Topic 1 – Overview of gVirtualXRay

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Dr Franck P. Vidal

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Rational for this Research

- Simulation of X-Ray attenuation extensively studied in physics;
- Different physically-based simulation code available;
- Physically-based simulation usually performed using Monte Carlo methods on CPU (often used in dosimetry for radiotherapy);
  - Very accurate; but
  - Computing an image requires a very very very long time (e.g. days or weeks);
- Ray-tracing is an alternative, but
  - Still relatively slow on CPU;
  - Does not easily take into account scattering;
    - Scattering does not necessarily matter in X-ray transmission imaging;
  - Does not include Poisson counting noise;
    - Poisson noise can be added as a post-process.

Medical Training using VR

- PhD (start 2003) and Postdoc (start 2006) in medical VR;
- Development of VR apps to train Interventional radiologists;
  - Stick needles and catheters in the human body whilst looking at images
  - Such as fluoroscopy;
  - Real-time X-ray images on a TV screen.
- Not interested in scattering;
- Noise is not an issue;
- Ray-tracing is viable in this context.

Need for a Simulation Library that is

- Open-source (with a flexible license)
  - Can be used in open-source projects

  - Can be used in closed source commercial applications too
- Fast
  - GPU implementation.
- Flexible
  - Available for most popular programming languages
- Cross platform
  - Run on GNU/Linux, Mac OS X and Windows
- Validated

In a nutshell, gVirtualXray is

- a C++ X-Ray simulation library
- Open source;
- Realtime;
- Portable;
- Validated;
- Available for many programming languages.

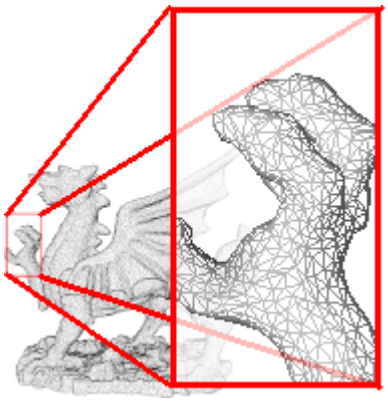
Fact sheet

- SVN repository hosted by 

- Implemented in  using 

- Cross-platform, the library works on
  - Windows, GNU/Linux, and Mac OS X,
  - Nvidia and AMD graphics cards,
  - Integrated GPUs,
  - Desktop PCs and Laptops.
- Is accurate (quantitative validation);
- Enable reproducible research;

- Supports XCOM: Photon Cross Sections Database from NIST National Institute of Standards and Technology;
- Uses polygon meshes to model 3-D geometries from popular file formats (eg. STL, PLY, 3DS, OBJ, DXF, X3D, DAE)



Example of wireframe model

Simulation supports:

- Various source shapes
  - Point source;
  - Cube source;
  - Parallel beam.
- Incident beams:
  - Monochromatic;
  - Polychromatic.
- Geometries:
  - Surface meshes (triangles);
  - Volume meshes (tetrahedrons). **NEW**
- Material properties:
  - Chemical elements (e.g. W for tungsten);
  - Compounds (e.g. H2O for water); **NEW**

  - Mixture (e.g. $Ti_{90}/Al_6/V_4$); **NEW**
  - Hounsfield units (for medical applications).

More recently

- Improved installation from source code.
- Converter from Abaqus files 2 STL files: **NEW**
  - The simulation works with volumetric meshes (tetrahedrons),
  - With surface meshes (triangles)
- Always working on improvements (when time allows)
  - Currently working on the deployment on SuperComputing Wales. **work-in-progress**
  - Port to Vulkan? **work-in-progress**
  - Maybe one day, a Matlab wrapper?

