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An Open Source Framework for Surgical Simulation

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ISC / NA-MIC / MICCAI Workshop on Open Source and Data for Medical Image Computing and Computer-Assisted Intervention

October 1st – Copenhagen (Denmark)

9TH MICCAI CONFERENCE 1-6 OCT.

Insight Software Consortium

Medical Motivation

- The surgery is progressing to **assisted and minimally invasive (MIS)**.

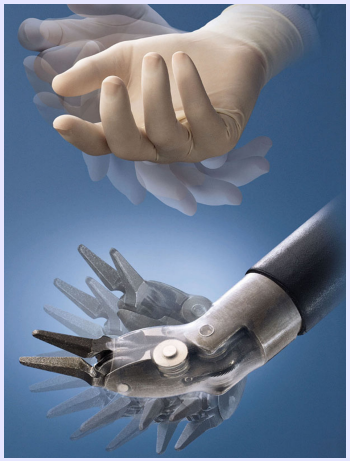
- **MIS** is changing the surgical procedures, and learning & training processes are needed.
- **Emergency or special situations** need to be trained under control.
- A new concept of surgery is starting:
  MIS + Robotic Assisted= MIRS.

- The complexity of the **MIRS Systems** requires specific, specialized and “localized” training.

Teaching Motivation

- Traditionally, the education of surgeons has consisted of "**learning on the job**".

This is **not** always **the best way to learn**, and **still more** in the case of **MIS/MIRS**, or **emergency situations**.



- Surgeons **need** to **learn** and **train**, using their know-how. The medical education methods have to adapt to the advances of medical technogoly.

Teaching Motivation

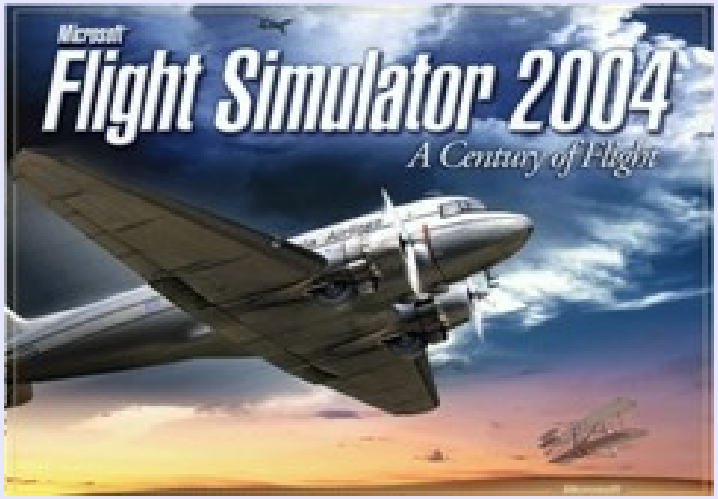
- MIS medical education is based on **physical simulators (hardware), corpses and ,in-vivo, animals.**

These techniques need the **expert supervision**.

- The **trend** is towards **virtual simulation training** before in-vivo.

Virtual simulation teachs basic skills (**expert supervision is not needed**) before training in-vivo.

- This is not a new idea. This **type of education** has been used successfully in other areas.



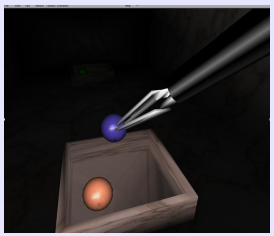
Open Source Motivation

- Virtual surgical simulation is an ongoing **research line**.
- There exists software for surgical simulation, **but...**.

Commercial packages are **so expensive** (i.e. for laparoscopic surgery, the **price of basic skills exercises is > 25000 €**) and the software architecture is **not open**.

Open source packages **don't fit our requirements**

OpenTissue (www.opentissue.org) a wonderful toolkit licensed under LGPL, but has a strong third-party dependency.



