ACTIVE Project

FP7-ICT-2009-6-270460

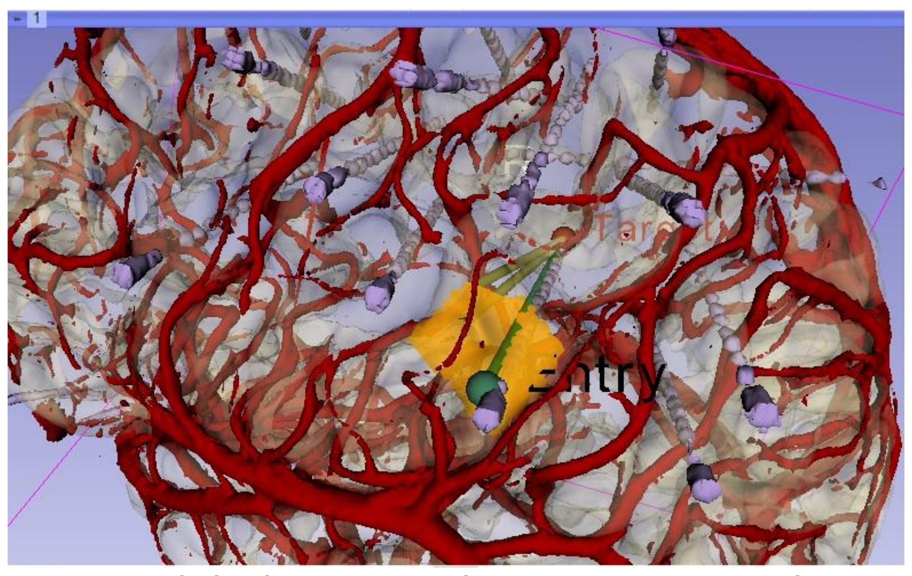
SEVENTH FRAMEWORK PROGRAMME

*A*ctive Constraints *T*echnologies for *I*ll-defined or *V*olatile Environments

ABSTRACT

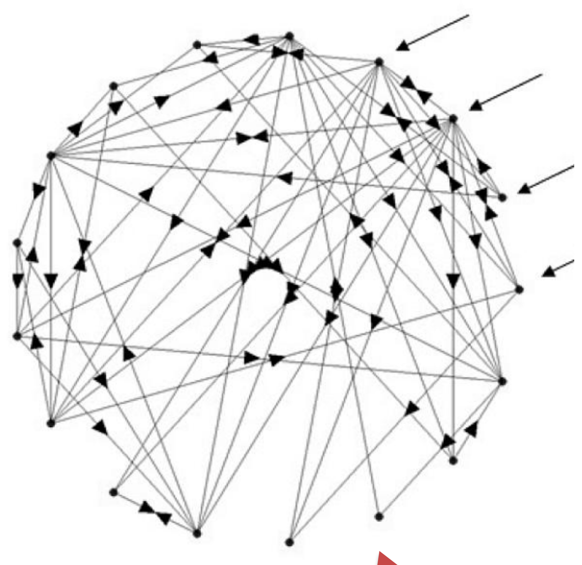
The ACTIVE project exploits ICT methods for the design and development of **an integrated redundant robotic platform for neurosurgery**. A light and agile redundant robotic cell with 20 degrees-of-freedom (DoFs) and an advanced processing unit for pre- and intra-operative control will autonomously and cooperatively operate with surgical staff. As the patient will not be considered rigidly fixed to the operating table and/or to the robot, the system will push the boundaries of the state of the art in the fields of robotics and control for the accuracy and bandwidth required by the challenging and complex surgical scenario. **Two cooperating robots** will interact with the brain that will deform for the tool contact, blood pressure, breathing and deliquoration. **Human factors** are considered by allowing easy interaction with the users through a novel haptic interface for tele-manipulation and by a collaborative control mode ("hands-on"). **Active constraints** will limit and direct tool tip position, force and speed preventing damage to eloquent areas, defined on realistic tissue models updated on-the-field through sensors information. The active constraints will be updated (displaced) in real time in response to the feedback from tool-tissue interactions and any additional constraints arising from a complex shared workspace. The overarching control architecture of ACTIVE will negotiate the requirements and references of the two slave robots. The operating room represents the epitome of a dynamic and unstructured volatile environment, crowded with people and instruments. The workspace will thus be monitored by **environmental cameras**, and **machine learning techniques** will be used for the safe workspace sharing. Cognitive skills will help to identify the target location in the brain and constrain robotic motions by means of on-field observations.

The ACTIVE scenario: two light weight robots are acting on the brain tissue, assisting the surgeon.

