Overview of SOFA Features

25.6.2008

Force Fields
Francois Faure

ConstantForceField

Constant forces applied to given degrees of freedom

" scenes/constantForce.scn
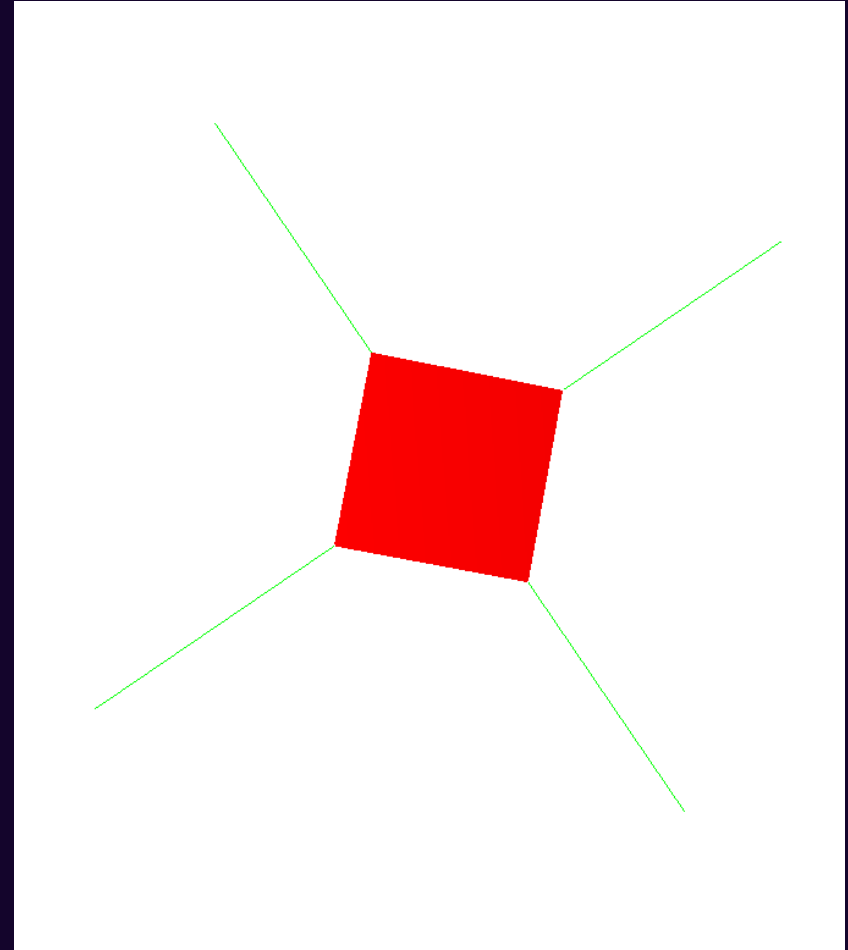
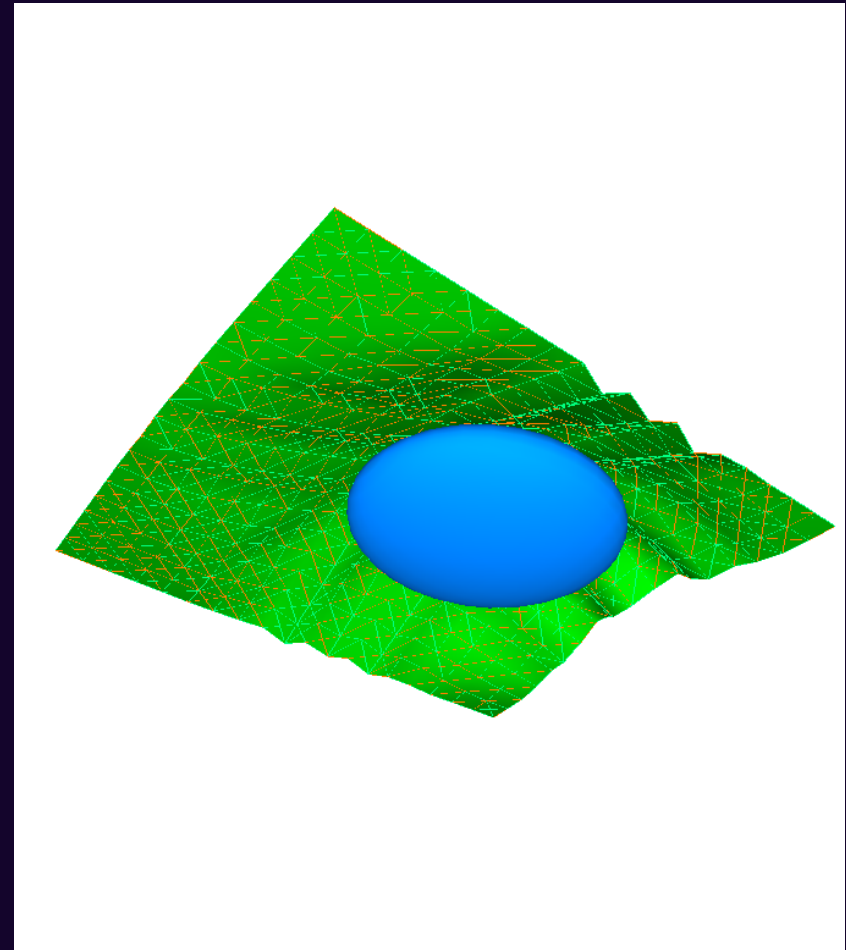# Implicit Force Fields

ConicalForceField
EllipsoidForceField
SphereForceField

- " Repulsion applied by a cone/ellipsoid/sphere toward the exterior
- " examples/conicalFF.scn
- " scenes/Ellipsoid.scn
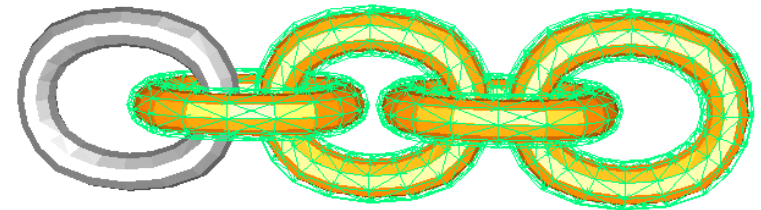- " scenes/triangleFEMSphere.scn

PlaneForceField

- " Repulsion applied by a plane toward the exterior (half-space)
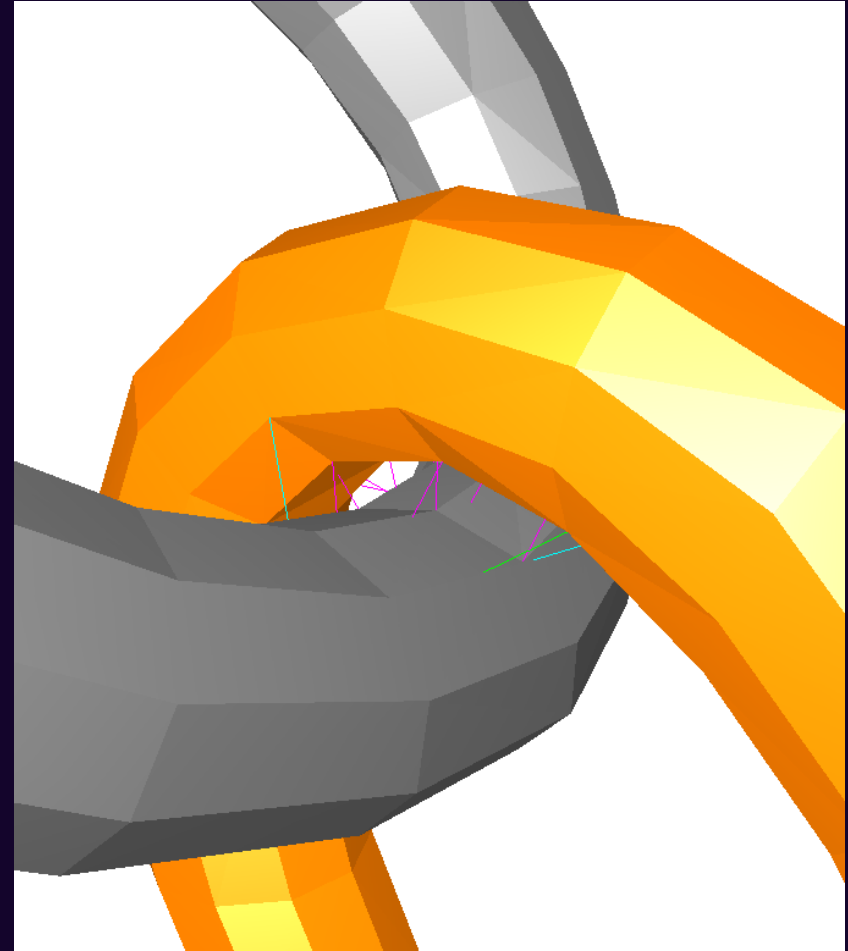- " scenes/2d.scn

MeshSpringForceField

Spring force eld acting along the edges of a mesh

  " scenes/chainSpring.scn
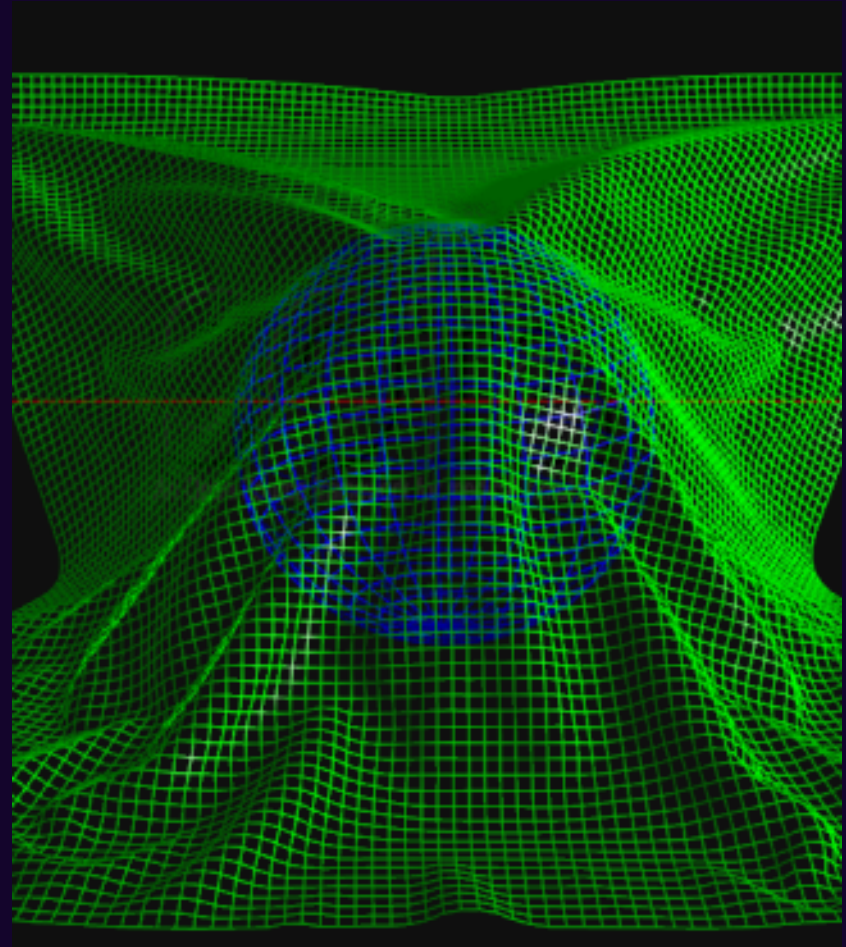
PenalityContactForceField

Contact using repulsive springs: in all our scenes using the proximity method to repulse objects in collision.

QuadBendingSprings
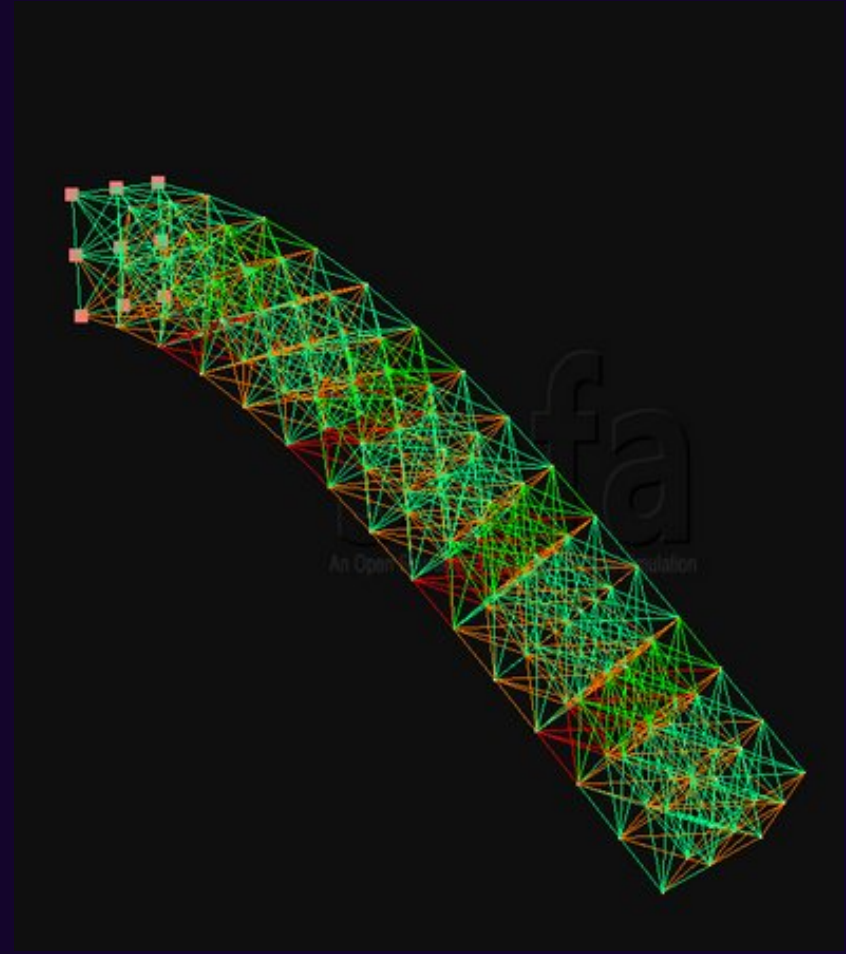
Springs added to a quad mesh to prevent bending

" scenes/quadSpringSphere.scn

StiffSpringForceField
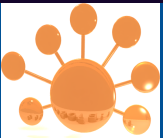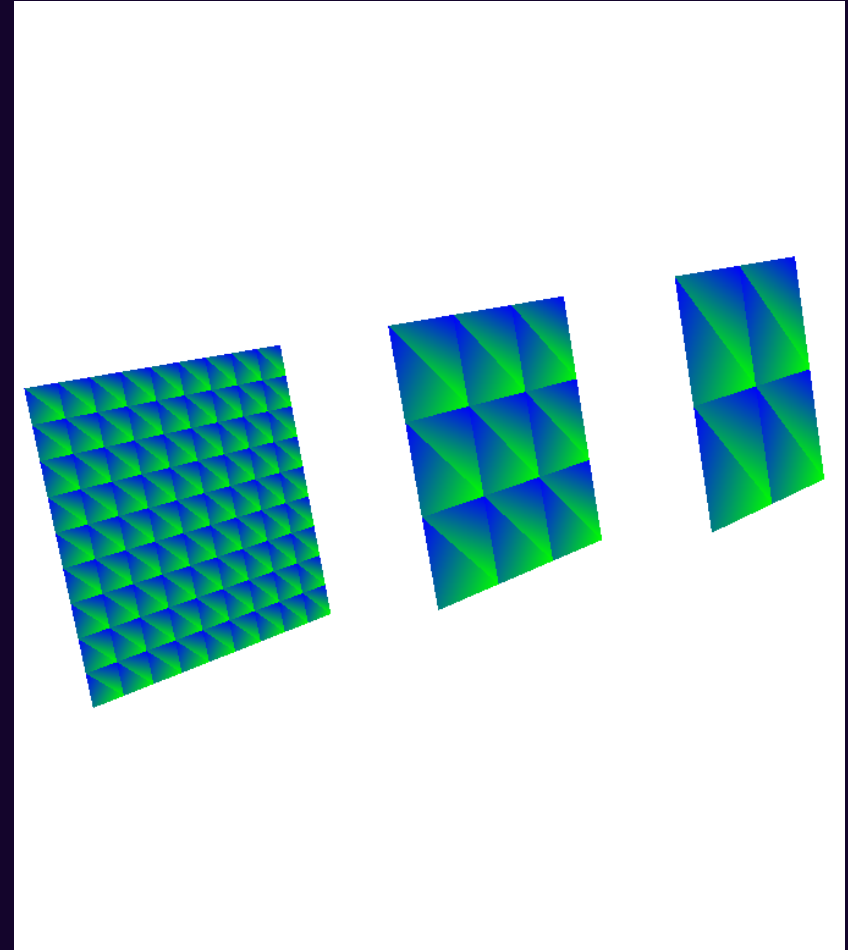
Stiff springs for implicit integration

- " can be used between two objects or between the degrees of freedom of the same object
- " examples/massSpring.scn

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

centre de recherche
GRENOBLE - RHÔNE-ALPES

TriangleFEMForceField
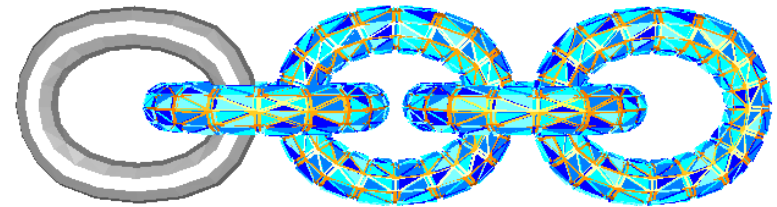
Triangular finite elements
  " scenes/triangleFEM.scn

TetrahedronFEMForceField

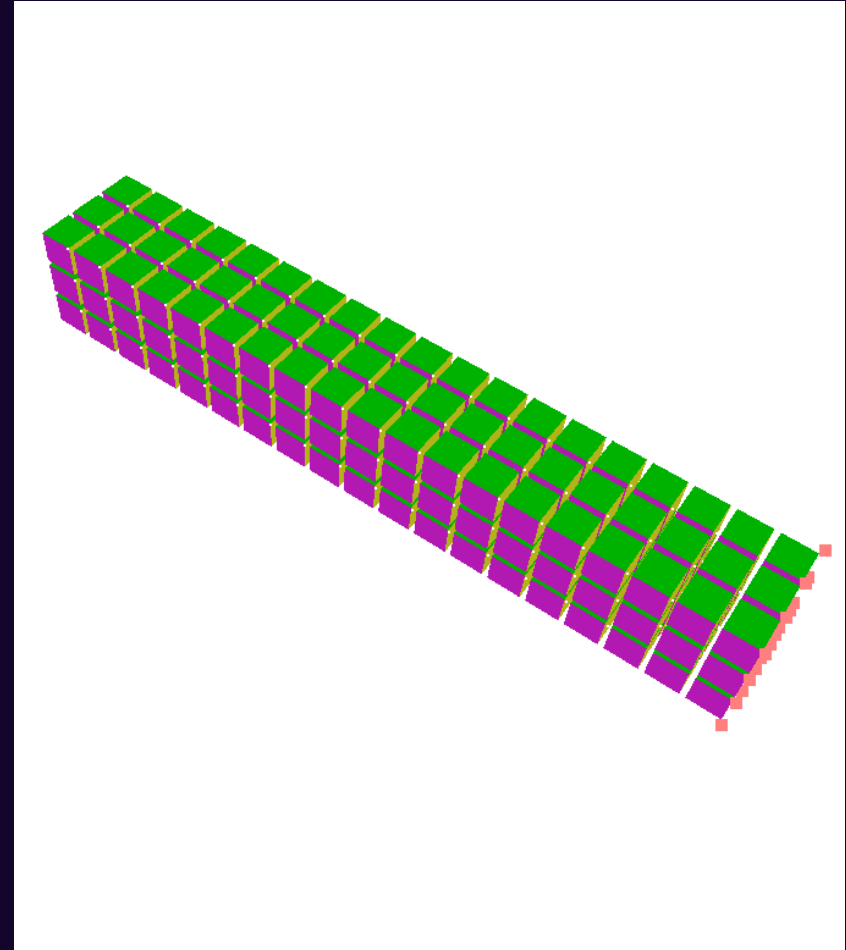Tetrahedral finite elements
- " scenes/chainFEM.scn

