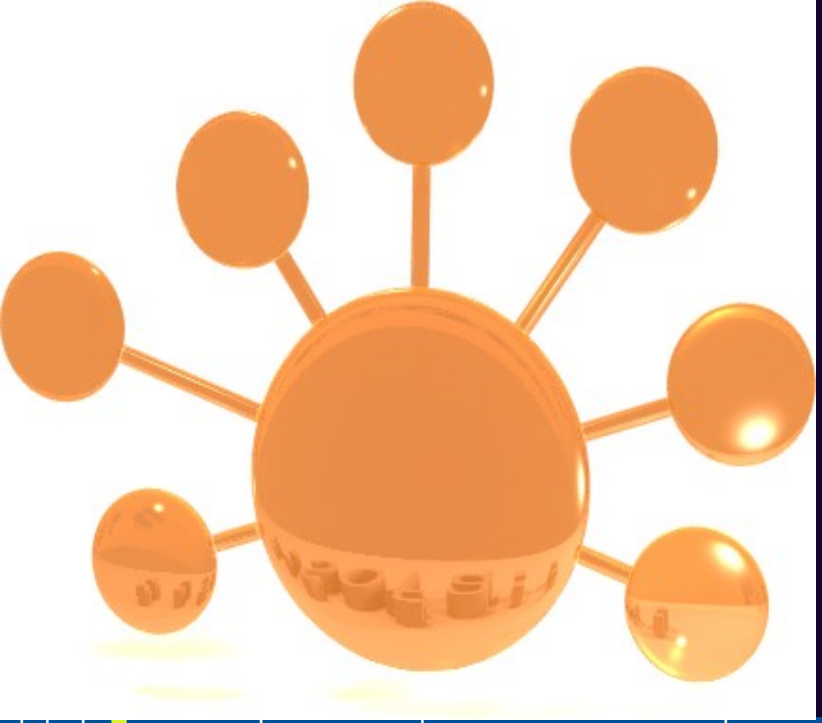


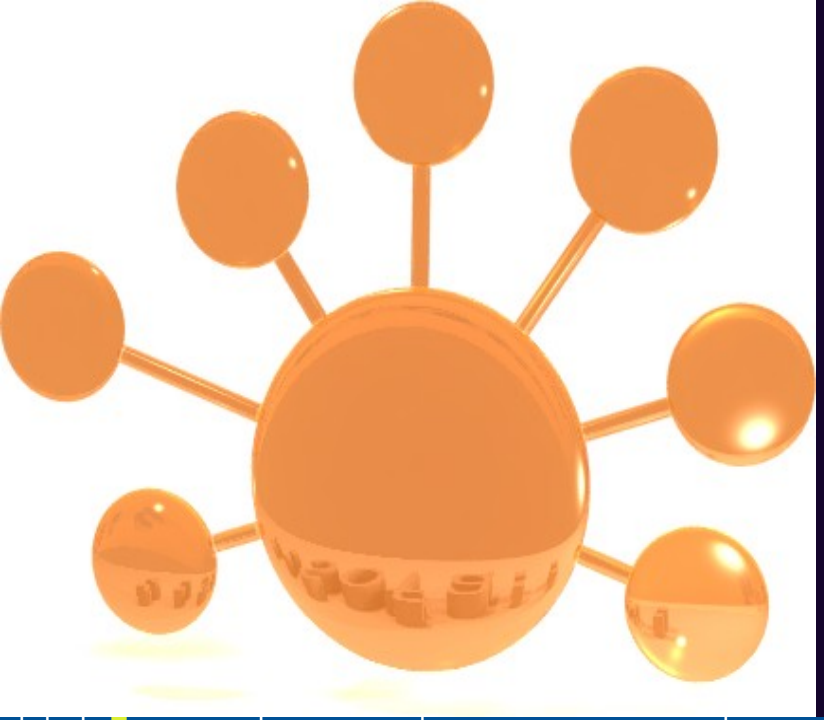
Overview of SOFA Features

25.6.2008

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

centre de recherche
GRENOBLE - RHÔNE-ALPES



Force Fields
Francois Faure

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

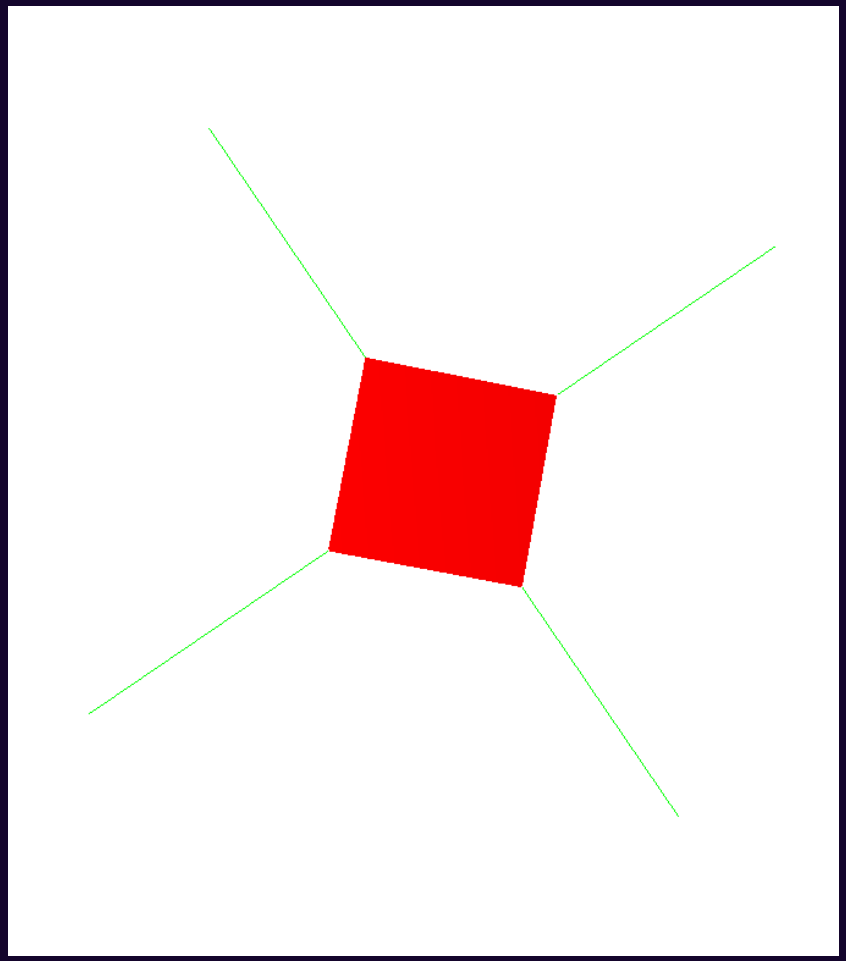
INRIA

centre de recherche
GRENOBLE - RHÔNE-ALPES

ConstantForceField

Constant forces applied to given degrees of freedom

- scenes/constantForce.scn



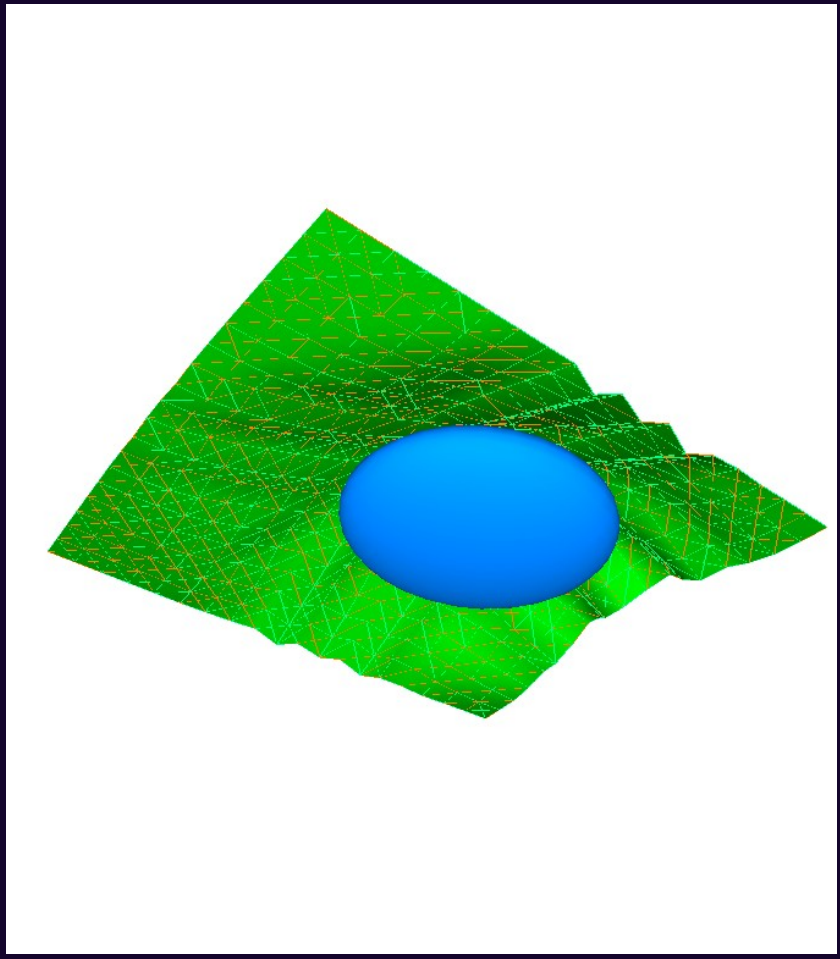
Implicit Force Fields

ConicalForceField
EllipsoidForceField
SphereForceField

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

PlaneForceField

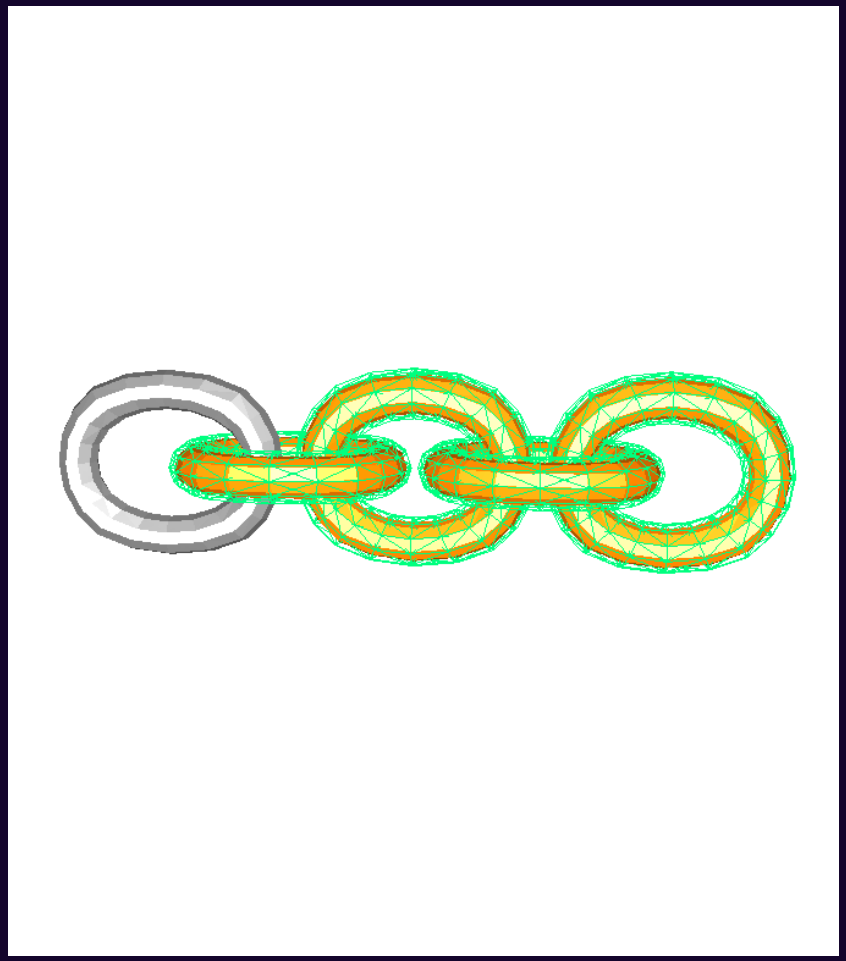
- Repulsion applied by a plane toward the exterior (half-space)
- scenes/2d.scn



MeshSpringForceField

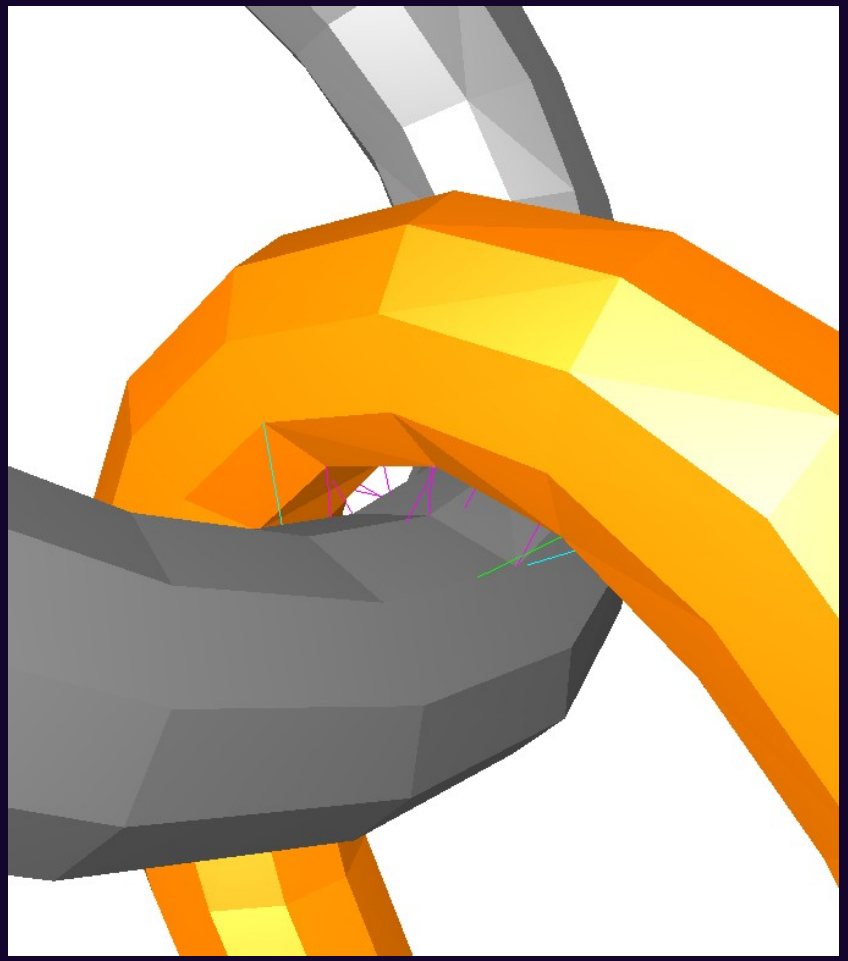
Spring force eld acting along the edges of a mesh

- scenes/chainSpring.scn



PenalityContactForceField

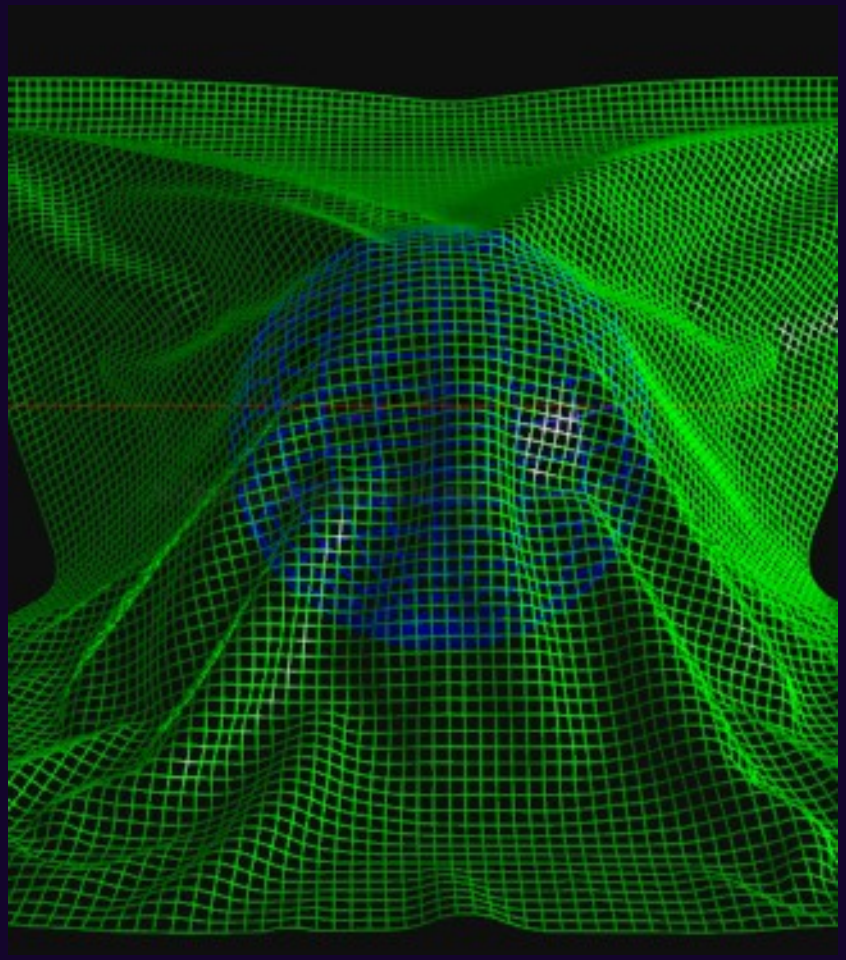
Contact using repulsive springs: in all our scenes using the proximity method to repulse objects in collision.