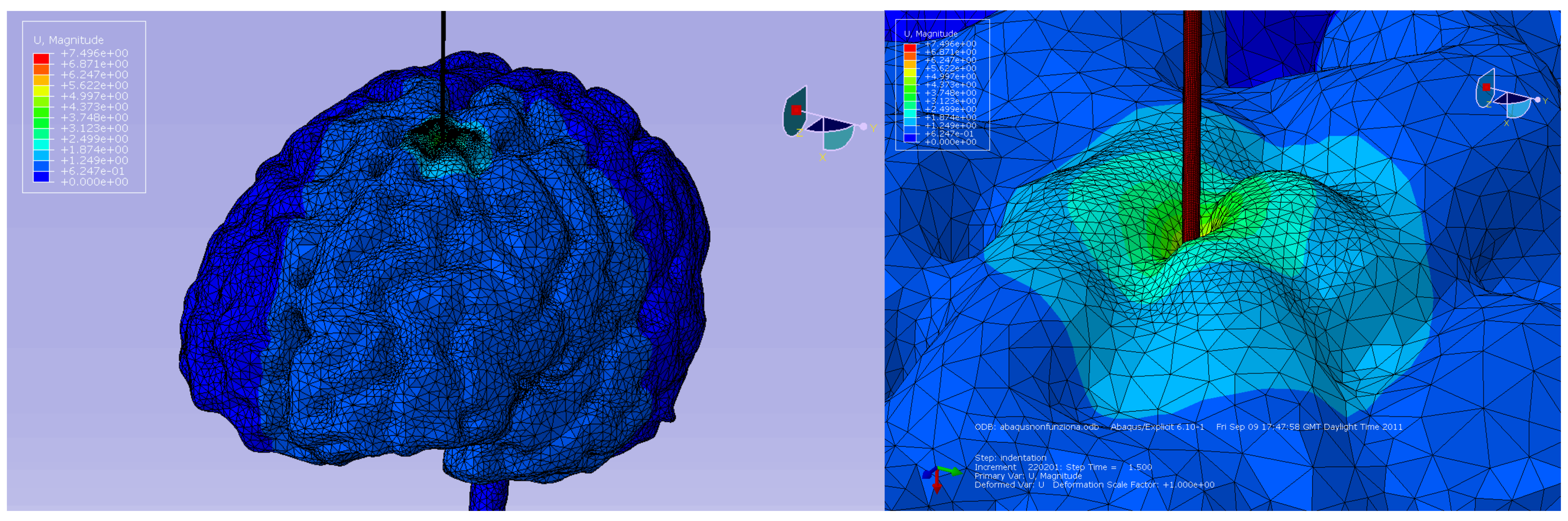


3D view of the brain in 3DSlicer environment, showing the electrodes actual trajectories verified using fluoroscopic acquisitions. The orange region indicates the possible entry region and the green cylinder indicates the best trajectory automatically computed between the best entry point and the target.

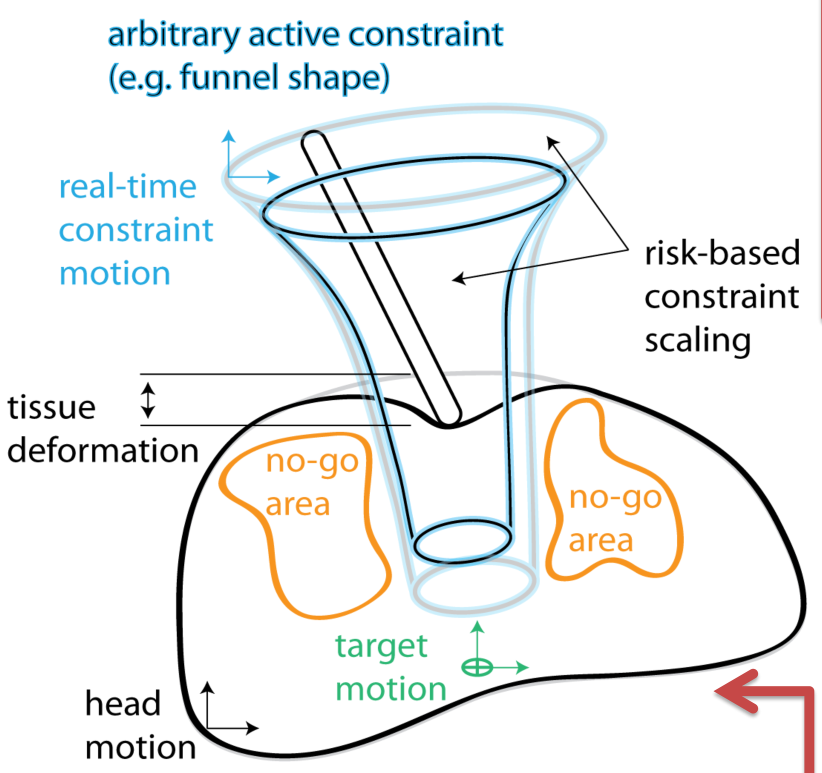
A graph from a representative patient during the seizure. Arrows indicate the lesional leads, that represent the most strongly connected sub-graph, with a density significantly higher than the that of the other groups.