HexahedronFEMForceField

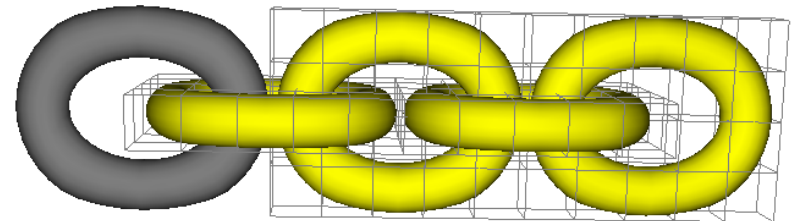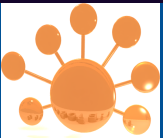Hexahedral finite elements

- " scenes/beamHexahedraFEM.scn
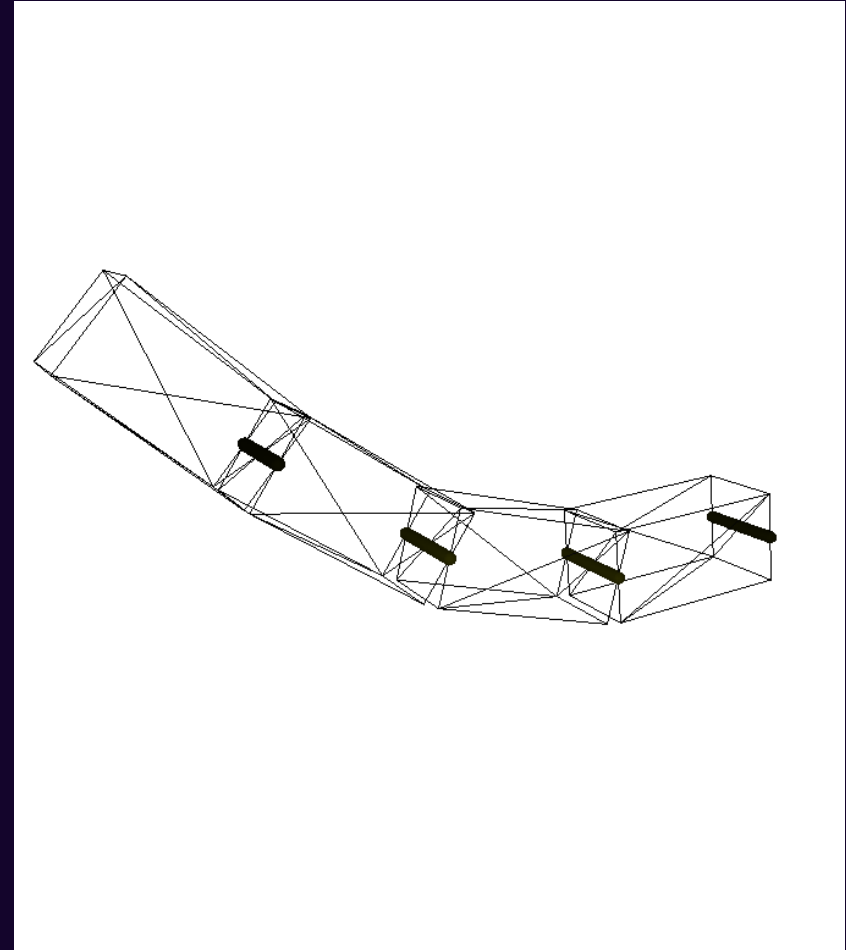
RegularGridSpringForceField

Spring acting on the edges and
faces of a regular grid
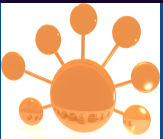
> " scenes/chainFFD.scn
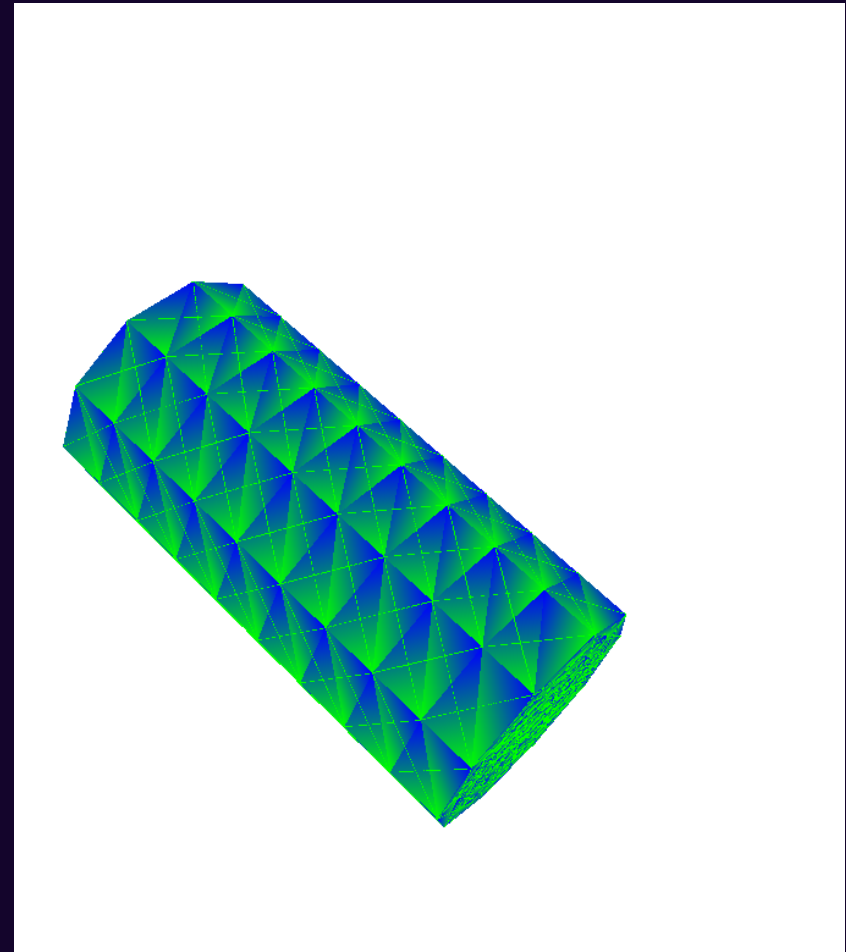
JointSpringForceField

Equivalent of the
SpringForceField but for Rigid

" examples/softArticulations.scn
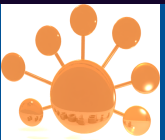
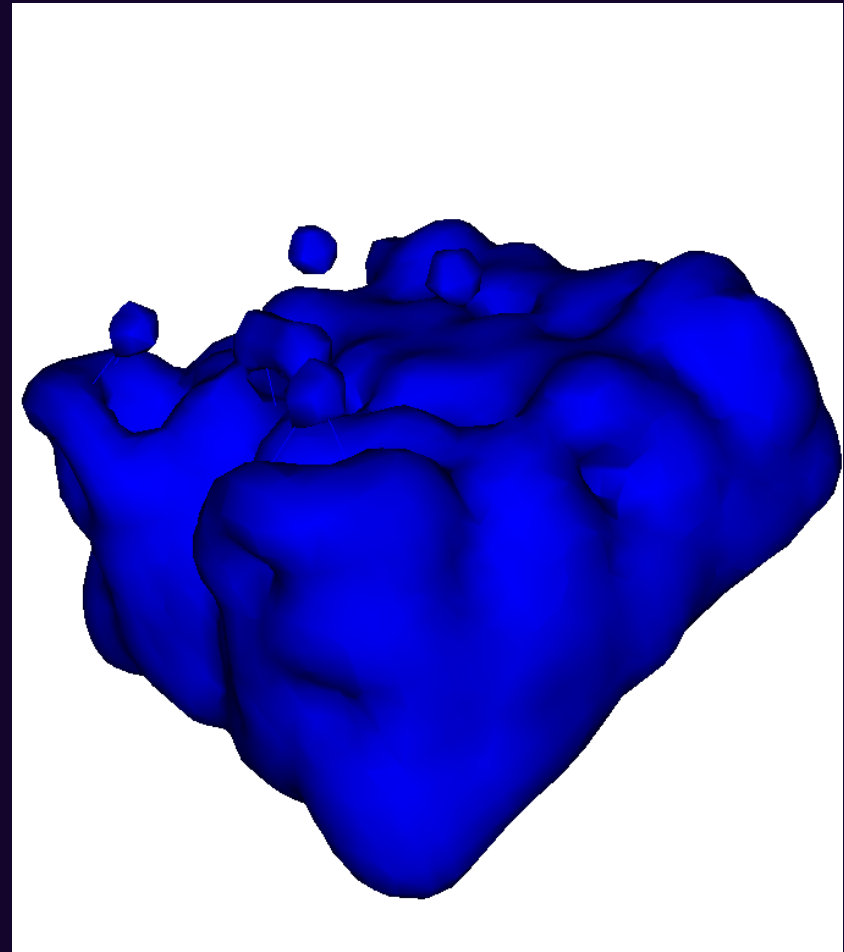# TrianglePressureForceField

Triangle Pressure

" scenes/TopoMap_cylinder3d.scn

LennardJonesForceField
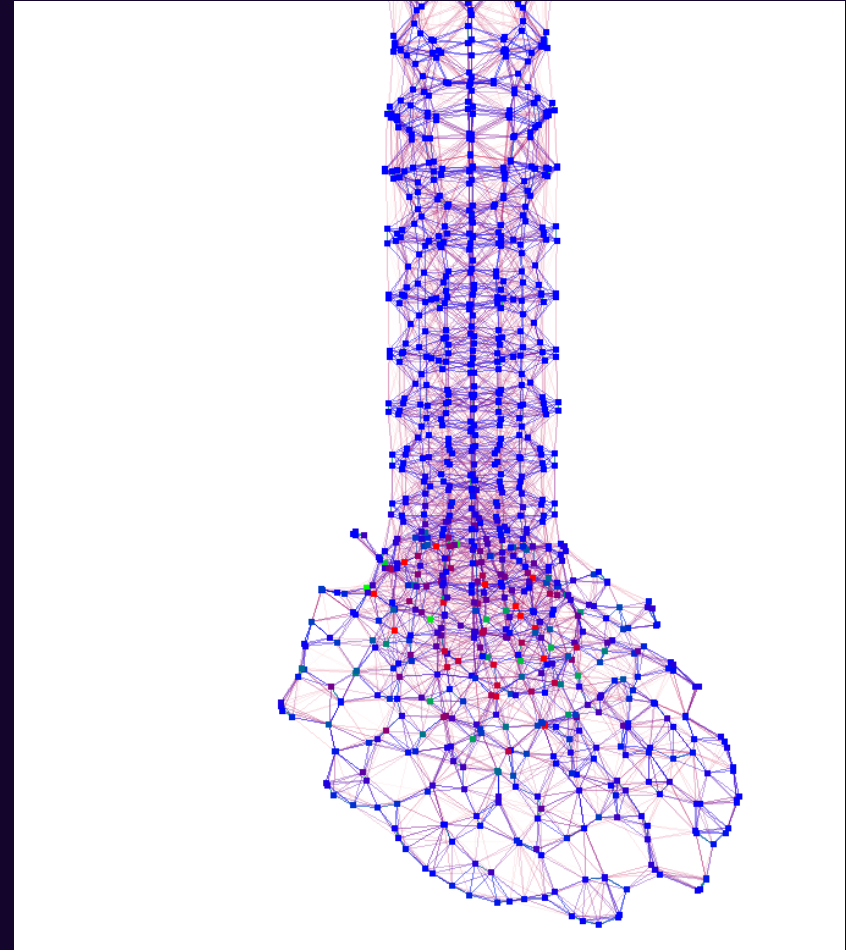
Lennard-Jones forces for fluid
" examples/fluidLennardJones.scn

SPHFluidForceField

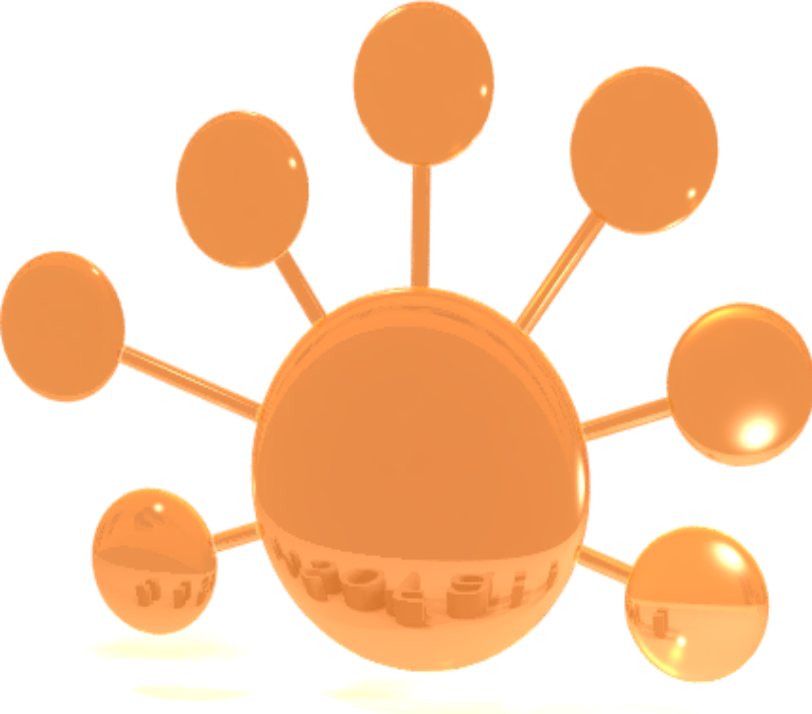Smooth Particle Hydrodynamics
   "   examples/demoSPHFluid.scn

Mappings
Francois Faure

BarycentricMapping

Mapping using barycentric coordinates of the child with respect to the cells of its parent

- " the most used mapping in Sofa
- " can be found in lots of scenes needing mapping between deformable objects
- " scenes/chainFEM.scn

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

centre de recherche
GRENOBLE – RHÔNE-ALPES
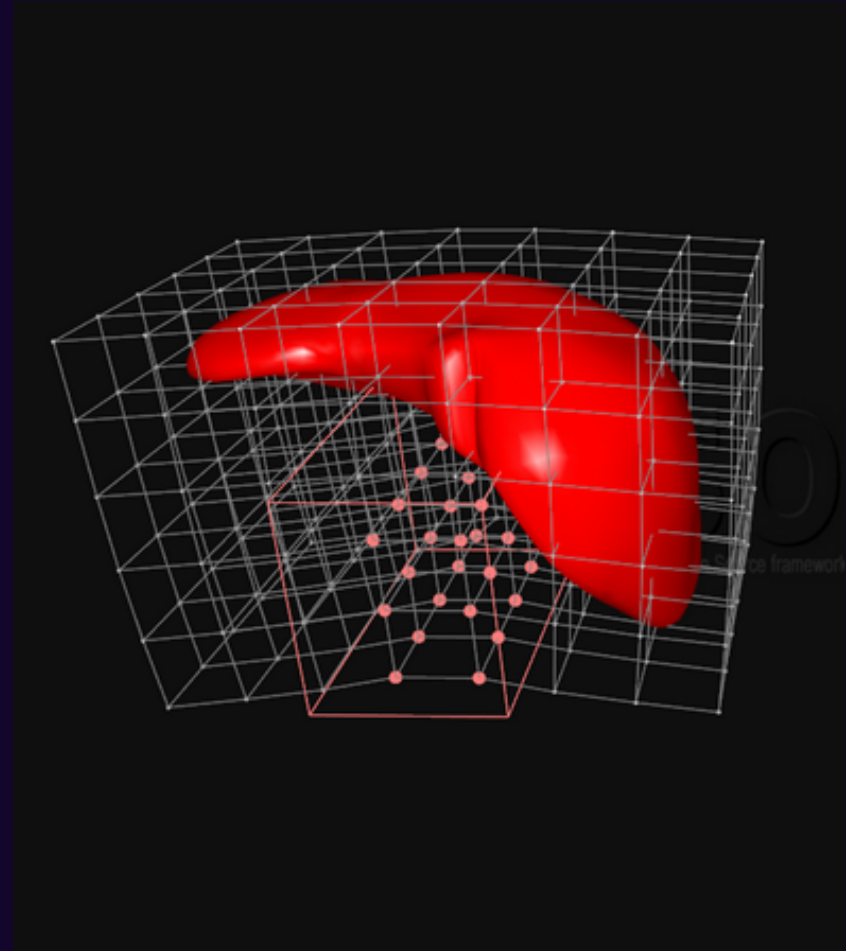
IdentityMapping

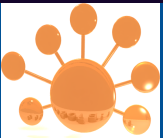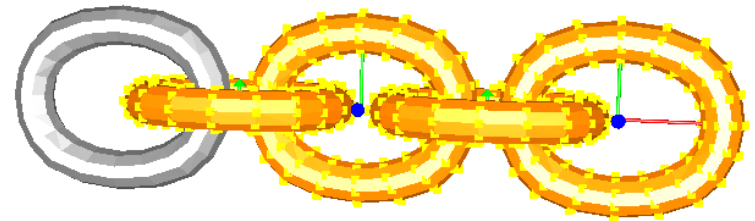Special case of mapping where the child points are the same as the parent points

- " can be used, e.g., for data conversion
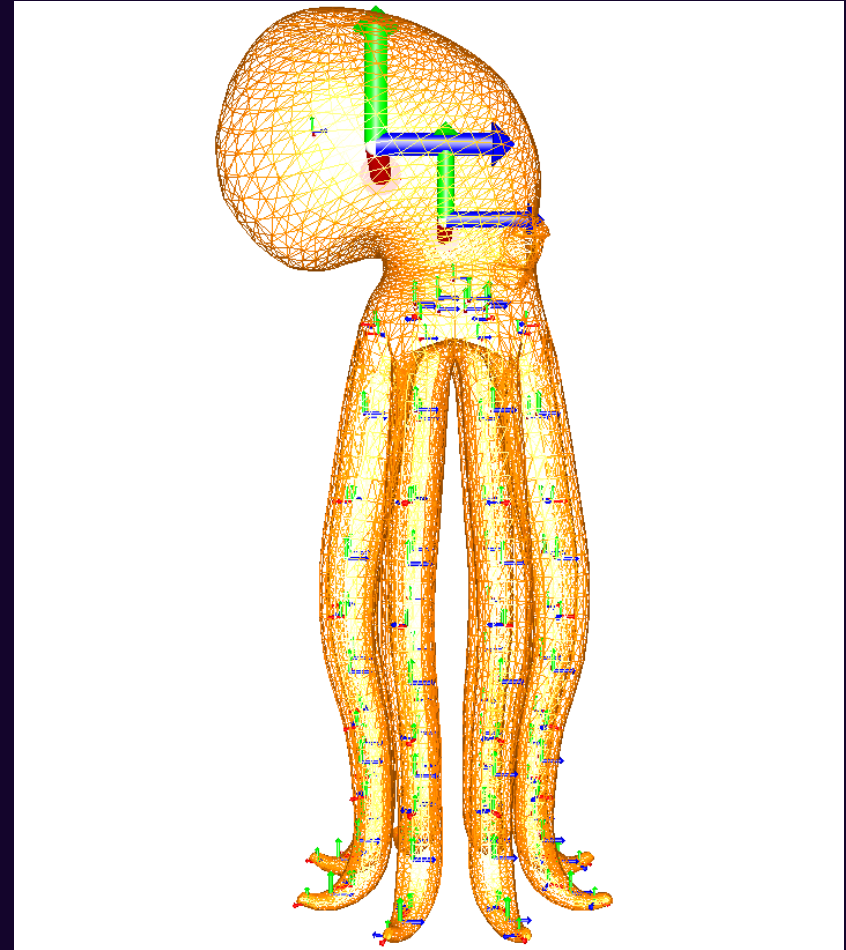- " examples/demoTshirtFEM.scn

