Augmented Reality approaches in robot-assisted surgery

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Description:
Robot-assisted surgery represents one of the major real-world achievements of robotics technology reached so far [1]. The availability of the Da Vinci robot from Intuitive Surgical has unlocked an unprecedented potential in intra-operative surgical setting by allowing surgeons to be projected inside a person's body via a 3D camera, and providing them with incredible precisions as far as intra-body navigation is concerned via hand and foot control, which would not be attainable otherwise with conventional laparoscopic instruments. While looking at a magnified 360 degree view of the operative field, the surgeon remotely moves the robot arms attached to surgical instruments [2].

In this PhD research proposal, we want to extend this support the surgeons further, by providing them with augmented visual information in their magnified 360 degree view. We want to superimpose such magnified view with a 3D model of the organ currently under surgery, previously obtained by PET or CT scans, in order to enable visibility of organ parts not visible in the magnified view. The 3D organ model's pose and deformation will be tracked during the whole surgery process [3]. In particular, PhD candidates will have to work on the following tasks:

1. Design and develop a distributed hardware/firmware/software architecture to obtain information related to the 3D organ model's posture, orientation, and deformation.
2. Design and develop model-driven and data-driven computational models for organ pose and deformation tracking.
3. Investigate appropriate techniques to present superimposed, augmented data to surgeons during the intra-operative procedure.
4. Perform real-world validation with a Da Vinci robot in a controlled environment.

The PhD student will work within an engaging, stimulating, and multi-cultural environment. He or she will be involved in the activities carried out jointly by the TheEngineRoom team and the Urology Clinic and the San Martino Polyclinic in Genoa, in particular with Prof. Carlo Terrone and Prof. Paolo Traverso. This will 36 involve also helping the team supervise MSc students in their thesis work, most notably students from the UniGe's Robotics Engineering program. To conduct the research activities, the PhD student will use a Da Vinci robot from Intuitive Surgical hosted in one of the operating room at the San Martino Polyclinic, and as a mock-up a state of the art dual arm manipulator, a system of multiple RGB-D devices, motion capture systems (two combined OptiTrack systems), wearable devices (both commercial and custom IMUs, custom data gloves), as well as AR/VR equipment (an Oculus Rift, a Hololens2).

Requirements:

- Firmware/software development in C/C++.
- Hardware design.

References:
[1] B. Crew. Worth the cost? A closer look at the Da Vinci robot's impact on prostate cancer surgery.

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[2] A. Navaratnam, H. Abdul-Muhsin, M. Humphreys. Updates in urologic robot assisted surgery. F1000Res. 2018;7:F1000 Faculty Rev-1948, 2018.
[3] F. Mastrogiovanni, C. Terrone, P. Traverso. Apparato di rilevazione e tracciamento della postura e/o della deformazione di un organo corporeo. Italian Patent Application number 10202000015322.

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