Spring (http://spring.stanford.edu/) a very interesting software package licensed under GPL and distributed at sourceforge.

Requirements

- We need **open source** and **multiplatform** software.
- We need open source and powerful **software development tools** for building, testing, versions controlling, genereting documentation automatically, etc.
- We need an open source **object-oriented approach to 3D graphics**.
- We need an open source **scripting language** for simple **GUIs**.
- We need an open source **software for 3D modeling, animation, rendering, post-production, interactive creation and playback**.
- We need to **connect** software for 3D modeling to object-oriented library for 3D graphics and 3D medical image processing (i.e. Slicer).
- We need a **wide community of development** to **share experiences** and **support**.
- We need a **flexible license**.

Requirements

"the **medical imaging industry** has, to our knowlegde, essentially universally **rejected** the idea of **accepting GPL code** in any work that might become a product".

"many **academic researchers** elect to **distribute** software in **binary form** during testing prior to publication, a practice **incompatible** with a **strict** interpretation of **GPL requirements**".

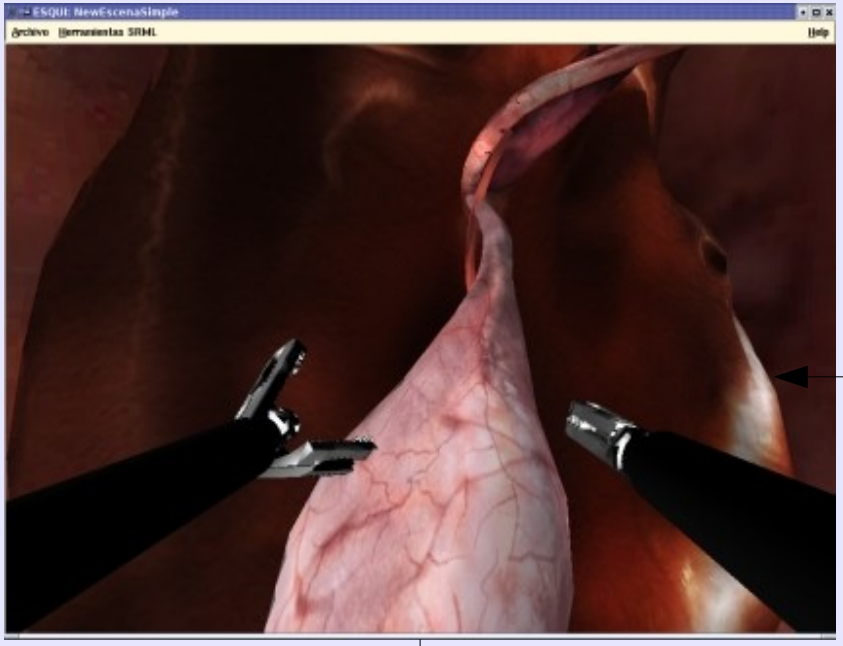
The NA-MIC Kit .. ISBI 2006 - Steve Pieper et al.