RigidMapping

Set the positions and velocities of points attached to a rigid parent
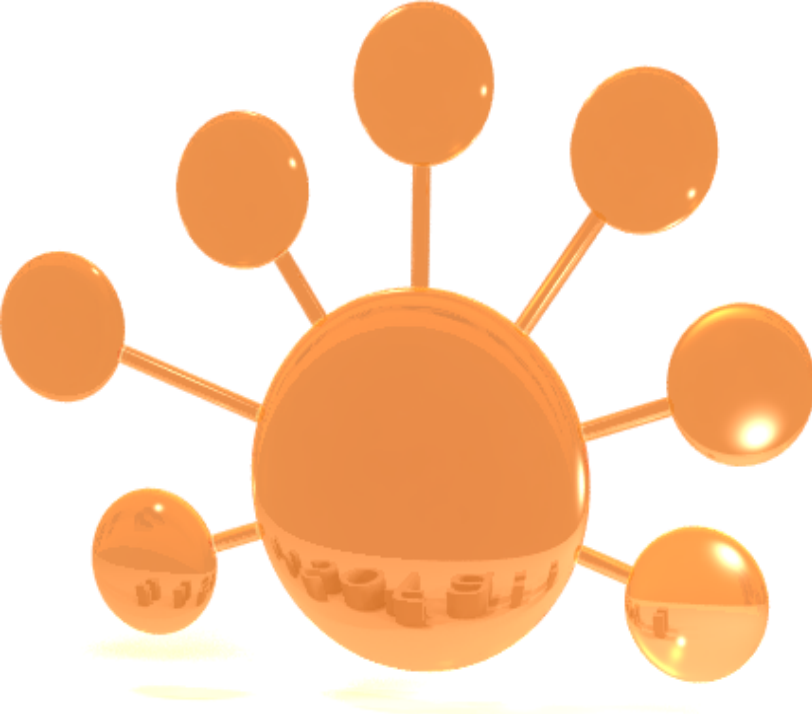
" scenes/chainRigid.scn

SkinningMapping

" examples/SkinnedRigidPendulum.scn

Constraints
Christian Duriez
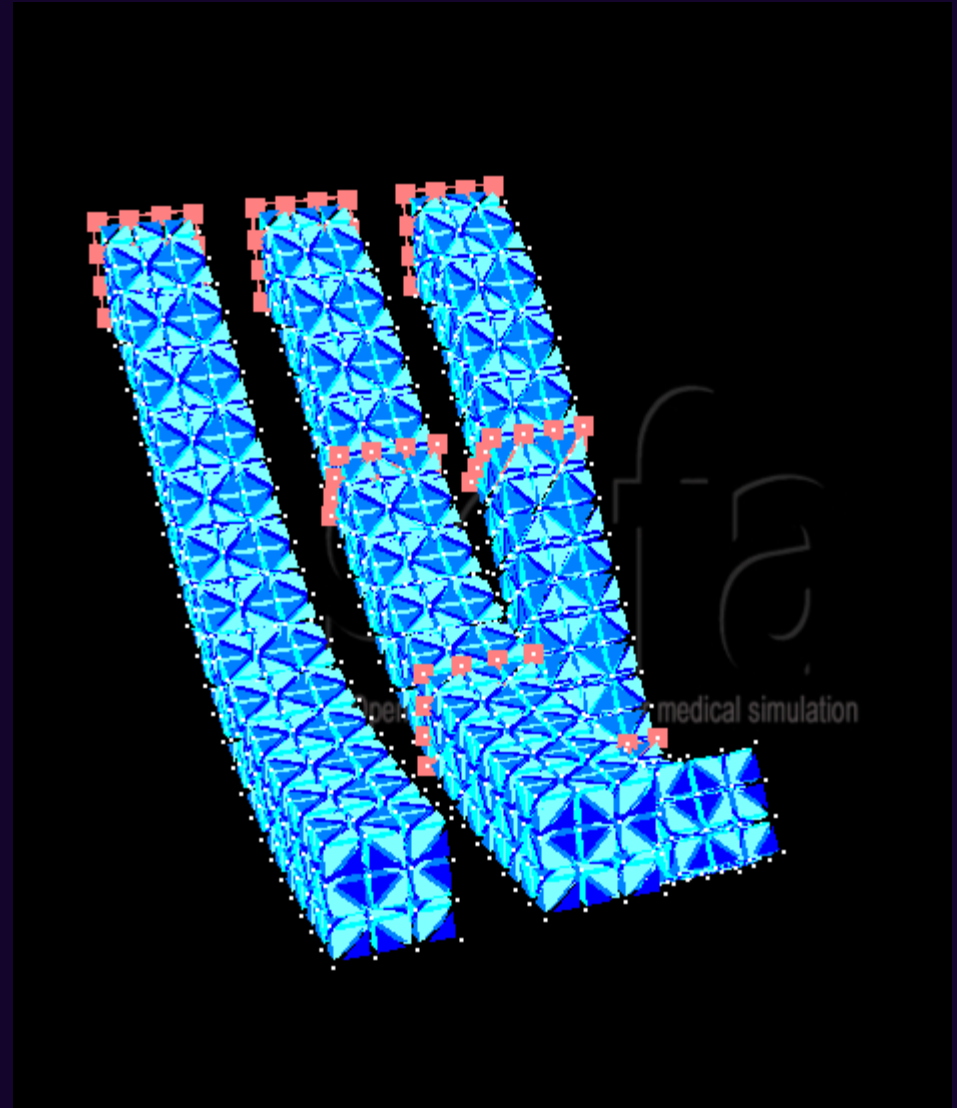
Constraints

Constraints with no motion:
- " Fixedconstraints
- " Box constraints

Bilateral constraints:
- " Attached constraints
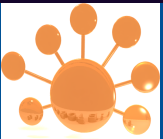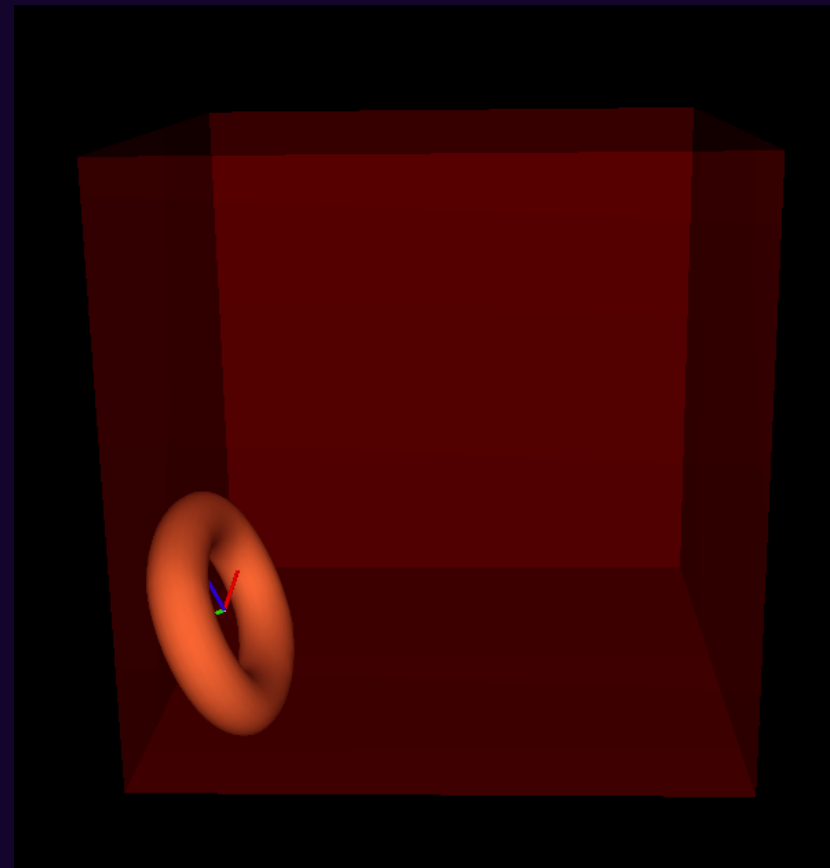
(solved by projection)

scenes\beamFEMAttach.scn

Constraints

Contraintes unilatérales (contact)
avec frottement

- Exemples\
  demoRigidFrictionContact.scn
- Exemples\
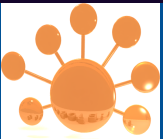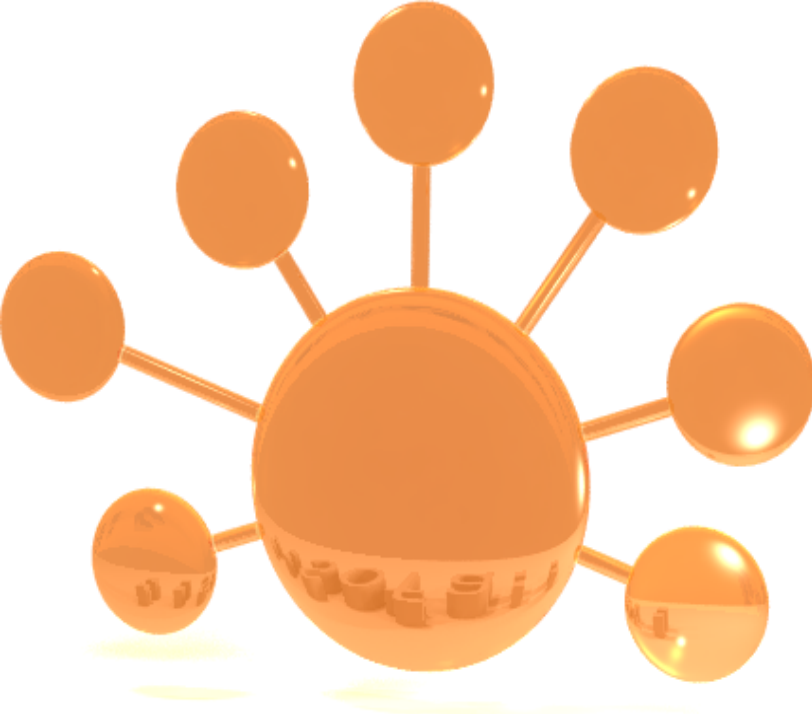 demoRigidFrictionContact2.scn

(LCP and NLCP solvers)

Constraints

Towards a unified process with constraints to allow for:

" Lagrange multiplier
" Degree of freedom reduction
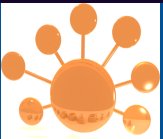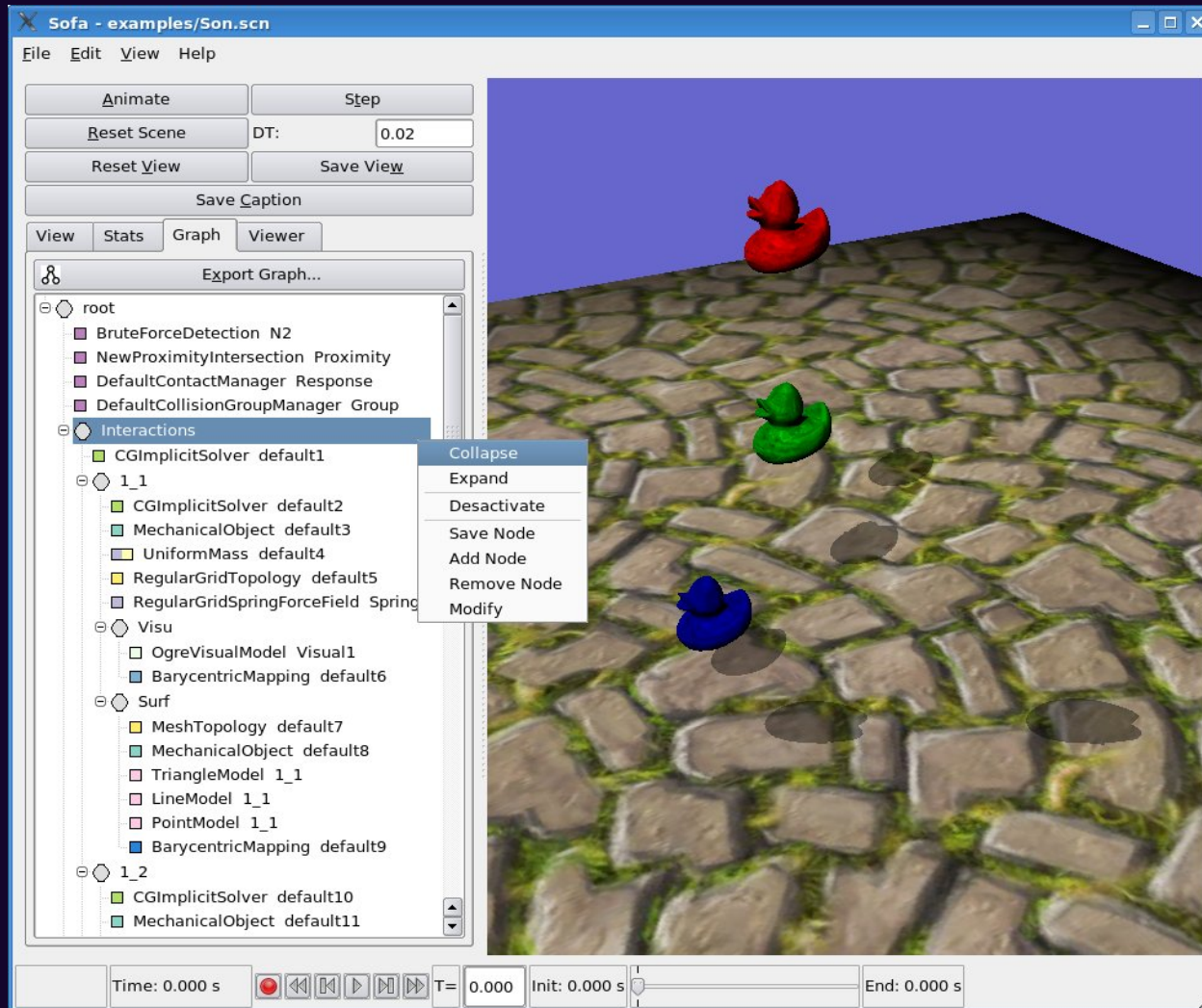" Direct constraint process

Not available yet...

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

centre de recherche
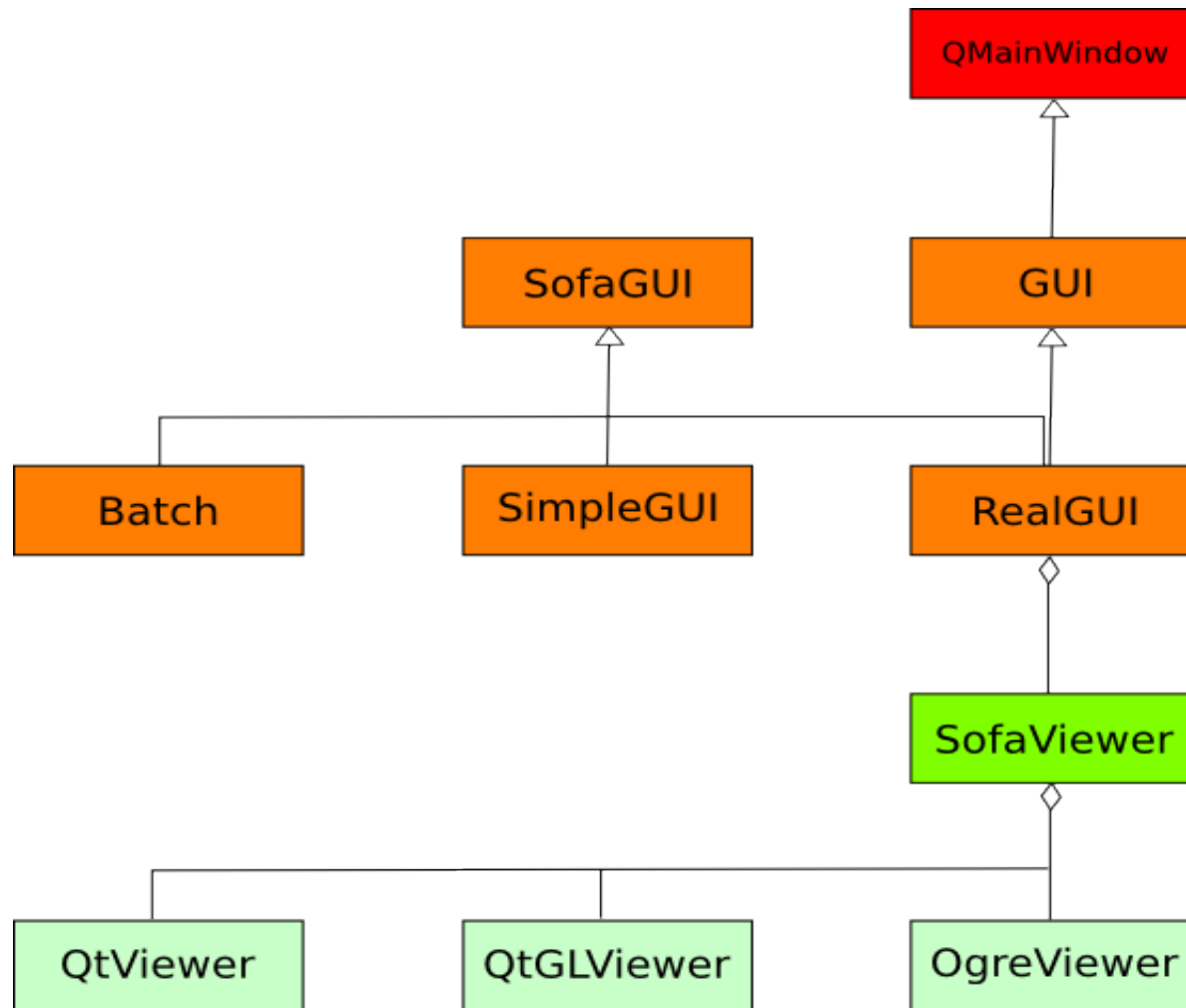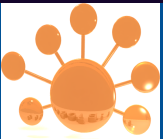GRENOBLE - RHÔNE-ALPES

GUI
Florent Falipou

GUI

GUI - Architecture

SOFA::MAYA
Michaël Adam

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

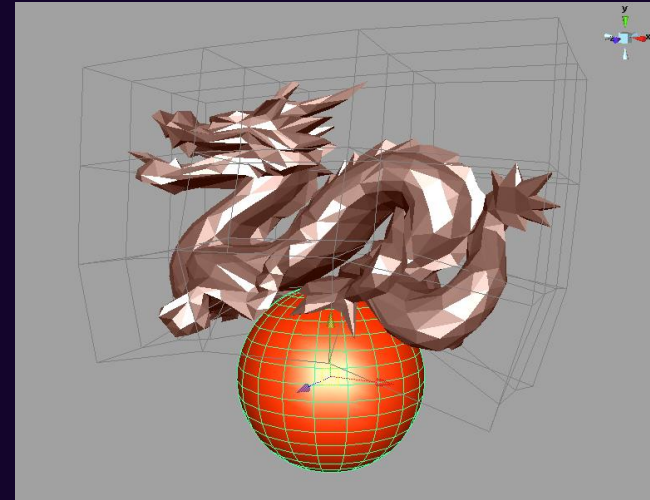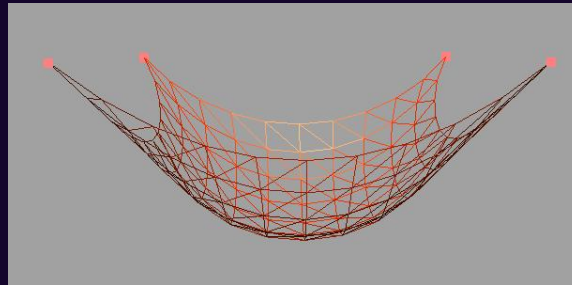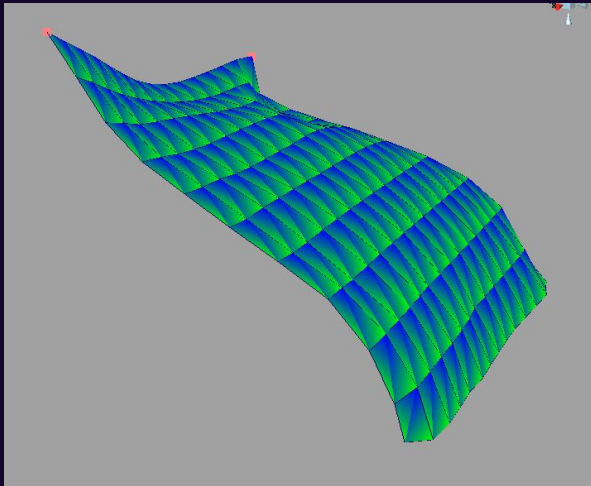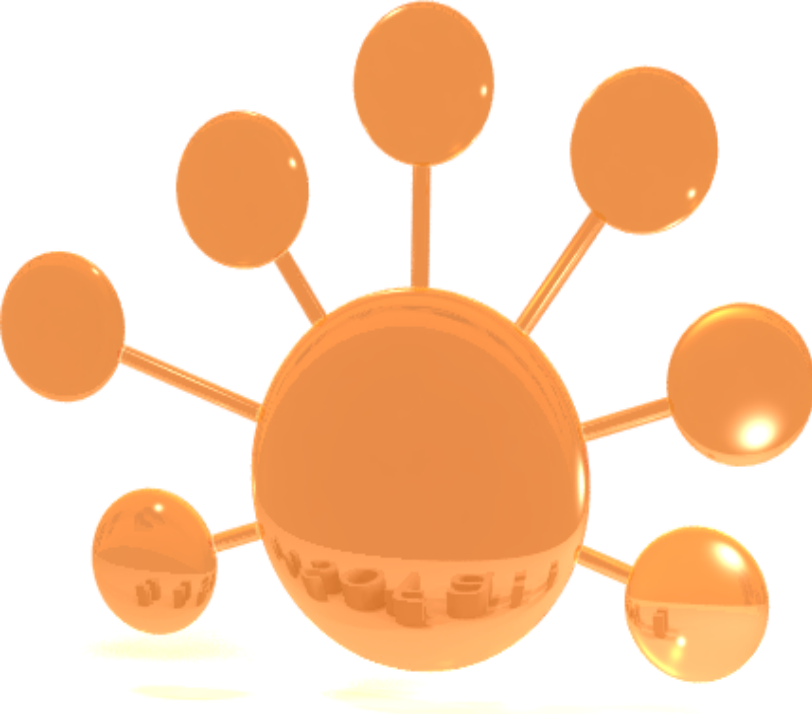centre de recherche
GRENOBLE - RHÔNE-ALPES