QuadBendingSprings

Springs added to a quad mesh to prevent bending

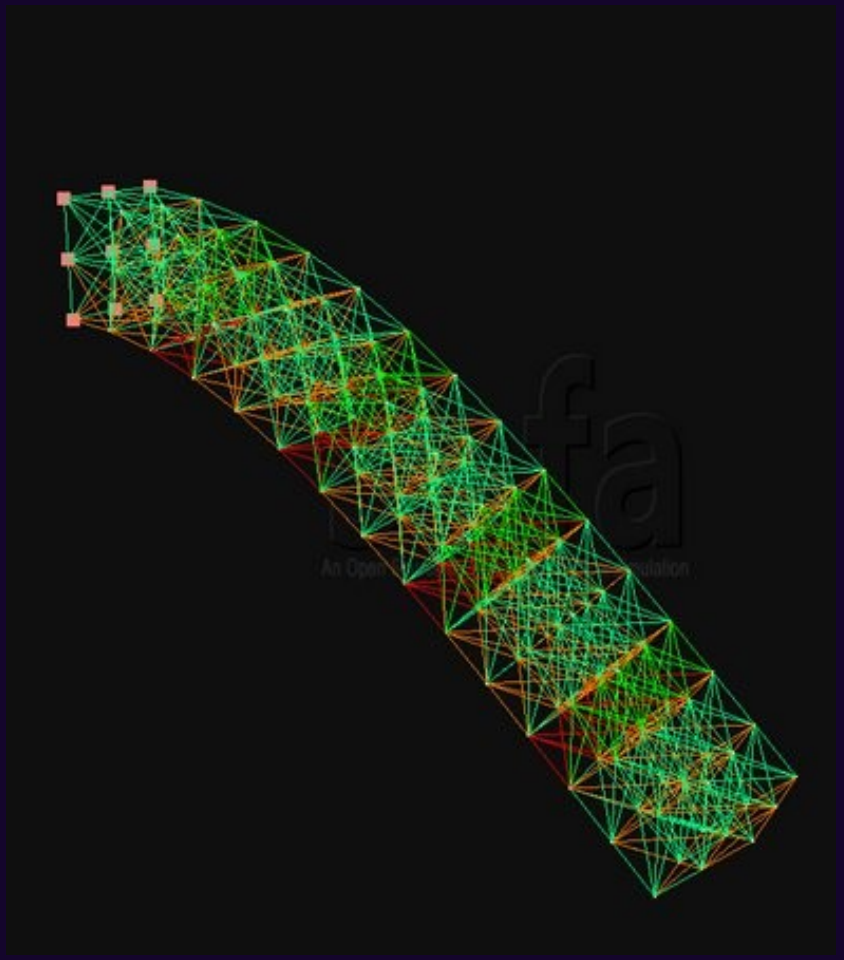
- scenes/quadSpringSphere.scn



StiffSpringForceField

Stiff springs for implicit integration

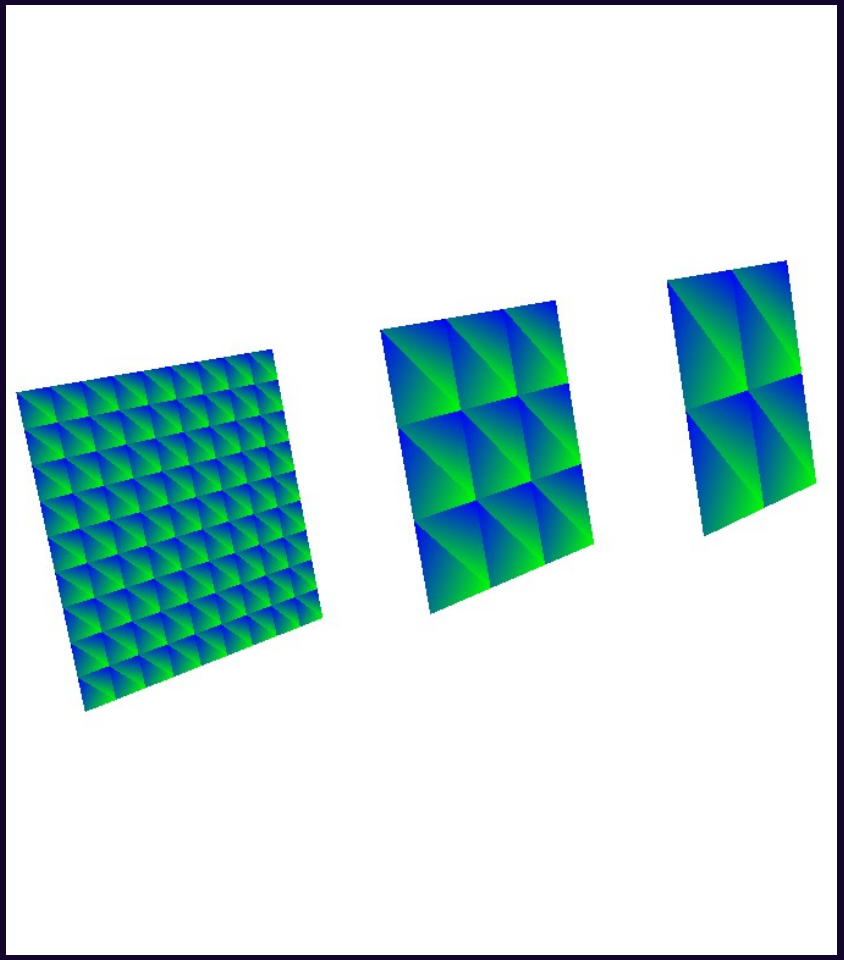
- can be used between two objects or between the degrees of freedom of the same object
- examples/massSpring.scn



