

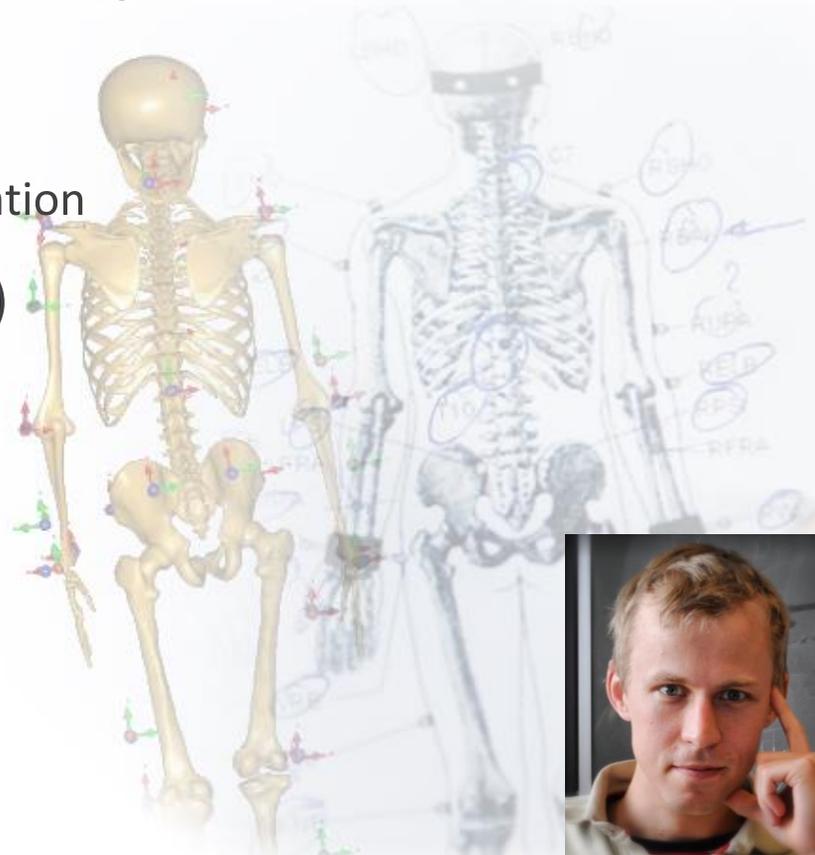


The new AnyBody Modeling System & Musculoskeletal Model Repository

TOUR AND OVERVIEW OF THE NEW 7.3 VERSION

Outline

- New features in the Modeling System 7.3
 - Core features
 - User interface features
 - New Reference manual and documentation
- New Model Repository (AMMR 2.3)
- Questions and answers



