Real-time surgery simulation with haptic rendering

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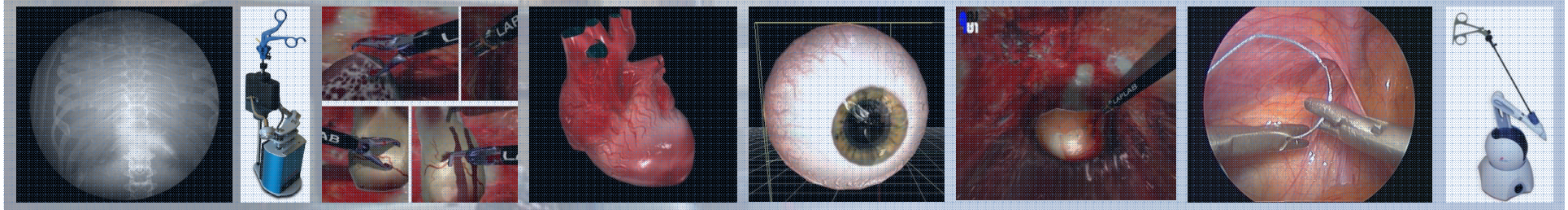
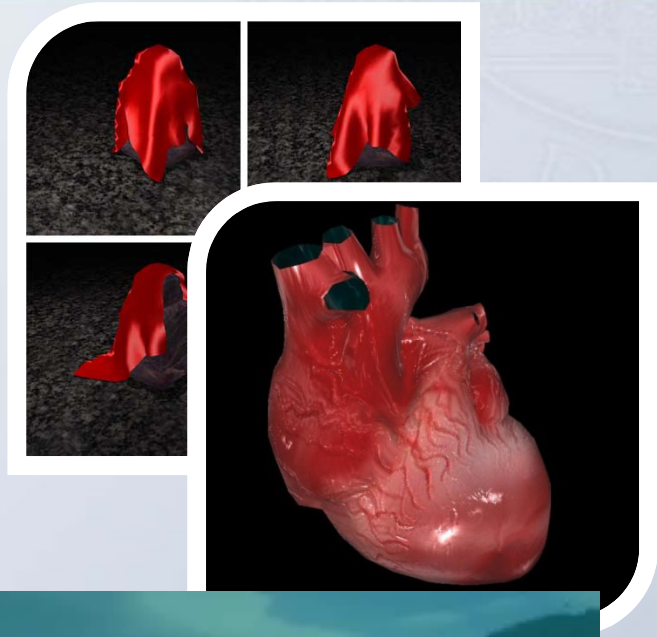


My PhD Subjects:

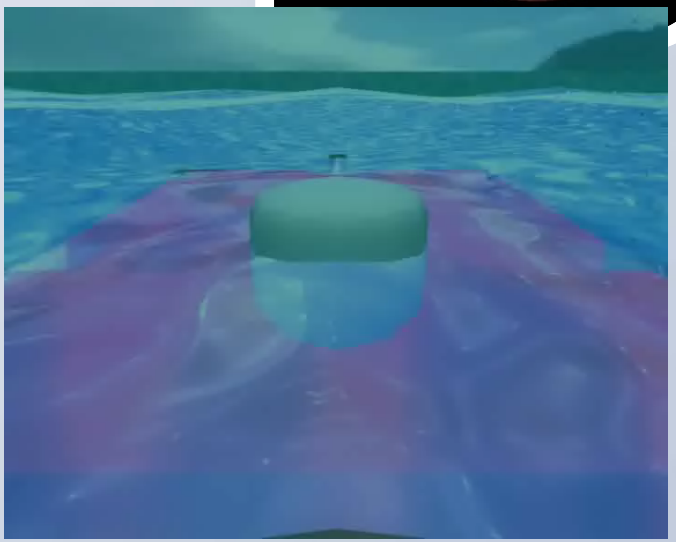
- **Research of new methodologies for soft body simulation**
  (haptics, surgery)
- **Real-time CG.**
- VR simulations for robotics
  (Kinematics, dynamics, robot-enviroment interactions, etc).
- HMI (Human Machine Interfaces).
- Educational mini-robot platform development.



