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Review Article

Surgical Planning Visualisation and Interaction System

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A B S T R A C T

Modern technologies significantly improve mini- mally invasive surgical procedures via the use of medical image processing and visualisation, 3D organ reconstruction, and intra- operative surgical guidance. Minimally Invasive Surgery is more common and well accepted as an alternative to the standard approach. Surgeons have some limitations while using this method. The restricted capacity to perceive depth and properly gauge the distance of objects during laparoscopic surgery may impede exact dissection or suturing. The use of innovative pre-operative planning tools has the potential to significantly advantage the surgeon. This study presents a visualisation and interaction system that allows surgeons to see a three-dimensional representation of a patient's organs, which is generated using CT images. Surgeons have access to many visualisation techniques during laparoscopy, and an Augmented Reality application allows them to choose the best locations for inserting trocars on a 3D virtual model. These patches might be seen on the patient's body. We have analysed two case studies. The gadget may be used for diagnostic purposes, as well as for planning surgical procedures and providing visual aid throughout the surgery.

Keywords: User Interface, Image-Guided Surgery, Aug- Mented Reality

Introduction

An emerging trend in the field of surgery involves a shift from traditional open procedures to minimally invasive laparo- scopic surgeries. In these operations, the surgeon relies only on the visual input provided by the laparoscope camera, since direct probing of organs is not feasible. Minimally Intrusive Surgery (MIS) has gained significant importance, and research in this subject is increasingly being embraced due to the less intrusive nature of these surgical procedures, which allow doctors to access the patient's body with less disruption.

The inside structure of the body and its organs may be visualised using advanced medical techniques, which enable medical treatments to be carried out with least harm or injury to the patients. The practice of Minimally Invasive Surgery (MIS) is gaining prominence as an effective approach.

Furthermore, it is becoming increasingly prevalent and is being embraced as a substitute for traditional methods. The affected region is accessed by minor surgical cuts on the

Identify applicable funding agency here. If none, delete this. body; specialised tools and a camera are introduced through these openings, allowing the inside activities to be shown on a monitor. The surgeon lacks direct visual access to the organs and so relies on camera pictures for guidance. This surgical procedure differs significantly from open surgery, since it does not provide complete visualisation and manipulation of the organs.

The benefits of using this surgical technique are apparent in the patient as it minimises stress, accelerates postoperative healing, and diminishes scarring. Although there has been some progress in achieving better results, these procedures still have some constraints for the surgeons. Specifically, the absence of depth perception and the challenge of accurately gauging distances between organs during laparoscopic surgery might hinder precise dissection or suturing. with any case, the total likelihood of problems is 8.0

The integration of current medical imaging capture with medical image processing has the potential to enhance patient care by providing guidance to surgeons. Medical image pro- cessing enables the detection and identification of anatomical and diseased features, as well as the creation of 3D models of the patient's organs. These models may be used to assist in guiding surgical treatments. Several research teams have addressed the challenge of segmentation and have devised algorithms that enable the automated or interactive extraction of the patient's organ models from CT-scan or MRI.[1,2] Augmented Reality (AR) technology offers the benefit of direct visualisation in both open surgery and minimally invasive surgery. It enhances the physician's field of vision by providing information from patient medical pictures.[3] AR technology is often used for teaching purposes in minimally invasive surgery.

The aims of this technology are to assist in pre-operative planning and provide enhanced visualisation during the actual process. During surgical procedures, Augmented Reality tech- nology enables the superimposition of virtual medical pictures onto the patient's body. This allows surgeons to have a visual representation similar to X-ray vision, giving them with a clear view of the patient's internal organs.[4] Driven by the advantages that Medical Imaging Systems (MIS) can offer to patients, numerous research groups are currently concentrating on creating systems to aid surgeons during surgical procedures. These groups have devised solutions to facilitate preoperative surgical planning and assist with intra-operative surgical pro- cedures.

Samset et al.[5] provide technologies that use innovative ideas in visualisation, robotics, and haptics to offer customised solutions for various therapeutic applications. The presentation will showcase instances of radio-frequency ablation for liver tumours, laparoscopic liver surgery, and minimally invasive heart surgery.