TriangleFEMForceField

Triangular finite elements

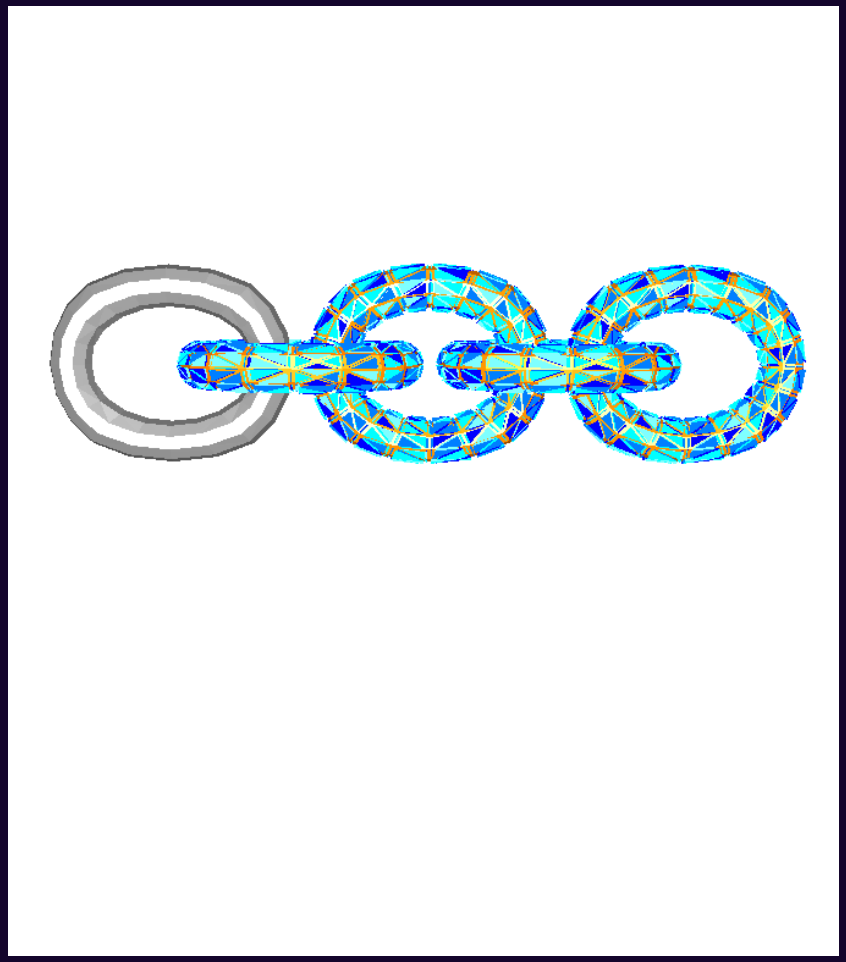
- scenes/triangleFEM.scn



TetrahedronFEMForceField

Tetrahedral finite elements

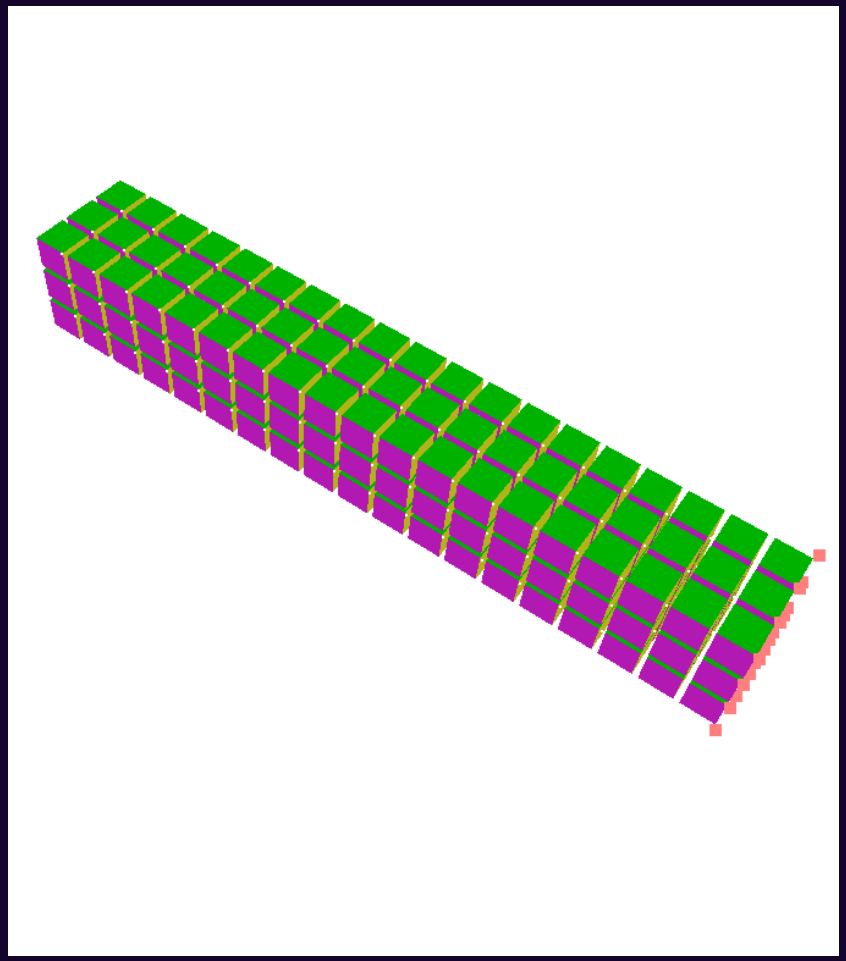
- scenes/chainFEM.scn



HexahedronFEMForceField

Hexahedral finite elements

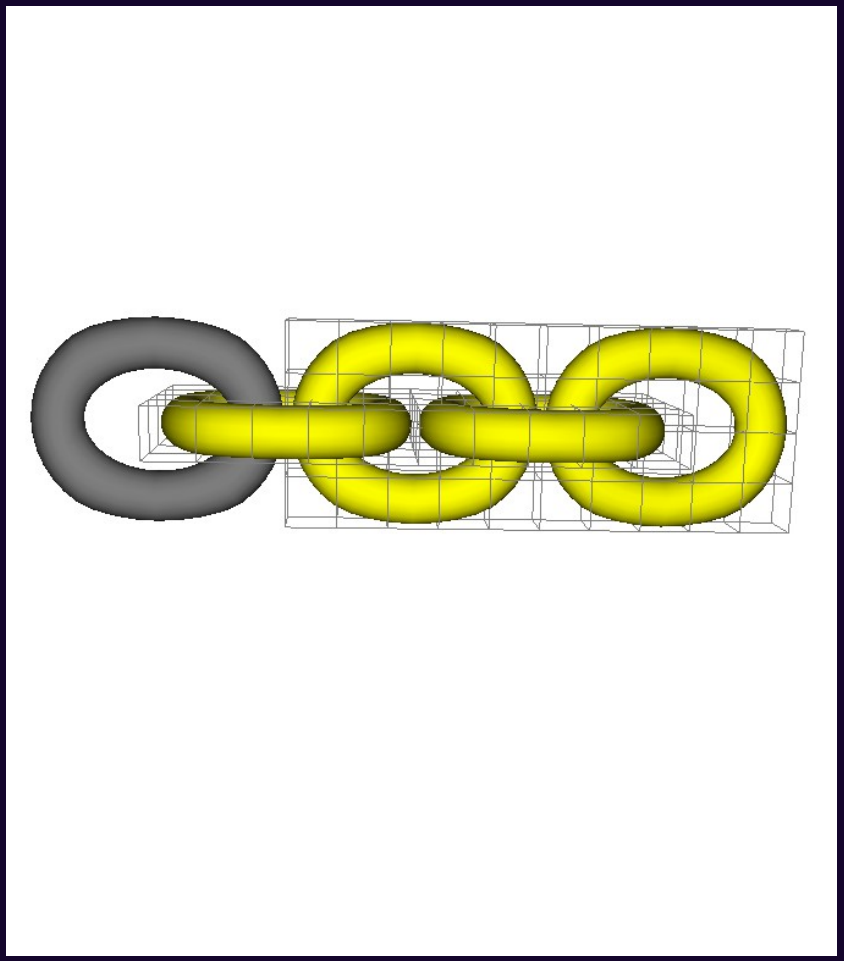
- scenes/beamHexahedraFEM.scn



RegularGridSpringForceField

Spring acting on the edges and faces of a regular grid

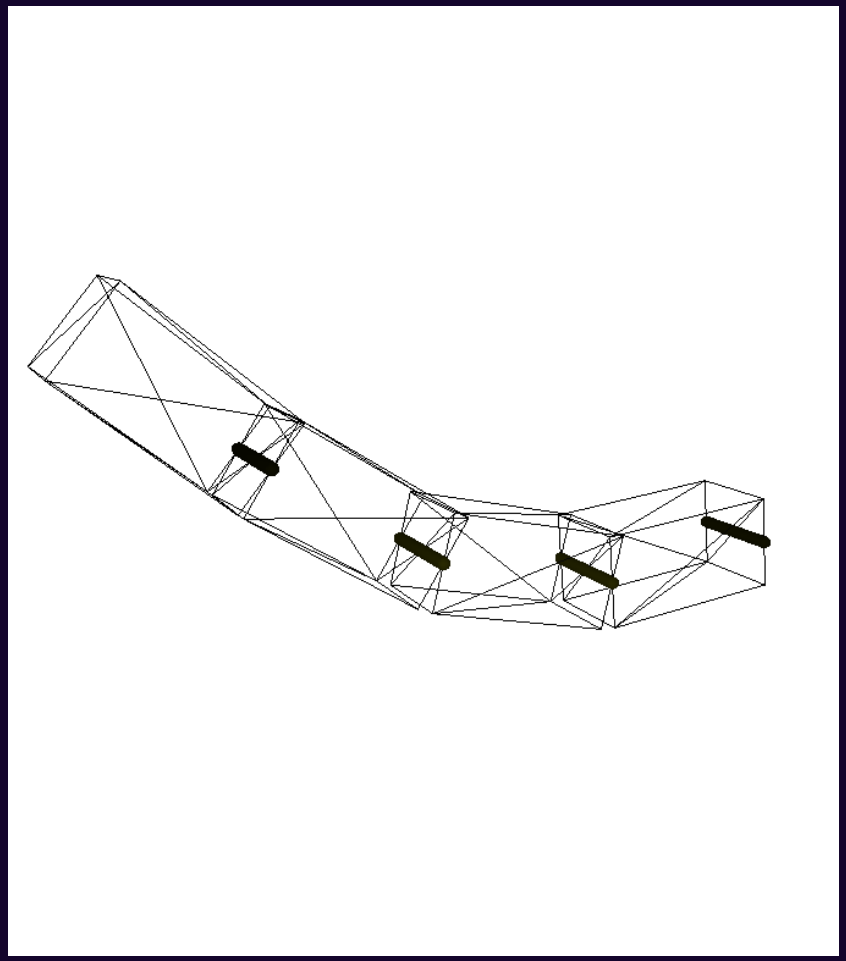
- scenes/chainFFD.scn



JointSpringForceField

Equivalent of the SpringForceField but for Rigid

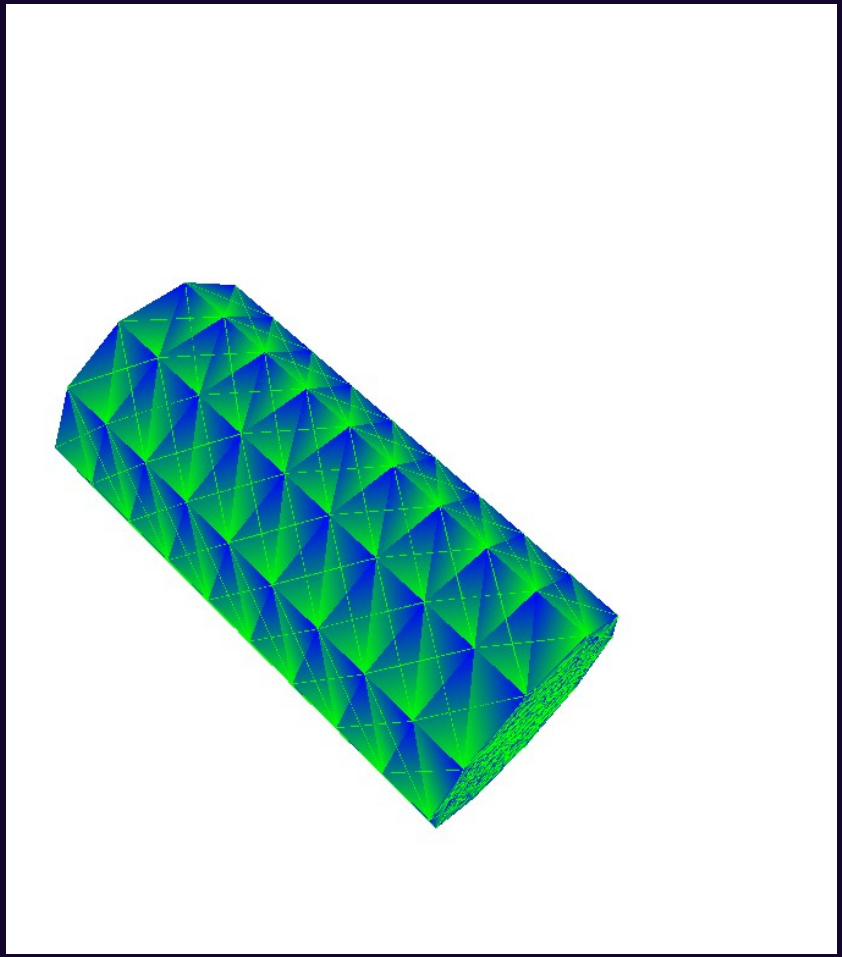
- examples/softArticulations.scn



TriangePressureForceField

Triangle Pressure

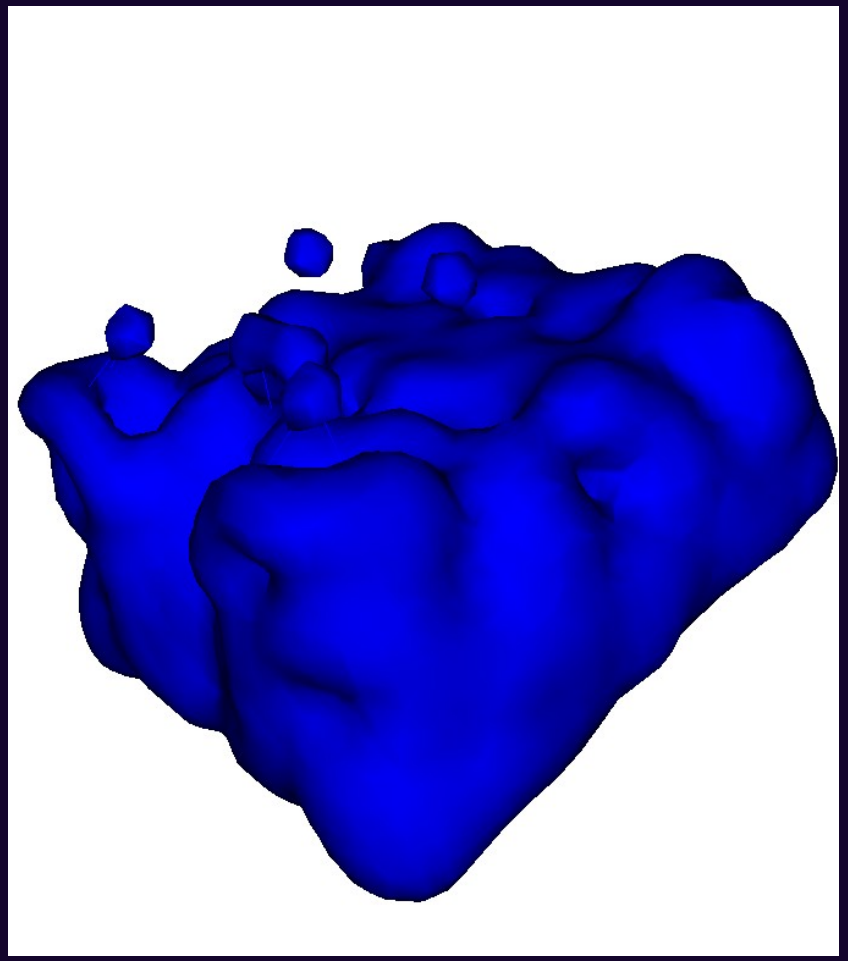
- scenes/TopoMap_cylinder3d.scn



LennardJonesForceField

Lennard-Jones forces for fluid

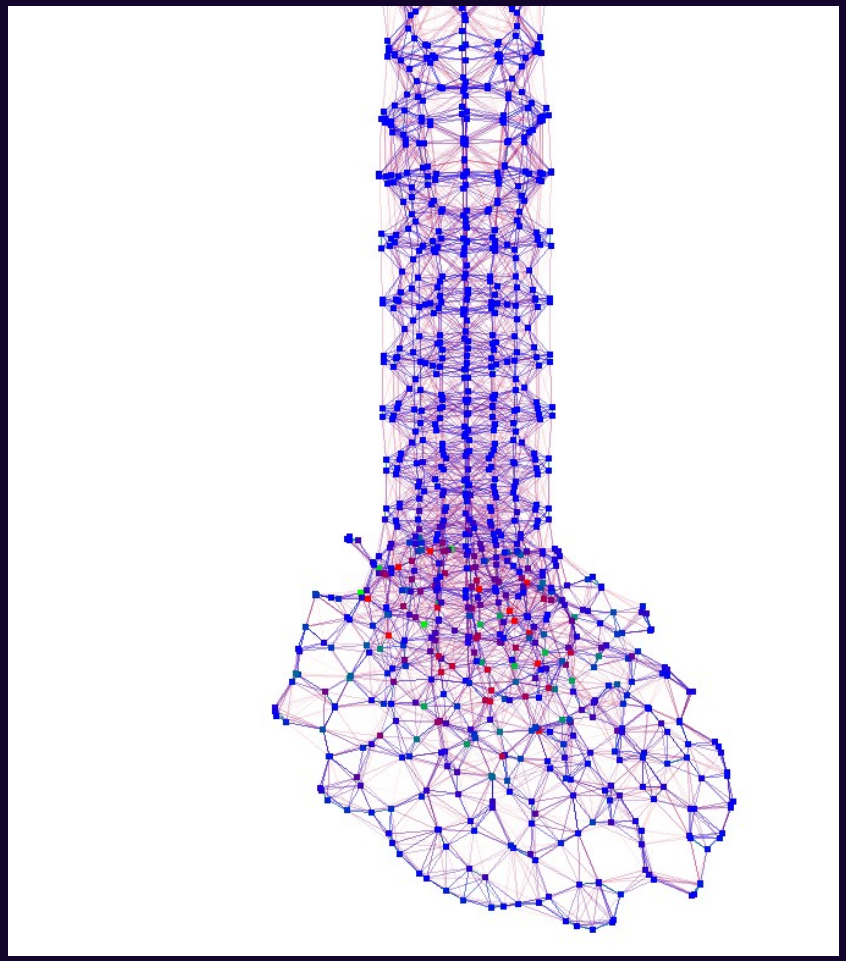
- examples/fluidLennardJones.scn

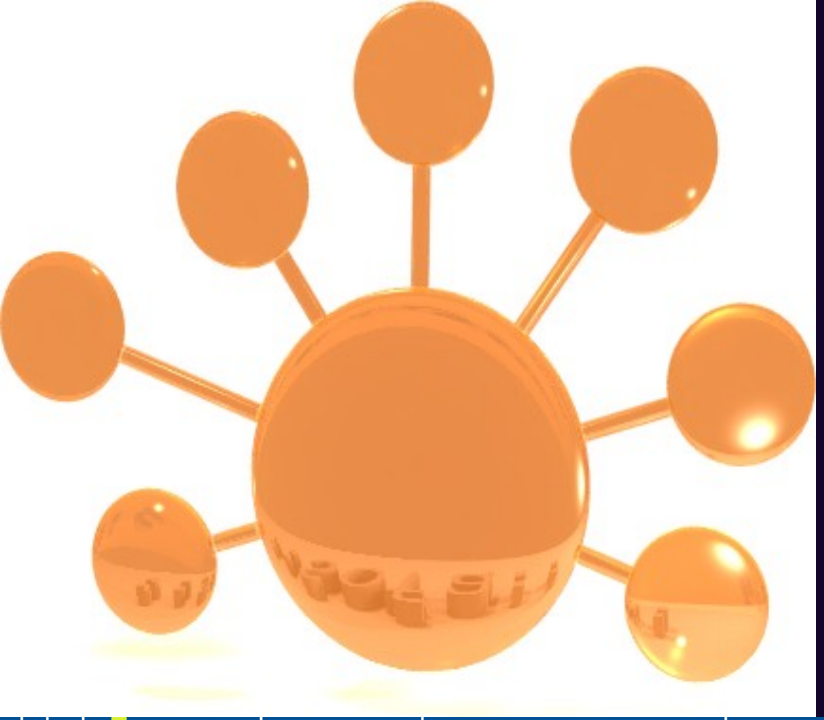


SPHFluidForceField

Smooth Particle Hydrodynamics

- examples/demoSPHFluid.scn





Mappings
Francois Faure

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

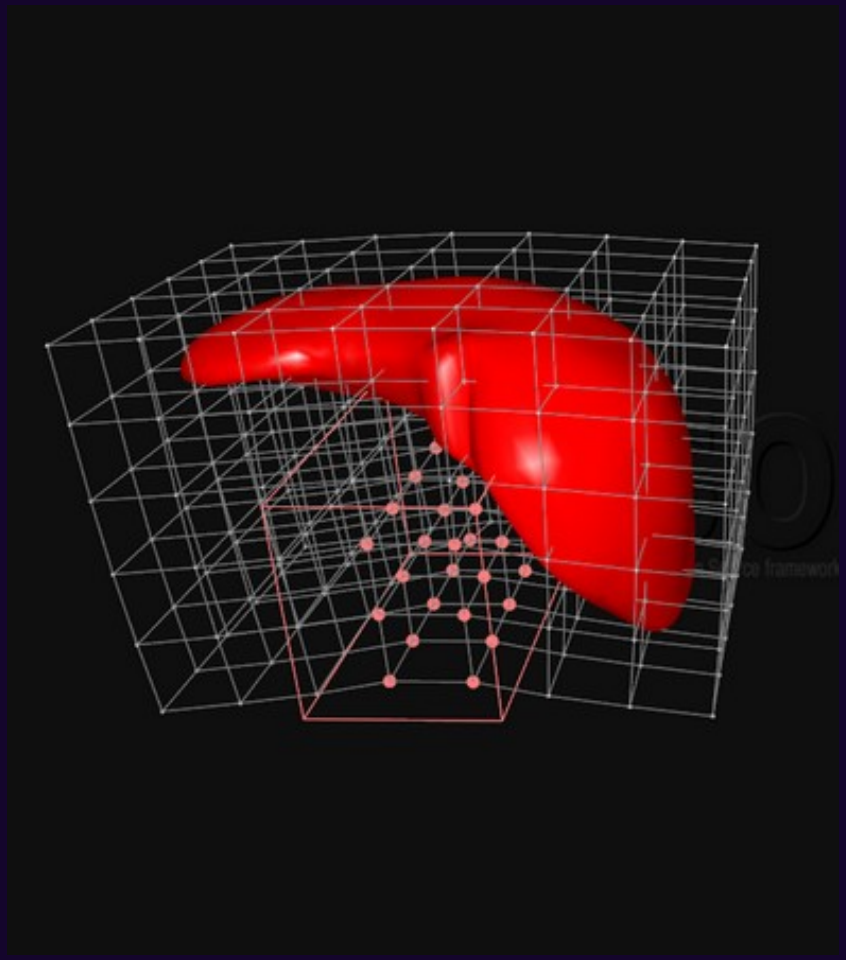
INRIA

centre de recherche
GRENOBLE - RHÔNE-ALPES

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



IdentityMapping

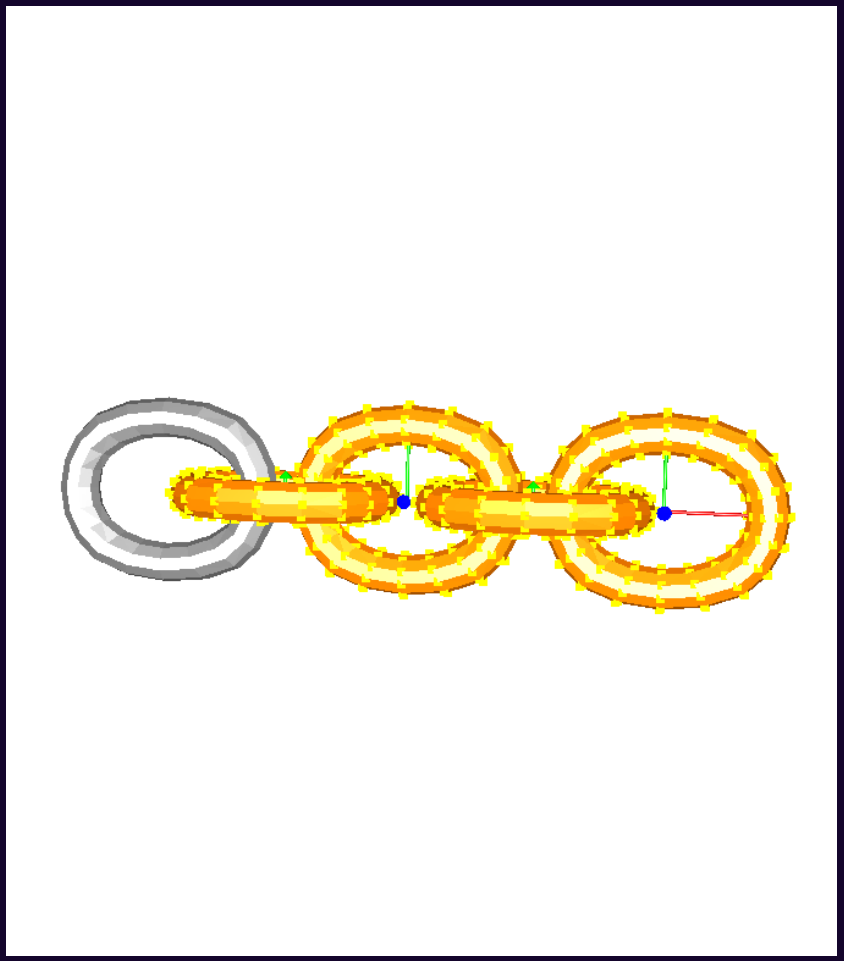
Special case of mapping where the child points are the same as the parent points

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

RigidMapping

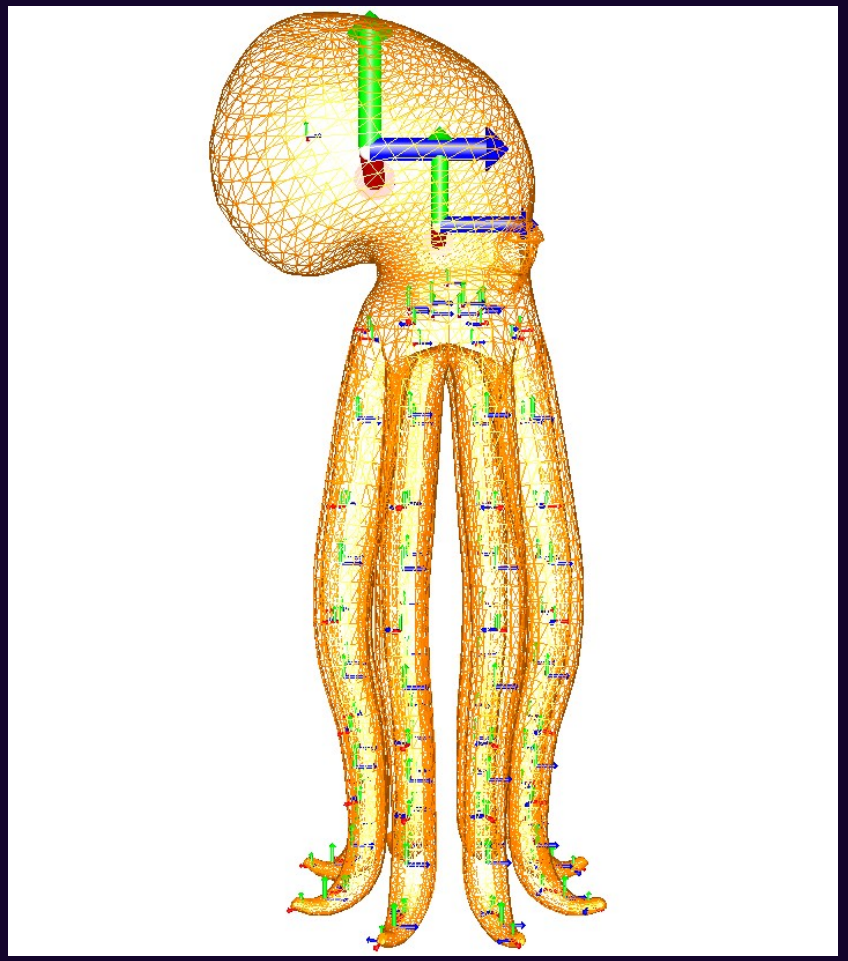
Set the positions and velocities of points attached to a rigid parent