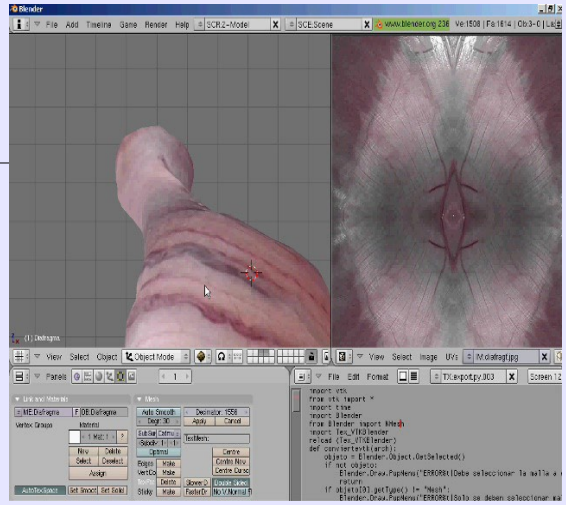
Our proposal: ESQUI

CMake
Cross-platform Make

Doxygen

Dart
Tests, Reports, and Dashboards

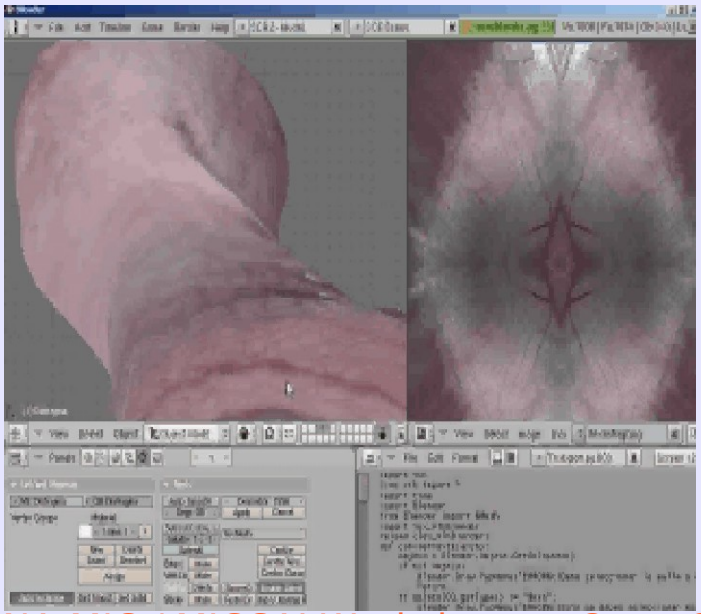




SUBVERSION

- **3D modeling** and the effects of **texture and realims** addition is done using **Blender** (www.blender.org).

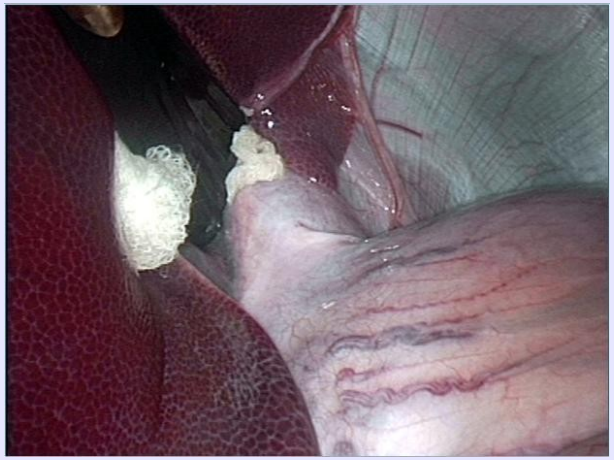
  - This is an open source and multiplatform software.
  - It presents tools for 3D modeling and post-production.
  - It has a command interface under python.

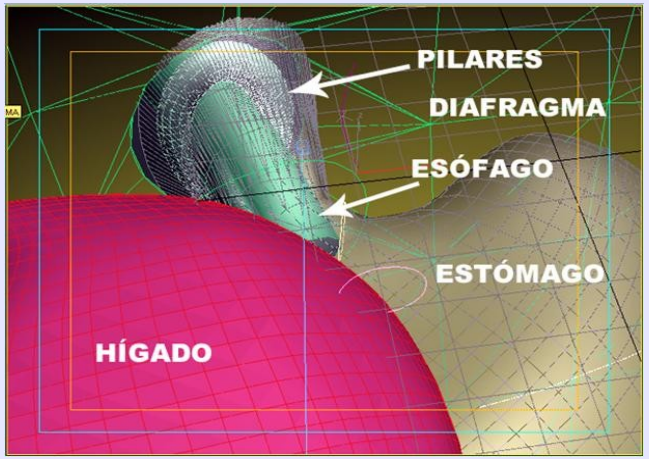


- We have **improved** a **vtk to Blender open source script** to exchange 3D models.