Bichlmeier et al.[6] address the issue of inaccurate percep- tion of depth and spatial arrangement in medical Augmented Reality (AR). They propose a novel technique for visualising medical data in real-time, which enhances the perception of three-dimensional medical imaging data and the positioning of surgical instruments in relation to the patient's anatomy. The authors propose a technique for incorporating surgical instru- ments into the Augmented Reality (AR) medical environment with the aim of enhancing navigation. Navab et al.[7] provide a novel interaction and 3D visualisation approach that offers a fresh option for using 3D virtual data in various augmented reality medical applications. The laparoscopic virtual mirror is a concept that involves creating a virtual reflection plane inside the live laparoscopic video. This enables for the visualisation of a mirrored side view of the organ and its contents. A clinical assessment was conducted to examine the perceptual benefits of including a virtual mirror into a laparoscopic Augmented Reality (AR) scenario.

De Paolis et al.[8] provide an Augmented Reality system designed to assist surgeons during the operating phase, with the aim of avoiding inadvertent damage to organs during surgical operations. The surgeon is given distance information and a visual representation of the distance between the surgical tool and the relevant organ is shown on the screen. This research introduces a sophisticated framework designed for visualising and interacting with 3D patient models of organs created from CT data.

The application enables the surgeon to select the locations for inserting the trocars on a virtual model. It also allows for simulating the insertion of surgical tools to ensure the accuracy of the chosen insertion sites. Additionally, the application utilises Augmented Reality technology to superimpose the selected entry points onto the actual patient's body.

The technology may be used to enhance the precision of diagnosis, aid in surgical preoperative planning, and facilitate image-guided surgery.

The Case Studies

In the field of Medical Imaging Systems (MIS), it is essen- tial to have access to the officially recorded photographs of the patient. These images are necessary for both pre-operative planning and providing advice during the surgery. Based on the medical picture.

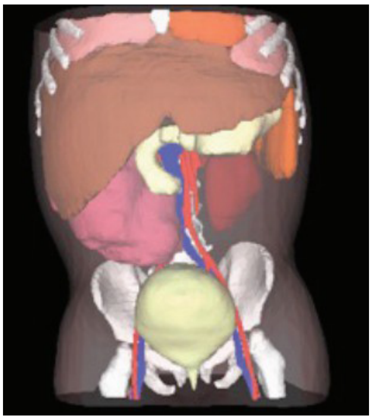

Figure 1.3D model of a child with a tumor at the kidney

By using advanced imaging techniques such as MRI or CT, we may generate a very effective three-dimensional reconstruction of the patient's anatomy. This reconstruction enhances the traditional slice view by replacing the grey levels in the medical pictures with colours that correspond to various organs.

The patient's organs were recreated in our case study utilising segmentation and classification techniques offered by ITK-SNAP,[9] resulting in 3D models. We conducted two distinct case studies, in which we observed that using a slice thickness of 3 mm resulted in aliasing effects on the reconstructed 3D models. These effects have the potential to introduce errors.

Consequently, we have given significant consideration to the process of smoothing the rebuilt models to ensure they closely resemble the actual organs.

Figure 1, displays the first case study of a two-year-old child who has a non-cancerous tumour located in the right kidney. The second case study, shown in Figure 2, is a twelve-year-old kid diagnosed with a peripheral nerve system tumour known as ganglioneuroma.

The User Interface

The programme is equipped with a customised user interface that enables the user to use the software's features. The application consists of four sections designed to assist surgeons in various stages of the surgical procedure, including case study, diagnosis, preoperative planning, selection of trocar entry points, and simulation of surgical instrument interaction. Using the patient's organ models, the surgeon may gather data on the patient, get information about the disease and diagnosis, and determine the optimal sites for trocar insertion. This technology may be used for both preoperative surgical.