Morten Enemark Lund
Sr. Consultant
R&D Engineer
AnyBody Technology

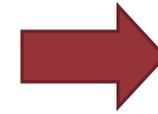
Musculoskeletal Simulation

Motion Data

Kinematics and Forces

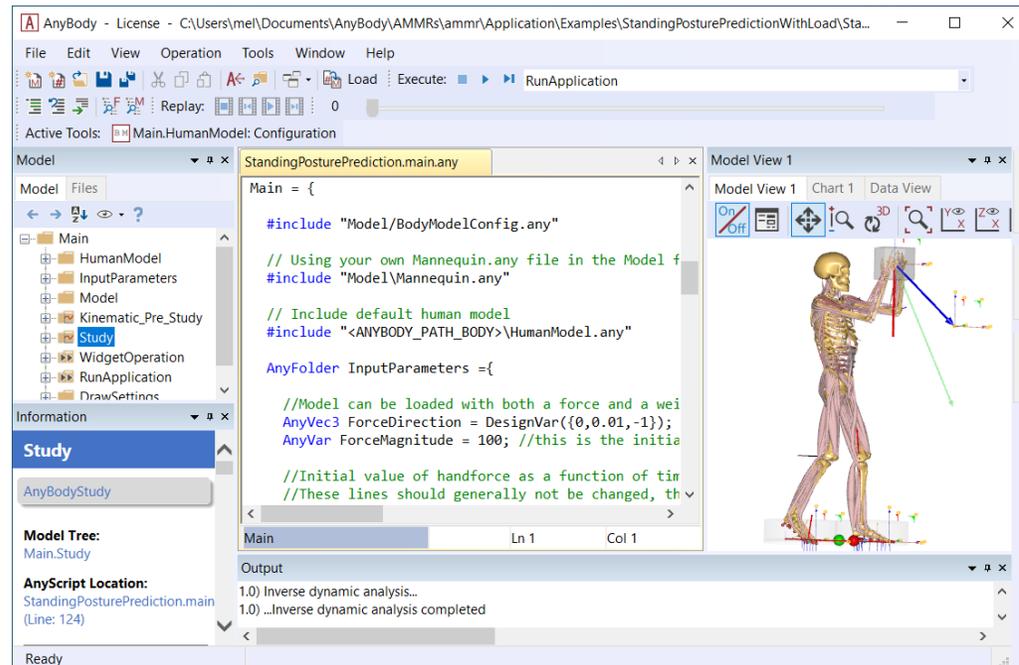


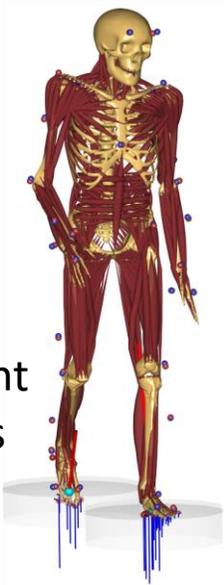
ANYBODY
Modeling System



Body Loads

- Joint moments
- Muscle forces
- Joint reaction forces

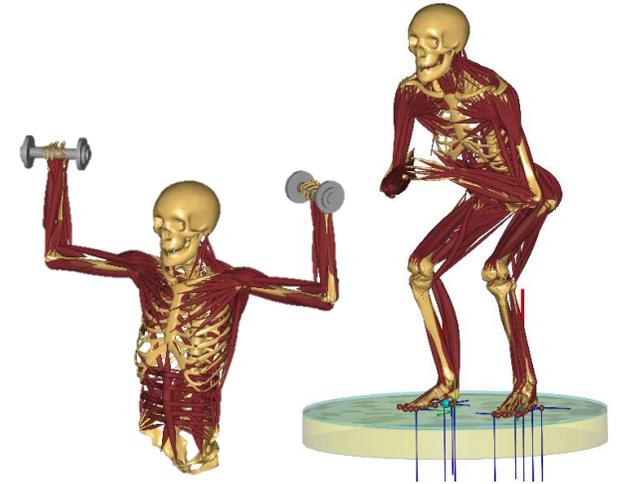




Movement
Analysis



Product optimization design

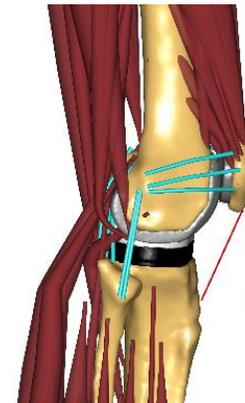
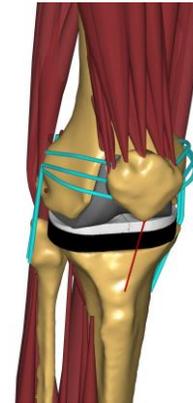
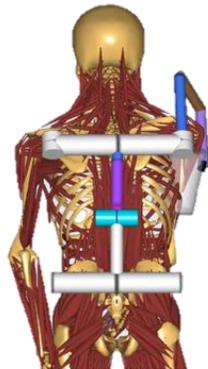


