Leveraging Open Source for Geographically Dispersed Workflows

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The VPH Approach

- Estimate future outcomes by simulating personalized physiological models
- Personalization mostly comes from imaging, but demographics and lifestyle are considered, too

- Typically, in a study:
  - the same *procedural* workflow needs to be repeated for all the subjects
  - the workflow is carried out by researcher that are either more technically minded or with a more marked clinical-background
  - specialized clinicians oversee the final quality of the results
A Common Denominator

- A common characteristic of the projects to be presented is that each of them assembles open-source or open-source-derived components to deliver innovative services.
The sum is bigger than its components

the orchestration of the three projects exemplifies a template of a new way to provide access to advanced solutions

MySpine

GIMIAS

VPH-Share
*** Route Information ***

MySpine → VPH-Share → MySpine @ VPH-Share

GIMIAS
MySpine Motivation

- Low back pain is a well-known and widely spread illness.
- Prevalence estimates for chronic low back pain between 6 and 11% (and annual direct cost of low back pain of 7,000 € per person)
- Billions of Euro are spent each year in Europe on treating this disorder.

(Juniper et al. 2009)
MySpine Goals

- Aims to create a clinical predictive tool to provide clinicians with patient-specific biomechanical and mechanobiological analysis.
- This tool will help to determine the best patient specific treatment for low back pain.
- The project will focus on disc degeneration pathology although the developed prototype system may be able to analyze other spinal pathologies as well.
MySpine Data Flow

- CT and MRI data (DICOM)
- Hounsfield and MRI intensity
- Degenerated disc
- Pfirrmann grade on all discs
- Height & weight
- Age

Patient-specific model:
- Patient-specific geometry
- Patient-specific mesh
- Patient-specific tissue definition

Patient-specific FEA:
- Patient-specific 3D L1-S1 lumbar spine
- Adjacent mono-segment
- Vertebra remodelling
- IVD changes
- Virtual clinical images
- Risk of degeneration and recommendation
***Route Information***

MySpine -> VPH-Share

VPH-Share -> MySpine @ VPH-Share

MySpine -> GIMIAS
GIMIAS is an open-source software platform for medical image analysis and physiological modelling, and for the prototyping of end-user applications.
GIMIAS – Imaging

**Visualization**
- Multimodality (CT, MRI, US, PET, ...)
- Multidomain (cardiology, oncology, vascular, neurology, ...)
- NPR and slice navigation
- Transfer function
- Lighting / shading
- Clipping
- Material properties
- 2D/3D Texturing
- GPU / CPU
- Ray Casting
- Intensity filtering (smoothing, enhancement, cropping, ...)
- Registration (rigid, affine, biplane, ...)
- Manual
- Segmentation
- Semi-automatic (Region Growing, Otsu, Threshold, ...)

**Processing**
- Signals
- Data Retrieval
- Physiological Modelling
- Applications

VTK, ITK, MITK, CTK-CLI, ...
GIMIAS – Physiological Modelling

Mesh Manipulation

- Global Filtering
- Local Surface Editing
- Cutting / Hole Filling
- Volumetric Mesh Generation

Boundary Conditions

Material Properties / Cells Annotation

Model Representation Languages (CellML / FieldML)

Post-processing / Multi-render libraries

- NITK - UTK / OpenGL
- cmGUI
- ...

NETGEN, TETGEN, ...

Post-processing
Multi-render libraries
GIMIAS 4 MySpine

- Proper handling of unstructured grids
- Enhanced **XNAT** connectivity
MySpine goals & needs

- Run 250 lumbar spine reconstructions in 3 weeks involving 6 Partners, 4 HPC facilities and 2 Medical centres.
- Provide a clinical prototype for validation by the medical centres and the project advisory board.
- Facilitate continuous deployment of upgrades and fixes to the users.
***Route Information***

- MySpine
  - GIMIAS
    - VPH-Share
      - MySpine @ VPH-Share
VPH-Share Overview

Patient Centred Computational Workflows

- Knowledge Management
- Knowledge Discovery Data Inference
- Semantic Services

Data Services: Patient/Population

Compute Services

Storage Services

HPC Infrastructure

Cloud Platform
VPH-Share Infostructure

- VPH-Share flexibility comes from a rich support layer (the infostructure) where services are made accessible to user through the web-based Master Interface.
VTK File Preview in LOBCDER

ParaView Web
VPH-Share Cloud Services

RESTful API for streamlined cloud management:
• on-demand spawning of VMs
• on-demand removal of VMs
• endpoint configuration (ports and URLs)
• VM configuration and
• start-up info injection
***Route Information***

MySpine → VPH-Share

GIMIAS

MySpine @ VPH-Share
Expected Outcomes of MySpine in VPH-Share

- MySpine workflow made available at anytime, in anyplace to all partners
- Deployment of software upgrades automatically accessible to all partners
- Facilitate connectivity between MySpine software platform and HPC facilities
MySpine@VPH-Share Main Components

- **VPH-Share**
  - MySpine (GIMIAS)
    - Image-based spine reconstruction

- **XNAT Database** (Clinical data & Images)

- **ICEBERG HPC Server**
  - N8 HPC Server
    - Python Script
      - Abaqus simulation: Short terms effects (+Matlab, Python)
      - Abaqus simulation: Ageing effect (+Matlab, Python)

- **AHE**

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**Center for Computational Imaging & Simulation Technologies in Biomedicine**

**The University of Sheffield**
Starting MySpine@VPH-Share: application selection (1/3)

VPH-Share is an online environment for the development, construction and storage of biomedical workflows. It is designed to help researchers, clinicians and software developers share resources - data and tools - to build workflows quickly and easily.
Starting MySpine@VPH-Share: application selection (2/3)
Starting MySpine@VPH-Share: application selection (3/3)
Starting MySpine@VPH-Share: cloud instantiation (1/2)
Starting MySpine@VPH-Share: cloud instantiation (1/2)

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1. Download of CT/mri of same session together in one click on Download button. 2. Upload of Segmentation and Alignment meshes (5 files) along with the Flamingo files upload. 3. Run simulation modified - included the session number of MR/CT scans as one of the arguments passed to run the simulation script. 4. HePlugin - Run Simulation using Application Hosting Environment (AHE). 5. The "Tools/Segmentation/Manual Correction of Meshes" is available in the workflow mode. Respective MySpine.xml workflow file should be added at `C\ Users\ (Username)\ AppData\ Roaming\ gimas\ v1.5\ MySpine\ Workflows`.

Web Applications: No web applications

WS/REST Services: No services

Other services: RDesktop

RDP is enabled

Application Upgrades

Already started

Cloud costs shown, are indicative only. In the context of the VPH-Share project, all cloud costs will be met by the project.
Connecting to MySpine@VPH-Share

GIMIAS 4 MySpine

Amazon Cloud Instance

Help, Support and Feedback
MySpine VM: Vertebra Segmentation
MySpine VM: MR/CT Alignment

Alignment of Disc and Vertebrae In MR
MySpine VM: FEM Generation

Patient Specific Finite Element Model
MySpine Workflow: Simulation on HPC

• Application Hosting Environment (AHE)
MySpine VM: Visual Assessment of Simulation Outcomes

Loading simulation: Bending and Weighting
*** Route Information ***

MySpine -> VPH-Share

VPH-Share

MySpine @ VPH-Share

GIMIAS

Thank You!

MySpine