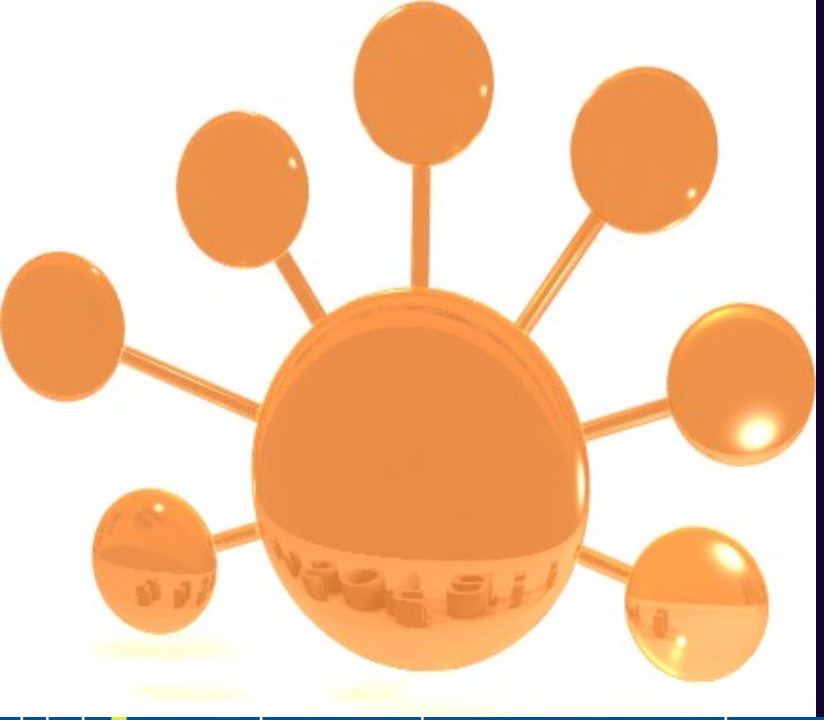
- scenes/chainRigid.scn



SkinningMapping

- examples/SkinnedRigidPendulum.scn





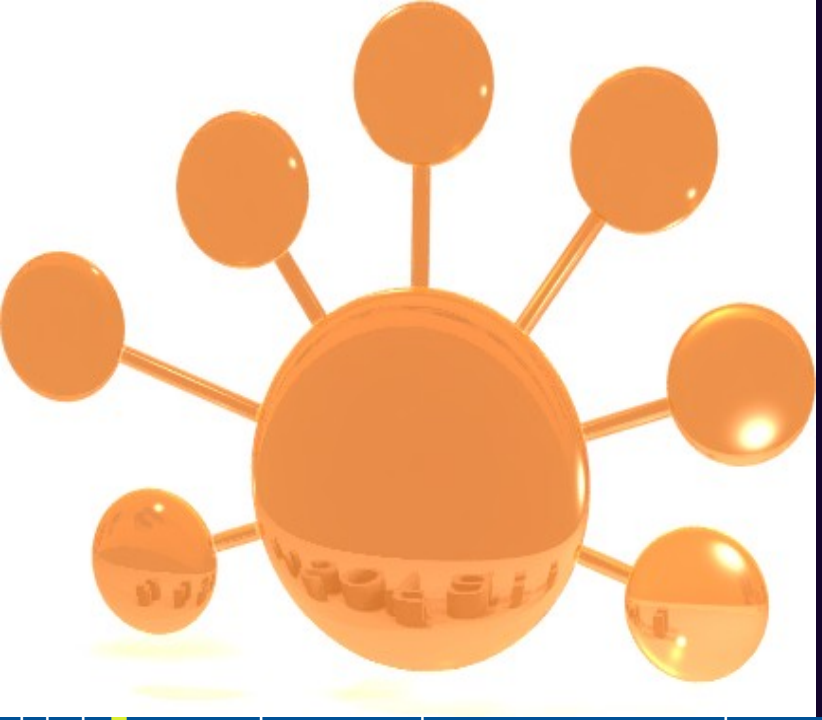
Constraints
Christian Duriez

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

centre de recherche
GRENOBLE - RHÔNE-ALPES

Constraints



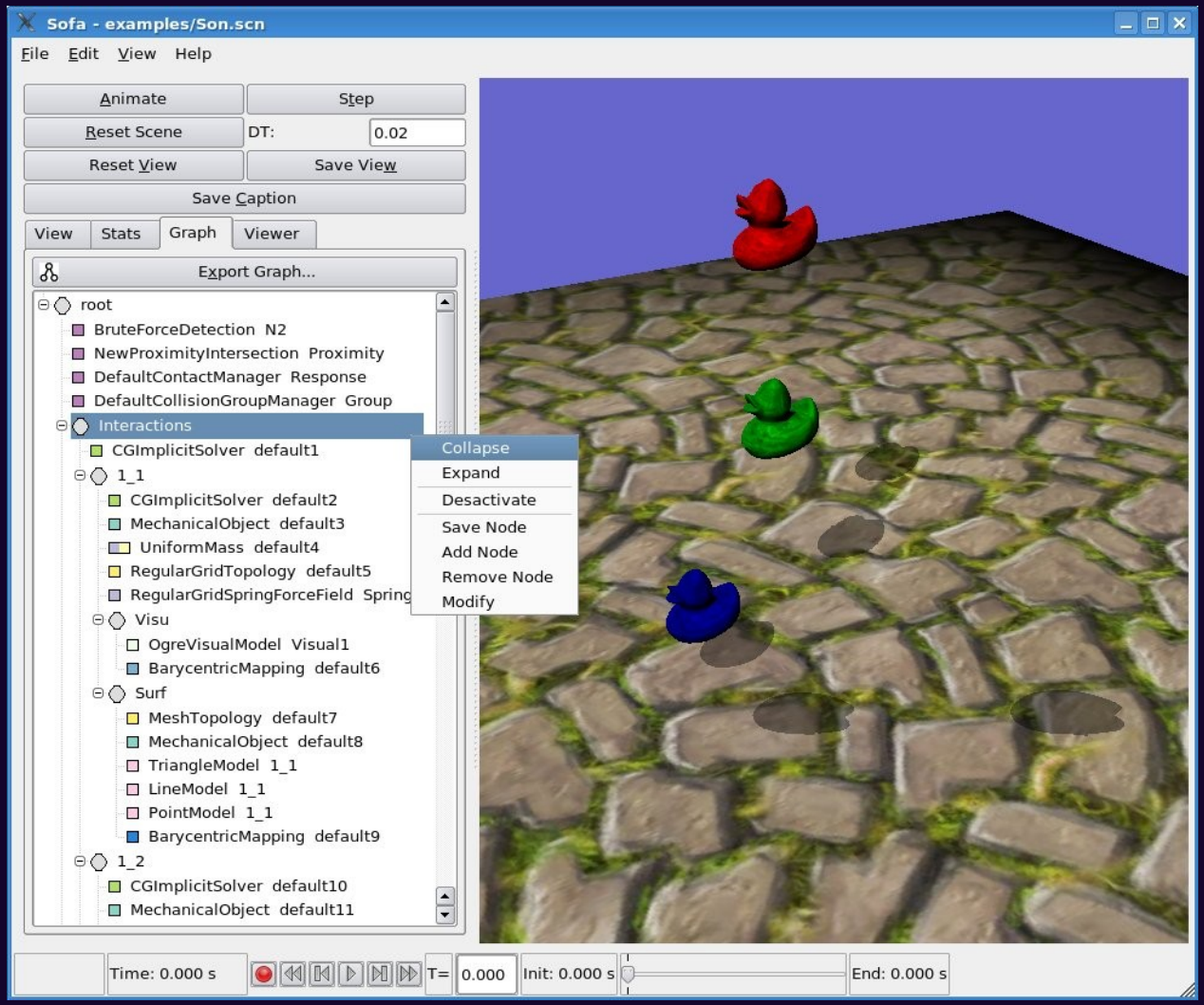
GUI
Florent Falipou

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

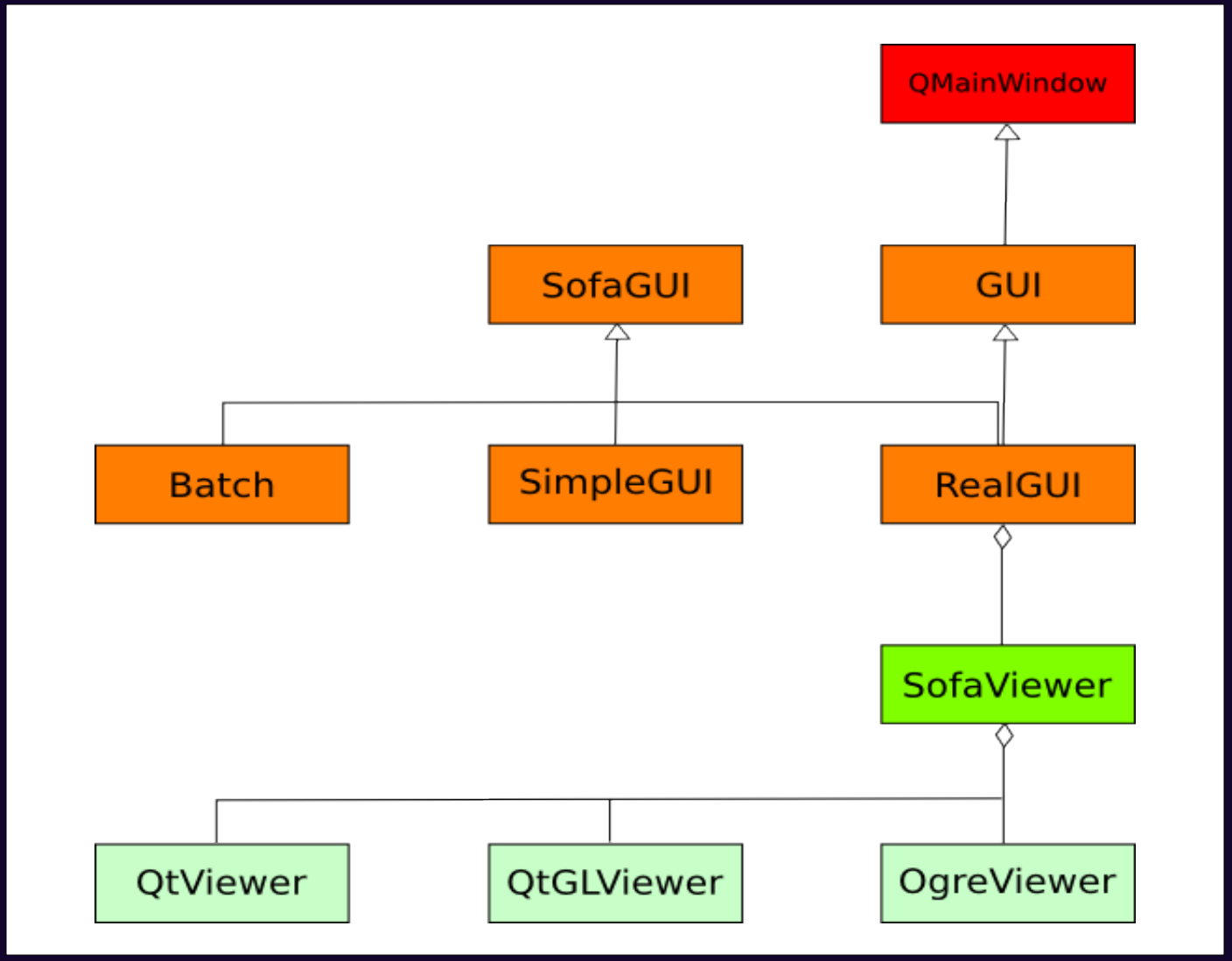
INRIA

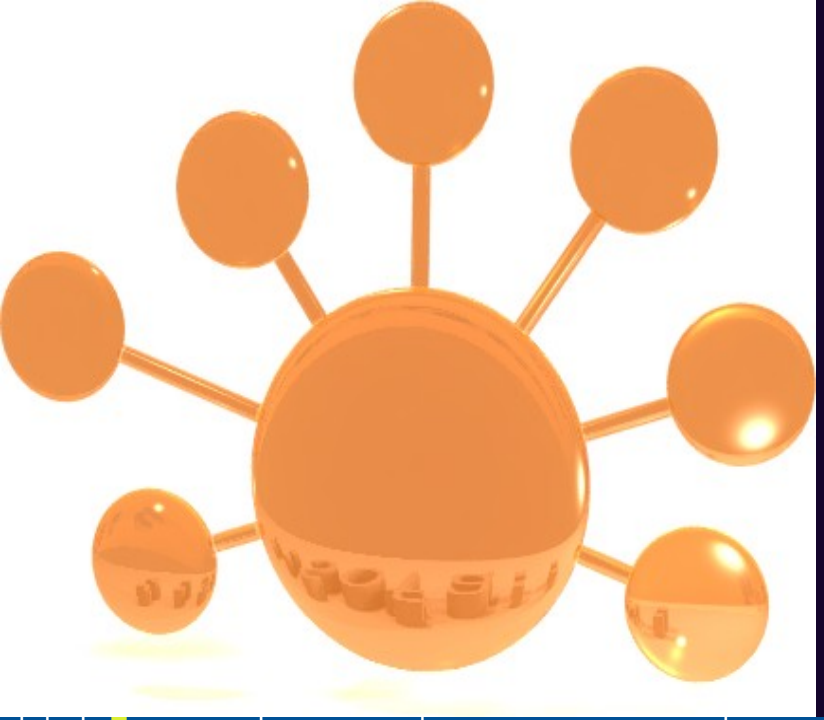
centre de recherche
GRENOBLE - RHÔNE-ALPES

GUI


Sofa - examples/Son.scn
File Edit View Help
Animate
Step
Reset Scene
DT:
0.02
Reset View
Save View
Save Caption
View Stats Graph Viewer
Export Graph...
root
BruteForceDetection N2
NewProximityIntersection Proximity
DefaultContactManager Response
DefaultCollisionGroupManager Group
Interactions
CGImplicitSolver default1
1_1
CGImplicitSolver default2
MechanicalObject default3
UniformMass default4
RegularGridTopology default5
RegularGridSpringForceField Spring
Visu
OgreVisualModel Visual1
BarycentricMapping default6
Surf
MeshTopology default7
MechanicalObject default8
TriangleModel 1_1
LineModel 1_1
PointModel 1_1
BarycentricMapping default9
1_2
CGImplicitSolver default10
MechanicalObject default11
Collapse
Expand
Desactivate
Save Node
Add Node
Remove Node
Modify
Time: 0.000 s
T=
0.000
Init: 0.000 s
End: 0.000 s

GUI - Architecture





SOFA::MAYA

Michaël Adam

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

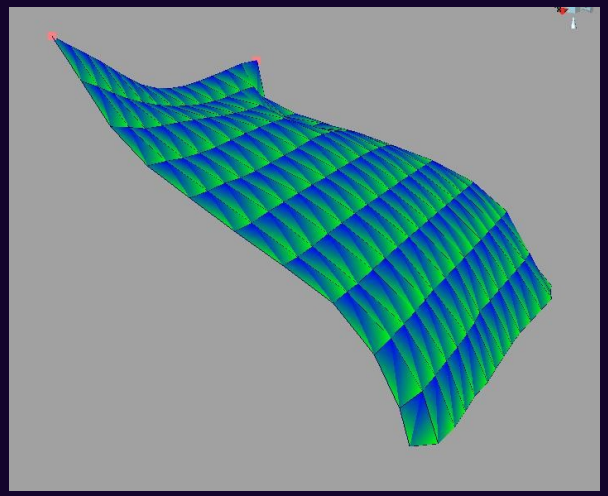
INRIA

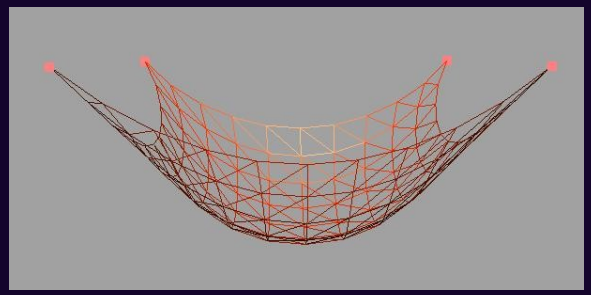
centre de recherche
GRENOBLE - RHÔNE-ALPES