Sports

ANYBODY
Modeling System



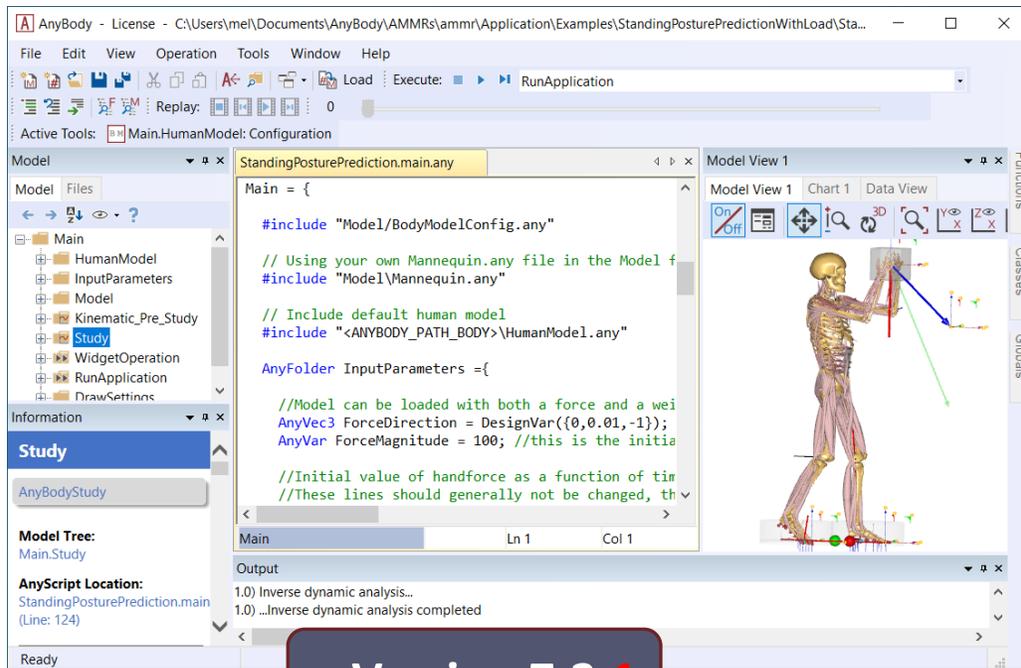
Assistive
Devices



Orthopedics
and rehab

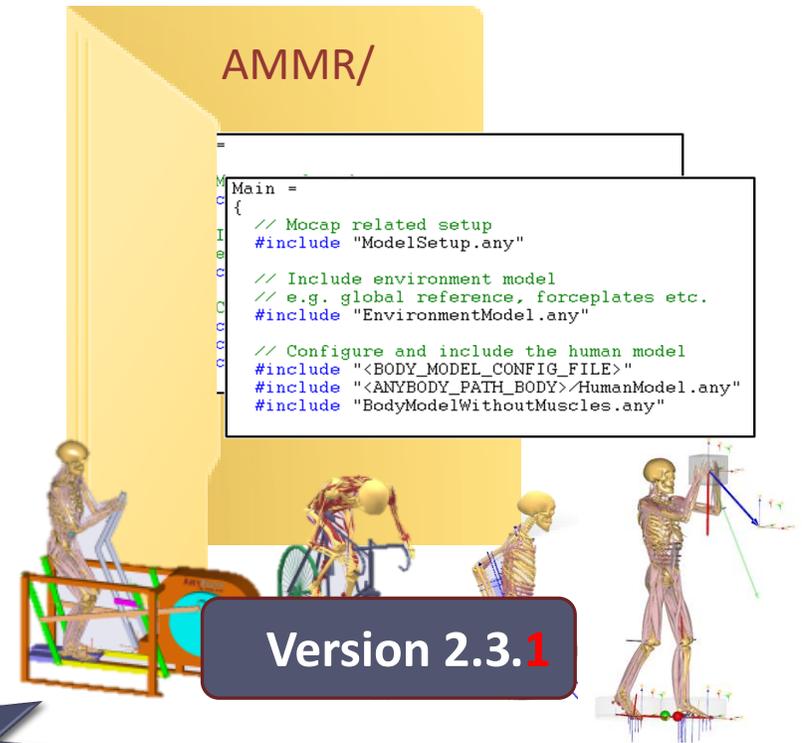
New AnyBody release

ANYBODY Modeling System



Version 7.3.1

Model Repository



Version 2.3.1

Just released!

