A laser-based registration technique for image guided laparoscopic liver surgery

Subject: Medizintechnik
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The accuracy of a navigated laparoscopic surgery depends on the precise detection of the organ's position and orientation (i.e. registration). Contactless registration of soft organs, such as the liver, would provide better accuracy because it does not deform the tissue. The aim of this bachelor thesis is to develop a non-contact registration technique based on surface scanning by using a laser tool in addition to the common laparoscopic equipment.

Introduction

Navigated laparoscopic surgery can be compared to the use of a navigation device. An accurate 3D-model of the patient's liver, showing the surface and the position of vessels and metastases is used as the map for the medical navigation system. When the liver's position and orientation is computed (i.e. registration), the navigation system provides instructions to the surgeon on how to move the tracked instruments in order to reach the target.

The registration is one of the crucial points in navigated surgery, because the accuracy of the whole surgery is depending on it. The main requirements and difficulties of the registration are a high precision and an easy, intuitive handling. Common registration procedures require contact to the liver, which exerts a deformation and may result in an inaccurate registration, if one does not proceed extremely carefully. Existing contactless registration procedures are complicated, inconvenient and expensive.

Principle

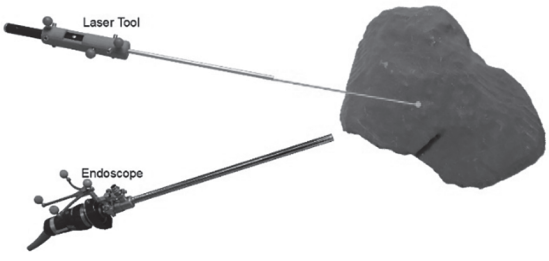
The process to calculate the laser spot's position and thus to reconstruct a surface is based on optical triangulation. The triangulation is a geometrical method of optical distance measurement. The laser spot's position can be calculated if it is detected in the endoscope's image, and the position of the laser tool and the endoscope is known. The software detects the laser spot in the endoscope's image automatically and calculates its position up to twenty times per second. These spots lie on the scanned liver's surface which can consequently be reconstructed.

Laser tool

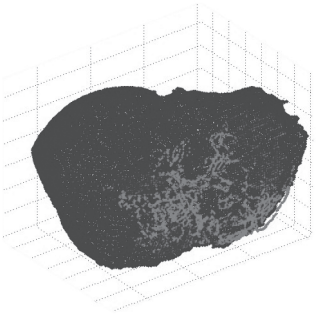
Since the laser pointer has to be sterile, a sterilizable bag is used. In addition a sterilizable, laparoscopic encasement is produced, where the laser can getting inserted and aligned.

Results

The registration technique developed in this thesis, is tested with rigid liver models. Registration accuracies, similar to common, more complicated registration procedures, can be achieved. Concerning to the advantages of the non-contact registration process and the good operability, the developed laser tool could replace hereafter common registration procedures.



Tracked laser tool and endoscope with projected laser spot on the liver



laser spot points (grey) are matched with the data of the model (black)

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