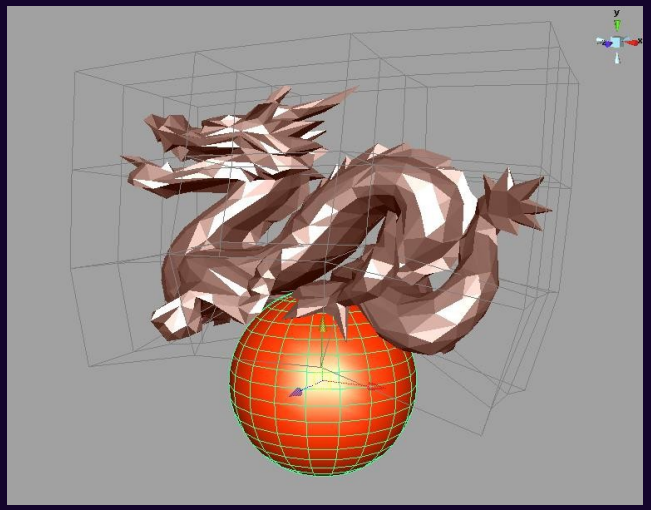
Current Possibilities

Simulate deformable objects with different Sofa models

- FEM
- Stiff Springs
- FFD Grid



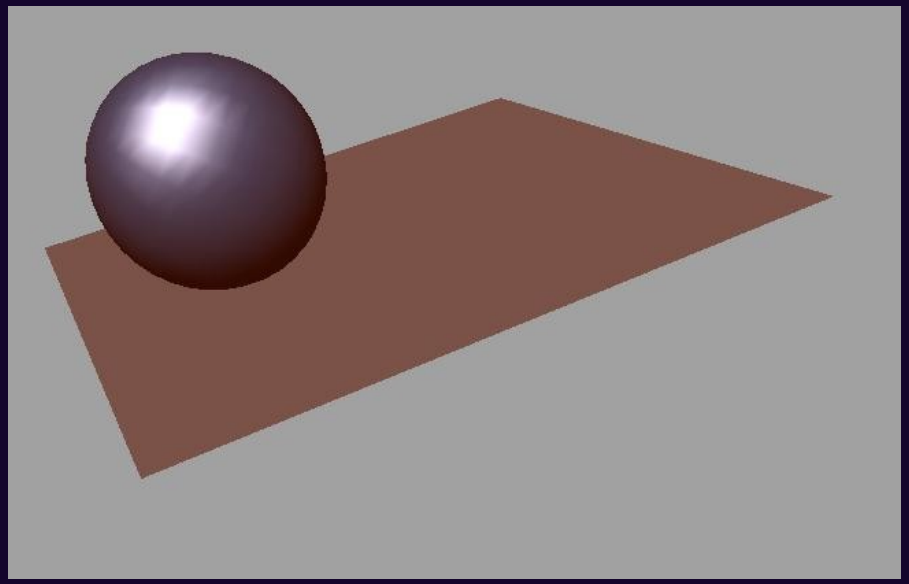




Current Possibilities

Simulate rigid objects

- active
- inactive

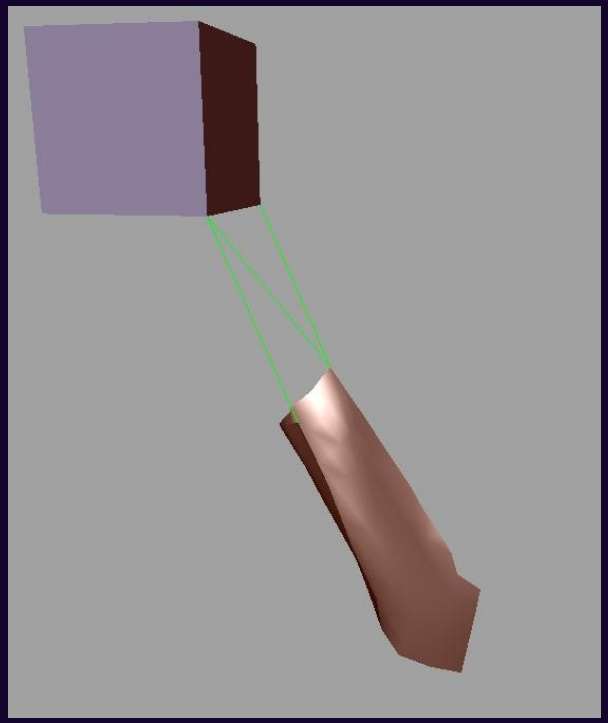


Current Possibilities

Perform collisions

Add constraints

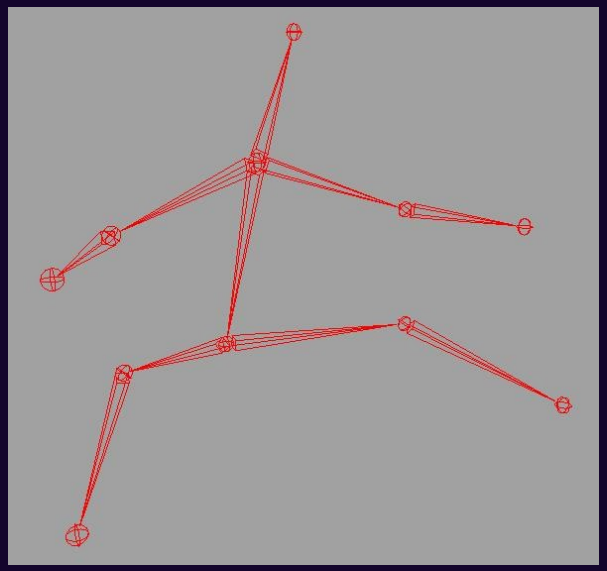
Build interactions

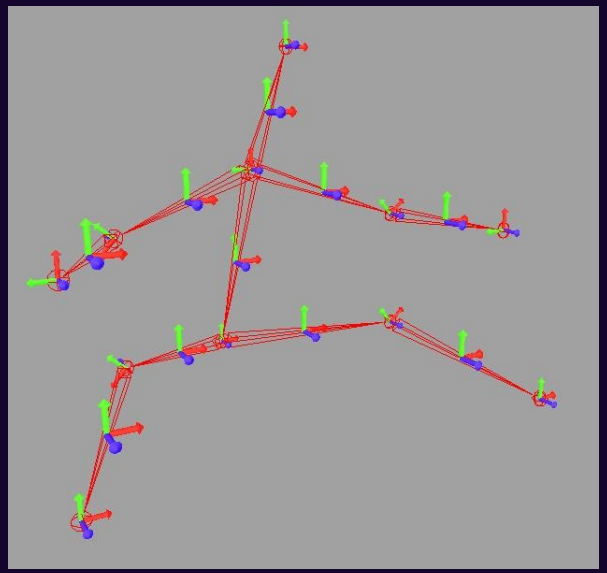


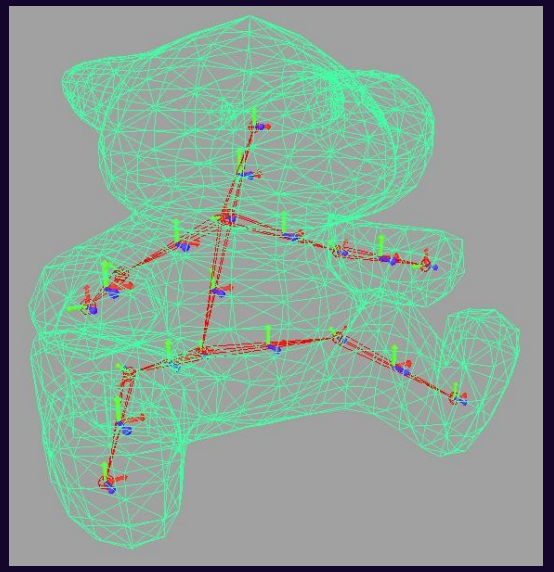
Current Possibilities

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.
-

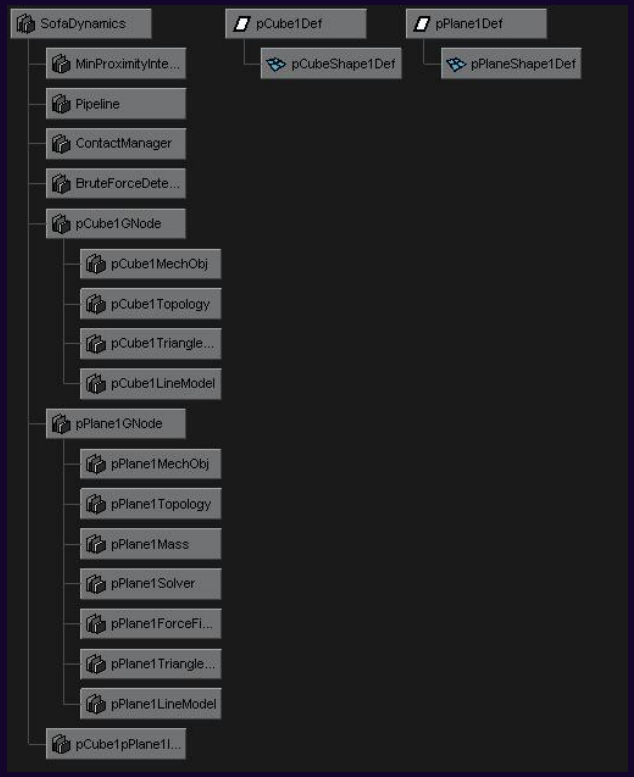
Import sofa scene

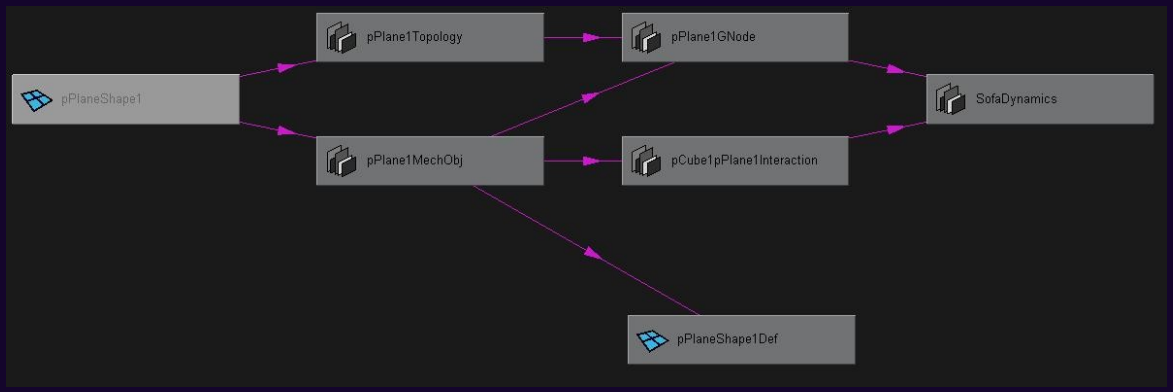
- Open a .scn file into Maya.
- Modify the scene, play the simulation using Maya interactivity.

Integration of SOFA

Make Sofa as a Maya plug-in

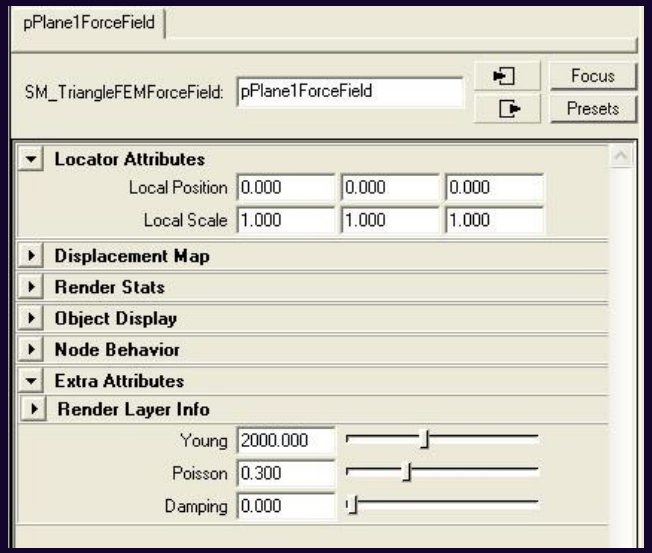
- Put the Sofa scene graph into the Maya scene graph.
- For each Sofa object, a Maya node is created.

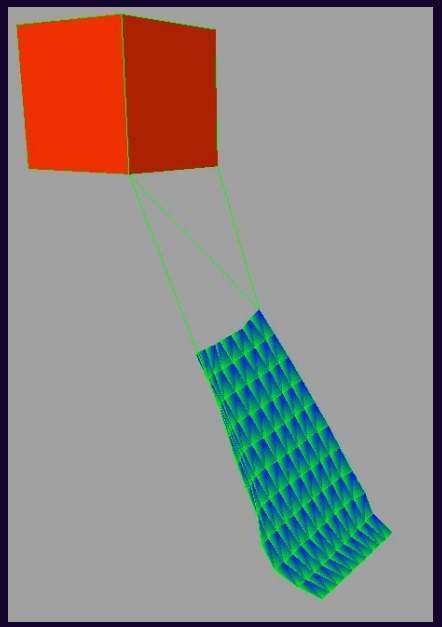


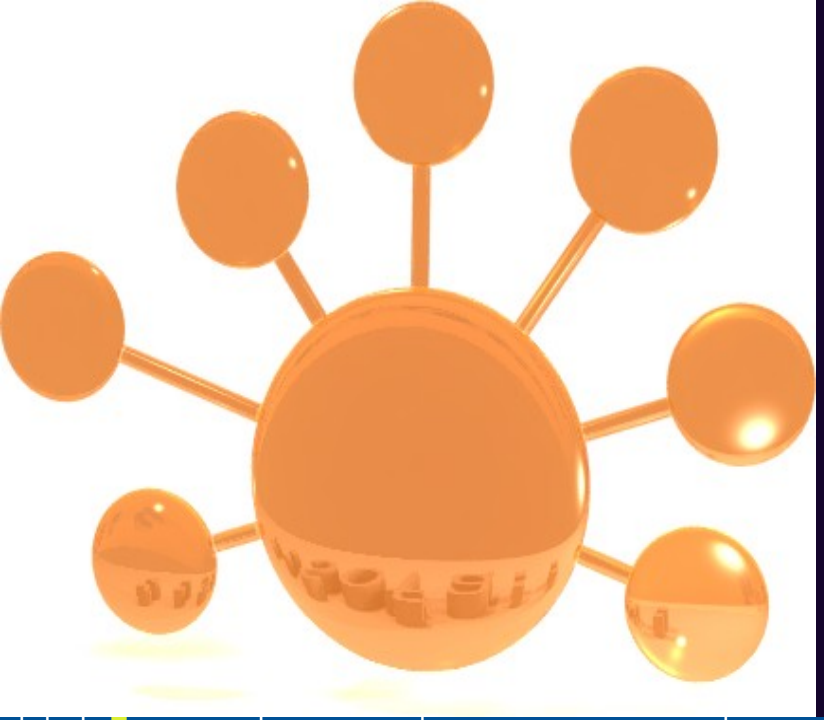


User Interface

- A Sofa menu.
- Sofa objects parameters can be changed.
- Sofa objects display is plugged into the Maya scene.







Using Blender Functionalities with SOFA

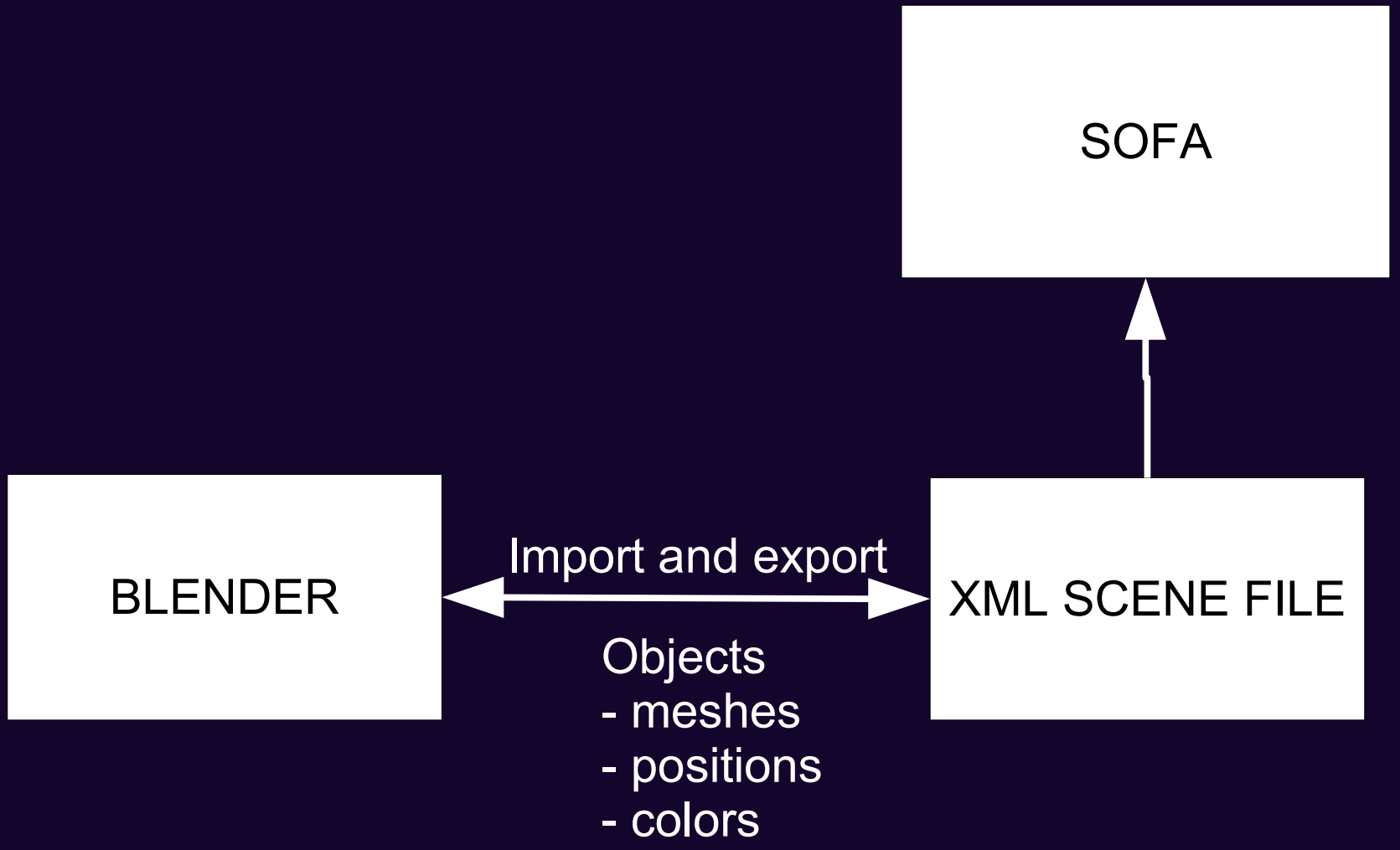
Vincent Vansuyt

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

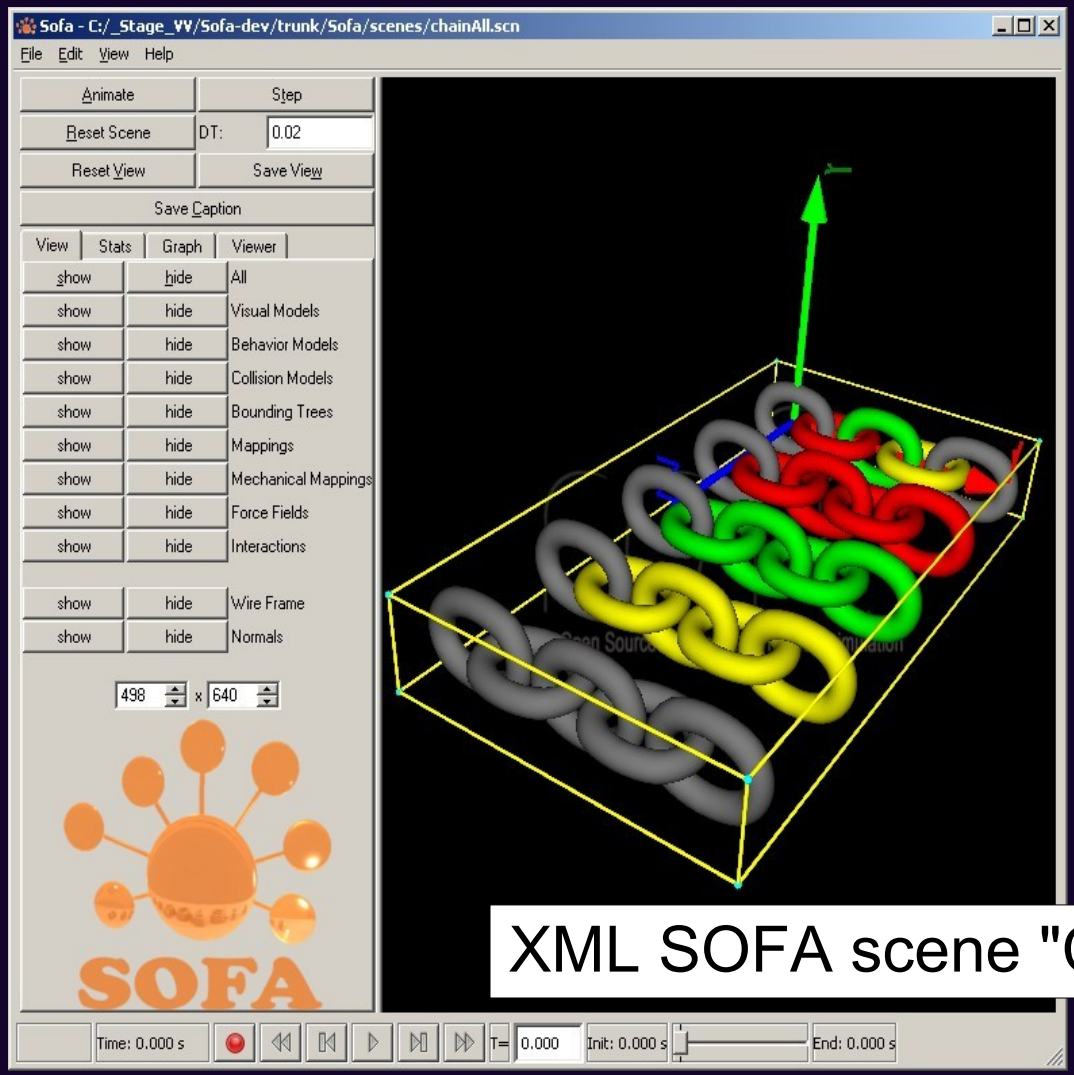
INRIA

centre de recherche
GRENOBLE - RHÔNE-ALPES

Blender's imports and exports for SOFA

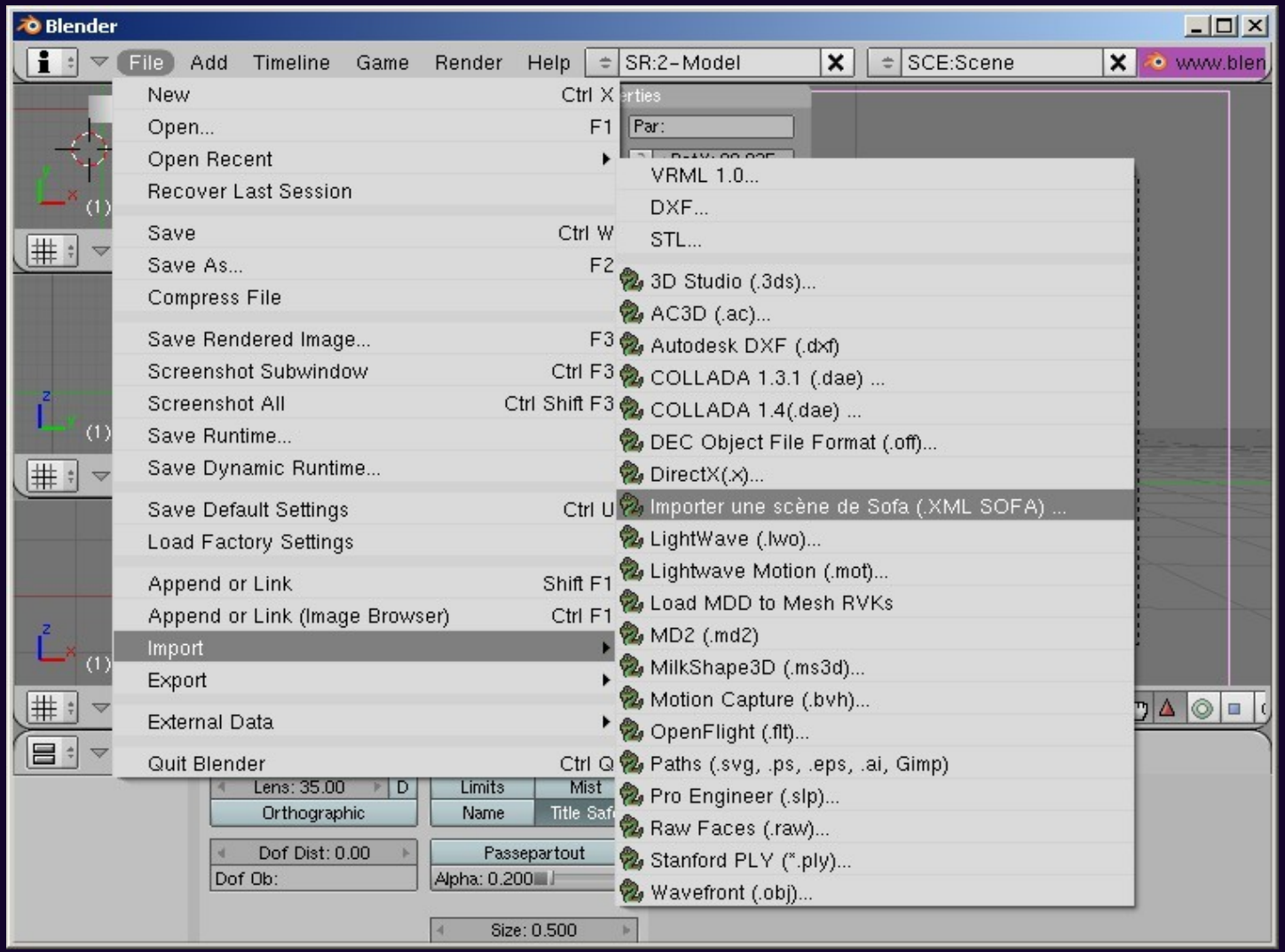


Blender's imports from SOFA (1/5)