How to get the new version?

anybodytech.com: Custo x

Sikker | https://www.anybodytech.com/downloads/customer-downloads/?no_cache=1

ANYBODY TECHNOLOGY INDUSTRIES SOFTWARE SERVICES EVENTS DOWNLOADS CONTACT

Edit profile Sign-out

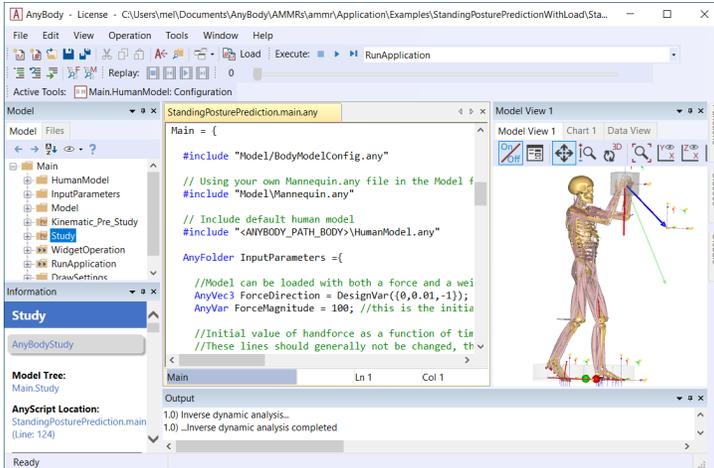
Search

AnyBody Modeling System

Download installers for the AnyBody Modeling System here.

AnyBody Modeling System (64-bit version)	v. 7.3.1.8217	2020.10.05	939M	Download Install Guide
Note: Organizations with floating licenses must run V12 or higher of the RLM license server (available below).				
AnyBody Modeling System (64-bit version)	v. 7.3.0.8065	2020.07.09	915M	Download Install Guide
Note: Organizations with floating licenses must run V12 or higher of the RLM license server (available below).				
AnyBody Modeling System (64-bit version)	v. 7.2.3.7075	2019.11.14	808M	Download Install Guide

https://www.anybodytech.com/download.html?did=anybody.alternate_download



New features

IN THE ANYBODY MODELING SYSTEM 7.3

Core system improvements



25 % Faster load times



Faster simulation times



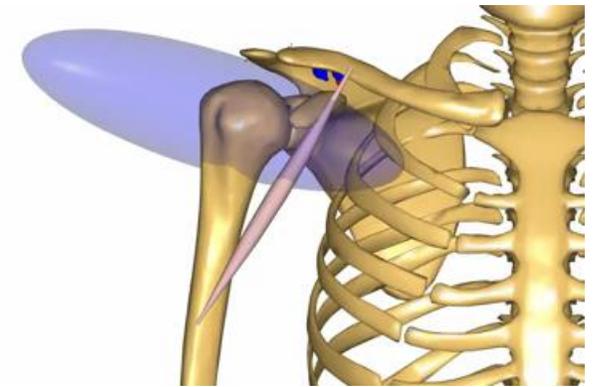
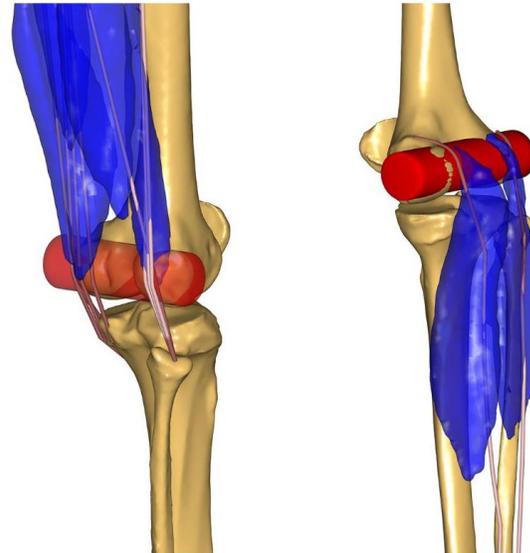
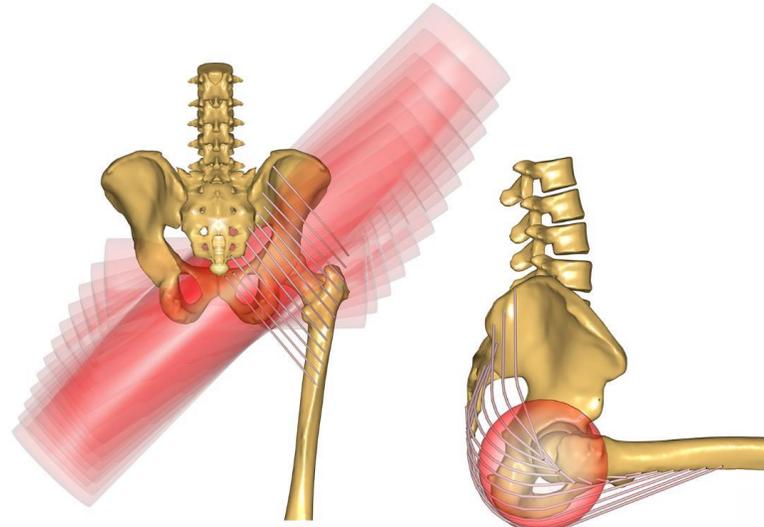
New wrapping algorithm



