

Open and Reproducible Musculoskeletal Research

Biomechanics

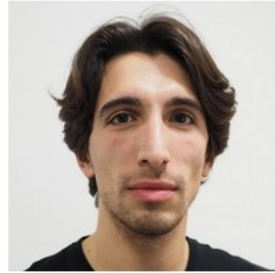
Who we are



Gianluigi Crimi
Rizzoli Orthopaedic
Institute, Bologna
Italy



Lorenzo Grassi
Lund University
Sweden



Gianluca Iori
SESAMI
Jordan



Martino Pani
University of
Portsmouth, UK



Enrico Schileo
Rizzoli Orthopaedic
Institute, Bologna
Italy



Fulvia Taddei
Rizzoli Orthopaedic
Institute, Bologna
Italy

- who has already joined
 - Giulia Fraterrigo (Rizzoli, Bologna), past few months
 - Mariska Wesseling (KU Leuven), at Maastricht workshop
- who is going to join?



Our Background

- Verification&Validation
- Open source software framework
 - ALBA (Agile Library for Biomedical Applications <https://github.com/IOR-BIC/ALBA>)

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Nik81	Updated albaPipeGenericPolydata and albaPipeWithScalar	9fa0366 6 days ago	10,174 commits
Base	Added Prostheses Management	3 months ago	
Common	Updated GetLineLineIntersection in albaGeometryUtils	last month	
Core	Added EnableViewSettings method	last month	
Docs	Renamed all maf files into Alba	3 years ago	
Examples	Fixed compilation, updated code to alba, use progressBarhelper	3 months ago	
GPUAPI	Multiple volume GPU slicing fix + GPUProvider is now a Singleton	7 months ago	
Gui	Added Enum	last month	
IO	Makefile updated for albaDLL build	2 years ago	
Installer	Update InstallerCommon check if extra process isRunning	26 days ago	
Interaction	Updated albaInteractor2DMeasure skip if pickedVME is gizmo	26 days ago	
JenkinsScripts	Renamed all maf files into Alba	3 years ago	
Libraries	Fixed Base Tests linking on DLL version	2 years ago	
Operations	Read in UpperCase mode	13 days ago	

About
Agile Library for Biomedical Applications
Readme
9 stars
6 watching
4 forks

Releases
No releases published

Packages
No packages published

Contributors 10

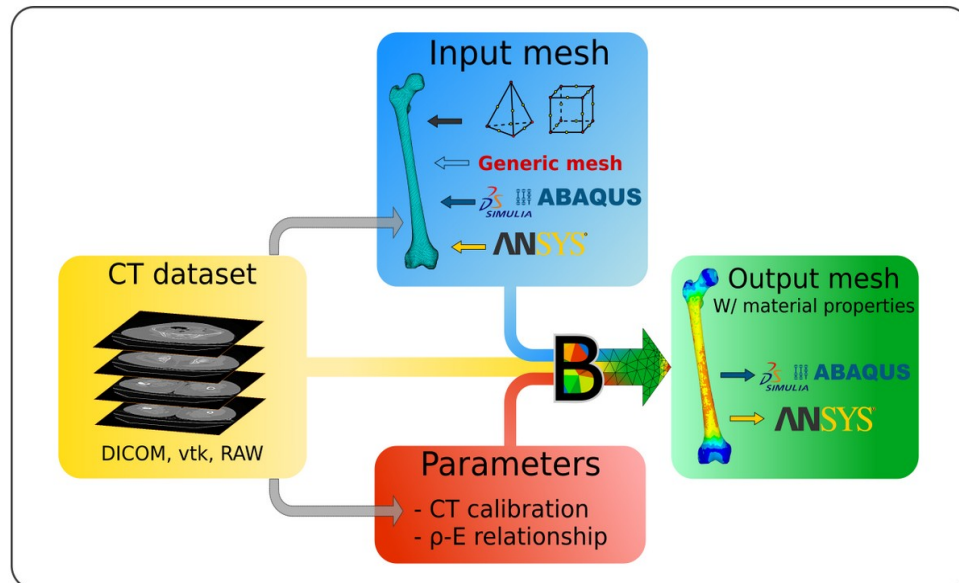
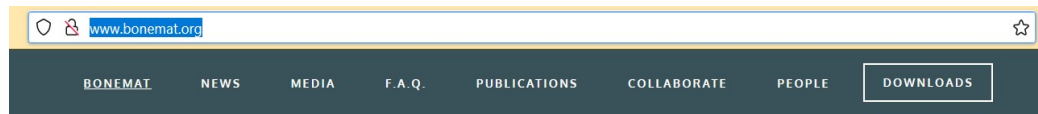