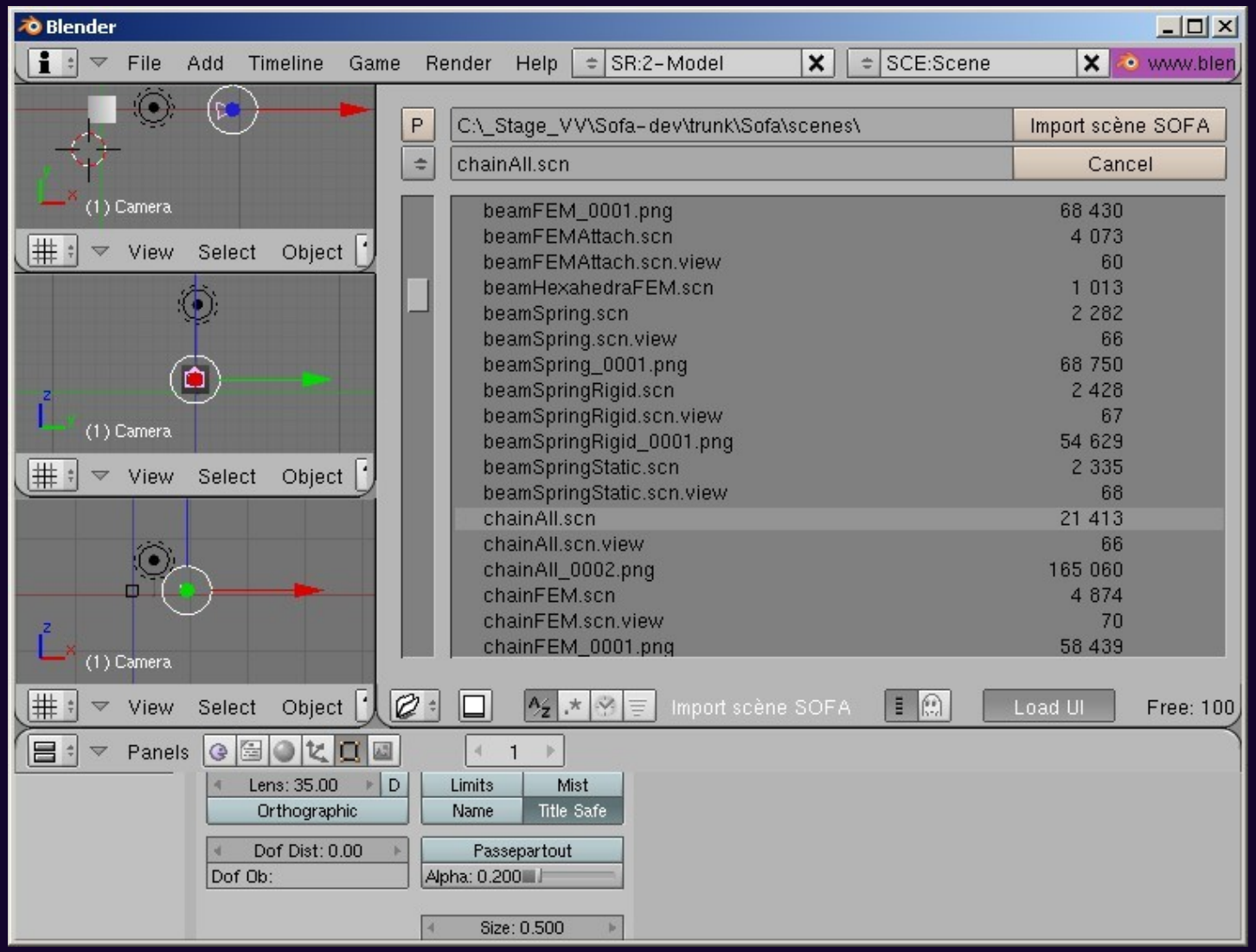


XML SOFA scene "ChainAll.scn"

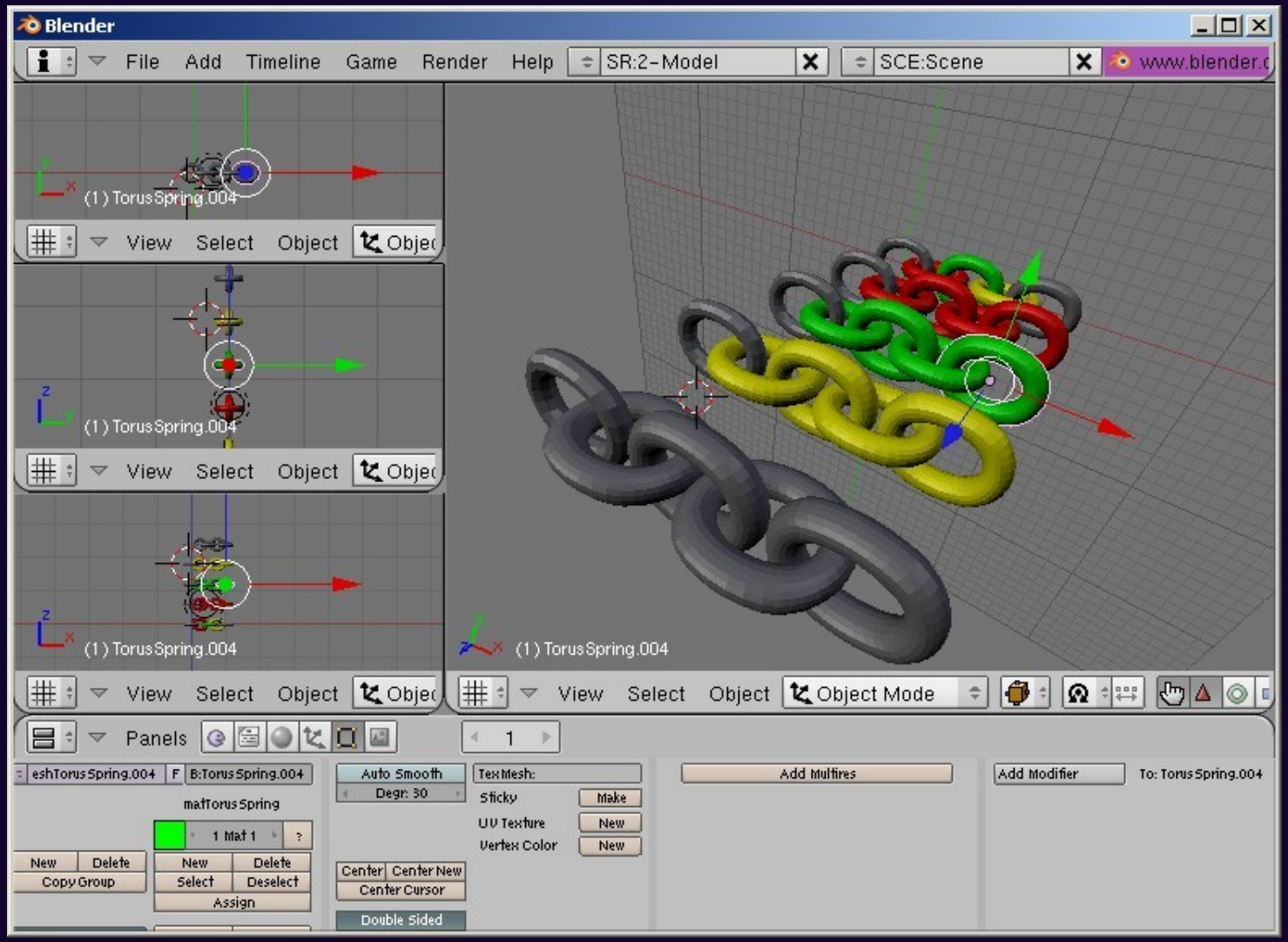
Blender's imports from SOFA (2/5)



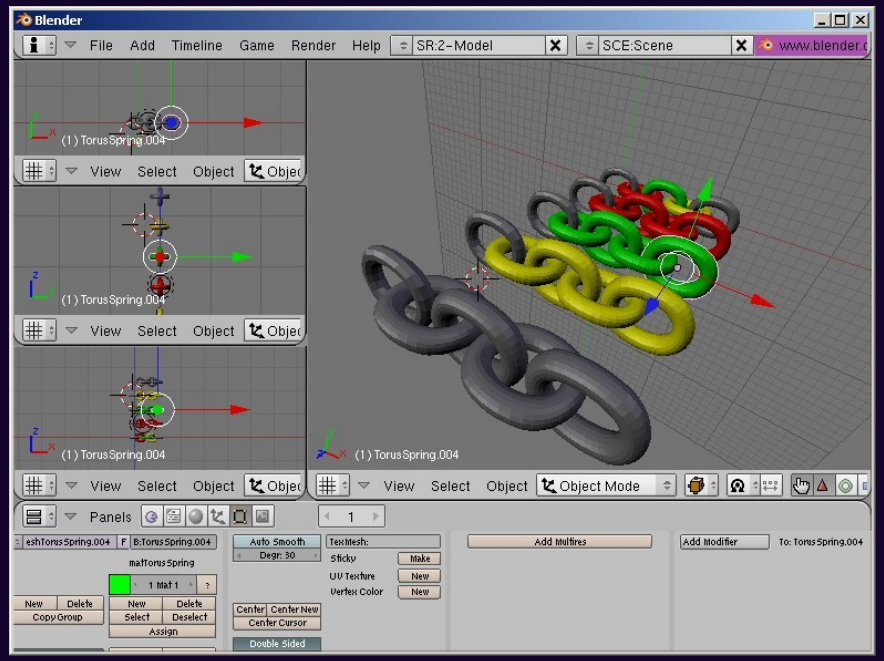
Blender's imports from SOFA (3/5)

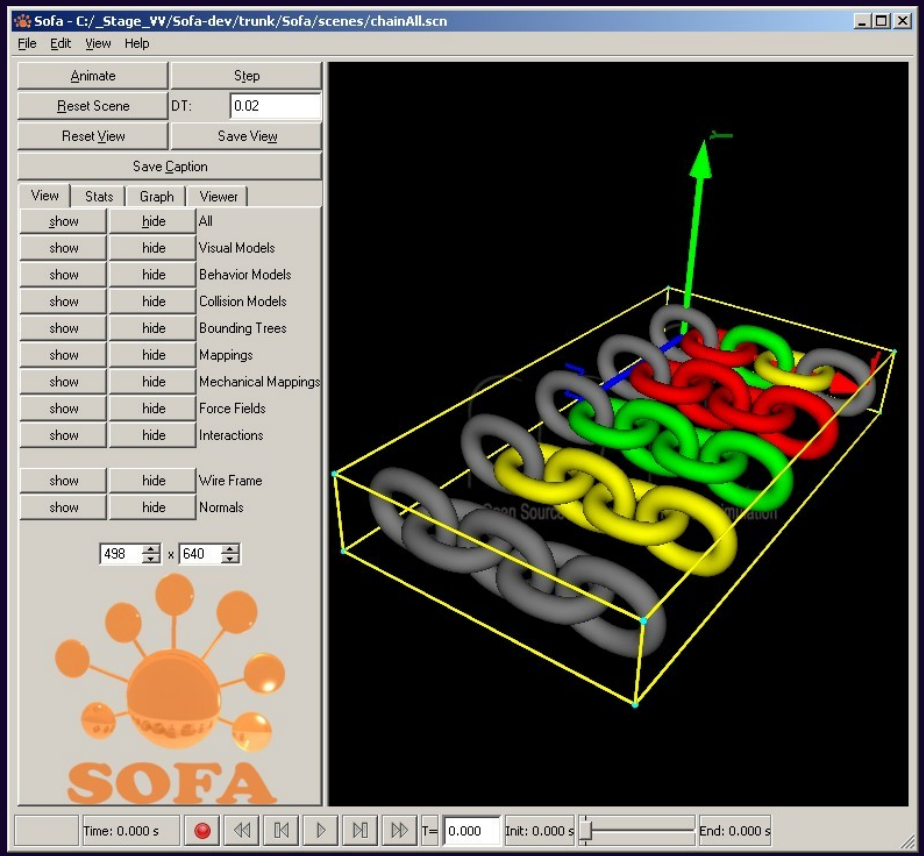


Blender's imports from SOFA (4/5)

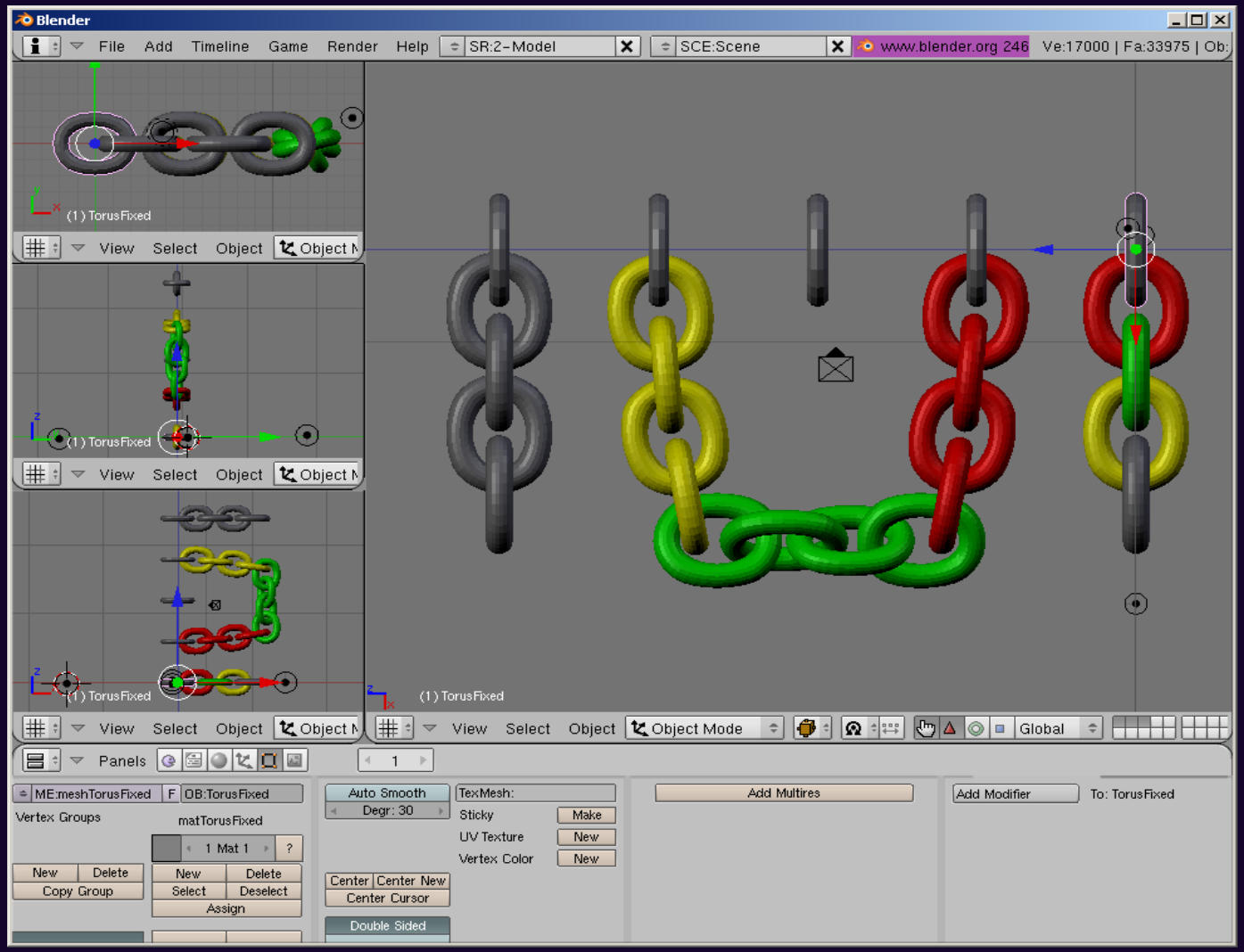


Blender's imports from SOFA (5/5)

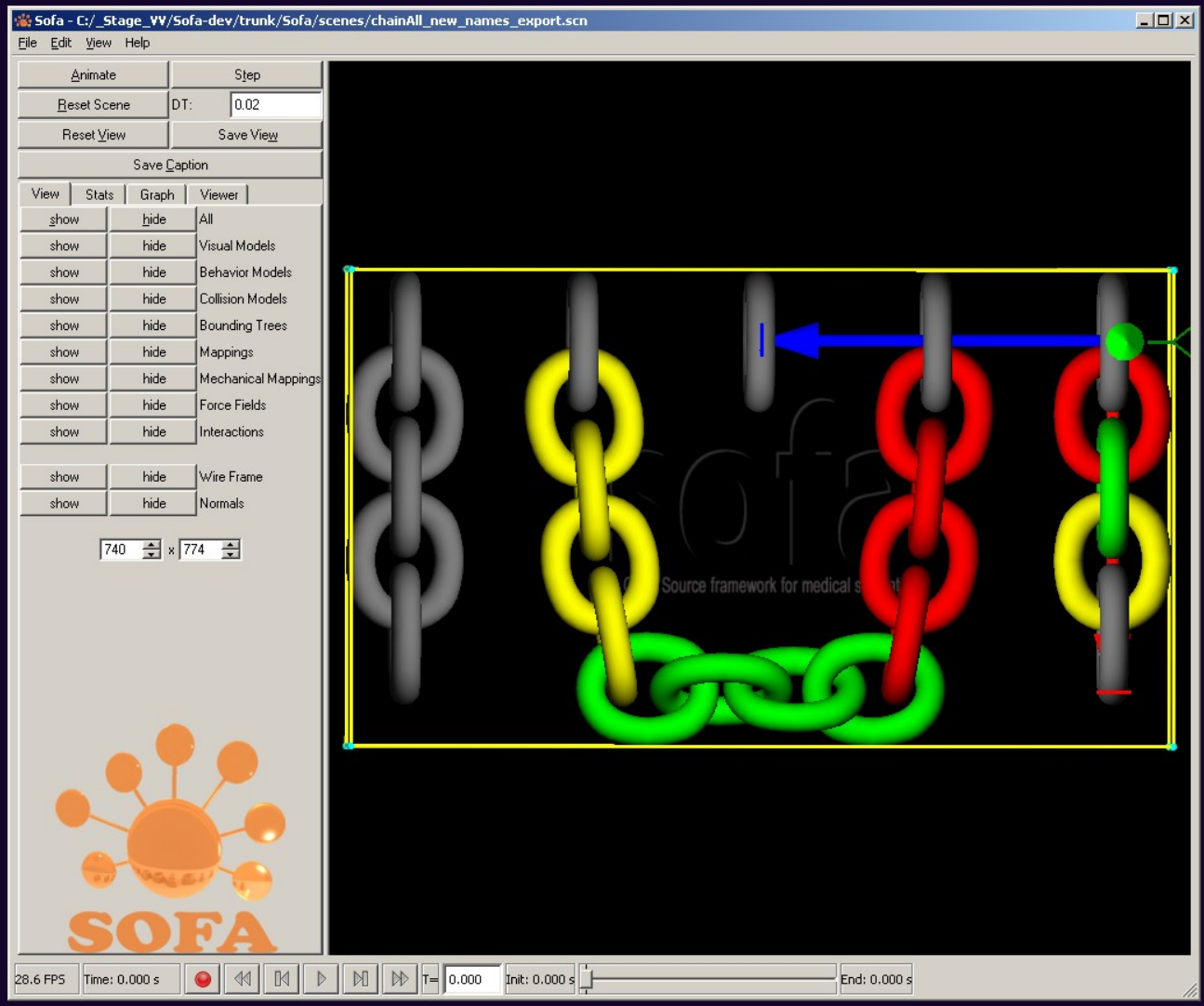




Blender's exports to SOFA (1/2)