More robust muscle wrapping

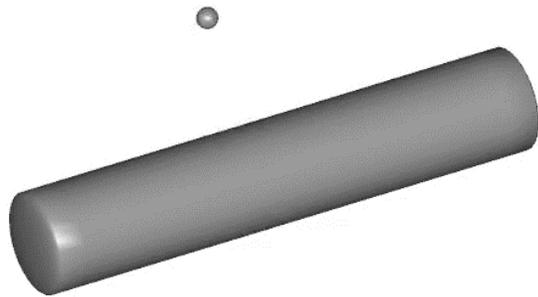
What is muscle wrapping

Idealized objects guides the muscle paths.



New wrapping algorithm

Old

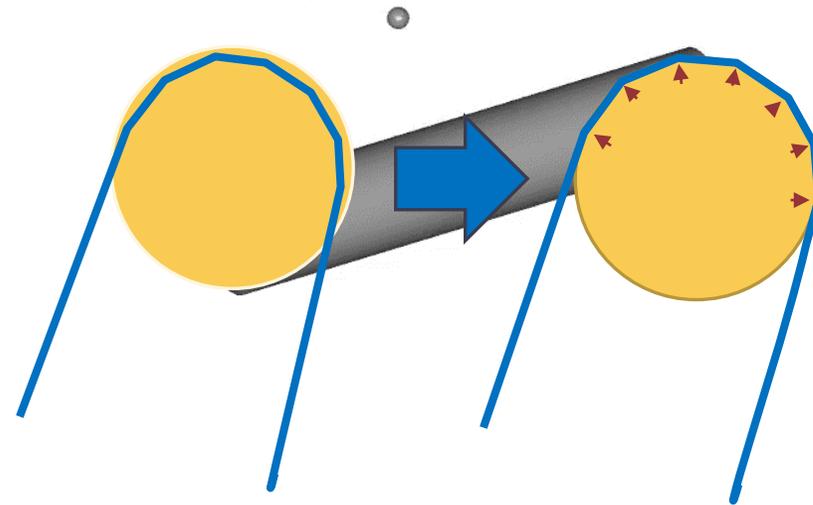


Default algorithm in 7.2

New

30x faster

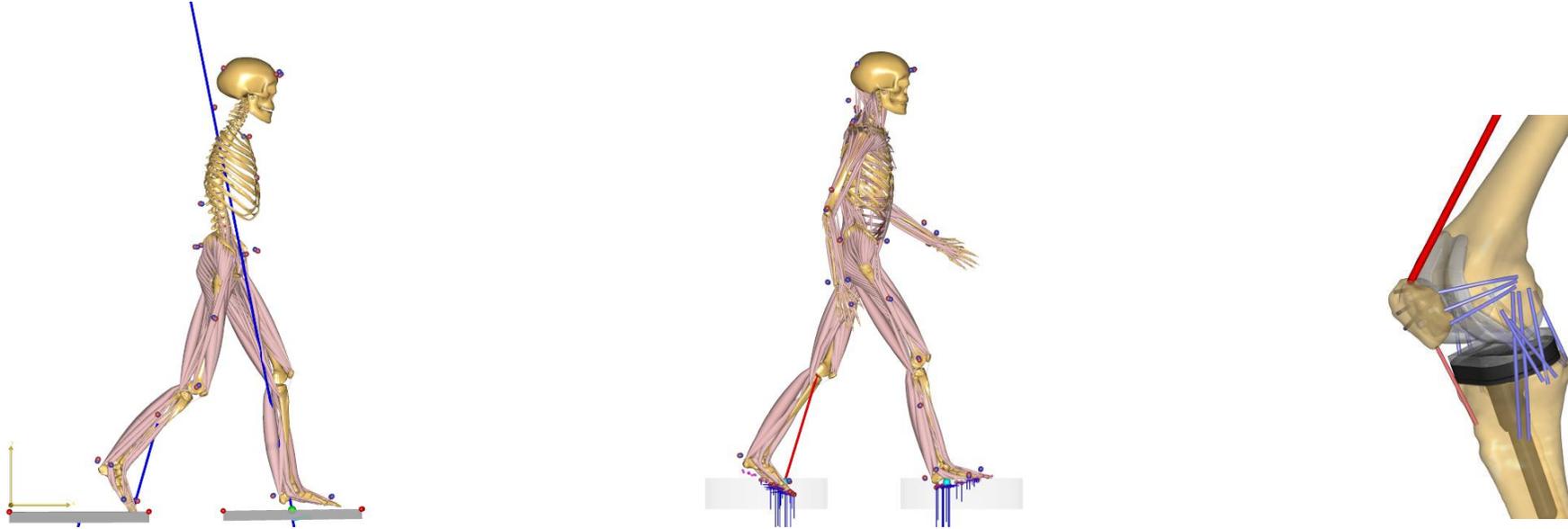