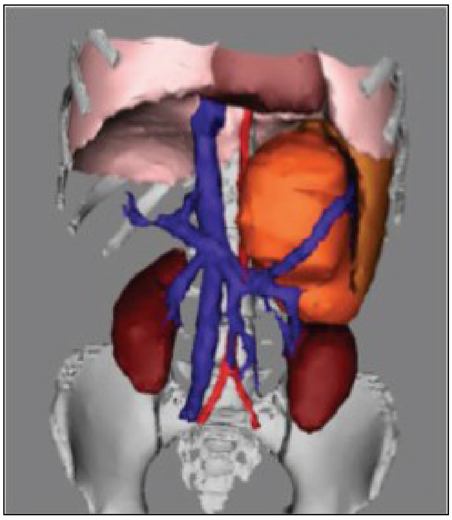

Figure 2.Virtual model of a child with a ganglioneuroma

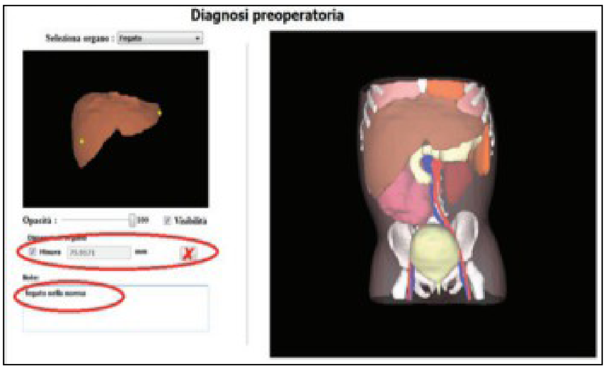

Figure 3.Measurement of organs

Planning and real-time surgical procedures. Furthermore, it may be used to explain the disease, the surgical technique, and the accompanying risks to the child's parents, with the objective of getting informed permission for the surgical surgery. The programme stores all the relevant information about the patient, including personal data, medical history, diagnosis, medical photos, 3D organ models, and surgeon's notes. This information is organised and stored in an XML file that is connected with each patient. One particular aspect of pre-operative planning is the visualisation of virtual organs, allowing physicians to get measurements of organ or pathological sizes as well as distances. This component is shown in Figure 3. Through a comprehensive examination of the 3D model, the surgeon may choose the trocar entry spots and verify whether these choices provide access to the organs involved in the surgical operation, ensuring the surgery can be performed optimally. Align these spots on the patient's body using Augmented Reality technology.

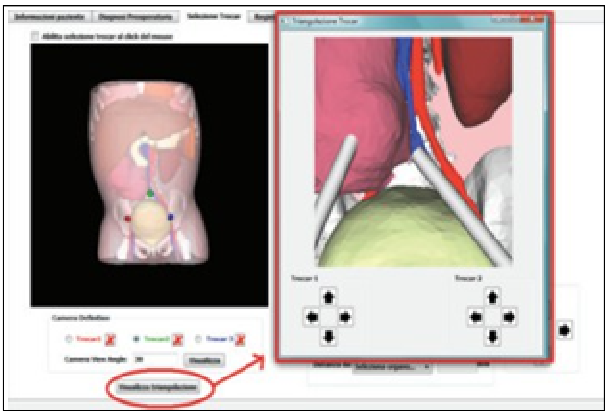

Figure 4.Simulation of the surgical tools interaction

I. THE AUGMENTED REALITY SECTION

Occasionally, the individual anatomical features of various patients may make a seemingly straightforward surgical op- eration more challenging, even when employing the typical insertion places for surgical equipment. The surgeon may encounter challenges in accessing the targeted organ or have difficulty in manoeuvring the surgical instruments. In this scenario, the surgeon must choose an alternative insertion site to effectively perform the surgical surgery in the most appropriate manner. The objective is to prevent this circum- stance from happening during the actual surgical operation by using the visual data obtained from the 3D models of the patient's anatomy. Our application utilises the Polaris Vicra optical tracker from NDI, which includes 2 IR cameras and a position sensor. The system detects retro-reflective markers attached to surgical tools or placed on the patient's body. By analysing the information from these markers, the sensor accurately determines the position and orientation of the tools within a defined measurement volume.

The tracker can determine the precise location of the tool in space with an accuracy of 0.2 mm and 0.1 tenth of a degree. Typically, the tracking technology is already integrated into the system.

In the implemented application, it is possible to evaluate whether the selected insertion sites effectively reach the par- ticular organ targeted by the surgical operation and enable the process to be carried out accurately. Additionally, the application allows for the simulation of the interaction of the surgical tools. In addition, we use augmented reality (AR) technology to display the exact positioning of the chosen locations on the virtual representation of the patient's body. In order to achieve exact and precise overlaying of virtual organs onto actual ones in augmented visualisation, a registration step is conducted. This phase relies on fiducial points. The augmented visualisation allows the clinician to see the selected entry places for the trocars on the patient's body, which helps during the actual trocar insertion process. Rooms and offers crucial assistance in improving performance during actual surgical operations.

