Breakthrough

The SMARTsurg Team designed and built a Robot Assisted Minimally Invasive Surgery demo unit.

The project incorporates key novelties/ advances for the next generation of surgical robotics:

1. The perception of "feeling" the instrument in the hands is restore back to the Surgeons via the development of highly dexterous anthropomorphic surgical instruments and wearable hand exoskeleton with haptic feedback
2. Active Dynamic Constraints using point cloud real time 3D reconstruction and wearable smart glasses for augmented reality allow Surgeon to safely perform procedures in areas close to veins or critical organs

The SMARTsurg demo unit has been evaluated by Surgeons for oncological, cardio-vascular and orthopedic procedures. .

Follow us on:

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Who are we?

A European partnership of ten partners from five countries

LEAD PARTNER:
University of the West of England/ Bristol Robotics Laboratory
United Kingdom
www.uwe.ac.uk, www.brl.ac.uk

Centre for Research and Technology Hellas/ Information Technologies Institute (CERTH/ ITI)
Greece
www.iti.gr

Polytechnic di Milano
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www.polimi.it,
www.nearlab.polimi.it/medical

Bristol Urological Institute (BUI) - North Bristol National Health Service Trust (NBT)
United Kingdom
www.nbt.nhs.uk/bristol-urological-institute

University of Bristol/ Translational Biomedical Research Centre (TBRC)
United Kingdom
www.bristol.ac.uk

European Institute of Oncology
Italy
www.ieo.it

Themis Orthopedic Center
Greece
www.the-mis.gr

Cybernetic
France
www.cybernetix.fr

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Smart wearable Robotic Teleoperated surgery

www.smartsurg-project.eu

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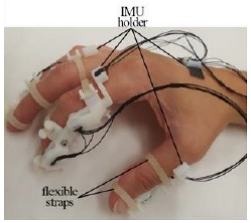
SMARTsurg main components

Hand/wrist master controller for high dexterity slave instrument

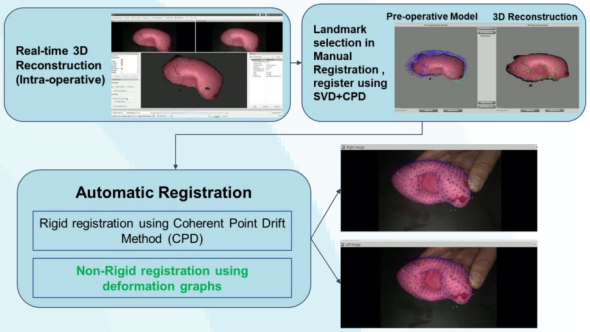


Our wearable anthropomorphic master has been developed and tested through several prototypes until we achieved the required level of usability, speed and accuracy. It tracks the motion of the thumb as well as the index and middle finger. Design considerations focussed on minimising the footprint and weight of the exoskeleton. Our final version contains only IMU sensors. Hand and wrist tracking controls Da Vinci and 3 fingered surgical tools. The user's wrist is attached to a Haption haptic master device which controls the slave manipulator.

Augmented Reality Toolkit

We extract 3D models from pre-operative MRI/CT scans using 3D Slicer software and performing surface polishing. We also utilise a Richard Wolf ENDOCAM Epic 3DHD stereo endoscopic camera for acquiring pairs of images of the intra-operative scene and retrieving disparity maps. We have developed a modified version of the Quasi Dense Stereo MAtching method that can be deployed in GPUs achieving real-time performance.

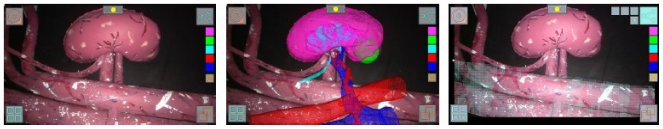
These disparity maps are then converted into 3D point-clouds. The pre-operative models and the reconstructed pointclouds are then used from non-rigid registration methods.



SMARTsurg main components

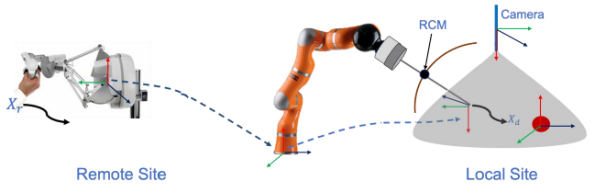
Graphic User Interface (GUI)

User interface of SMARTsurg includes a GUI in augmented reality to help the surgeon in locating targets (e.g. tumours) and critical structures (e.g. nerve bundles and vessels). The GUI has been realized in the ROS (Robot Operating System) environment with C++ code. The graphics are produced by using the Visualization Toolkit libraries (VTK). The goal of the GUI is to visualize the live endoscopic images with augmented reality features and defining active constraints, intraoperatively and preoperatively. Also, endoscope images are displayed on 3D glass, HTC VIVE PRO



Remote Centre of Motion

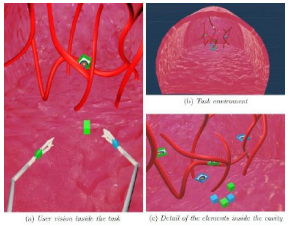
The proposed solutions implement the robot controller to manage the Center of Motion (RCM) constraint by using trajectory planning without modifying the low-level control structure. Also, decoupled impedance control, and hierarchical control have been navigated in our project to manage this motion constraint during the teleoperation control. The kinematic error of the RCM constraint and the interaction force between the tool shaft and abdominal wall are further analyzed.



SMARTsurg main components

High dexterity master-slave for minimally invasive surgery

Our anthropomorphic approach is based on creating a human-like grasping and manipulating tissue during surgery. The three-fingered instrument contains six degrees of freedom (dof), with each finger containing two-dof and only capable of planar motion. The maximum grasp force of the instrument was selected to be 40 N, matching that of the maximum force of the da Vinci instruments. For simplicity in design, the three-fingers are to be identical in motion capabilities and dimensions. Thus, the joint ROM (Range of Motion) for the MCP (metacarpophalangeal) was chosen to be 90 and 105 degrees for the PIP (proximal interphalangeal). Further, based on the length of da Vinci jaws, the total length of a finger was specified to be 50 mm. A ratio between the length of the proximal and middle (distal for thumb) phalanges was calculated based on three human subjects. The average ratio for the index and middle finger length was found to be 1.65, and 1.2 for the thumb. This ratio was used to determine the length split between the two links of each digit.



We also explored additional degrees of freedom of the instrument shaft and compared usability and efficiency of performing simple tasks with the 3-finger tool and with Da Vinci Endowrist in a virtual surgical environment.