Current Possibilities

Simulate deformable objects with different Sofa models

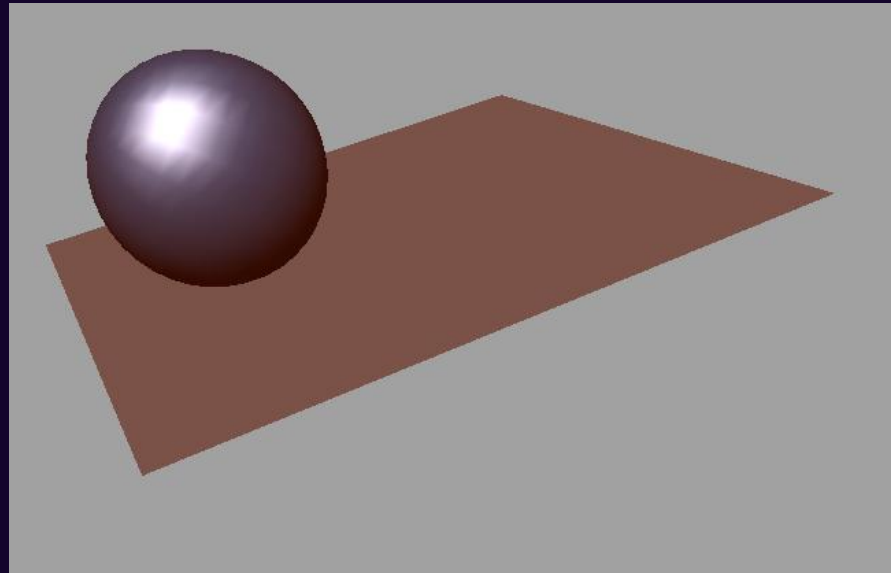- FEM
- Stiff Springs
- FFD Grid
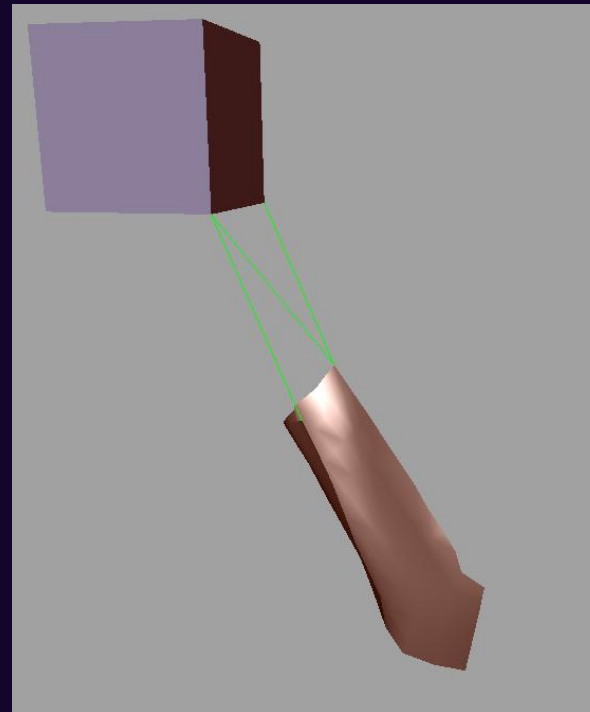
Current Possibilities

Simulate rigid objects
- " active
- " inactive

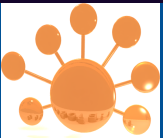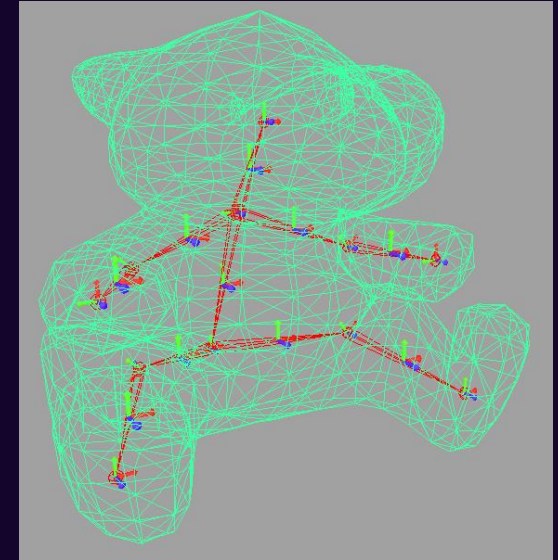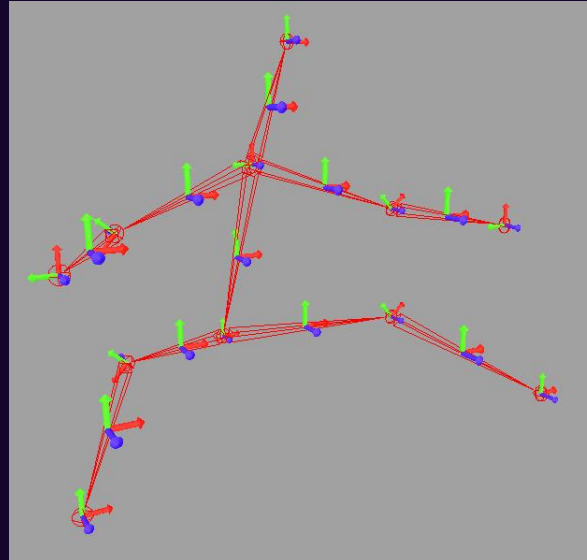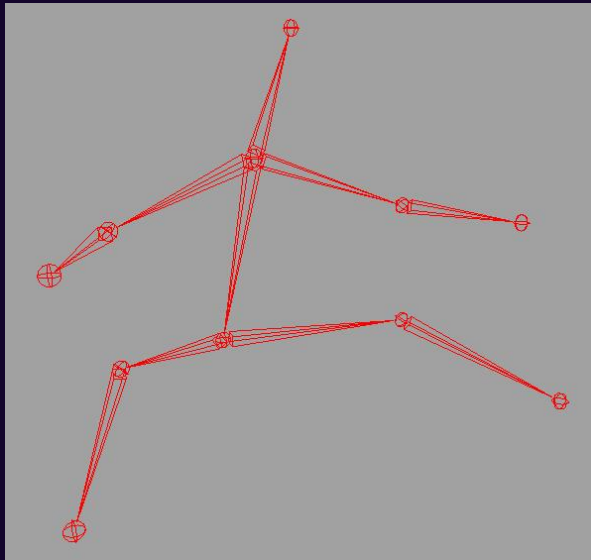# Current Possibilities

Perform collisions

Add constraints

Build interactions

Current Possibilities

Simulate articulated bodies

" Create the Sofa rigid body structure directly from Maya skeleton.

" Create the associated skinning in Sofa from the skinning weights used in Maya.

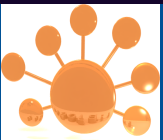# Current Possibilities

Export sofa scenes

" Save a scene created with Maya to .scn file.
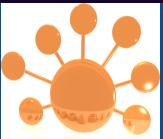
" Then open it directly into Sofa.

"

Import sofa scene
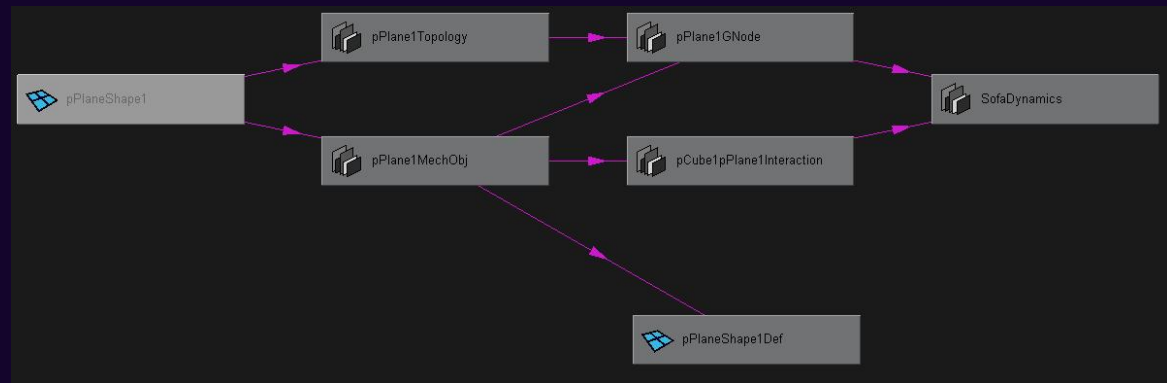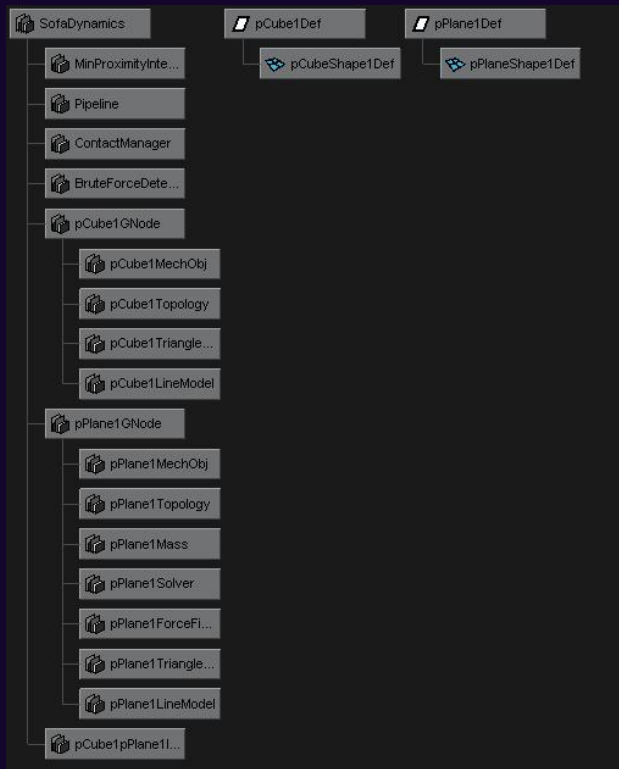
" Open a .scn file into Maya.

" Modify the scene, play the simulation using Maya interactivity.

Integration of SOFA

Make Sofa as a Maya plug-in

- " Put the Sofa scene graph into the Maya scene graph.
- " For each Sofa object, a Maya node is created.

User Interface

- A Sofa menu.
- Sofa objects parameters can be changed.
- Sofa objects display is plugged into the Maya scene.
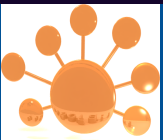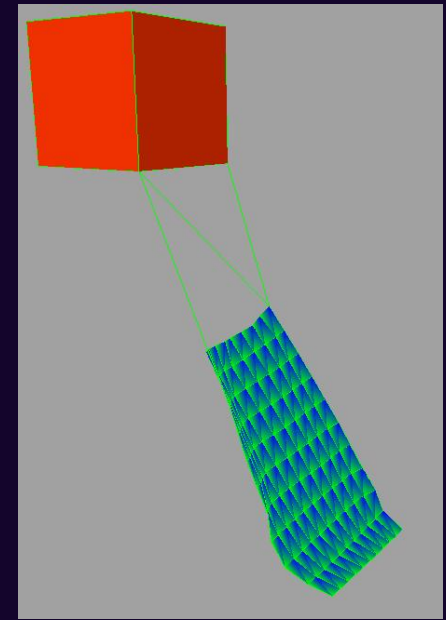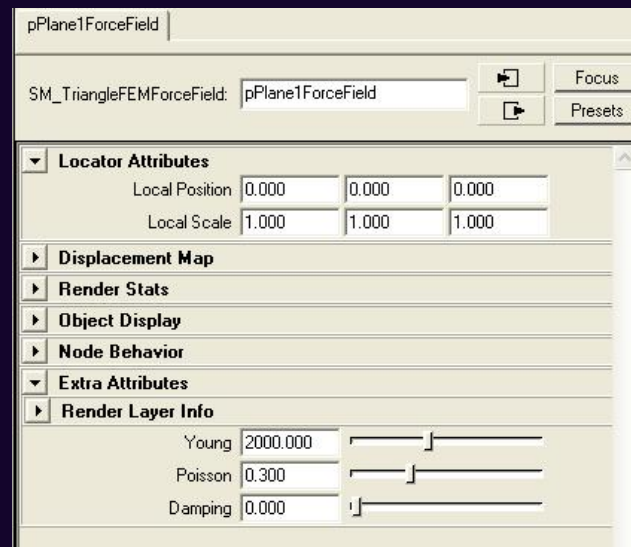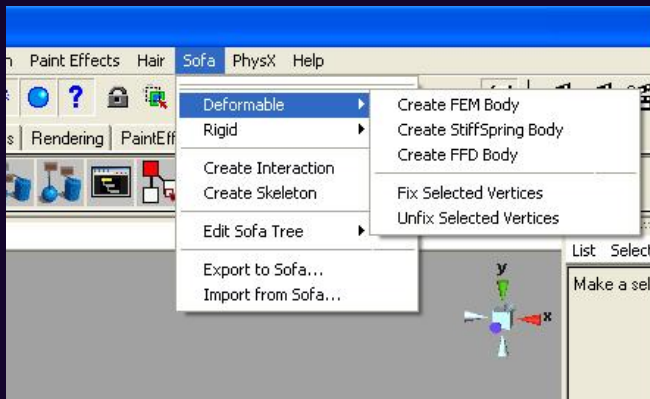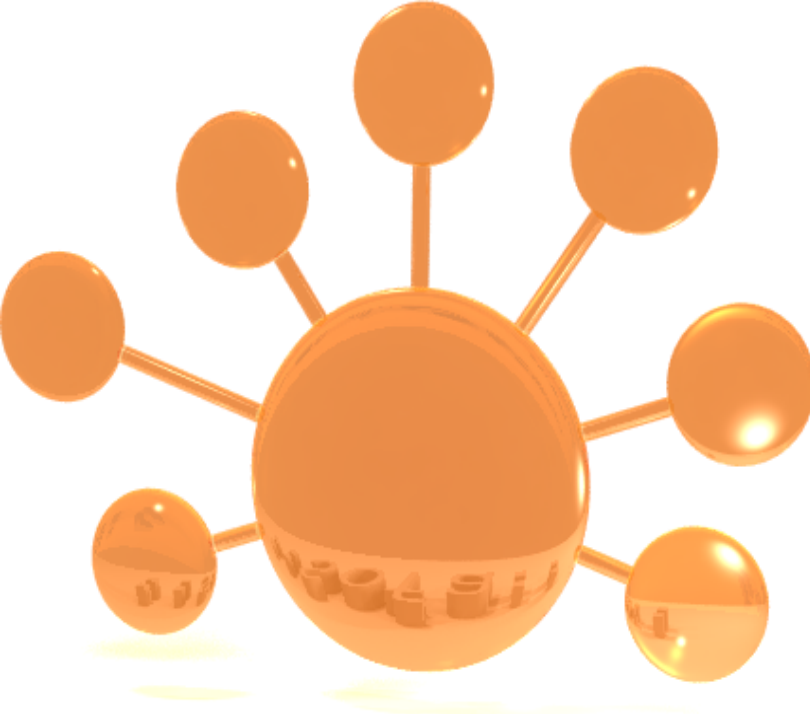
Using Blender Functionalities with SOFA
Vincent Vansuyt