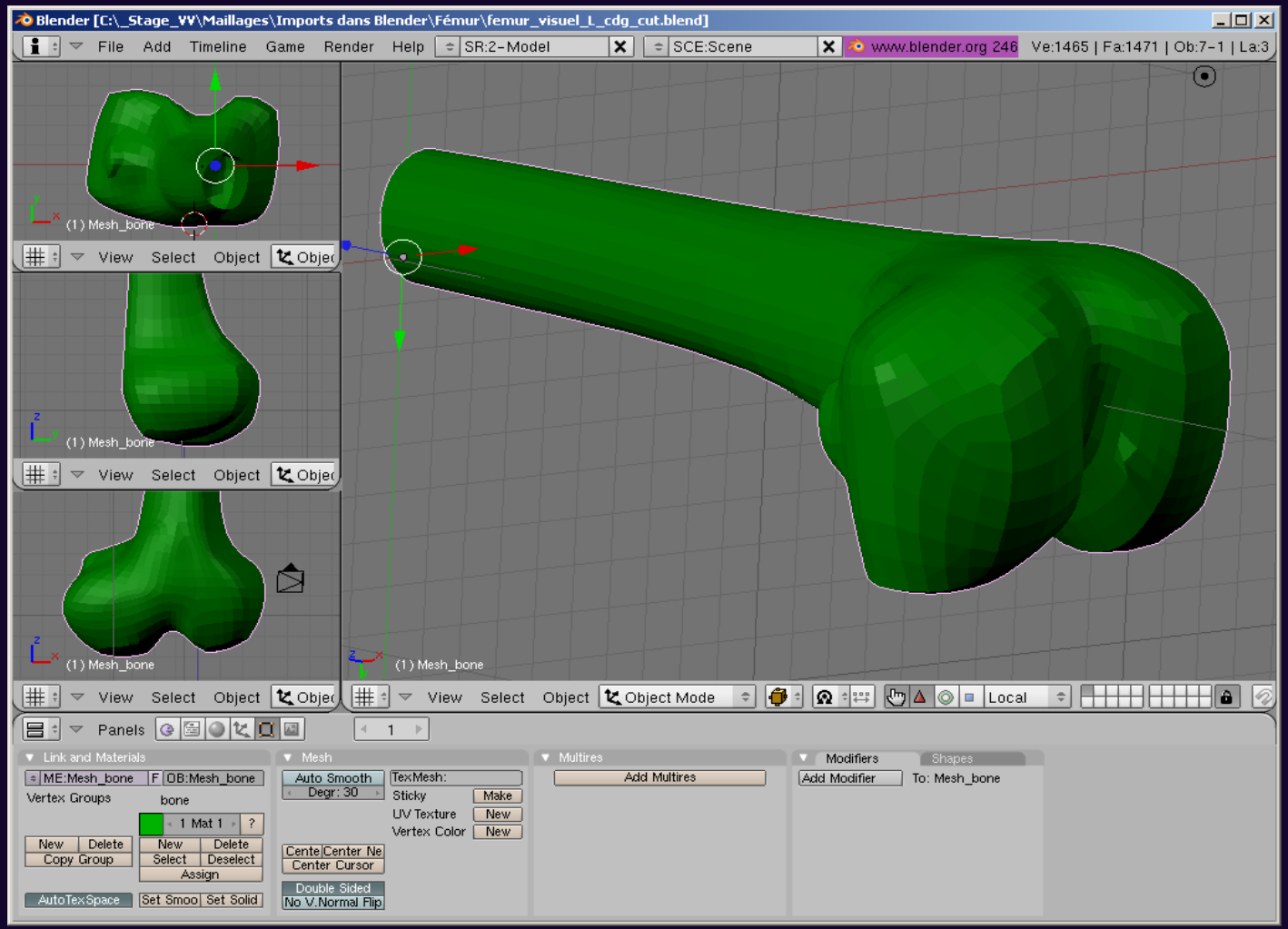
Blender's exports to SOFA (2/2)



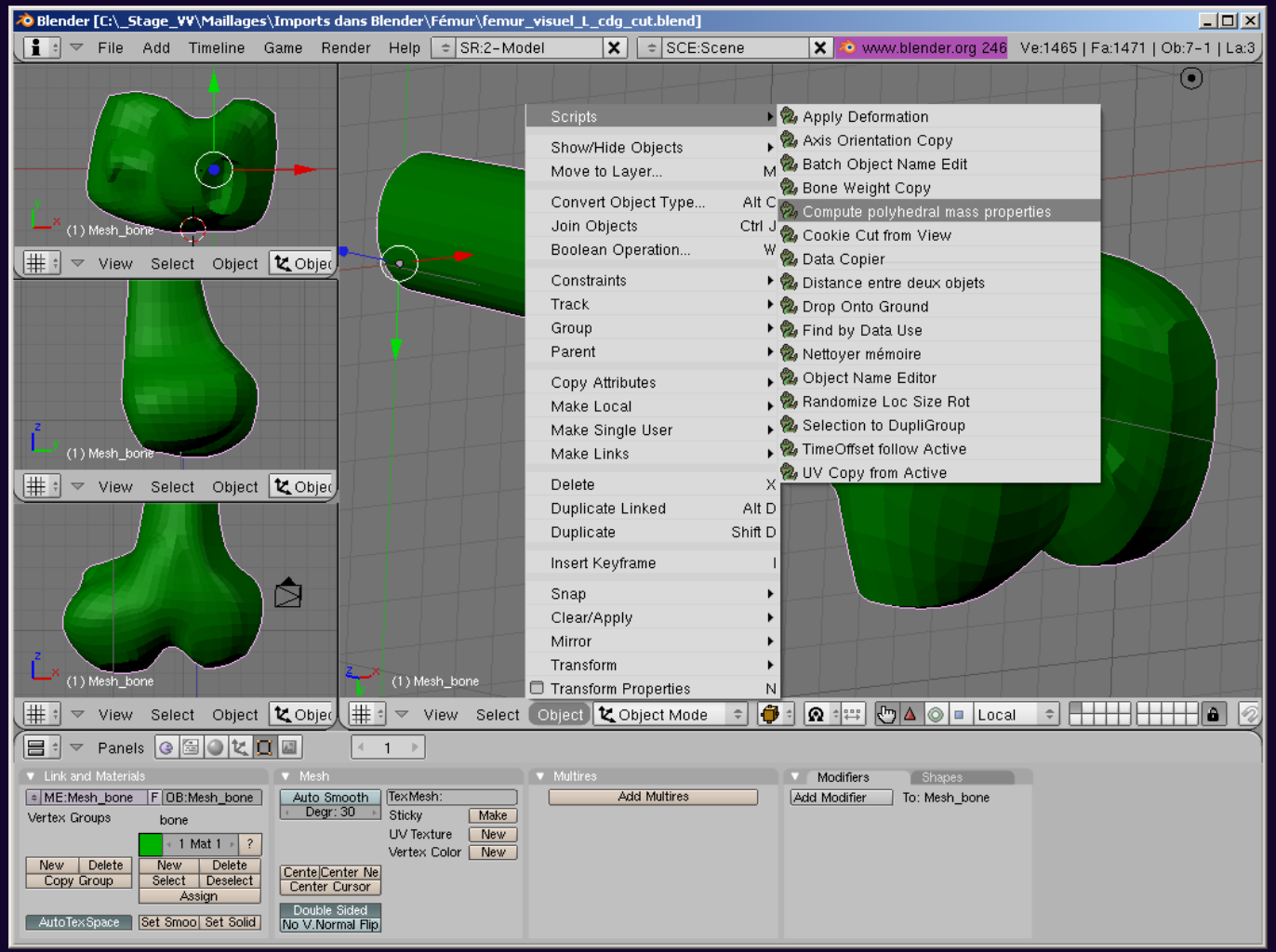
Computing mesh center of mass and inertia matrix (1/7)

Brian MIRTICH's C-code transposed into Python-code for Blender

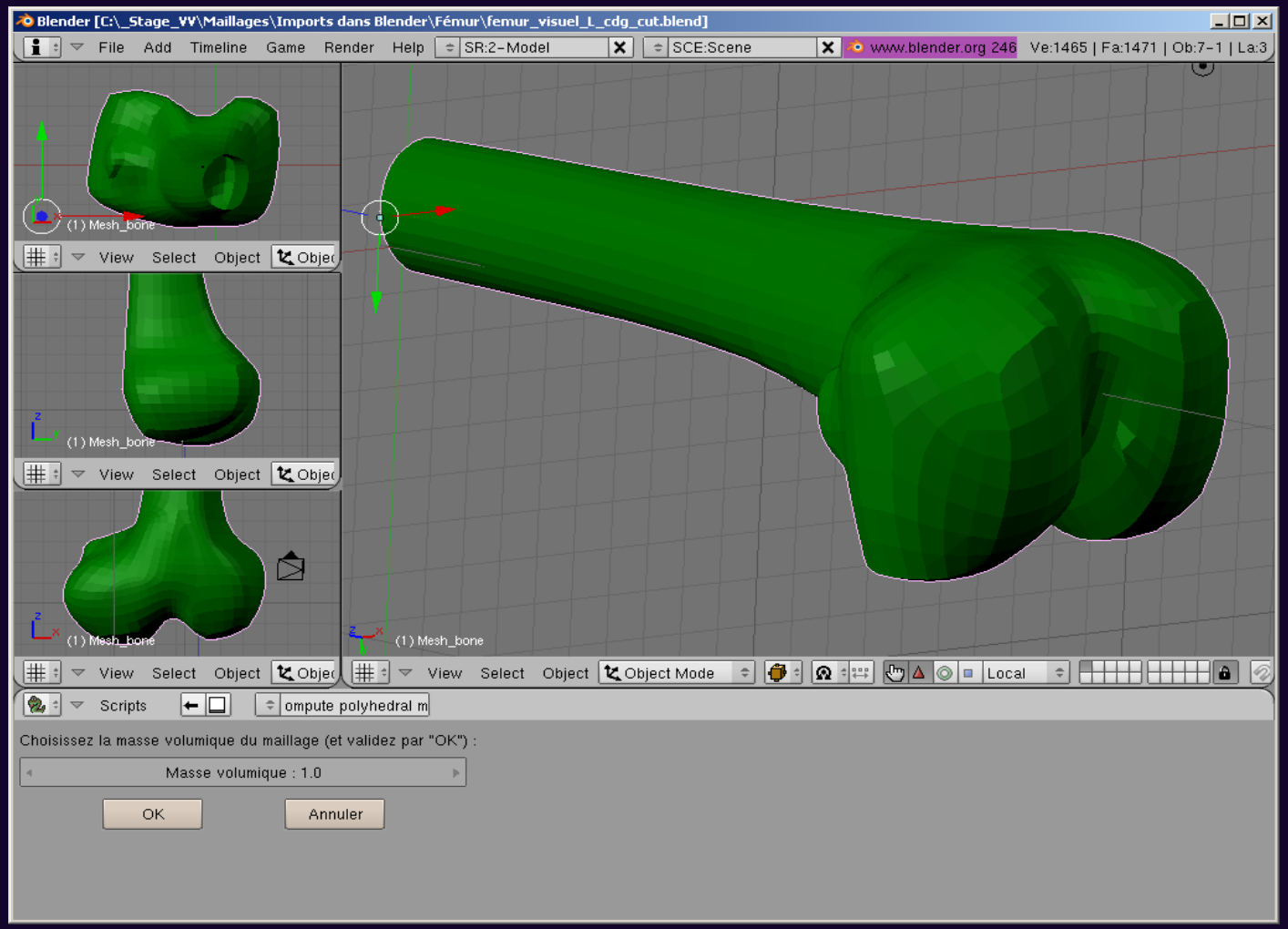
Computing mesh center of mass and inertia matrix (2/7)



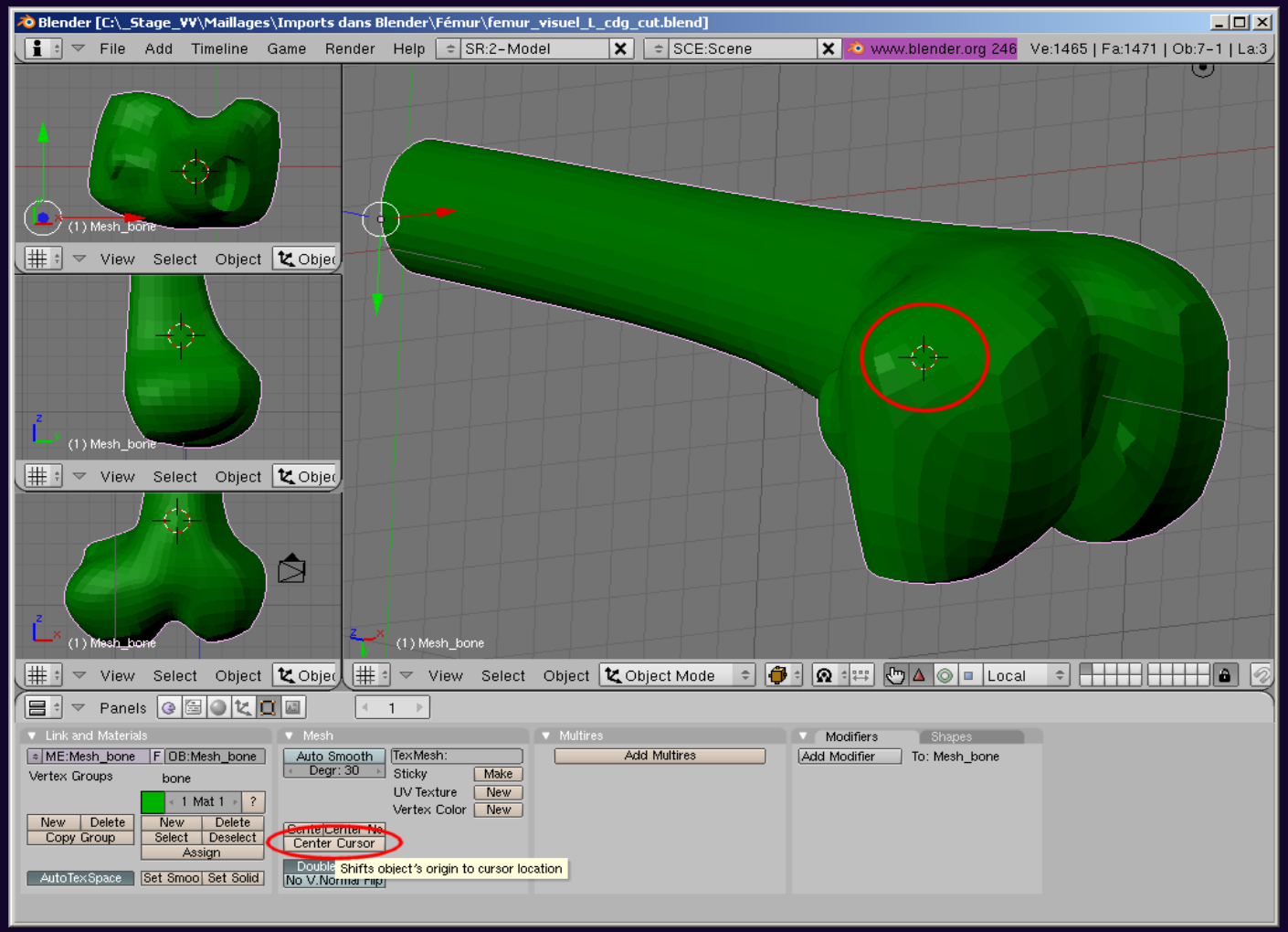
Computing mesh center of mass and inertia matrix (3/7)