Our Background

- Freeware for image2model workflows

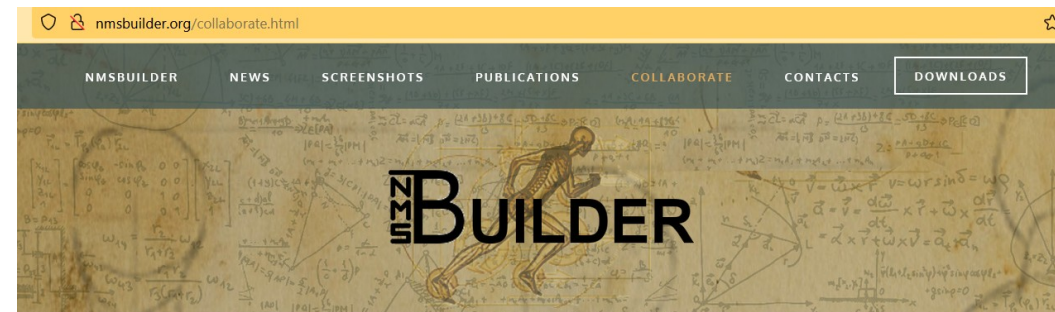
Bone FE models

Bonemat (www.bonemat.org)



Musculoskeletal Models

NMSBuilder (www.nmsbuilder.org)



HOW TO COLLABORATE

We believe that NMSBUILDER has a great potential to promote personalized applications of musculoskeletal modeling and simulations of movement.

This software application can be considered as a work-in-progress tool.

You may be interested in the project through

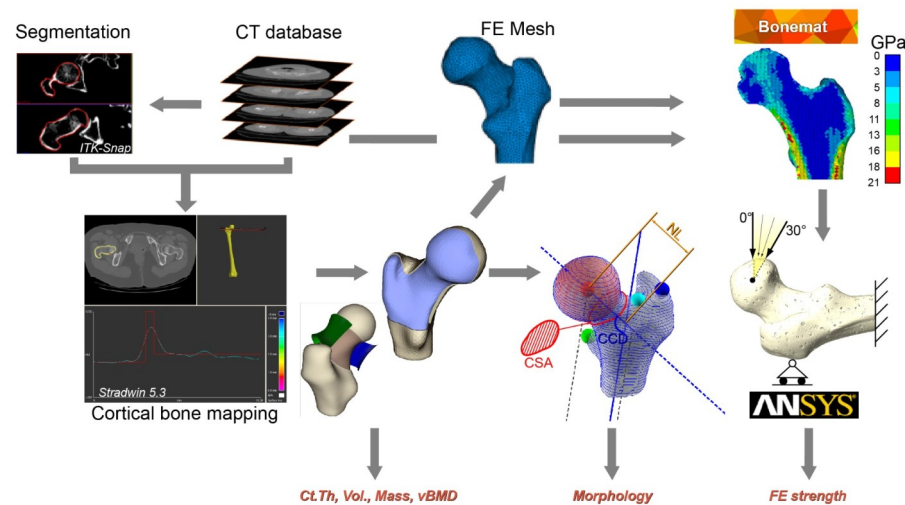
- Bug reports and suggestions of software enhancement (experts@nmsbuilder.org)
- Software development with us (info@nmsbuilder.org)
- Requests for specific tools or software versions personalized for your applications (info@nmsbuilder.org)