ESQUI: Scenes Description

- A **surgical scene** is very **complex**, still more if it is for a surgical simulator.





- A **general description file** is needed. This file should be **clear**, **extensible** and **adaptable**.
- Surgical Reality Modeling Language (**SRML**) is a descriptor file of the virtual surgical scene.
  - Path to virtual models (organs and tools) and textures.
  - Information about biomechanic model, haptics, cameras, etc.
  - Environment properties.
- Avoid multiple ascii files without any structure. Also, it is **useful** for **step-by-step teaching exercises**.

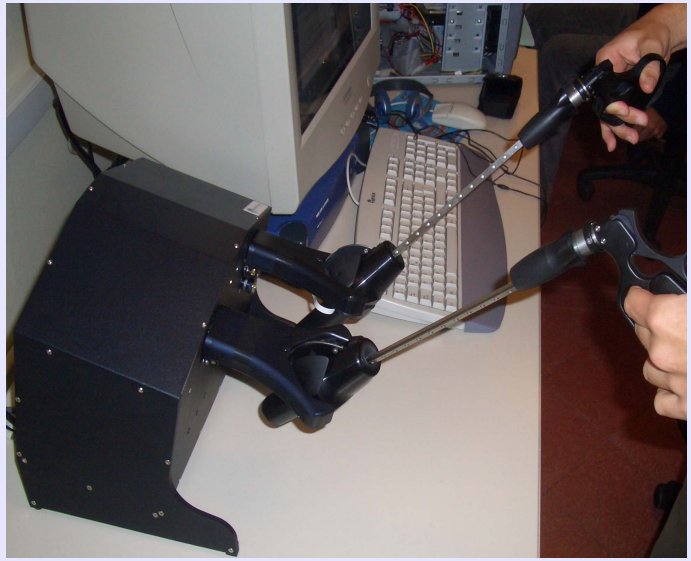
ESQUI: Simulation and Human-Machine Interfaces

- **Virtual simulation** needs **deformations (biomechanics)** and **collisions** models.

