SOFA Technical Committee #7
Report

Date: 20/05/2019 - 22/05/2019
Location: Inria Sophia-Antipolis
Please find here the slides of all presentations.

Attendees

- Behnam Binesh (remote), SiMedix, Iran
- Erik Pernod, InfinyTech3D
- Federico Spadoni, InfinyTech3D
- Gaetan Desrues, Inria Sophia-Antipolis
- Jaume Banus, Inria Sophia-Antipolis
- Hervé Delingette, Inria Sophia-Antipolis
- Ryadh Haferssas, Inria Strasbourg
- Frédéric Roy, Inria Strasbourg
- Omar Boukhris, Inria Strasbourg
- Jean-Nicolas Brunet (remote), Inria Strasbourg
- Hadrien Courtecuisse (remote), Inria Strasbourg
- Stéphane Cotin (remote), Inria Strasbourg
- Thierry Gaugry, Inria Rennes
- Damien Marchal, Inria Lille
- Bruno Marques, Inria Lille
- Yinoussa Adagolodjo, Inria Lille
- Hugo Talbot, SOFA Consortium
- Guillaume Paran, SOFA Consortium
Synthetic agenda of STC#7

Day 1 - Monday 20th May (pm)
14:00 - Opening STC#7
14:10 - Consortium activity
14:30 - SOFA activity (part 1)
  Roadmap tasks
16:00 - Coffee break
16:30 - SOFA activity (part 2)
  Out-of-roadmap tasks
  Roundtable
18:00 - End of Day 1

Day 2 - Tuesday 21st May
09:00 - Defining v19.12 roadmap (part 1)
  Expected technical evolutions, among the possible topics
  Objective: determine what can be accomplished for v19.12
10:00 - Coffee break
10:30 - Defining v19.12 roadmap (part 2)
12:30 - Lunch
14:00 - Validating v19.12 roadmap
14:15 - Coding sprint
18:00 - End of Day 2

Day 3 - Wednesday 22nd May
09:00 - Coding sprint
15:30 - Closing STC#7
Reports and updates

SOFA report
You will find all information regarding the report on SOFA, its activity and the consortium activity within the STC#7 slides.

Roundtable
Here is a quick overview of each participant current work with SOFA.

Jaume: Using the SofaElectophysiology plugin of the Epione team (Inria Sophia-Antipolis), electro-mechanical cardiac simulations, VTKLoader work, in other languages (C).

Gaetan: Flexible plugin for mechanical heart simulation and work on reduced number of DOFs. A collaboration with UCSD (mjbarrow) could be of interest.

Hervé: HighOrderMeshing/FEM plugin (quadratic or more) in collaboration with Titane team (Inria Sophia-Antipolis) (https://www.inria.fr/equipes/titane). Currently trying to update to latest SOFA. Future work: adaptive order of the mesh (with a dedicated format supporting high orders) + 1D-2D BSplines.

Ryadh: Methods for linear solvers relying on the hpddm library (mp-intefaced)
Next step: link this library to SOFA as a plugin (domain decomposition methods, multigrid methods)
Parallelization of the decomposed resolution: construction of a preconditionner (1CPU), inversion of the local system matrix could be done on GPU

Omar: Clear coupling with the openCV lib and end up with a unique version of this work.
Development of an interpreter to ease the writing of new C++ classes from a simple grammar
Also linked to the work of Flexible like FEM project from JNB

Thierry: Working as the SOFA engineer in the Hybrid team (Inria Rennes) working on specific projects like HeadlessRecorder, Python.

 Damien: Research engineer in Defrost team (Inria Lille) supervising work on SofaQtQuick, SofaPython and SoftRobot.

Bruno: Now in Defrost team (Inria Lille). Working on Data Updates, SofaQtQuick and Python.

Yinoussa: Working on SOFA Launcher Cluster simulations (see out-of-roadmap presentation)

Erik: Indiedev intensively working on topology, topological changes, Unity3D, UnrealEngine.

Federico: Recently working as indiedev with a focus on multithreading and collision.
Roadmap task progress

All presentations and slides are publicly available:
https://drive.google.com/open?id=1SHoD1qCv5oG1UEjb2JTA5g4uMHHe--128

SofaPython - Damien Marchal

Not much work since last STC: decision was made to use Python PyBind11
Many advantages : SOFA as a library, properly share counter, use usual python writing, implement new models and algorithms in Python etc. A Trello board has been created, do not hesitate to ask for access.

→ See the dedicated presentation for details.

Data updates - Bruno Marques

The problems related to data update were analyzed and listed at last STC#6. Next steps mainly consist in:
- Update of data, now proposals are open
- Component State: ongoing work and visualization of it would help
These two tasks should be addressed in the 6 coming months.

→ See the dedicated presentation for details.