Motivation

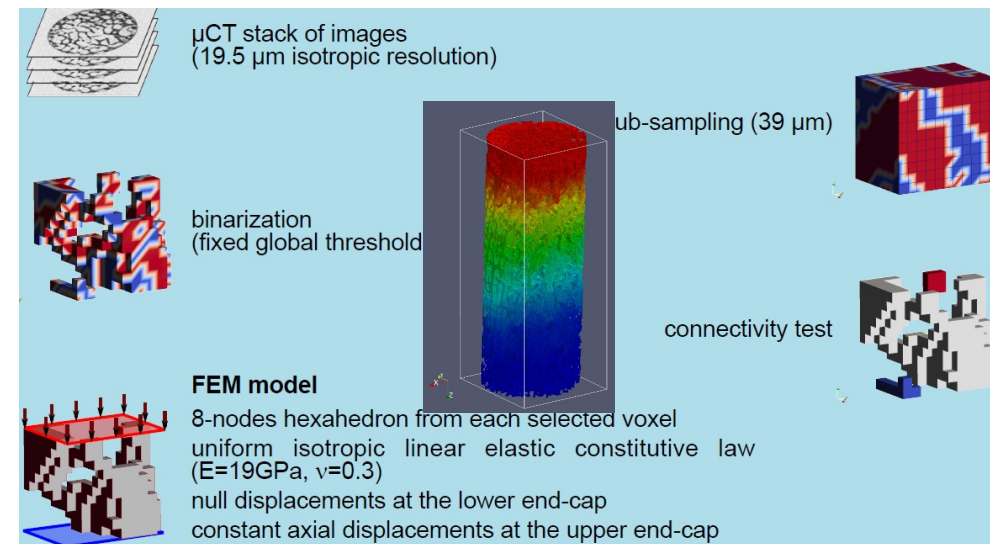
- CT2FE/image2model: recent literature reviews
 - “studies need to start converging... to make FE applicable to clinical settings.” (Lee et al., JMBBM 2019)
 - “Results...motivate the adoption of a standardized approach/workflow for image-based FE modeling of the femur.” (Falcinelli and Whyne, CMBBE 2020)
 - “Short term keys to improve image-to-FE in osteoporosis: ..., ..., increase reproducibility and cross-validation of models” (Schileo and Taddei, Curr Osteoporos Rep 2021)
 - “...even commendable efforts to compare the performance of different modelling strategies on the same data contain clearly inappropriate workflows (Kluess et al., 2019), thus denoting the absence of standardization of basic methodologies.” (ORMR Manifesto, <https://jcmsk.github.io/manifesto.html>)
- CT2FE: experience (Have you ever tried to replicate...?)

Short term aims

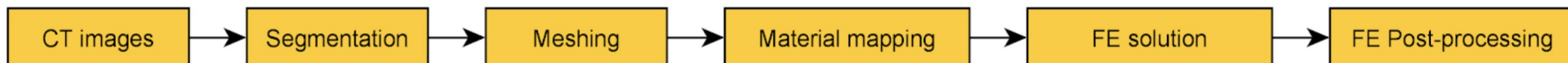
- CT2FE workflow (macro level)



- MicroCT2FE workflow (micro level)



(at least partly) Shared pipelines



Remote work (2021- first half 2022)

- MicroCT2FE workflow

- Agreed on a pipeline
- Existing code translated
- New code written
- Platforms/tools harmonised



Gianluca Iori



Martino Pani

- CT2FE workflow

- Agreed on a pipeline
- Work on ALBA framework so that operations on data (e.g. Bonemat) can be exposed in Notebooks
- Holding on for a few months now (human resources...)

JC|MSK Workshop (last week in Maastricht!)