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

centre de recherche
GRENOBLE - RHÔNE-ALPES

Blender's imports and exports for SOFA

SOFA

BLENDER

Import and export

XML SCENE FILE

Objects
- meshes
- positions
- colors
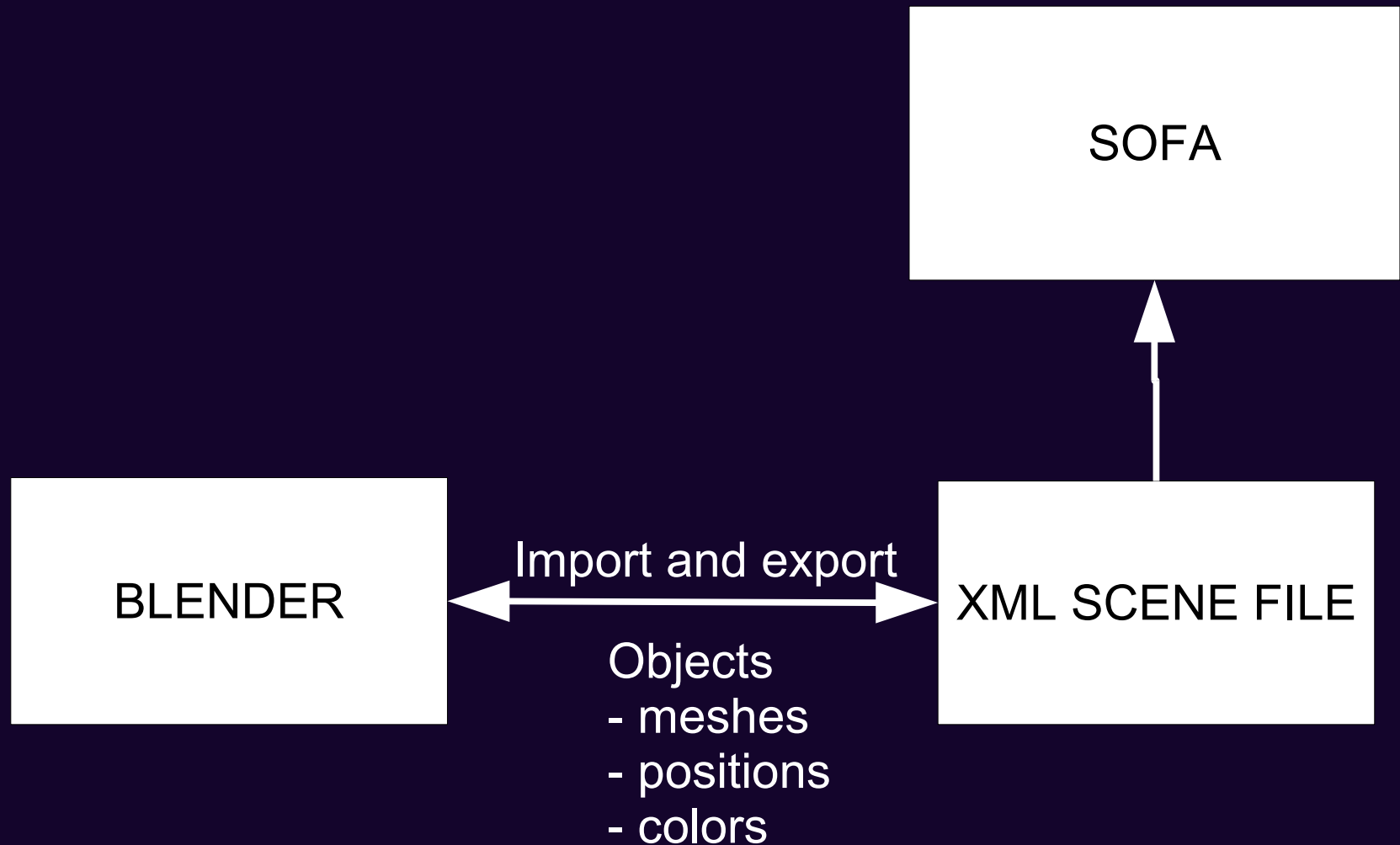
Blender's imports from SOFA (1/5)
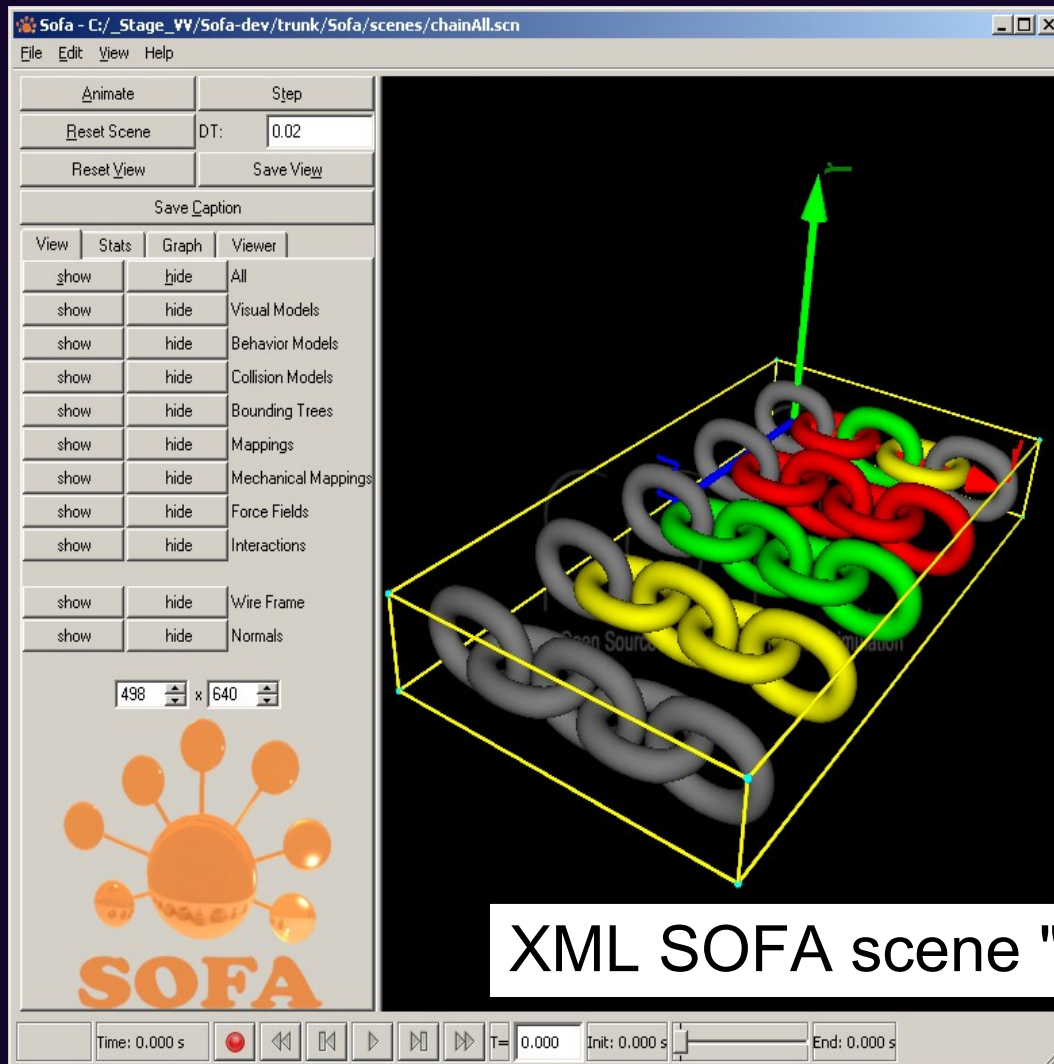
XML SOFA scene "ChainAll.scn"
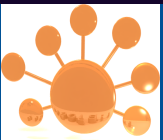
Blender's imports from SOFA (2/5)
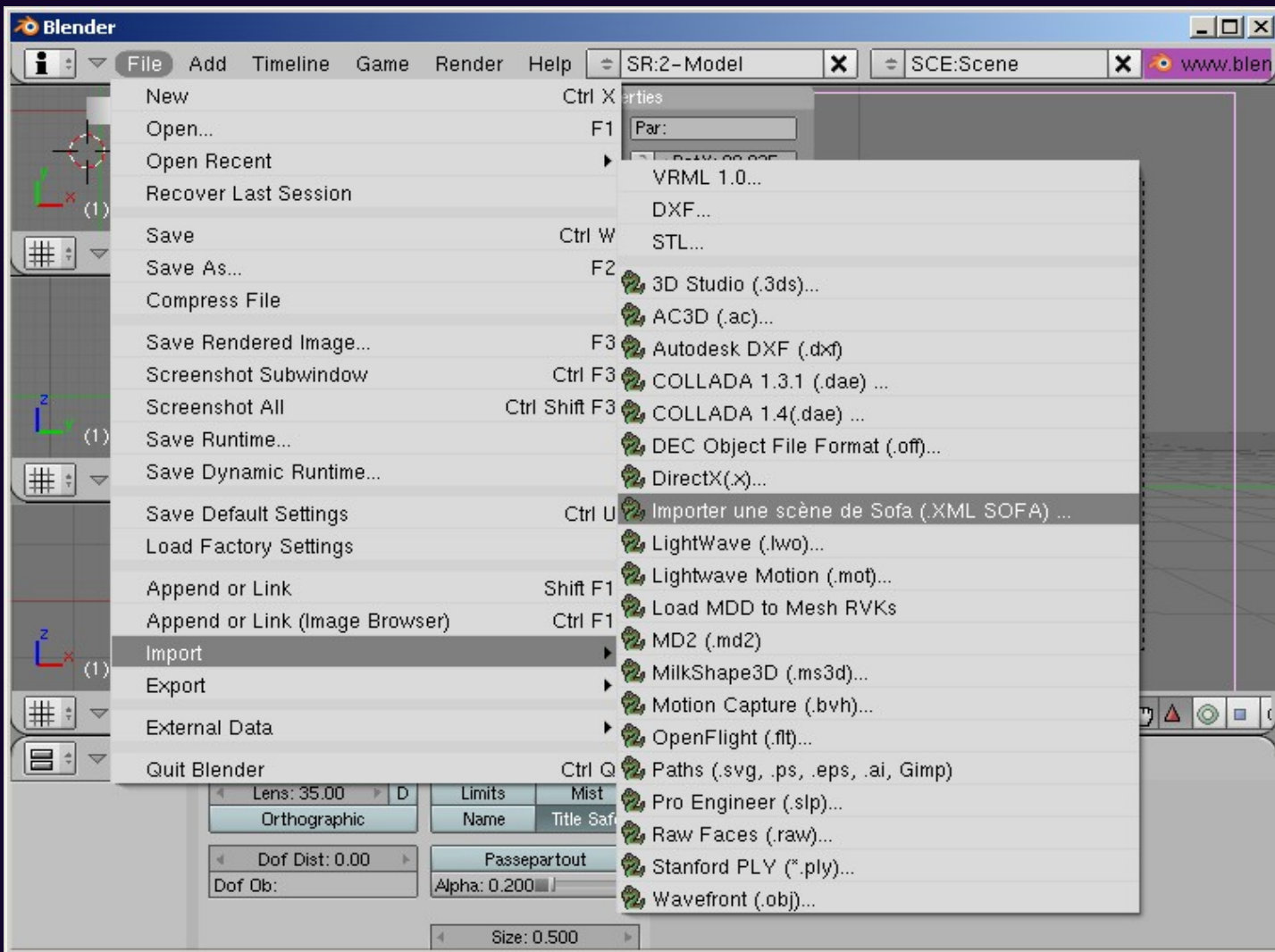
Blender's imports from SOFA (3/5)
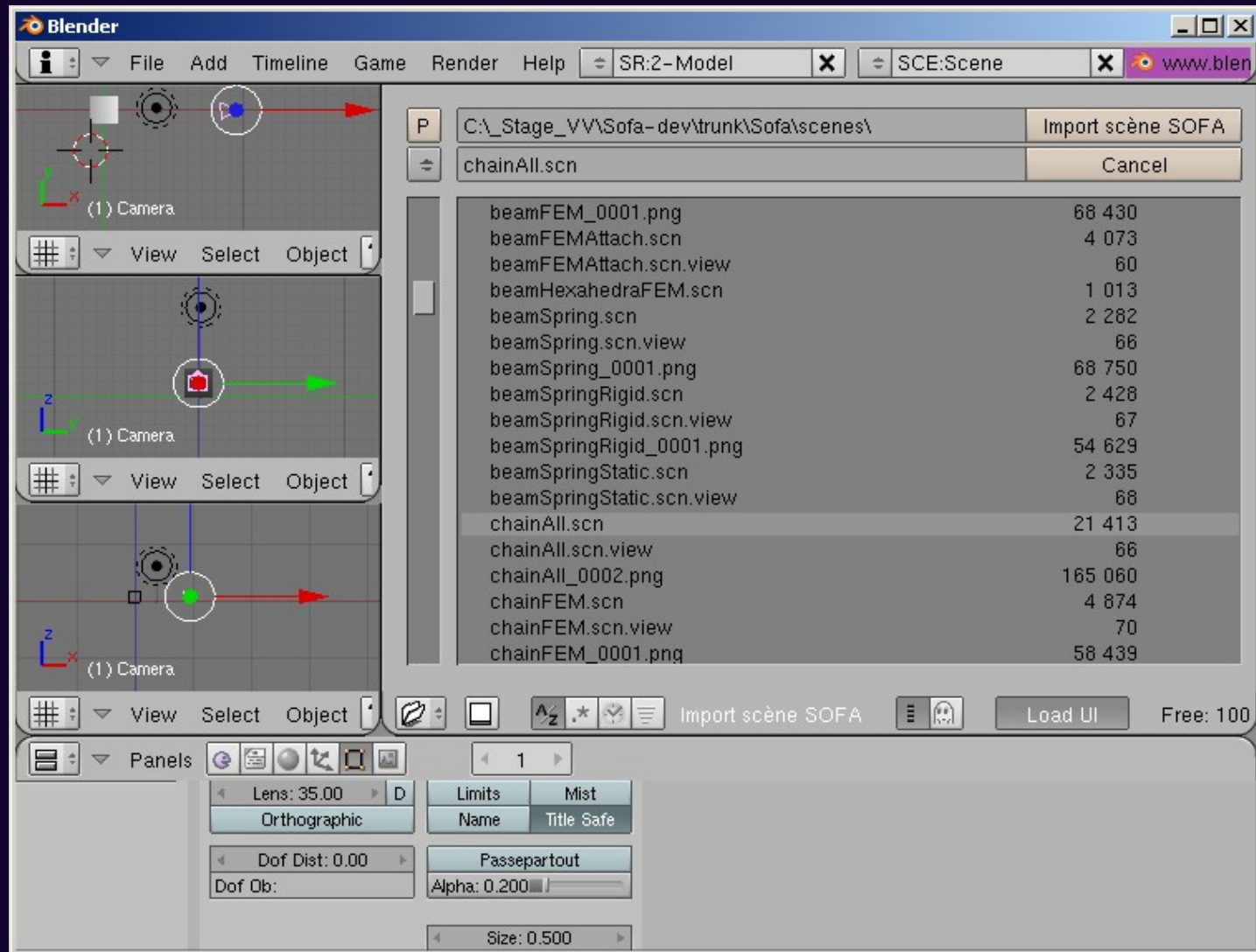
Blender's imports from SOFA (4/5)
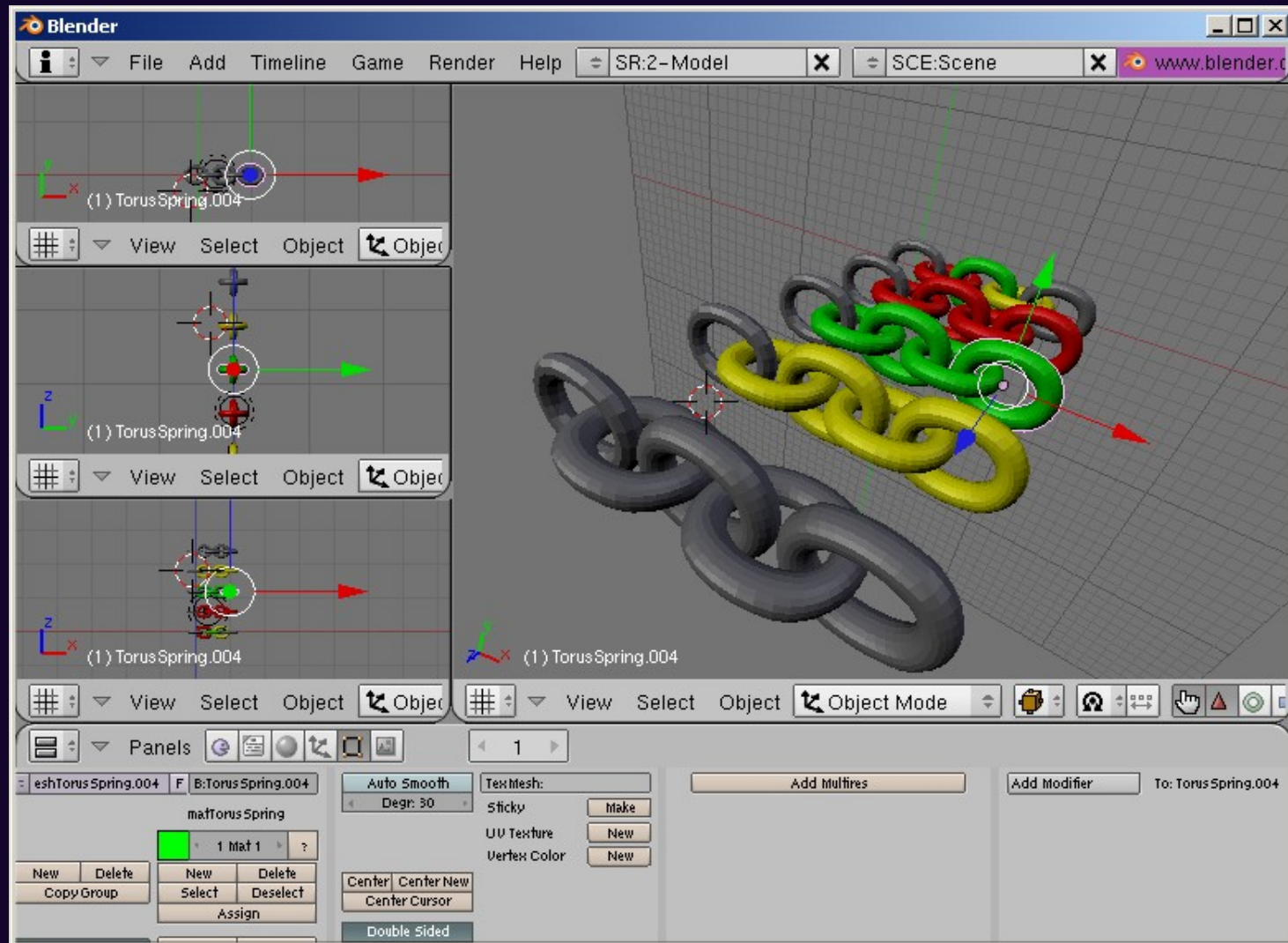
Blender's imports from SOFA (5/5)
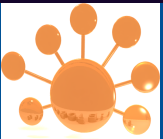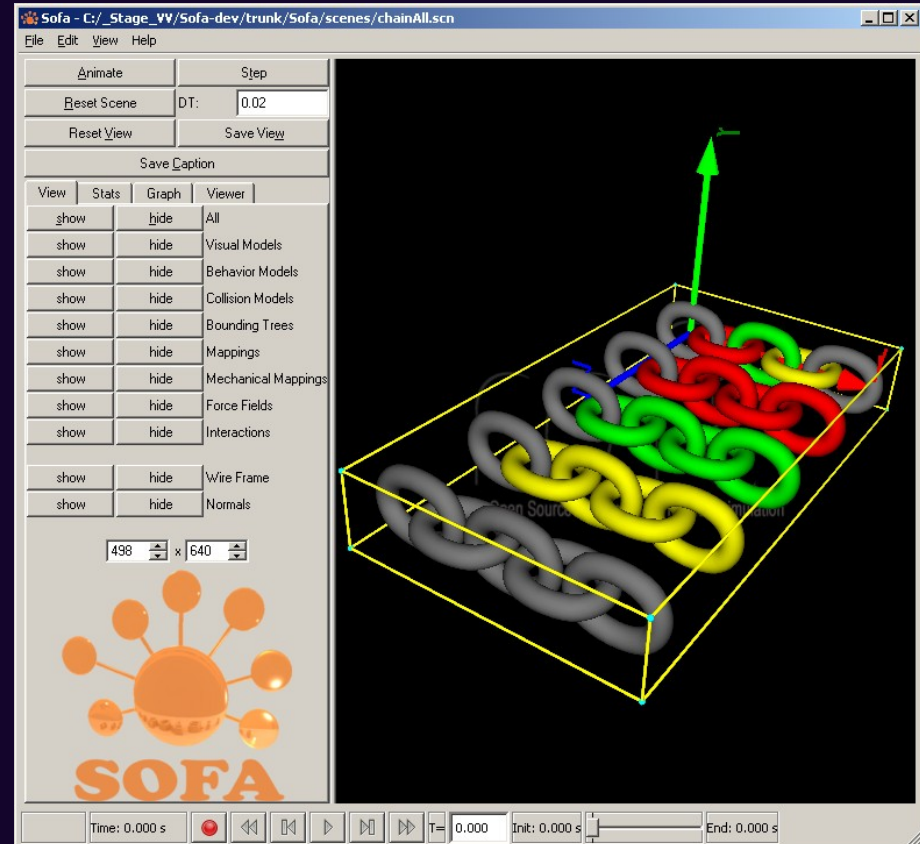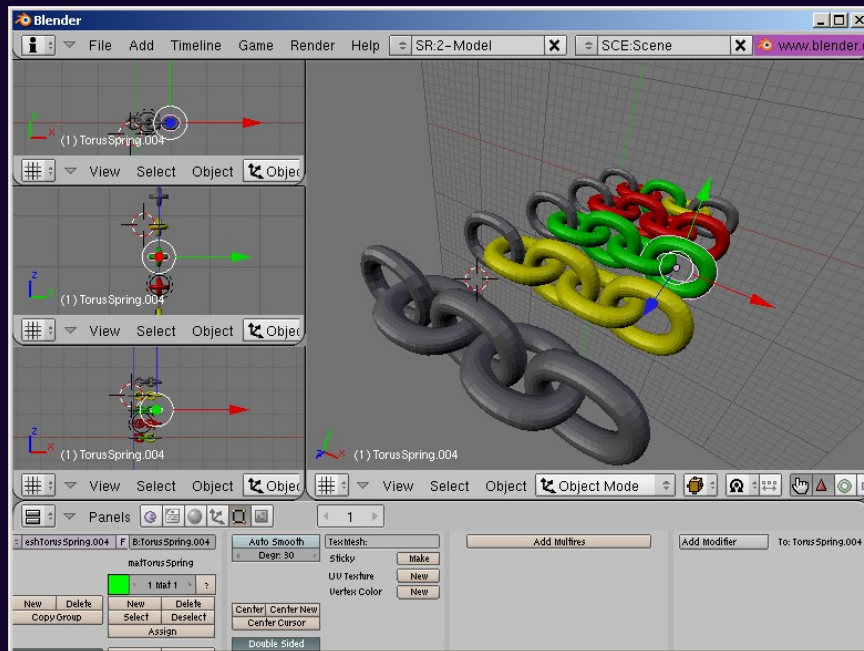
Blender's exports to SOFA (1/2)
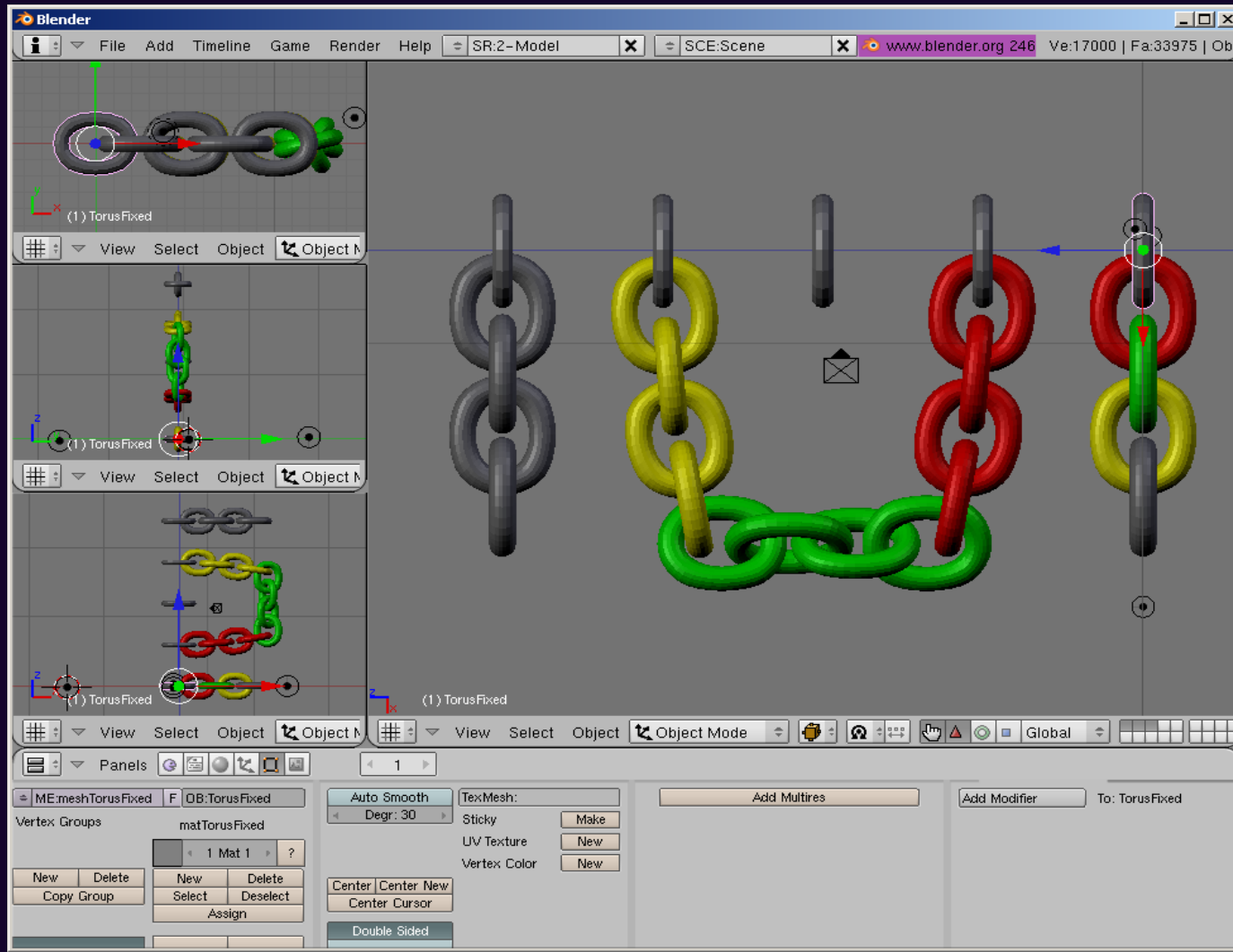
Blender's exports to SOFA (2/2)
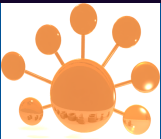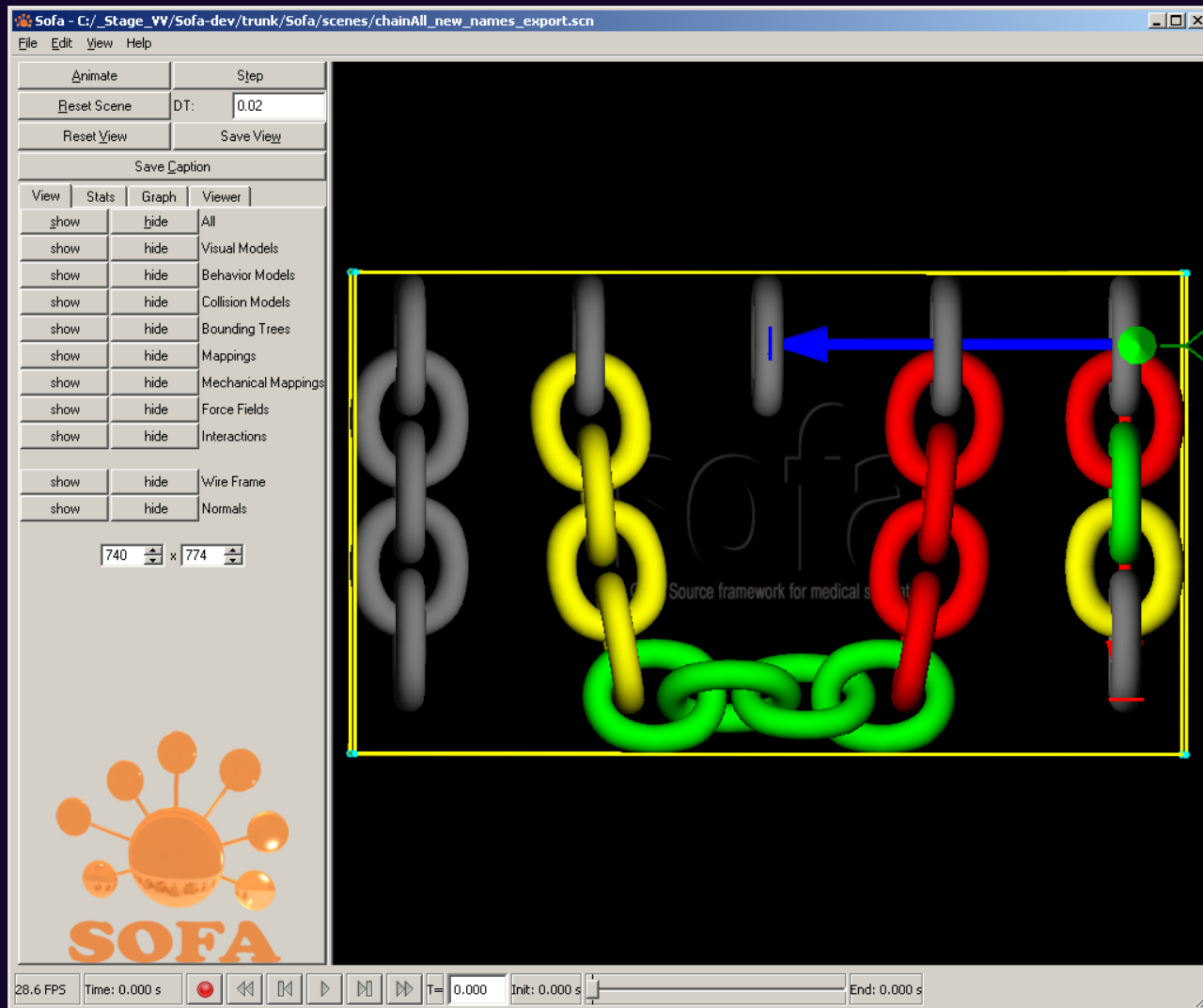
Computing mesh center of mass and inertia matrix (1/7)