Figure 4 depicts the dedicated part for simulating the inter- action between surgical instruments. It allows for adjusting the

Figure 5.Augmented visualization of the entry points

Entrance locations of the trocar by using the arrows. Figure 5 displays an enhanced visualisation of the selected trocar entry points on a dummy representing the patient's body.

Conclusions and Future Work

The programme provides a tool to display the three-dimensional reconstructions of the patient's organs, which are created by segmenting CT scans. It also allows for the simulation of trocar implantation to ensure the accuracy of insertion locations. An integrated user interface enables a straightforward and effective use of the designed programme. Additionally, the system stores patient and pathology data that the surgeon may input. It also features an Augmented Reality module that assists in positioning the trocars on the patient's body during the actual surgical process. Precise incorporation of virtual organs into the actual picture is achieved using a suitable registration process that relies on fiducial points.

The advanced platform may assist the physician in the diagnostic process and in the pre-operative preparation when opting for a laparoscopic approach. This assistance might also facilitate improved communication between clinicians and the parents of patients, enabling the acquisition of their informed consent.

The platform has undergone testing on study cases that have previously been performed by the surgeon. The next stage will include validating the built application on a fresh study case, following all the necessary processes from diagnosis to preoperative planning and the first phase of the actual surgical operation. Future work includes the development of a new Augmented Reality system that may assist surgeons in various stages of the surgical operation.

References

1. Camara, O., Colliot, O., and Bloch, I. Computational Modeling of Thoracic and Abdominal Anatomy Using Spatial Relationships for Image Segmentation. Real Time Imaging, 2004, 10(4), 263-273..
2. Kitasaka, T. et al. Automated extraction of abdominal organs from uncontrasted 3D abdominal X-Ray CT images based on anatomical knowledge. Journal of Computer Aided Diagnosis of Medical Images, 2005, 9(1), 1-14.
3. Furtado, H., and Gersak, B. Minimally Invasive Surgery and Augmented Reality. New Technology Frontiers in Minimally Invasive Therapies, 2007, 195-201.
4. Sielhorst, T., Obst, T. et al. An Augmented Reality Delivery Simula- tor for Medical Training, Workshop on Augmented Environments for Medical Imaging (MICCAI 2004), 11-20.
5. Samset, E., Schmalstieg, D., Vander Sloten, J., Freudenthal, A., De- clerck, J., Casciaro, S., Rideng, Ø., and Gersak, B. Augmented Reality in Surgical

Procedures. SPIE Human Vision and Electronic Imaging XIII, 2008.

6. Bichlmeier, C., Wimmer, F., Michael, H.S., and Nassir, N. Contextual Anatomic Mimesis: Hybrid In-Situ Visualization Method for Improving Multi-Sensory Depth Perception in Medical Augmented Reality. Sixth IEEE and ACM International Symposium on Mixed and Augmented Reality (ISMAR ’07), 2007, 129-138.
7. Navab, N., Feuerstein, M., and Bichlmeier, C. Laparoscopic Virtual Mirror - New Interaction Paradigm for Monitor Based Augmented Reality. IEEE Virtual Reality Conference 2007 (VR 2007), Charlotte, North Carolina, USA, 2007, 10-14.
8. De Paolis, L.T., Pulimeno, M., Lapresa, M., Perrone, A., and Aloisio, G. Advanced Visualization System Based on Distance Measurement for an Accurate Laparoscopy Surgery. Joint Virtual Reality Conference of EGVE - ICAT - EuroVR, Lyon, France, 2009.
9. Yushkevich, P.A., Piven, J., Cody, H., Ho, S., Gee, J.C., and Gerig, G. User-Guided Level Set Segmentation of Anatomical Structures with ITK-SNAP. Insight Journal, Special Issue on ISC/NA-MIC/MICCAI Workshop on Open-Source Software, 2005.
10. NDI Polaris Vicra. Available at http://www.ndigital.com/.