Interactive Poster: Virtual Preoperative Laparoscopic Camera - Visualization and Modeling System

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ABSTRACT

Laparoscopy is a minimally invasive procedure which has been an invaluable tool for diagnosing abdominal pathology in patients [1]. However, it still requires the insertion of surgical instruments in to the abdominal cavity and subsequently carries the morbidity of pain and risk of bleeding and infection. Recent advances in CT and MRI technology have allowed virtual examination of the human body without the need for invasive procedures. Virtual Laparoscopy would allow similar diagnostic capability as conventional laparoscopy but without the morbidity associated with surgical procedures [2]. In this paper we developed a virtual laparoscopic camera, based on a *patient specific* CT data, which can be used in the preoperative planning as well as an advanced surgical teaching tool.

We started from the typical clinical abdominal CT data consisted of 56 slices with resolution 512x512 each. Internal organs were then segmented based on tissue density through the deformable model approach [3]. We used atlas based human organs as initial coarse surface models. The organ models (triangular meshes) were then subdivided using interpolating modified Butterfly subdivision [4] . Regular Laplacian smoothing was applied to subdivided meshes to improve triangle aspect ratios.

The models were manually scaled and approximately positioned and oriented within the scan. Final fit was accomplished by iterative automatic procedure, deforming every model according to CT data image forces and model tension elastic forces [5]. Image forces attracted the model to the image features and elastic forces, due to deformation energy of the model, ensured its smoothness. Additionally, we provided several fixed control points on the scan to ensure quality of segmentation.

To simulate the deformation of abdominal cavity insufflation, we considered the abdominal wall as an elastic membrane and computed its displacement under pressure. We described it by the Laplace equation with fixed boundary conditions and constant external forces due to insufflation. Numerical computations were then performed using 2D linear Finite Element Method [6].

In order to achieve visual realism we textured the models with characteristic patterns coming from images of real human organs. The texturing was performed using the methodology of lapped textures [7] . The mesh was covered with a number of overlapping patches textured independently; when rendering the patches were drawn successively on top of each other. Since each single patch does not have much curvature the textures appear without distortion.

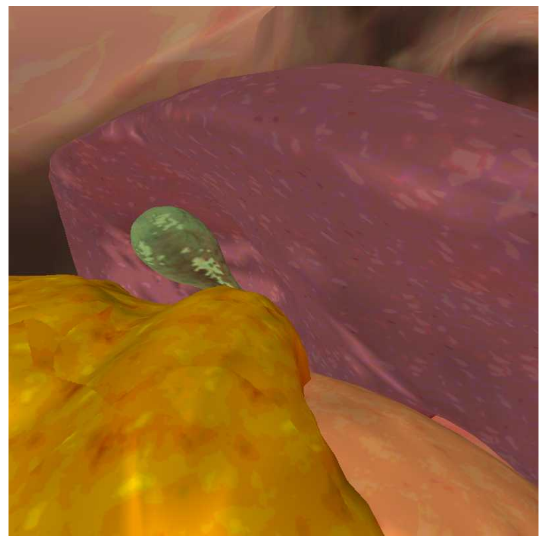

Figure 1: Snapshot from a virtual laparoscopic fly-through. The camera is positioned in abdominal cavity above the upper part of intestine, facing gallbladder and right lower part of kidney.

The final model of the abdominal cavity and selected organs can be then viewed through a virtual camera controlled by a user as a fly-through simulator. Snapshot from a virtual laparoscopic fly-through is presented in Figure 1.

In conclusion, virtual reality preoperative planning camera simulator uses *patient specific* data for the model in order to allow the surgeon to see anatomic relationships as they appear during the actual procedure on the patient and practice a complex surgical intervention before the surgery.

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