Brian MIRTICH's C-code transposed into Python-code for Blender
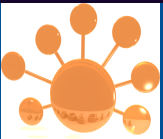
Computing mesh center of mass and inertia matrix (2/7)
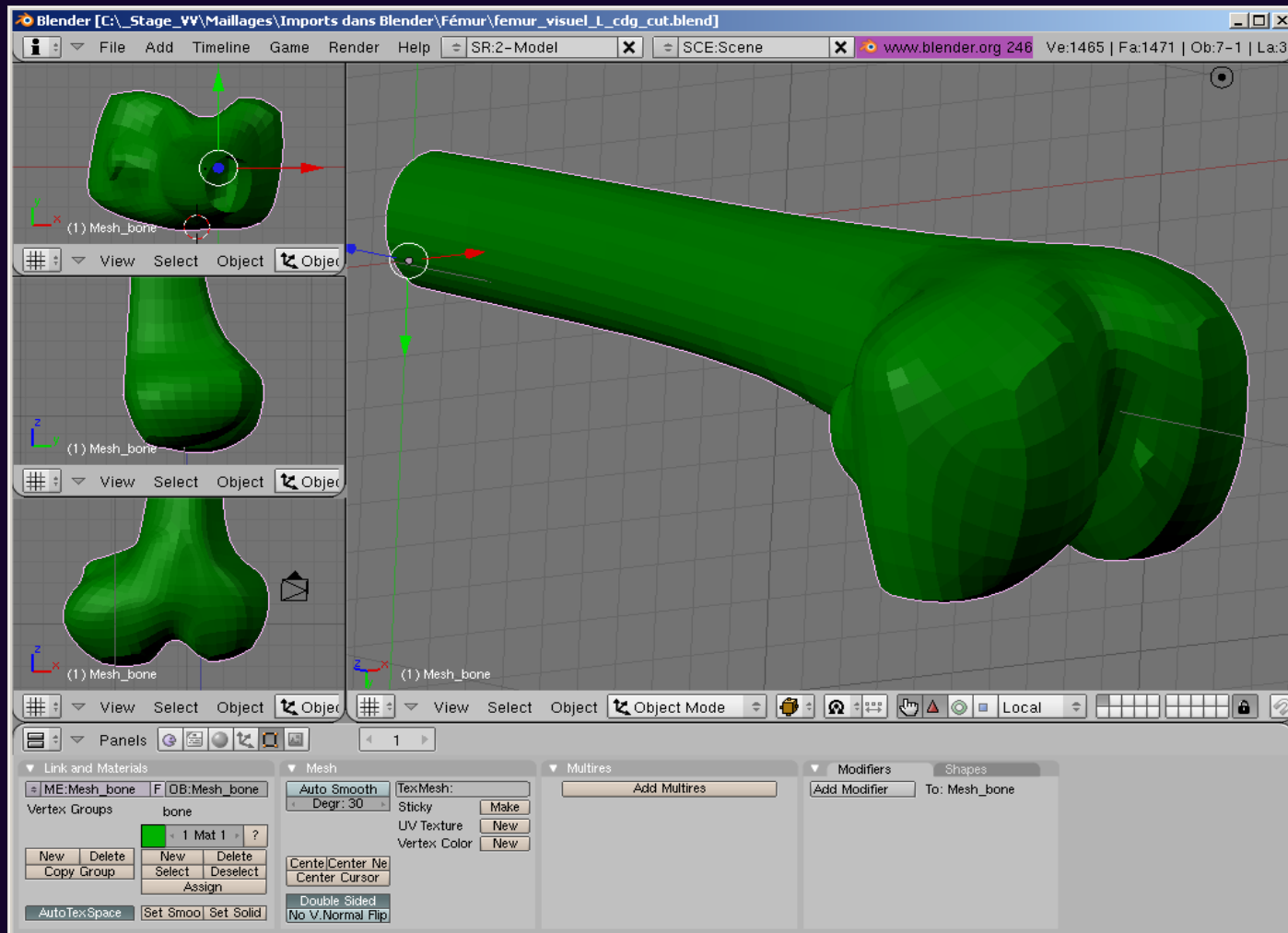
Computing mesh center of mass and inertia matrix (3/7)

Computing mesh center of mass and inertia matrix (4/7)
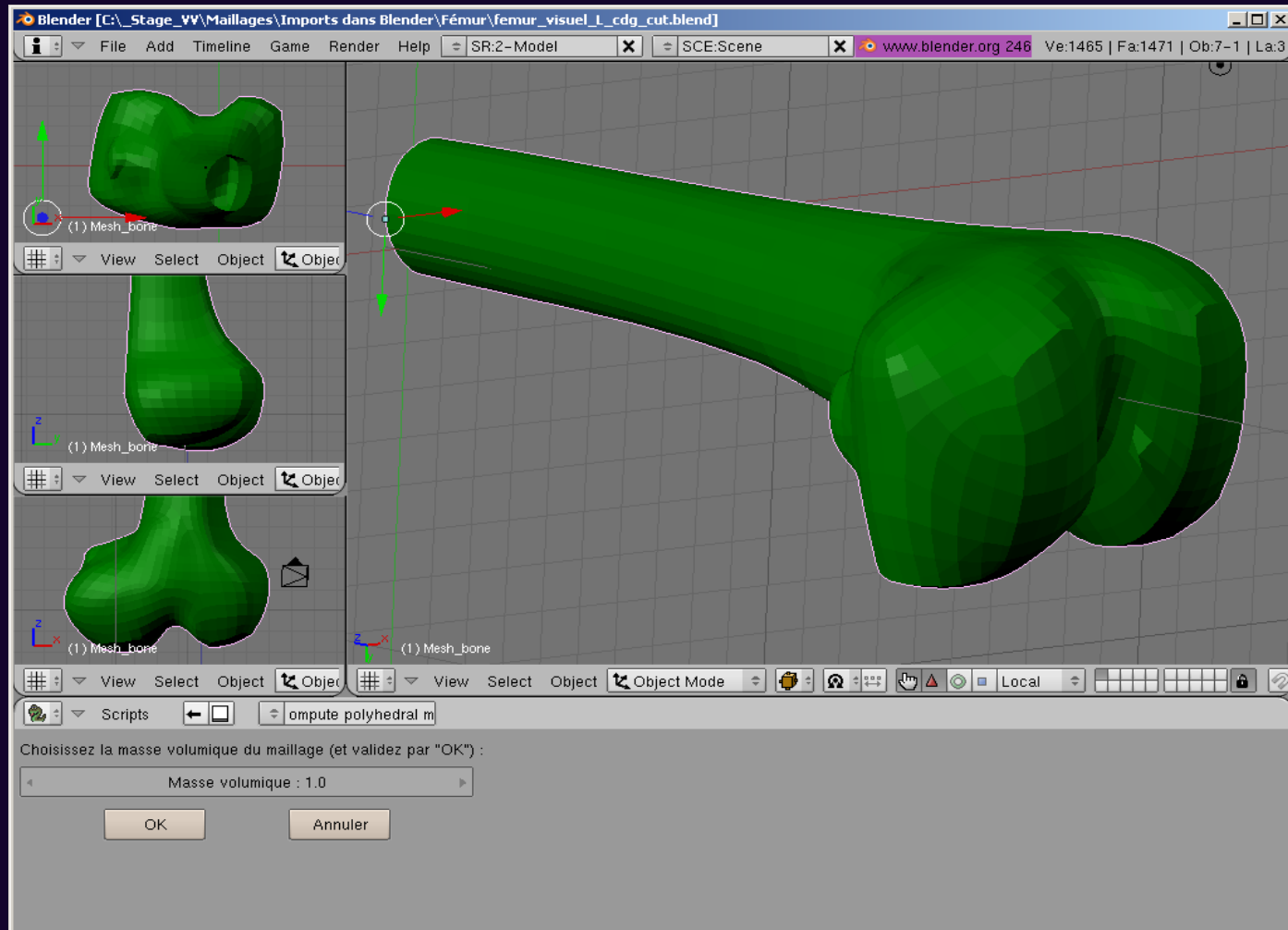
Computing mesh center of mass and inertia matrix (5/7)
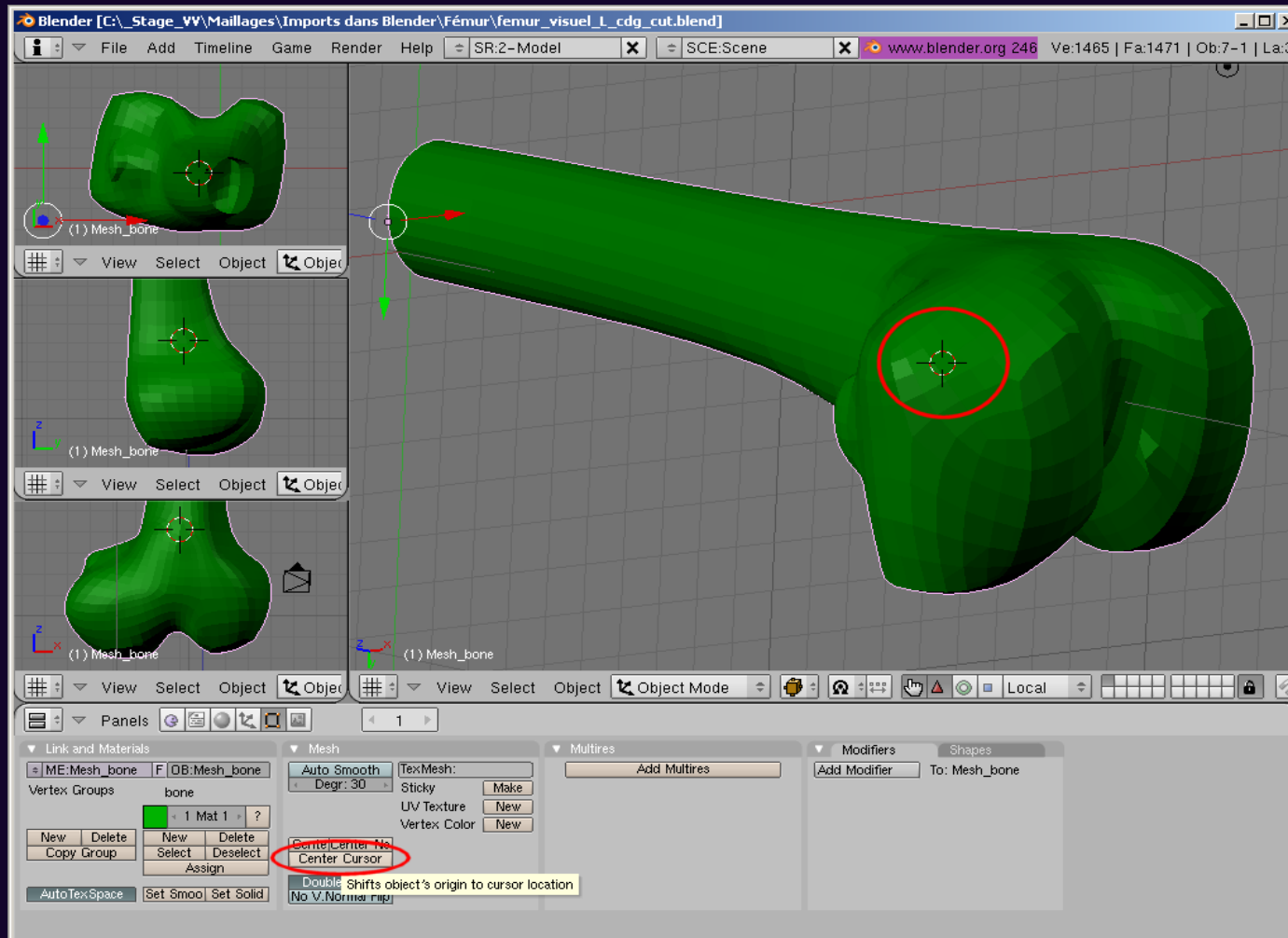
Computing mesh center of mass and inertia matrix (6/7)
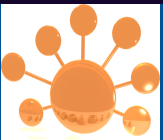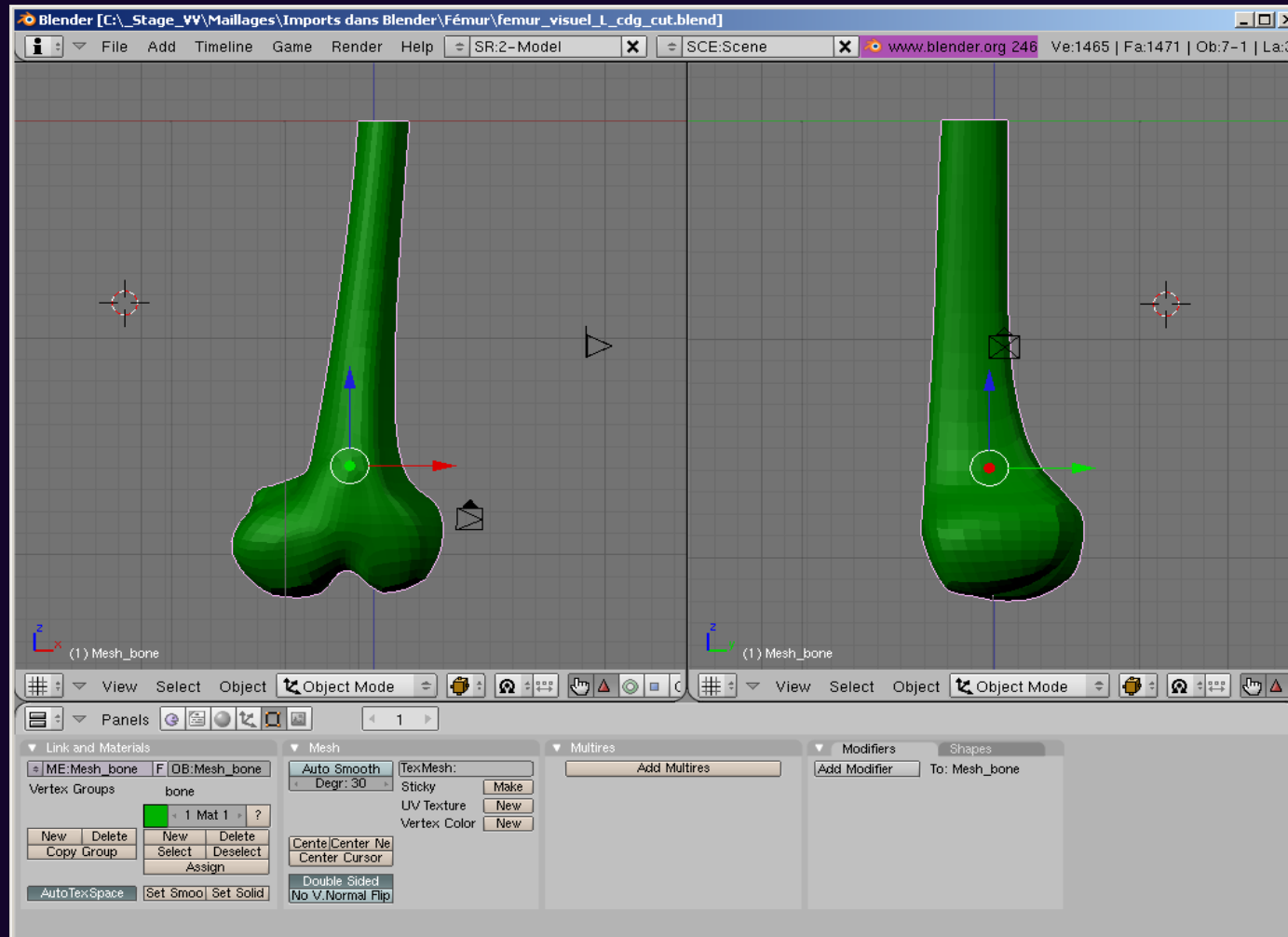
Computing mesh center of mass and inertia matrix (7/7)