Applications of gVirtualXRay

- Teaching particle physics to undergraduates;
- Virtual Reality Simulation;
- Virtual Testing Lab
- Design new clinical imaging modality to reduce dose exposure
- Teaching radiography in medicine

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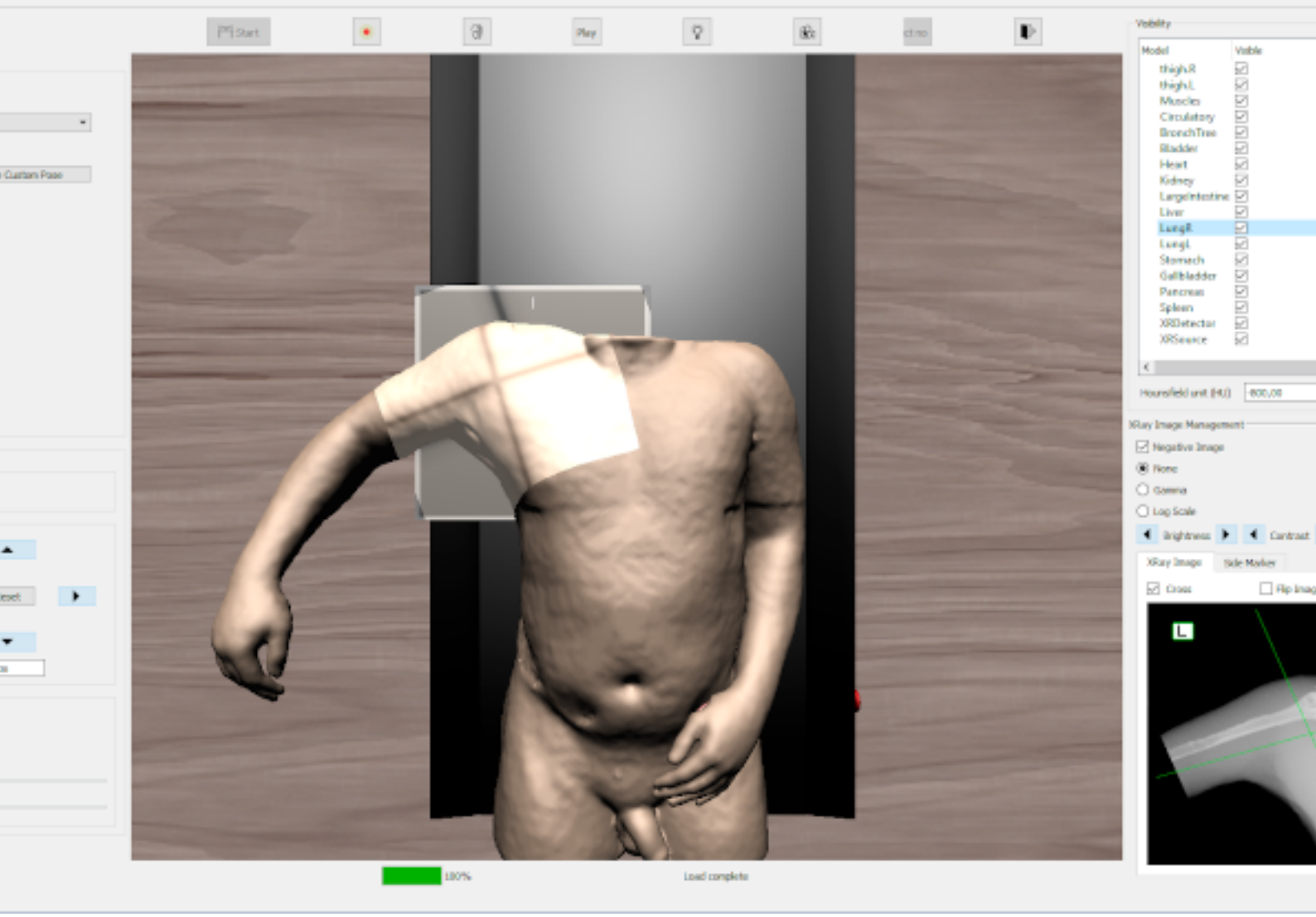

GUI of radiography tool