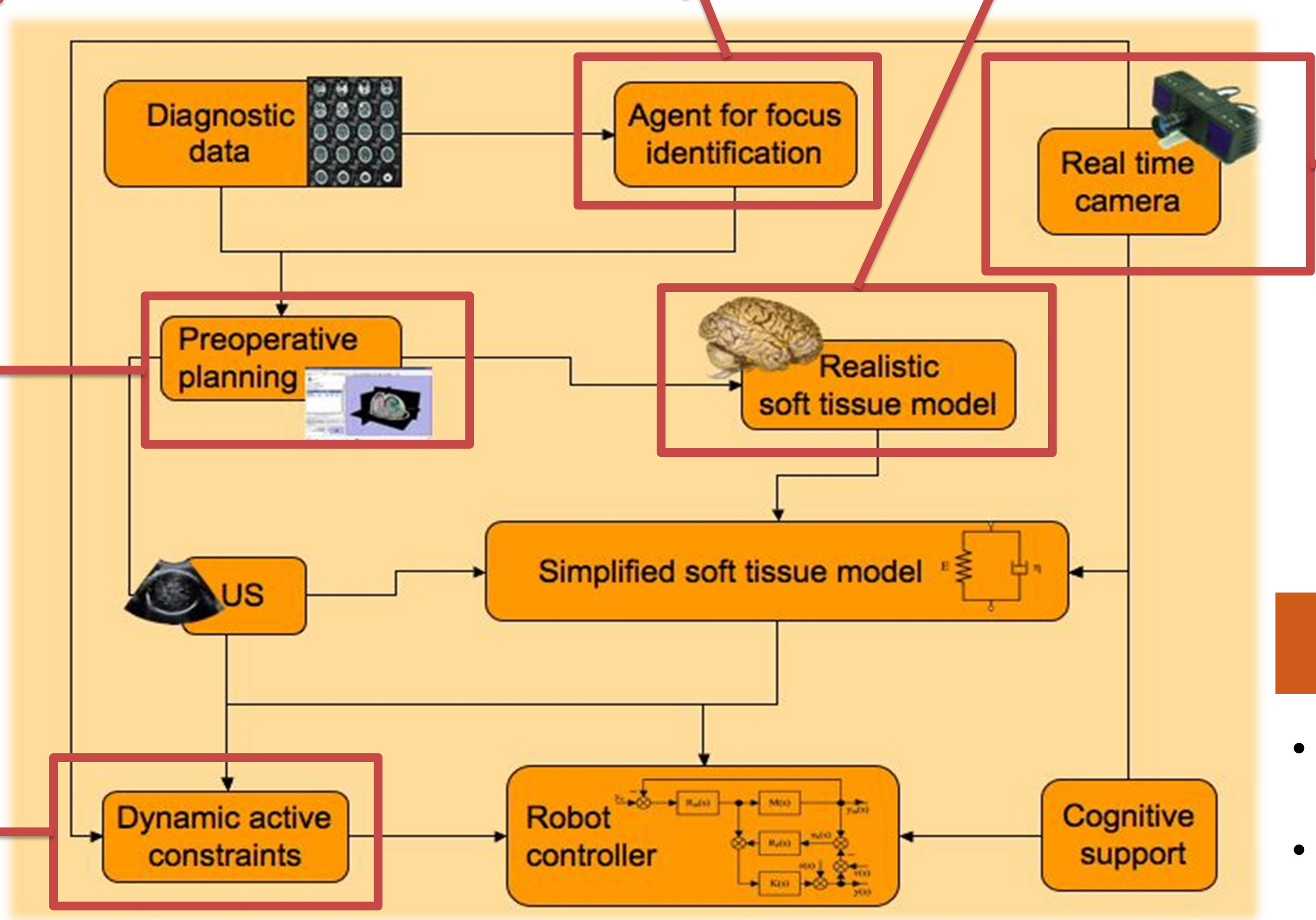
Left: Soft tissue indentation in Abacus Explicit. The brain material has been modelled as incompressible, isotropic, hyper-visco-elastic. Right: zoom of the indentation area.



The operating scenario. Environmental cameras are supervising the scene and the robots are cooperating with the surgeon.



Example of a 'funnel' shaped active constraint which confines the tool so that it cannot penetrate the two 'no-go' tissue areas as it moves towards a target pose. As the tissue deformation is not fully known, the constraint is scaled to ensure the patient safety.



Scheme of the ACTIVE control workflow.

SCIENTIFIC CHALLENGES

- Real-time cooperative compensation of unpredictable surgical target motion;
- Human-robot dependable cooperation and workspace sharing;
- Master slave semi-active architecture providing dynamic virtual constraints into a modeled volatile environment;
- Cognitive competences for high level cooperation among robots and human operators;
- Augmented sensing and machine intelligence for estimating the target location and for driving robot activity through cognitive estimate of environment and target modifications.

THE CONSORTIUM

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