Elements d'inertie et centre de gravite pour le maillage "Mesh_bone"

Masse =   +323.034402
Volume =   +323.034402
Masse volumique = +1.000000

Centre de gravite : (+7.239683,   +2.364255,   -8.008470)

Matrice d'inertie avec comme origine, le centre de gravité :

$$I = \begin{pmatrix} A = & +7103.159067 & -F = & +103.644440 & -E = & -859.320463 \\ -F = & +103.644440 & B = & +7608.784218 & -D = & +393.847155 \\ -E = & -859.320463 & -D = & +393.847155 & C = & +1897.386123 \end{pmatrix}$$

$$A = \int_V \left(y^2 + z^2\right) dm \quad D = \int_V (y.z)\, dm$$
$$B = \int_V \left(x^2 + z^2\right) dm \quad E = \int_V (x.z)\, dm$$
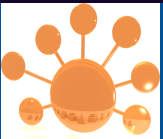$$C = \int_V \left(x^2 + y^2\right) dm \quad F = \int_V (x.y)\, dm$$

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

centre de recherche
GRENOBLE - RHÔNE-ALPES
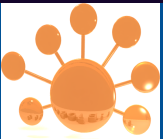
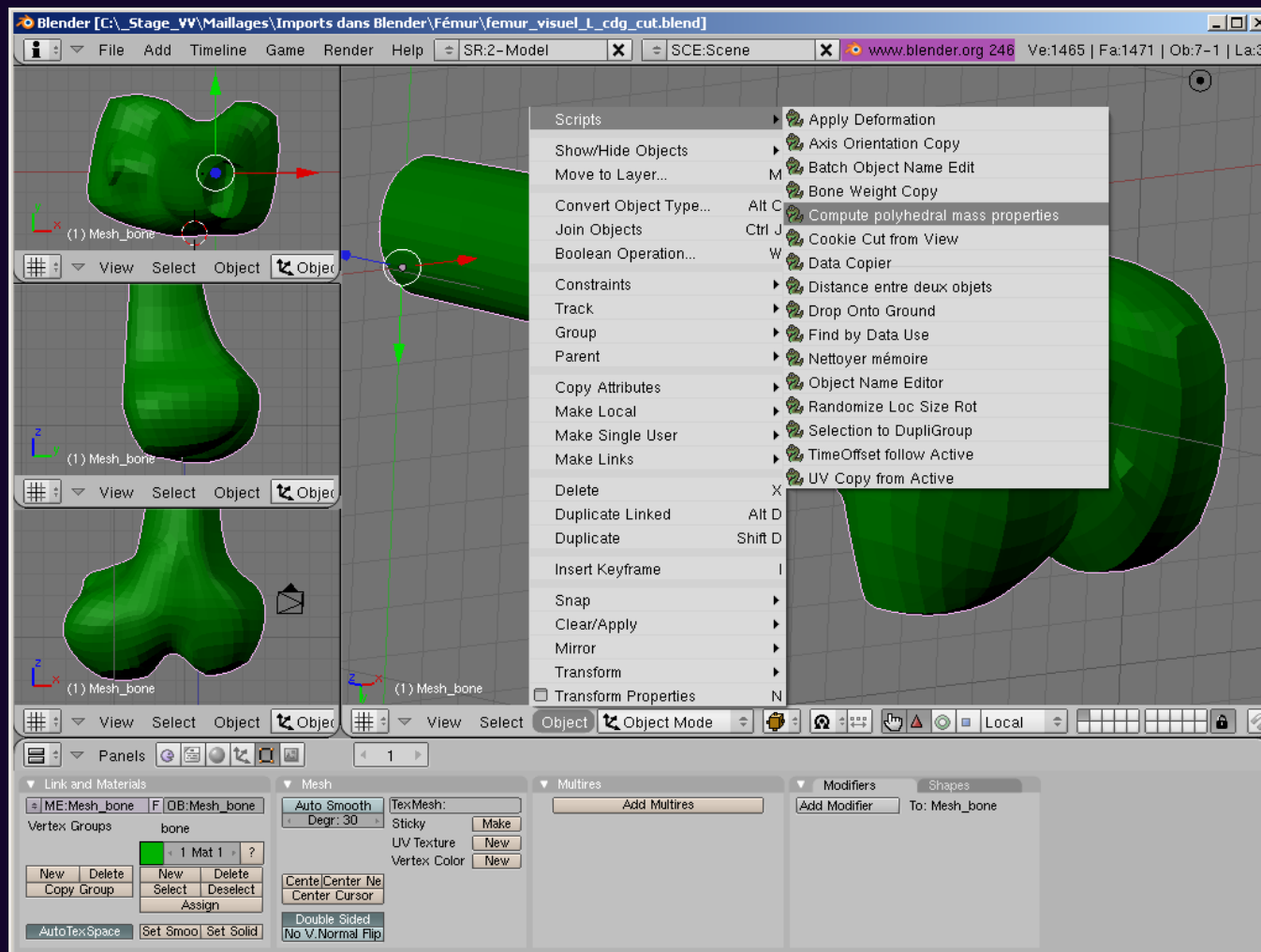# Articulated Bodies
Christian Duriez

Articulated Bodies

Articulation could be defined between rigid bodies

- " Defines a hierarchy of articulated bodies in the scene graph
- " Between a parent and a child an center of articulation is defined
- " Several articulation (translation or rotation) could be defined on this center
- " BVH files can be imported in sofa

examples\
articulatedRigidObject.scn

examples\
manWalking.scn
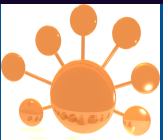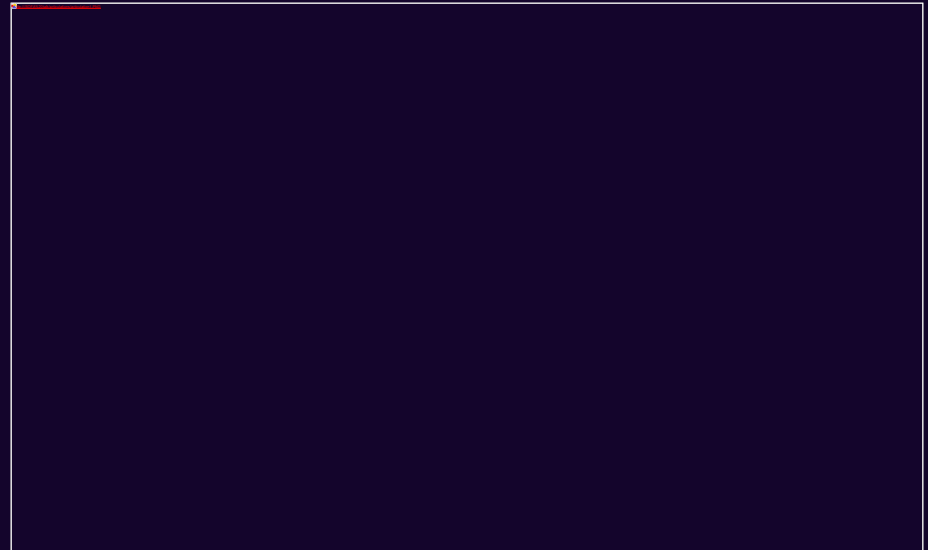
Articulated Bodies

The articulated structure is computed through a mapping

- " The only degrees of freedom are the articulations
- " Forces can be applied on the rigid mesh and sent up through the mapping
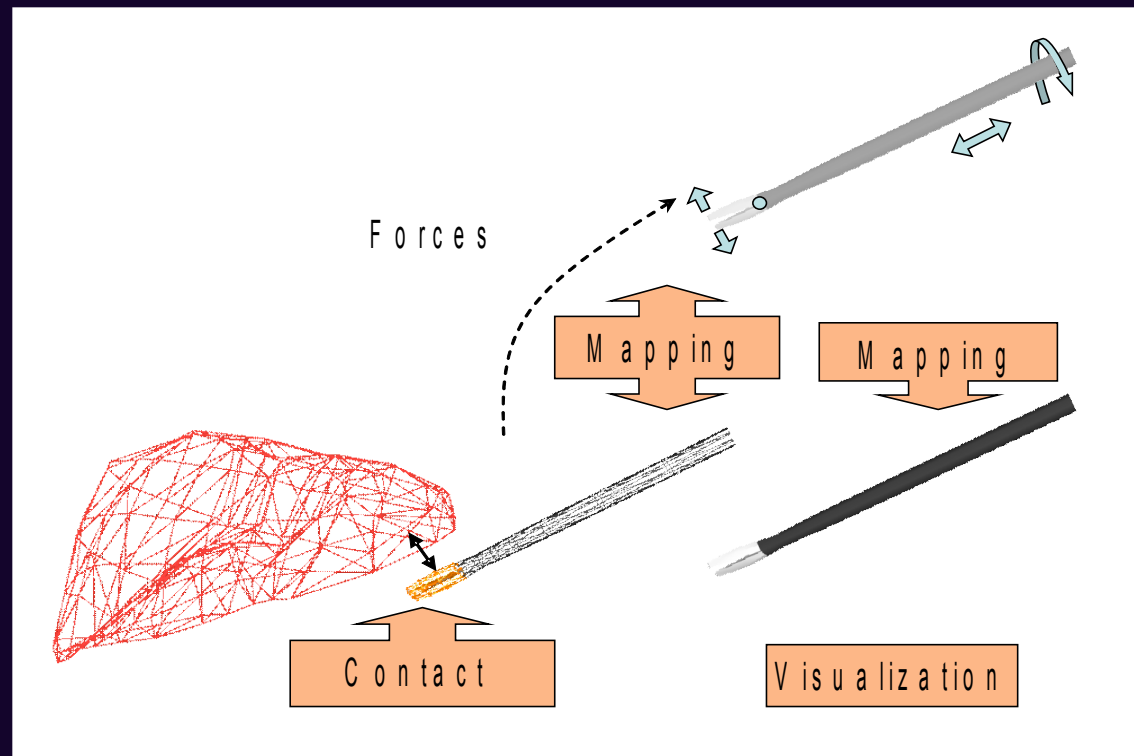
Soft Articulations
Michaël Adam

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

centre de recherche
GRENOBLE – RHÔNE-ALPES

Soft Articulations: Concepts

- Objective : simulate articulations using stiff forces (no constraint)
  - +: More stable, there is always a solution
  - - : Not yet optimized for tree structure

- Use of 6-DOF springs
  - Stiffness on each axis of translation and rotation. Null stiffness in the allowed directions.
  - Implemented on standard Sofa rigid types
  - Need a specific mapping (rigid to rigid)
  - - : Currently instabilities in case of large rotations

¤
|-- MechanicalObject<Rigid> *bones DOFs*

|-- Mass *rigidMass*

|-- SimpleConstraint *optional constraints*

|--¤
    |-- MechanicalObect<Rigid> *joints DOFs*

    |-- RigidRigidMapping *bones DOFs to joints DOFs*

    |-- JointSpringForceField *6-DOF springs*
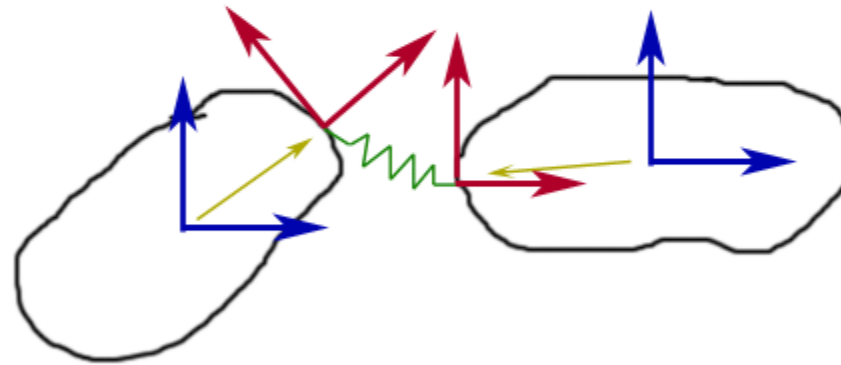
Corresponding Scene Graph

Skinning

- A simple skinning mapping is used for now.
  - It is possible to give directly the weights list to the mapping.
  - Else, user defines a number of references n that will be used for mapped points.
  - Then, each mapped point will search its n nearest DOFs, and then compute the skinning weights ($w = 1/d^2$).

Parallelization
Everton Hermann

Parallelization

- Extract tasks from the scene graph

- Tasks Scheduling and Partitioning

- Static and dynamic assignment between sofa objects and processors

- Task Graph visualization

- Parallel execution of tasks inside an object and between different objects

- Implemented using KAAPI/Athapascan

CUDA
Jeremie Allard

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
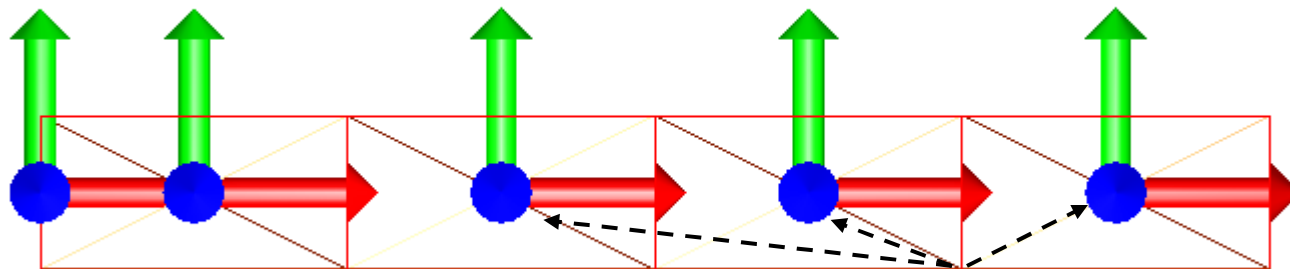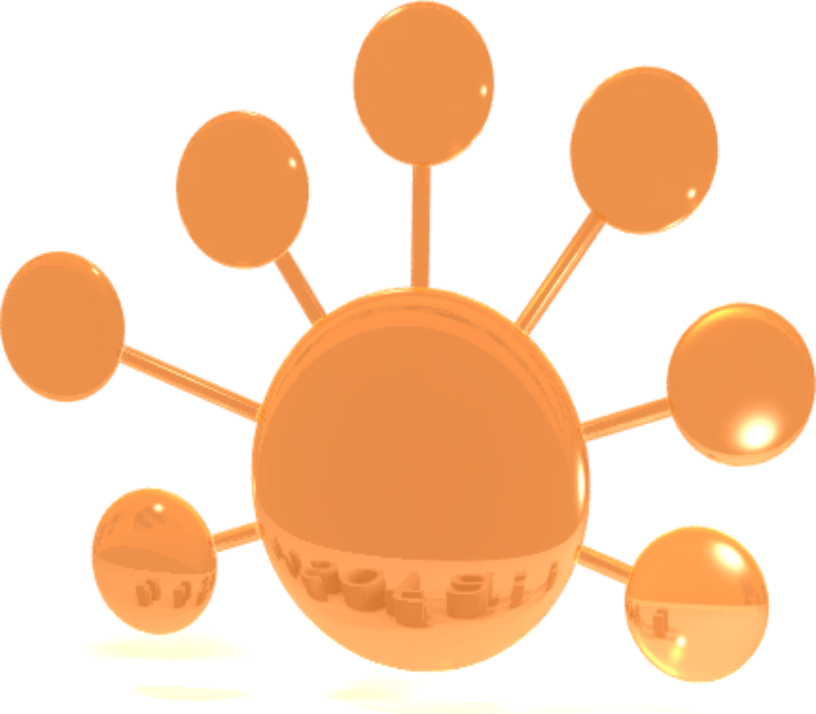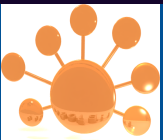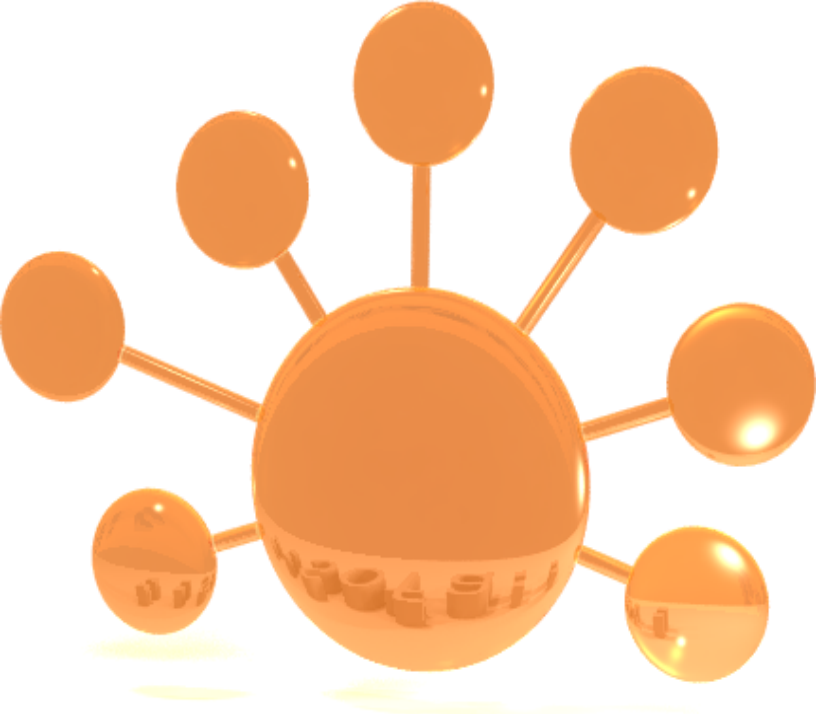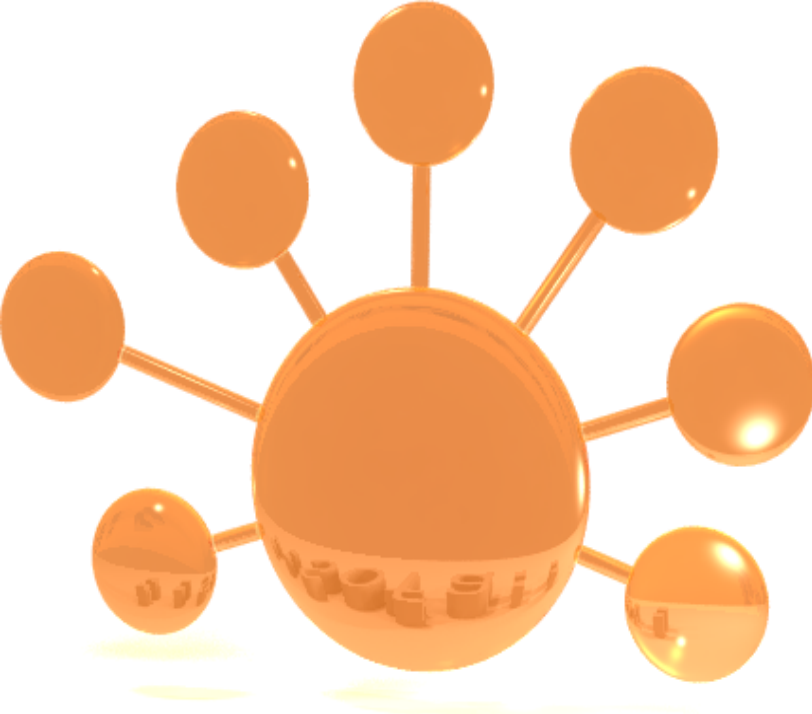ET EN AUTOMATIQUE

