Report N°2 MSc Thesis: Active Constraints

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Title: *To Be Defined*

General guidelines

Development of surgical training tasks implementing Active Constraints of different nature and with different levels of intervention, in order to evaluate their efficacy and role in Robot-Assisted Minimally Invasive Sugery.

- *Phase 1:* Software Development in a virtual environment (Unity)
- *Phase 2:* Implementing on the dVRK, followed by experimental tests with data gathering, analysis and validation

Work planned from the previous Report

- Using "Active Constraints/Virtual Fixtures: A survey" as a guide, implementing at least one of every kind of virtual fixture described in the paper and in the cited and referenced literature (guidance / avoidance / redirection, trajectory / surface / volume-based / force-field, static/dynamic, *etc.*).
- Literature research and first implementation (software-wise) of real surgical tasks (not limited to surgical training) where to apply the virtual fixtures implemented above.

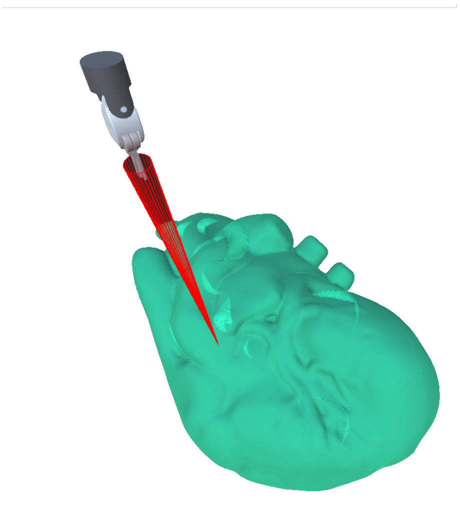
Progress

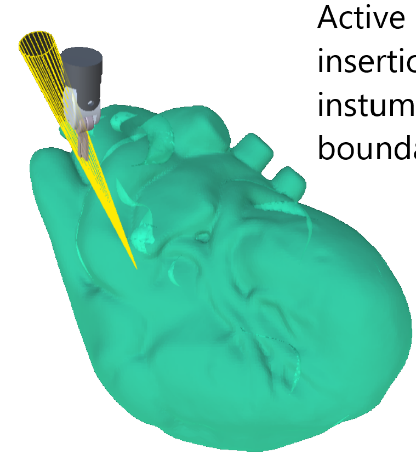
- Implemented the *Surface Guidance Active Constraint* described in "Dynamic 3-D Virtual Fixtures for Minimally Invasive Beating Heart Procedures" (link here), which functions properly in the virtual surgical scenario
- Implemented the *Guidance-on-insertion Active Constraint* described in "Vision-assisted control for manipulation using virtual fixtures" (link here)
- Implemented the *Force-field-based Obstacle Avoidance Active Constraint* described in "Real-Time Obstacle Avoidance for Manipulators and Mobile Robots" (link here)
- Built a way of evaluating the surgeon performance while performing the task. The planned trajectory, the executed trajectory and the force generated from the active constraint can be exported and read, visualized and analyzed through a simple MATLAB script (for now, planning to move to Python)
- Identified in "Objective evaluation of expert and novice performance during robotic surgical training tasks" (link here) and in its cited literature a guide for choosing, constructing and evaluating surgical training tasks
- Studied the concepts necessary for building a virtual surgical simulation in Unity (collision detection, object pick&place, *etc.*)

Next Steps

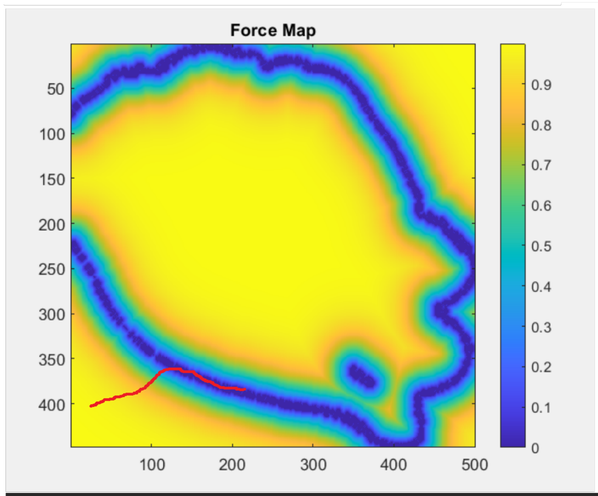
- Implementing the last few remaining virtual fixtures described in "Active Constraints/Virtual Fixtures: A survey" and in the related literature
- Creating at least one functional surgical task in the virtual environment in Unity

Screenshots

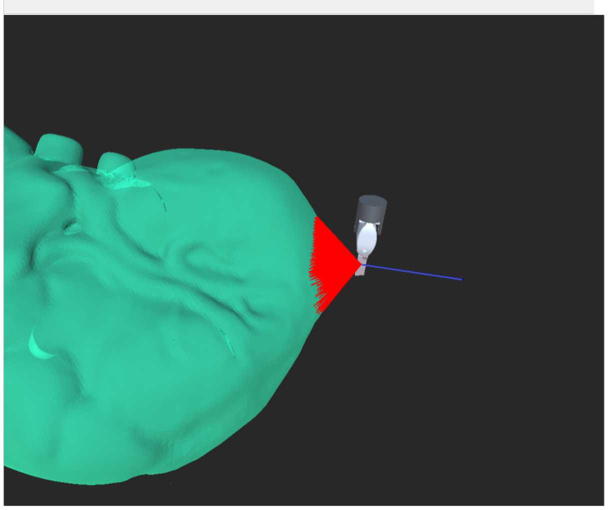




Active Constraint on the insertion of the surgical instument (cone-shapec boundary)



2D slice of the mesh of heart with the executed trajectory and the normalized force map generated from the virtı fixture



Obstacle avoidance VF