UNIBOT

AIRobots

UAV simulator



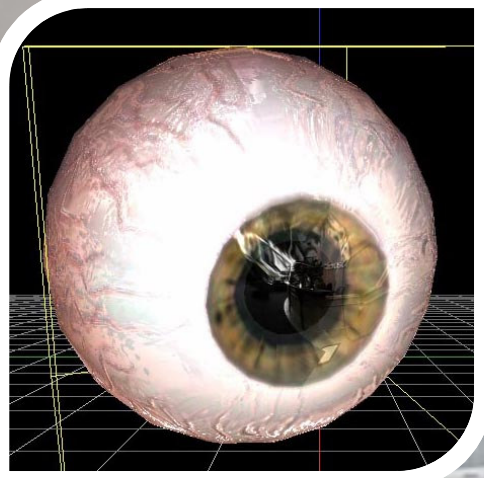
Underwater robot simulator

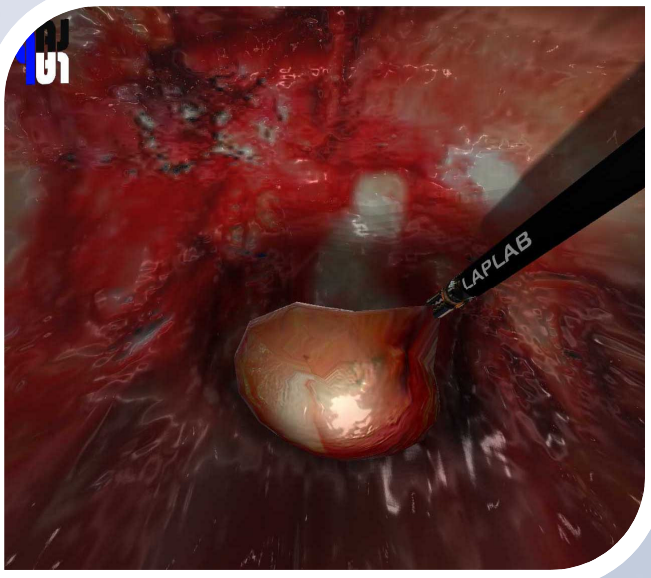
Simulation of complete surgical tasks requires:

- **Soft body model** capable to simulating organs

  (deformations, cuttings, collision detection and response etc.).

- **Surgical tools model.**
- **Very fast 3D engine** for realistic rendering.
- Algorithms for **tasks analysis and evaluation.**