INRIA

centre de recherche
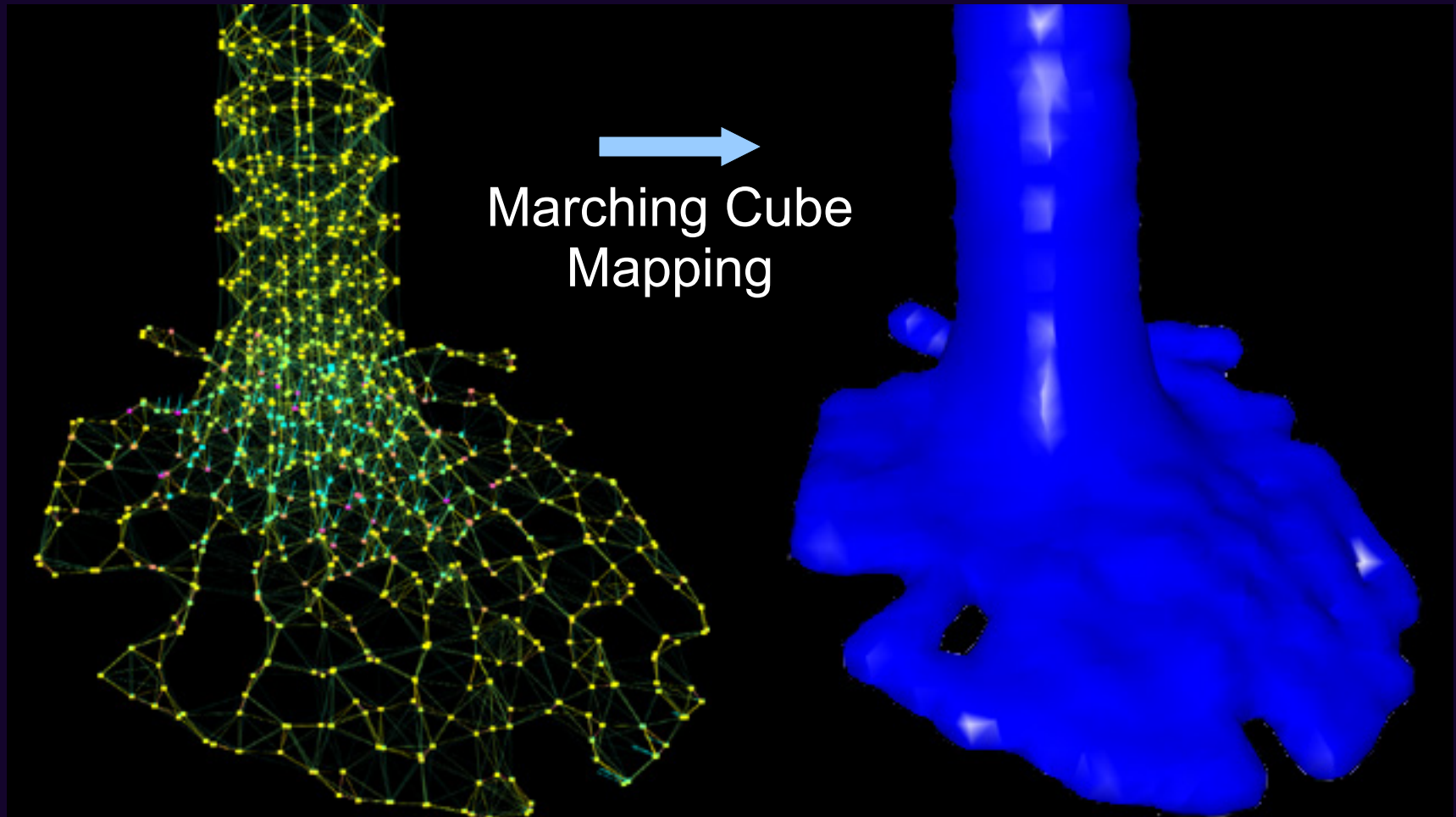GRENOBLE - RHÔNE-ALPES

CUDA

Demo !

Fluids
Jeremie Allard

SPH Fluids

Marching Cube Mapping
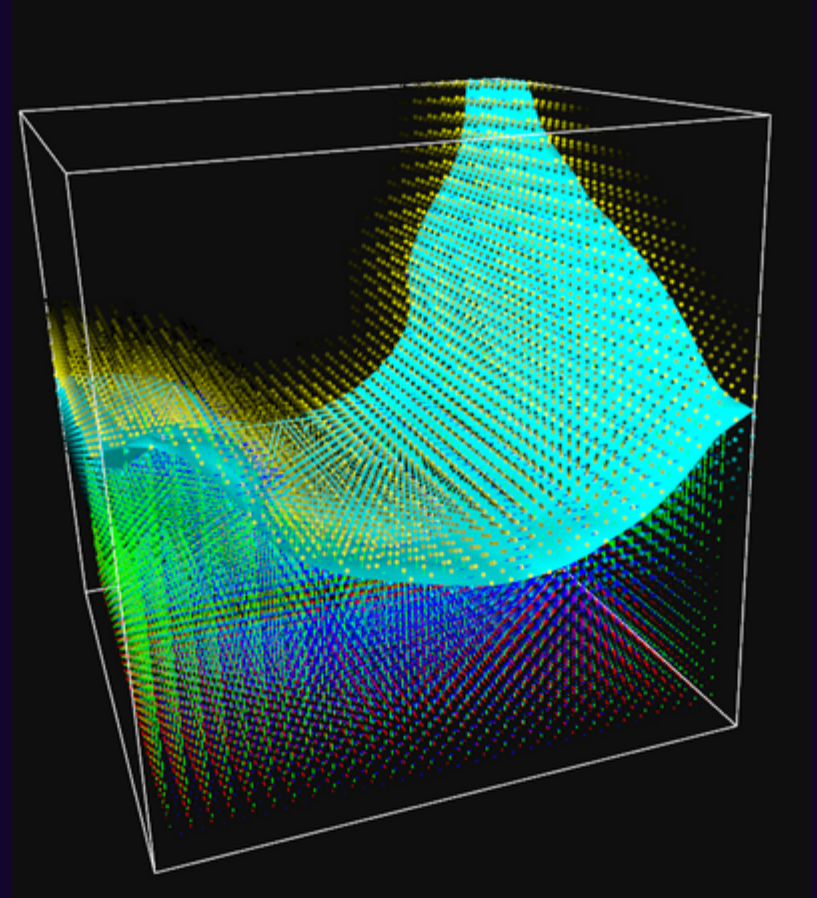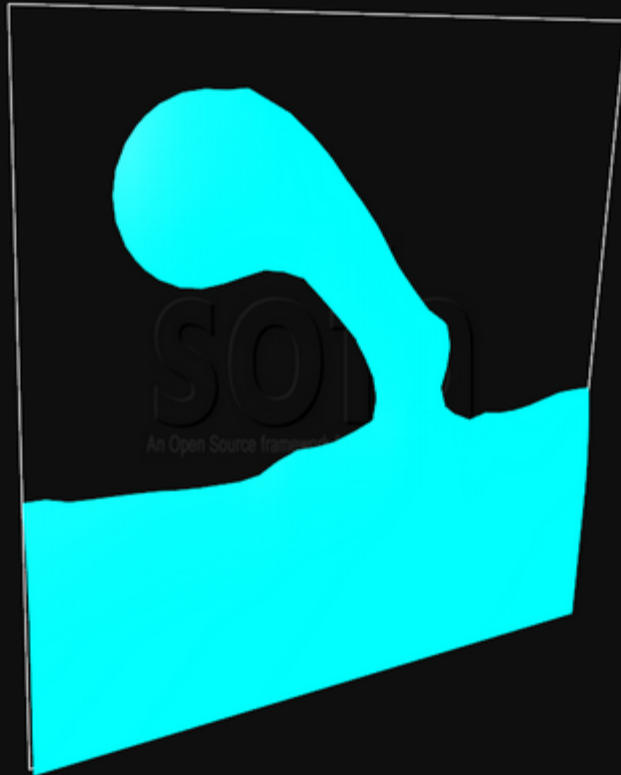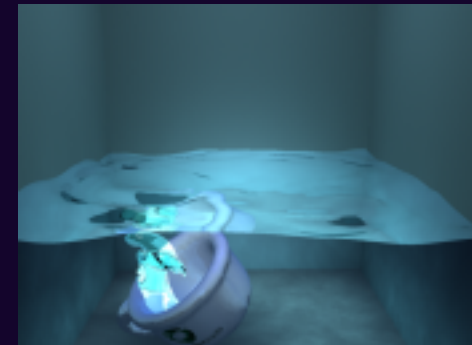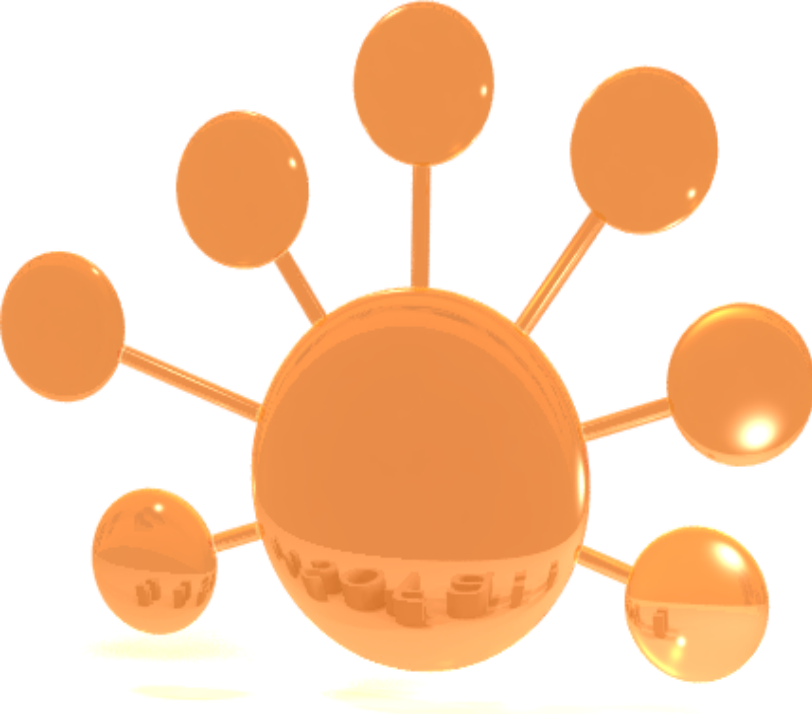
Interaction with other objects
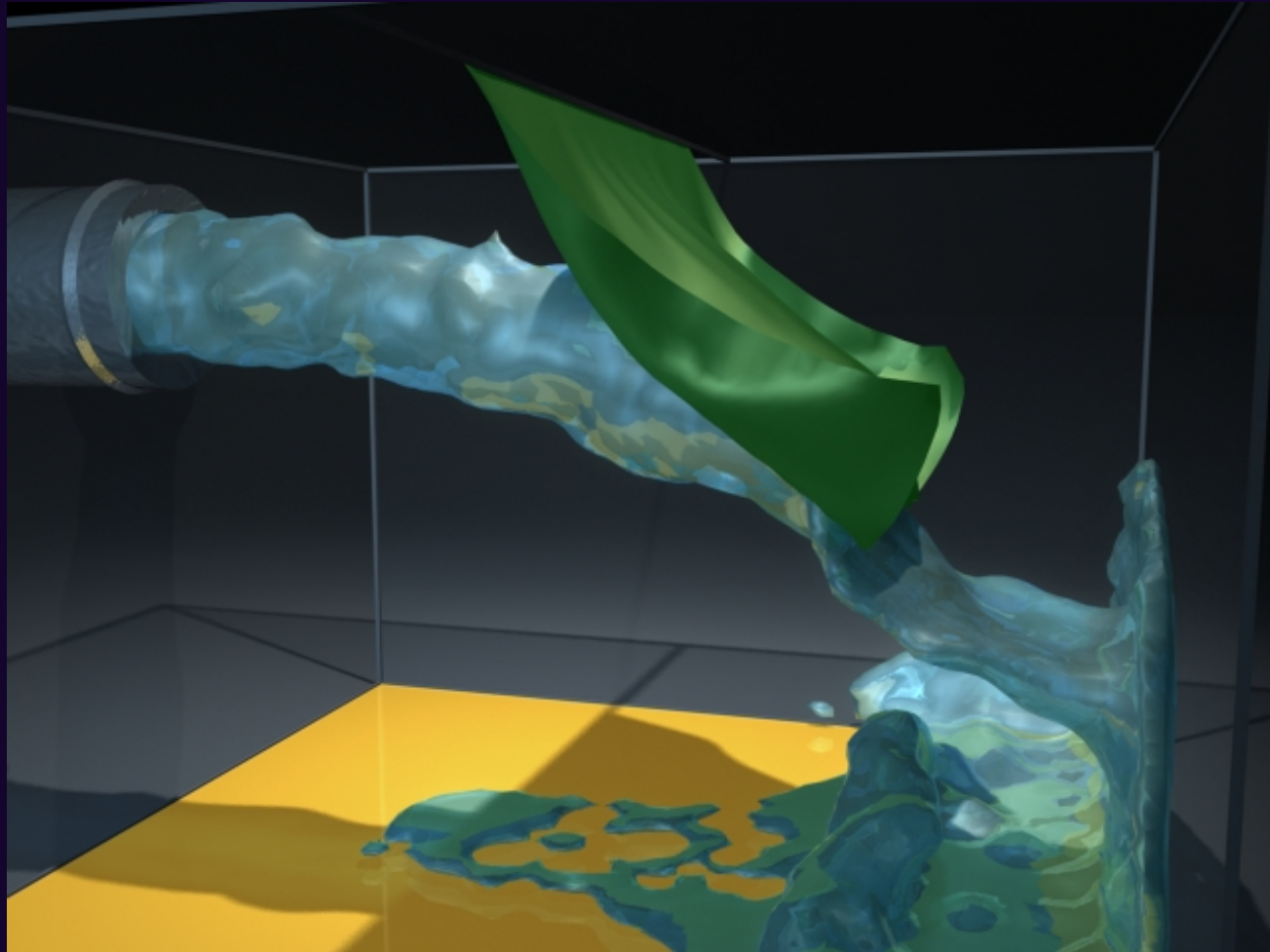
Eulerian 2D/3D Fluid

Future Works

- Interactions between eulerian fluids and other objects

- GPU-based implementation

- More advanced models

Haptics
Christian Duriez

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

centre de recherche
GRENOBLE - RHÔNE-ALPES

Haptic Devices in SOFA

Haptic devices interface the user to the simulation via the sense of touch by applying:

- **forces,**
- **vibrations and/or**
- **motions**

Support for Phantom devices has been implemented in SOFA using the Sensable OpenHaptics Toolkit
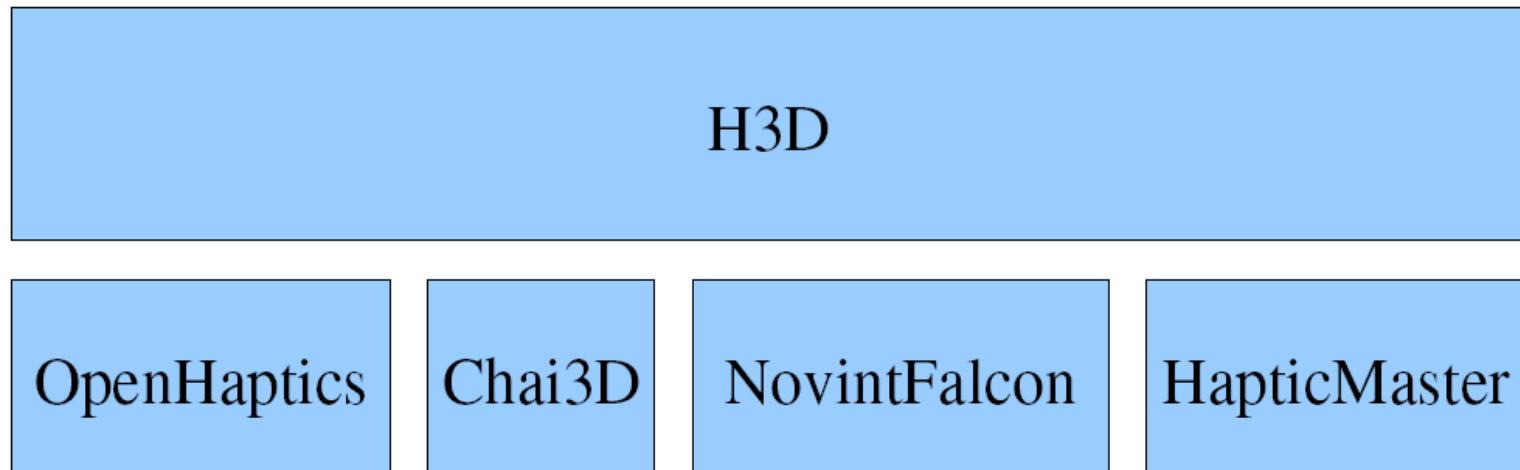
Now in development...

Each haptic device company has his own SDK

H3D API offers a high-level scripting interface that unify the SDK of the most popular haptic devices

This layer will be used as soon as possible in SOFA

The next release

Some examples will be included in the next release

- **Cataract surgery simulation**
- **Dental surgery simulation**
- **Other general examples (using different geometrical objects and algorithms)**