Multithreading - Federico Spadoni

The work on multithreading in SOFA progressed. Multithreading can be used not only at the component level but also at the simulation level. One interesting application is the computation of collision detection.
Now, this work even allows for a mixed approach CPU-GPU allowing a fully asynchronous execution. Acceleration already measured with multi-CPU.
Future steps to come:
- Interesting to couple with LinearSolver applications (Mimesis - Ryadh)
- Deformable object on the GPU
- Make it compatible with SofaCUDA plugin (refactoring required)

→ See the dedicated presentation for details.
Out-of-roadmap important contributions

Erik: Topologies
A lot of work done in understanding and cleaning the existing API. Visitors were almost all removed and the process relies on the Data updates. Todo: finish the TopologicalData pipeline, check physics and tests.

→ See the dedicated presentation for details.

Guillaume: Packaging
To facilitate binary generation and distribution, important changes have been made to SOFA CMake API, adding new features like the possibility to obtain a clean plugin installation even when building it through SOFA.

→ See the dedicated presentation for details.

Damien: runSofa2 / SofaQtQuick
Ongoing project designing a new GUI from the QtQuick project of Anatoscope. Now cleaned and closer from Blender & Unity3d. Still in stabilization phase.
It already proposes a start of a new Modeler, using Python with prefab. A live demonstration was made based on the SofaQtQuick open-source project with these prefabs.

→ See the dedicated presentation for details.

Omar: OpenCV
The objective of this work is to obtain a clean coupling with the openCV lib and end up with a unique version of this plugin (two plugins were coexisting).
On his spare time, Omar is also looking at developing an interpreter to ease the writing of new C++ classes from a simple grammar (linked to the modular-FEM project in the Mimesis team with Jean-Nicolas Brunet)

Ryadh: FreeFEM interpreter comparable to FEnics.
Methods for linear solvers relying on the hpddm library (mp-intefaced)
Next steps: link this library to SOFA as a plugin (domain decomposition methods, multigrid methods)
Parallelization of the decomposed resolution: construction of a preconditionner (1CPU), inversion of the local system matrix could be done on GPU

Younes: SOFA Launcher Cluster simulations
Large simulations needed at Defrost, done on clusters using SOFA Launcher. Objective : a lot of simulations needed for shape optimizations (genetic algo).
Binary for non-SOFA-experts to use SOFA online: using the Docker on Grid5000 people can configure their SOFA (using SOFA Package Manager SPM)
SOFA v19.12 roadmap

Here is the roadmap for the next 6 months that has been discussed and approved by the SOFA Consortium members.

Multithreading

Description
The task on Multithreading restarted a year ago and is a wide challenge. The idea is to propose multi-CPU and GPU optimizations of SOFA. It requires to focus on thread safety in the code and to build new tools and algorithms.

To exploit the CPU parallelism, task and scheduler design is used. That is an efficient way to scale the computation to all the CPU cores available on a machine without directly manipulating threads.

The Multithreading plugin provides a task scheduler implementation and a few SOFA component design to create tasks that can be executed concurrently.

The parallelization can be performed at component level when two or more independent components can be executed in parallel using a specific multithreaded AnimationLoop. The next step would be to allow for constraint solving in parallel. A parallel version of the ConstraintSolver is therefore the first objective.

“Multithreading” v19.12 roadmap
1. Parallelize deformable object solver algorithms
2. Convert SofaCuda plugin components to Cuda task async system

More information
Main contact: Federico Spadoni

Topologies

Description
Work on Topologies is mainly done by one of our independent devs Erik Pernod. Being very open to suggestions and contributions, it was added on v19.12 roadmap.

“Topologies” v19.12 roadmap
1. Remove the old pipeline: topology events visitor / handleTopologyChange methods
2. Transform TopologicalMapping into TopologicalEngines
3. Complete list of component that handle topology change and test them: #810
4. Add doc on topology change
5. Add doc on how my component can handle topology change

More information
Main contact: Erik Pernod
SofaPython3

Description
Improving SofaPython has been in SOFA devs objectives for a long time. Multiple ways have been explored around Python3 upgrade (see the dedicated branch) and bindings improvement. The ending of Python2 support being very close (2020), we have to move forward on this project.

From Damien’s works and presentation, it seems obvious that we have to work on a Python3 implementation of SOFA bindings. The idea is to create an independant SofaPython3 plugin giving us complete freedom on tools and architecture. PyBind11 had been collectively chosen for bindings implementation. The objective for v19.06 would be to propose a transition state by permitting to switch between Python2 and Python3. Both version being independant, the bindings will differ.

“SofaPython3” v19.12 roadmap
→ See the dedicated Trello board

More information
Main contact: Damien Marchal
Gitter chat room: https://gitter.im/sofa-framework/SofaPython3

SofaQtQuick

Description
SofaQtQuick is the project of a new GUI for running simulations. Replacing runSofa by something more flexible and user friendly has been discussed for a long time. The project being more and more used and developed by Inria Lille engineers, we shall now propose concrete objectives for v19.12.