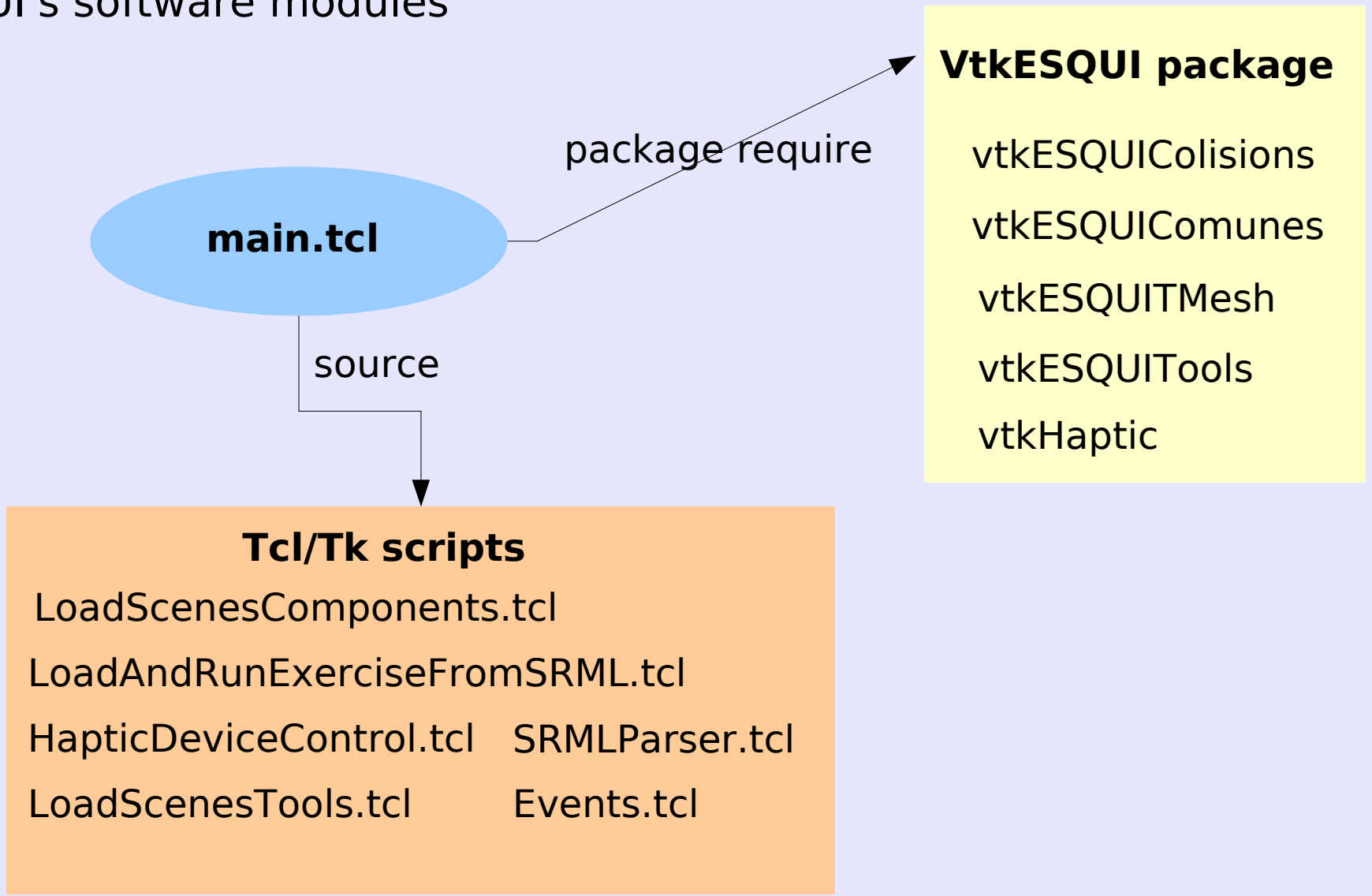
ESQUI contains **VTK classes** to include new algorithms for **deformation** or **collisions**. At the present version, we have wrapped under VTK the collision algorithm ColDetect Library (Laugier et al.) and implemented the biomechanic model (mass-spring) of C. Monserrat's Thesis.

- **Virtual simulation** needs an **human-machice interface (haptic)**.

ESQUI contains **VTK classes** to include new **haptic devices**. At the present version, we have wrapped under VTK the API of a commercial laparoscopic device (LSW - Immersion).



ESQUI's software modules



main.tcl: AbrirArchivo $file at (LoadAndRunExerciseFromSRML.tcl)

create and initialize objects
vtkColision
vtkToolCollection
vtkOrganCollection

extract data from **SRML** : SRMLReadVersion at (SRMLParser.tcl)

<scene> <Tools **load data vtkToolCollection**></Tools><scene>
<undeformable> <UnDefModel **load data static models**>
</UnDefModel></undeformable>
<deformable> <DefModel **load data that can be deformed**
vtkOrganCollection ></DefModel></deformable>

vtkColision load vtkToolCollection/vtkOrganCollection

initialize **vtkSimulation**

ESQUI from Inside

Static Models: SRMLReadVersion “Undeformable”

<undeformable> <UnDefModel **load data that cannot be deformed**>
</UnDefModel></undeformable>

LoadUndefModels $list at (LoadSceneComponents.tcl)

Rendering

Dynamic Models: SRMLReadVersion “Deformable”

<deformable> <DefModel **load data that can be deformed**
></DefModel></deformable>

LoadDefModels $list at (LoadSceneComponents.tcl)

vtkT2Mesh (biomechanic model)

vtkOrganCollection

ESQUI from Inside

Tools and environment: SRMLReadVersion “scene”