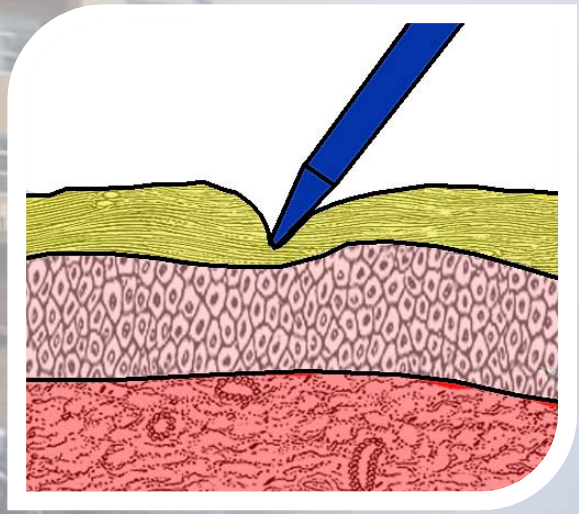


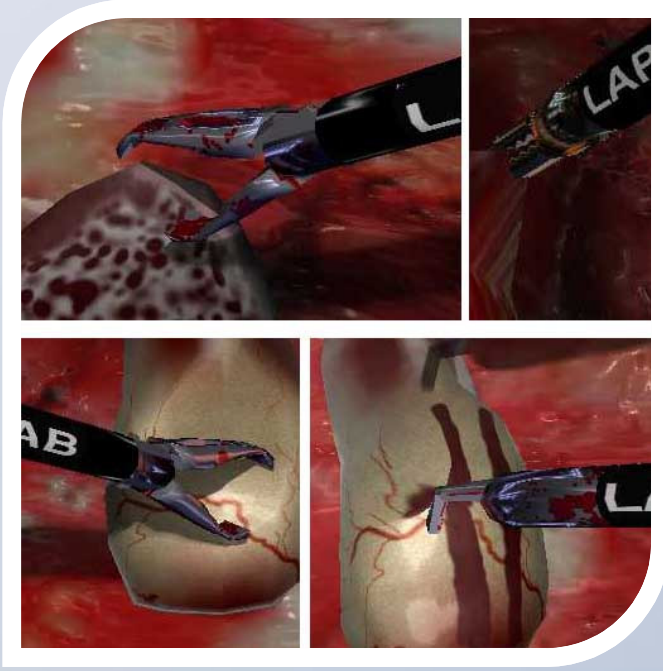


Soft body model for surgery simulations:

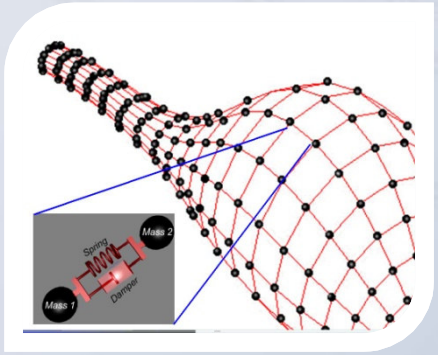
- **Complex shapes** and **multi-body enviroment.**
- **Simulation of cuttings and fractures.**
- **Haptic functionalities (~1Khz sample rate).**

- Possibility to use new hardware features (i.e. PhysX, CUDA, etc.).
- Multi-level surface rendering.
- Haptic textures.



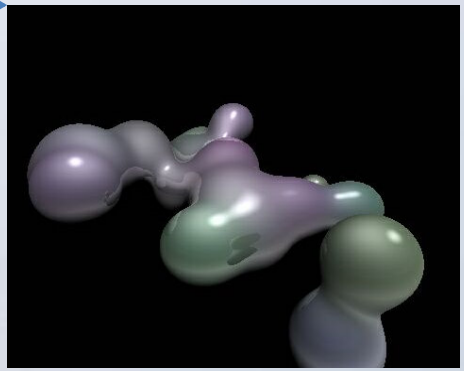


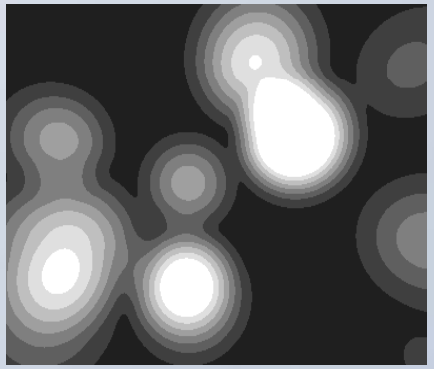
The **classic approach** is Mesh based (**Spring-Damper-Mass**).
Advantages: Isotropy, very accurate in off-line simulations.
Limitations: Mesh cuttings and fractures, collision detection, multi-body, expensive.



Mesh-less approach (using Metaballs +BDTree)

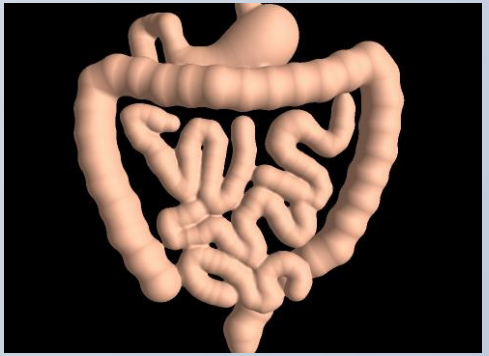
Advantages:
- **Fast collision detection** using Complex shapes.
- **Multi-body**.
- **Cuttings and fractures**.
- Haptic Textures (lookup tables or procedural).
- **Multi-level** properties (i.e. stiffness, dumping, etc.).
- Fluid simulation.





