degrees of freedom: linear as well as rotated around the linear axis. Furthermore, it delivers odometry information obtained from encoders mounted on the actuation motors.

Step 2: Writing the driver software

Specialized driver software allows the robot to be controlled manually using a joystick or in a software based way using the Robot Operating System (ROS).

Step 3: Testing

Tests were conducted gradually in order to quickly isolate possible error sources. First tests only addressed the robot and the driver software, while further tests also included the EM tracking system.
The motion and tracking data was recorded simultaneously for later use in the algorithm enhancing step.

Step 4: Enhancing the tracking algorithm

The tracking algorithm was adapted to using the odometry information in order to enhance the position prediction precision. Furthermore, a realtime interface was implemented using the NDI ToolBox API, thus allowing tracking of the catheter while performing the tests and in later applications, of course, actual surgery.

Result

The system provides good overall tracking capabilities, the inserter robot performed considerably well. An improved mechanism for the insertion mechanism is proposed in order to overcome friction problems that appeared when rotating the catheter.
As the driver software as well as the tracking algorithm is designed to work with ROS, future research and experiments could include the implementation of autonomous navigation using position control algorithms.

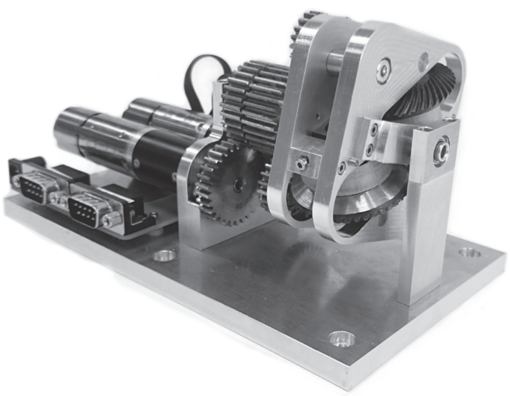

Figure 1: The catheter driving robot

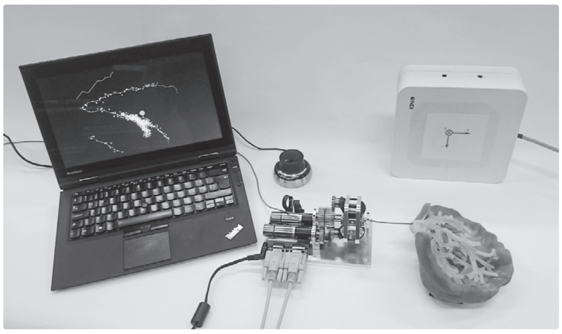

Figure 2: Test setup with joystick, catheter driver, EM tracker and liver model