“SofaQtQuick” v19.12 roadmap
1. Modeling features (GL)
2. Bugfixes, refactoring, perfs & tests
3. Component states, DDG graph, etc.. (Data Update)
4. Asset store, asset previews, UX aspects
5. Merge SofaDefrost/SofaQtQuick changes in sofa-framework/SofaQtQuick

More information
Main contact: Damien Marchal
Gitter chat room: https://gitter.im/sofa-framework/SofaQtQuick
More projects

Besides the main roadmap tasks, a lot of projects are going to evolve in the next 6 months.

User Experience

The whole community is working on making SOFA user experience better and better. Here are some objectives for v19.12:

- Improve documentation
- Create video tutorials
- Launch SOFA Continuous Delivery and link SOFA Package Manager to its artifacts

Sofa Launcher

This project is held by Yinoussa Adagolodjo from Inria Lille. → See the dedicated presentation for details.
Its objectives for v19.12 are:

- run in Docker
- Sofa launcher on the Grid5000
- Frontend for Sofa plugin test

SparseMatrices & Solvers

Updating the way matrices are stored and handled in SOFA was already discussed at the previous STC. At this STC#7, Ryadh (post-doc at Mimesis, Inria Strasbourg) and Federico Spadoni (freelance SOFA) discussed how solvers could be accelerated using model decomposition coupled with multithreading. On this project, the matrix format could also be revisited.

Simplified collision-constraint pipeline

For several months, Hadrien and Omar (Mimesis, Inria Strasbourg) are working on a simplified pipeline to compute collision detection and response. This work is done for now in a plugin and could be publicly proposed.

High Order Topologies

Within the Epione team (Inria Sophia-Antipolis), Herve Delingette and his team are working on model the cardiac electrophysiology. To do so, they are also focusing on high-order topologies as support of interpolation of physical models.
In this process, two main questions are now arising:

- Loading high-order meshes
- Create standard format for high-order meshes, this would be a unique initiative!

Flexible

Several developers within the community (MJ Barrow or Gaetan Desrues) are interested in working again on the Flexible project. Flexible principle is to distinguish the physical model and the space integration. Several ideas came up:

- Create a simplified (template-less) approach similar to Flexible (JN Brunet)
- GPU version of Flexible (MJ Barrow)
- using Flexible for model order reduction (Gaetan Desrues)
DSL approach

Work on online/runtime generation of SOFA multiphysics components (as in FreeFEM/Fenics):

- Use-case: hyperelastic material on finite elements and meshless approaches where the elastic energy is defined in a domain specific language. We expect that it creates a force field with addforce, addDforce, addMBKToMatrix. Needs to define a material through an array of values.

- Require symbolic differentiation (e.g. sympy), code generation (C++, Theano/Pytorch/Tensorflow, python, LLVM, OpenCL)

- Require abstract classes for numerical integration, shape function definition, of elastic materials.

- Potentially involved persons: Damien, Hervé, Christian, Jean-Nicolas, Stéphane, MJ Barrow.
As usual, a coding sprint was organised to finalize some pending tasks. The tasks were listed as GitHub issues and can still be accessed.

- Issue #1051 Update regression test to compare only last iteration position
  PR #1061 Add option in regression-test to check first and last iteration.
  Status: open
- Issue #994 investigate wrong behavior in CollisionGroup
  PR #1060 Fix wrong search of deformable object node
  Status: open
- PR #1059 Fix relocatable plugins
  Status: merged
- Issue Fix crash on CI with scene HexahedronForceFieldTopologyChangeHandling.scn
  PR #1056 Clean output data when doUpdate in BoxROI
  Status: merged
- Issue #957 ExtVec3Type could be removed
  PR #1055 Remove ExtVecType
  Status: open
- Issue #1043 Some classes have duplicate constructors
  PR #1054 Remove duplicate ctor + prettify some code
  Status: merged
- PR #1053 Update example + add comments
  Status: merged
- PR #1052 ADD Regression as external project
  Status: merged
- PR #1047 remove remaining SOFA_WITH_FLOAT
  Status: merged (#1048)
- PR #1046 Remove DETECTIONOUTPUT_BARYCENTRICINFO
  Status: merged (#1048)
- Issue #799 Uniform all threshold, epsilon or PI usage
  PR #1045 fix PI issues
  Status: merged (#1048)
- Issue #799 Uniform all threshold, epsilon or PI usage
  PR #1049 Standardize epsilons in SOFA
  Status: merged
- Issue #989 Lonely #endif without its #ifdef in SimpleGUI.cpp
  PR #1044 Fix compilation SofaGUIGlut
  Status: merged
- PR #1042 FIX WinDepPack INSTALL_INTERFACE
  Status: merged
- Issue #652 : supporting new VTK format
  PR #1037 Change error into warning in MeshVTKLoader
  Status: merged