Limitations:
- Cloth simulations.
- **Edges modeling**.
- **Complex tuning** procedure (i.e. Isotropy, etc.).
- **Not very accurate**, but represent a good choice for training systems.

~100 metaballs →



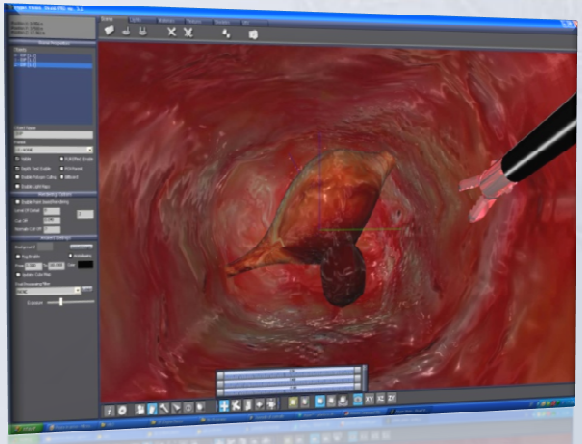
Developed Software

VREngine

It is a 3D engine optimized for real-time simulations (based on OpenGL APIs).

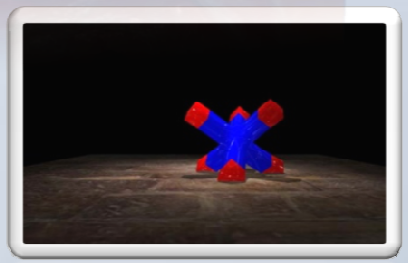
Features:

- Parametric and procedural material description (shaders).
- Animation Support (kinematics, mesh blending, skinning, VPU, etc.).
- Lights and Shadows (realtime and pre-processing).
- Frame post processing + Particle FX (for special effects).
- More rendering profiles (polygonal, PBR/Voxel, etc.).
- Stereo capabilities.

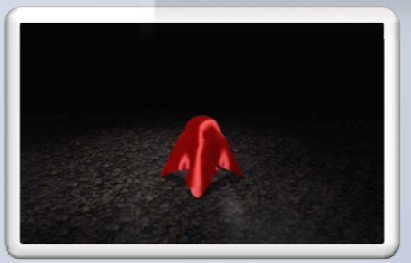


Druid PRO

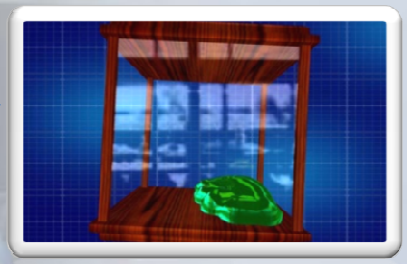
It is a Tool used for content editing (not modeling).



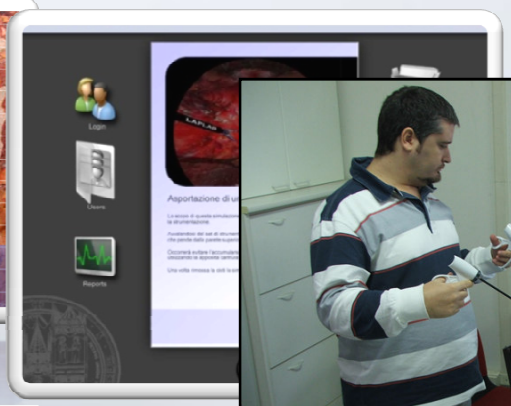
Soft Body Library I - Mesh Based Approach



Soft Body Library II - Mesh-less Approach (Work in progress)



The LapLab simulator (2007-2008)



Angioplasty

Laparoscopy

Now I'm working on a new simulator based on new soft body models

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Thank you for your attention
Any questions ?

Contact info

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