Jupyter JCW_voxelFE_CalculiX Last Checkpoint: ieri alle 13:19 (unsaved changes)

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Run

Ciclope voxel uFE pipeline @ JCW_2022

From a CT image of trabecular bone to voxel-uFE model solution in Calculix

Created on: 23.05.2021
Last update: 10.06.2022

- Data source: LHDH project (IOR Bologna, Italy)
- More info on the dataset source [here](#)
- For info on the solver visit the [Calculix homepage](#)

The pipeline can be executed from the command line using the **ciclope** command:

```
python ciclope.py test_data/LHDH/3155_D_4_bc/cropped/3155_D_4_bc_0000.tif test_data/0.0195 0.0195 0.0195 -r 2 -t 63 --voxelfe --template input_templates/tmp_example01_0
```

Type `python ciclope.py -h` to display the ciclope help with detailed information on command line arguments

Configuration

```
In [1]: import sys
        sys.path.append('./../..')

In [2]: import numpy as np
        import dxchange
        import matplotlib
```

Jupyter JCW_tetraFE_CalculiX Last Checkpoint: ieri alle 15:01 (unsaved changes)

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Not Trusted conda (ciclope)

Ciclope tetra uFE pipeline @ JCW_2022

From micro-CT image to tetrahedra-FE model solution in Calculix

Created on: 23.05.2021
Last update: 11.06.2022

- Data source: LHDH project (IOR Bologna, Italy. For info on the dataset see [here](#))



```
graph LR; A[CT images] --> B[Segmentation]; B --> C[Meshing]; C --> D[Material mapping]; D --> E[FE solution]; E --> F[FE Post-processing]
```

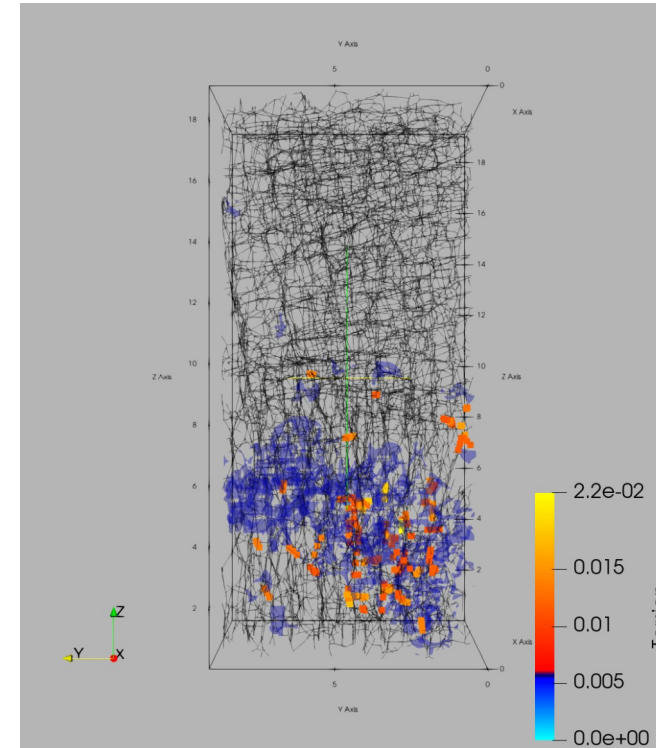
The example implements the following ciclope pipeline:

- ☒ Load and inspect microCT volume data
- ☒ Image preprocessing
 - ☒ Apply Gaussian smooth (optional)
 - ☒ Resample the dataset (optional)
 - ☒ Segment bone tissue
 - ☒ Remove unconnected clusters of voxels
- ☒ Generate 3D Unstructured Grid mesh of tetrahedra
 - ☒ Generate high-resolution mesh of triangles of the model outer shell (optional for visualization)
- ☒ Generate tetrahedra-FE model for simulation in CalculX or Abaqus from 3D Unstructured Grid mesh
 - ☒ Linear, static analysis definition: uniaxial compression test
- ☒ Launch simulation in Calculix. For info on the solver visit the [Calculix homepage](#)
- ☒ Convert Calculix output to .VTK for visualization in Paraview
- ☒ Calculate apparent elastic modulus from reaction forces

...and now attempting a live demo...

Outlook

- Short term
 - Micro Workflow
 - Heterogenous material mapping
 - Truss-based FE model
 - Use combined with experimental data
- Medium Term (1-2 y)
 - Complete Macro Workflow(s)
 - Micro Workflow: application to large datasets
- Long term
 - Cross validation/application of macro workflow
 - Other aims to be steered by the community



Thank you!



...willing to join ORMR?