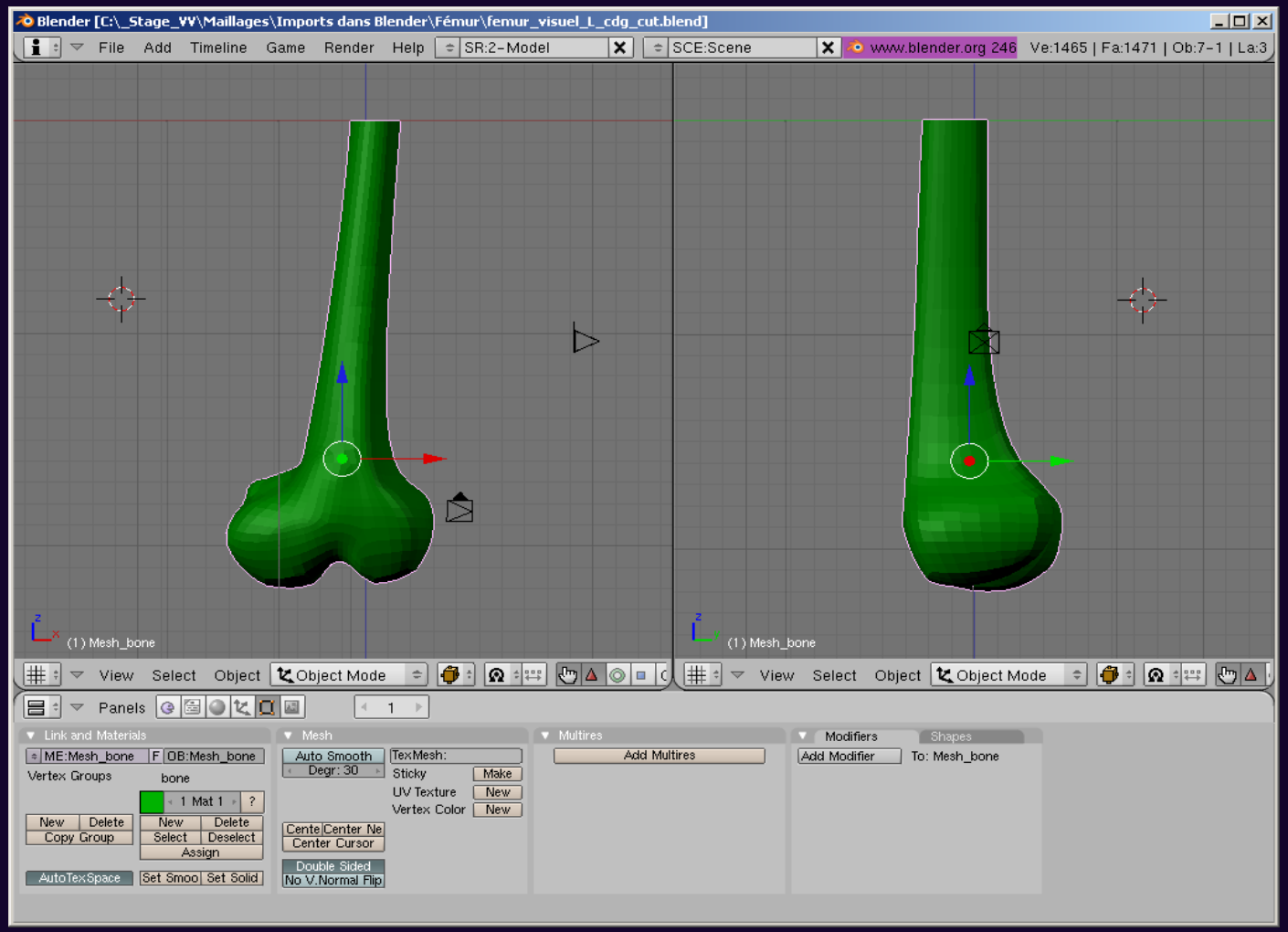
Computing mesh center of mass and inertia matrix (4/7)



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



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



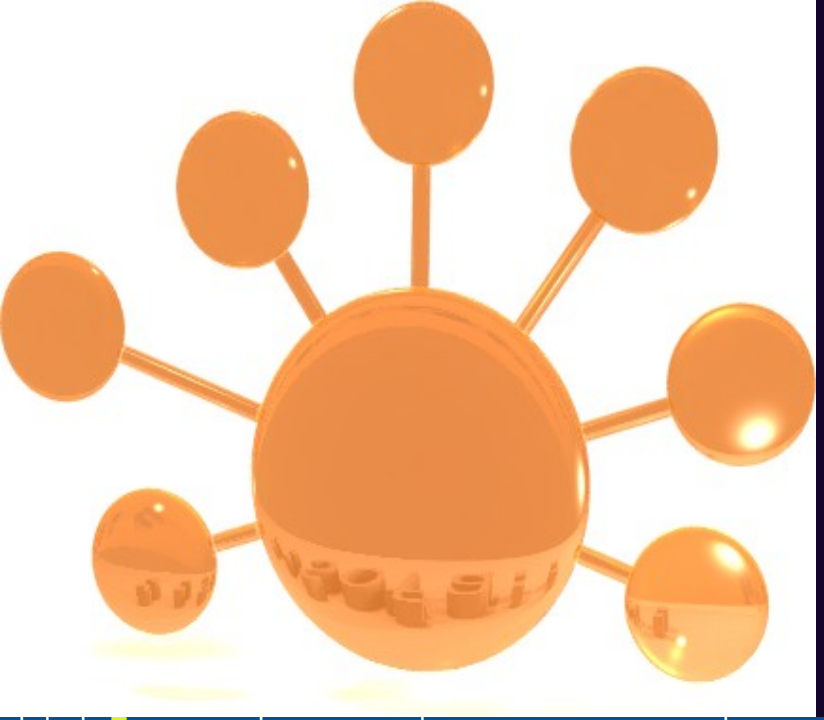
Computing mesh center of mass and inertia matrix (7/7)

```
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 :

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

$$\begin{array}{ll} A = \int_V (y^2 + z^2)\, dm & D = \int_V (y.z)\, dm \\ B = \int_V (x^2 + z^2)\, dm & E = \int_V (x.z)\, dm \\ C = \int_V (x^2 + y^2)\, dm & F = \int_V (x.y)\, dm \end{array}$$



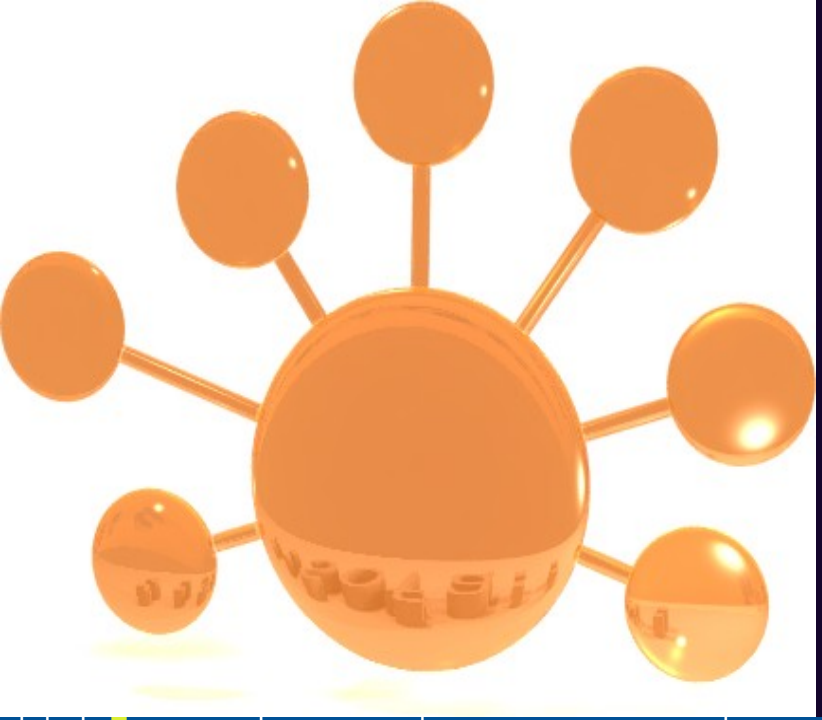
Articulated Bodies
Christian Duriez

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

centre de recherche
GRENOBLE - RHÔNE-ALPES

Articulated Bodies



Soft Articulations

Michaël Adam

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

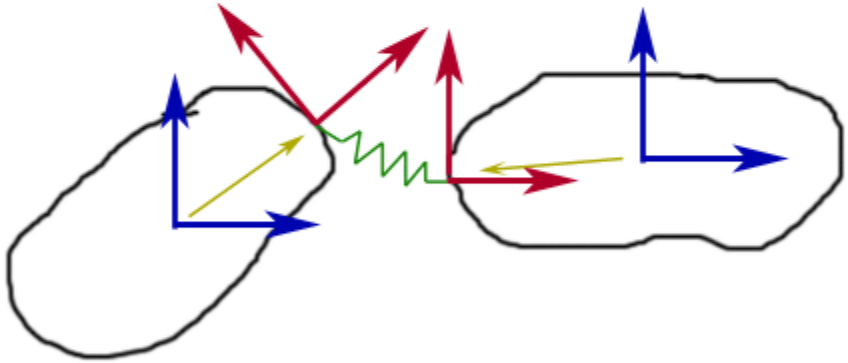
INRIA

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

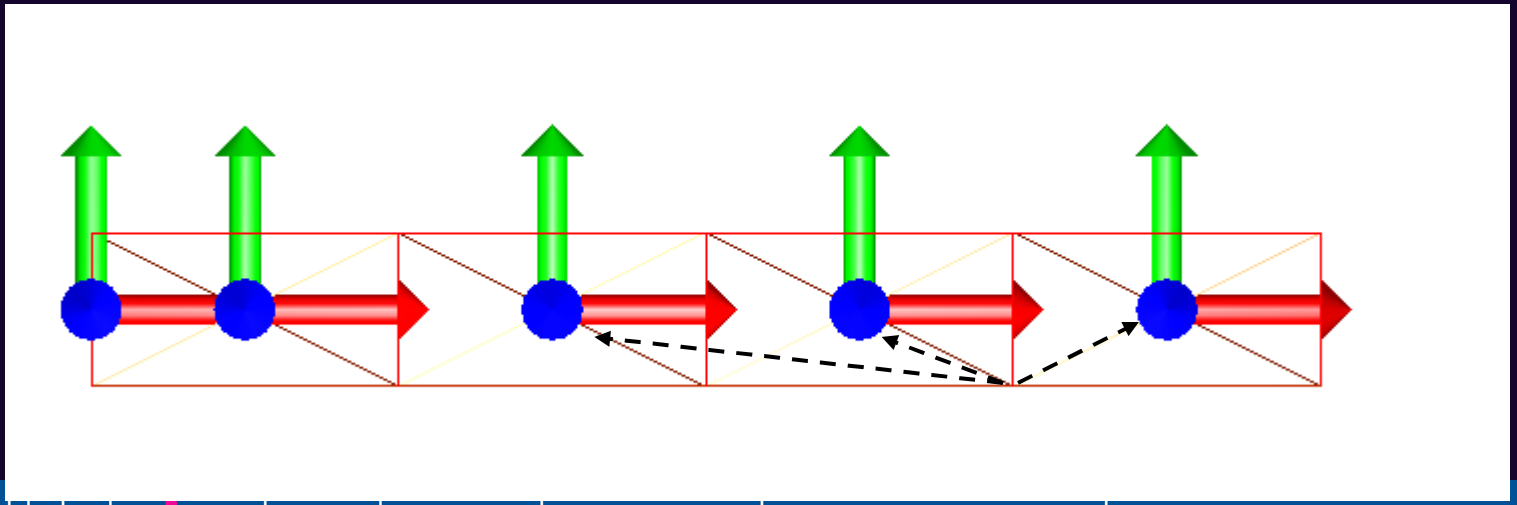
```
¤
|-- MechanicalObject<Rigid> bones DOFs
|
|-- Mass  rigidMass
|
|-- SimpleConstraint optional constraints
|
|--¤
   |-- MechanicalObect<Rigid> joints DOFs
   |
   |-- RigidRigidMapping bones DOFs to joints DOFs
   |
   |-- JointSpringForceField 6-DOF springs
```

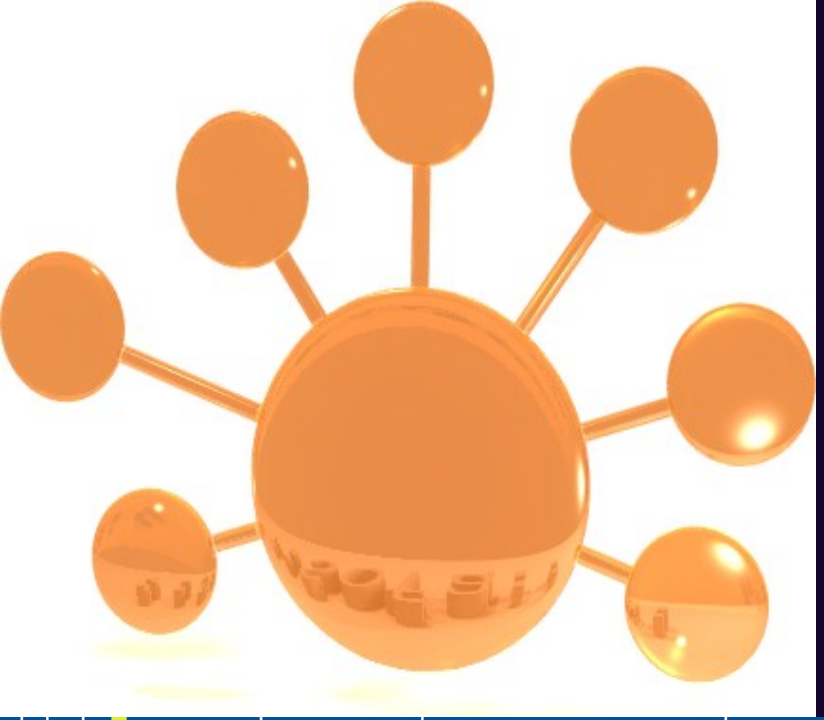


Corresponding Scene Graph

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

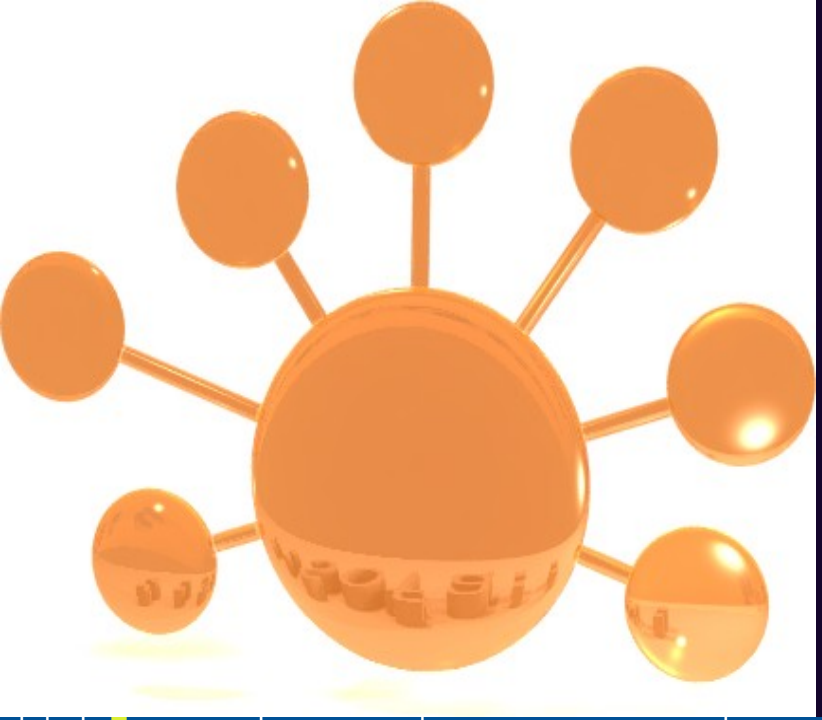
INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

centre de recherche
GRENOBLE - RHÔNE-ALPES

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

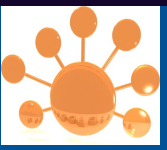
Jeremie Allard

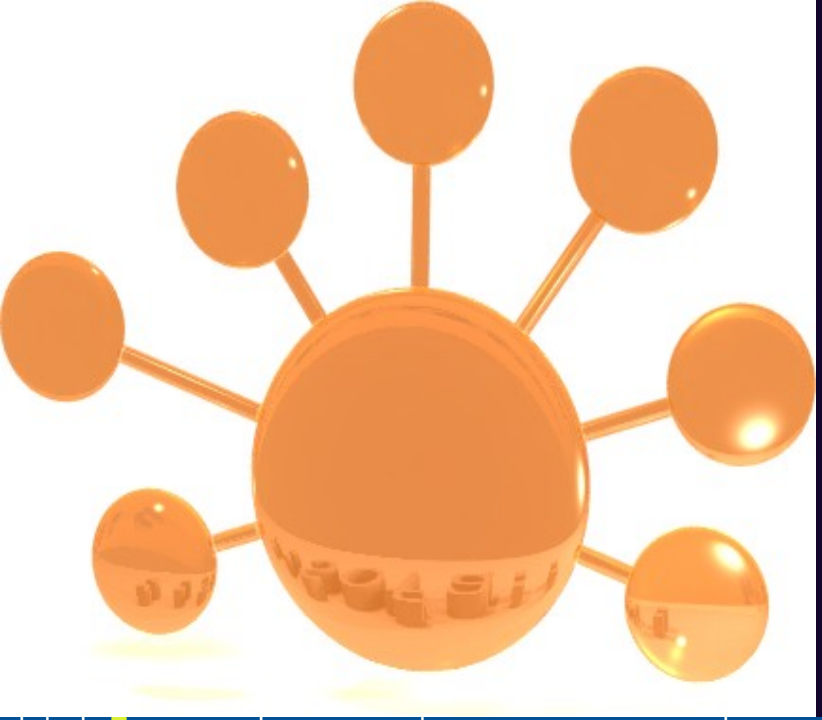
INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

centre de recherche
GRENOBLE - RHÔNE-ALPES

CUDA





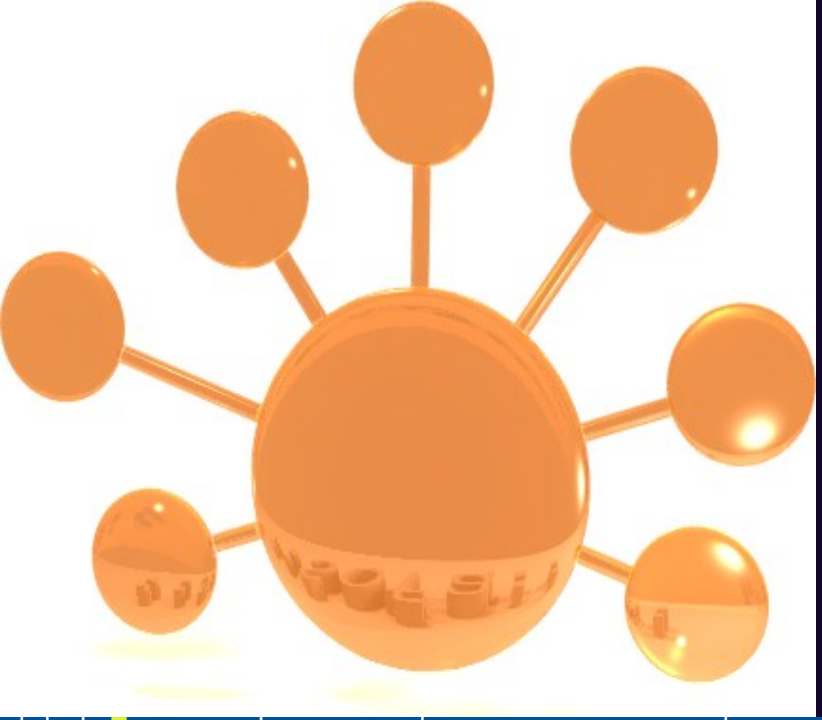
Fluids
Jeremie Allard

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

centre de recherche
GRENOBLE - RHÔNE-ALPES

Fluids



Haptics
Christian Duriez

INSTITUT NATIONAL
DE RECHERCHE
EN INFORMATIQUE
ET EN AUTOMATIQUE

INRIA

centre de recherche
GRENOBLE - RHÔNE-ALPES

Haptics