LoadEnvironment $list at (LoadSceneComponents.tcl)

vtkLight

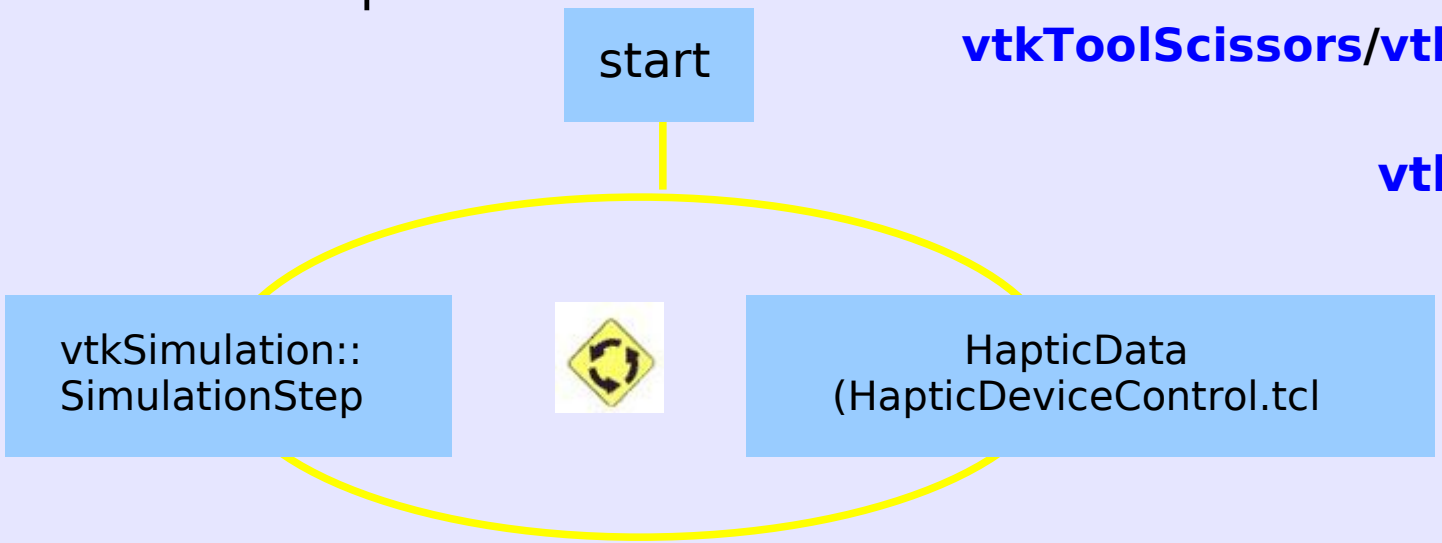
vtkCamera

NewAddTool at (LoadSceneTools.tcl)

vtkToolScissors/**vtkToolGPincers**

vtkToolCollection

Simulation Loop:



Conclusions and Future lines

We have presented a framework for virtual surgical simulation. This framework is:

- Open source and multiplatform.
- Adaptable to any type of MIS.
- Adaptable to any type of haptic.
- Propose a virtual scene description file: SRML.
- Exchange virtual scenarios with 3D medical image software.

However, we **have too much work to do**:

- Translate to english source code comments and documentation, and the GUI menu. Improve install file and a the quickstart (urgently).
- We have to improve the biomechanic and collision models. Include more algorithms (i.e. vtkBioeng collision library) (urgent).
- Include the haptic force feedback.
- Open our subversion server.
- Install and use dart for testing, report and dashboards.
- Implement a python script to export SRML files from Blender.
- Implement didactic exercises and a database module to report score/statistics.
- We need medical validation and clinical feedback. We are starting to work with some endovascular surgeons.
- etc.

Acknowledgments

This presentation will be uploaded to the IJ site.

Thank you

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