- New two step algorithm:
 1. Initial solve with penetration
 2. Final pushout onto the surface



Experimental in 7.3

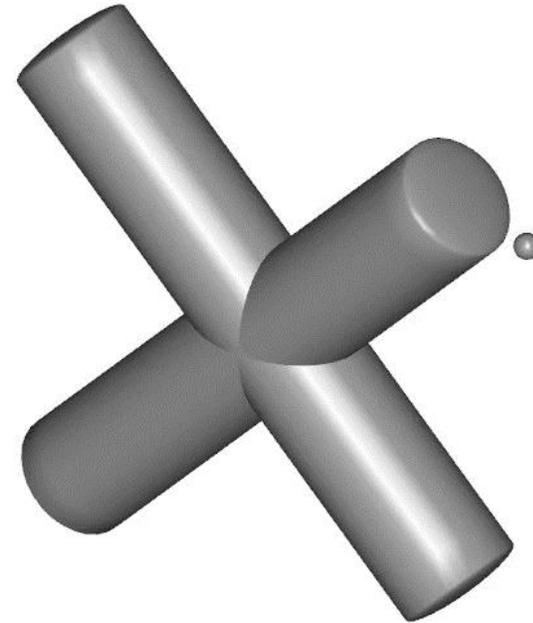
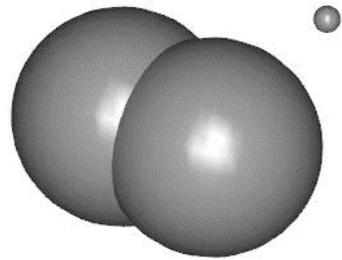
Default in 7.3.1

Speed improvements



Model	Analysis	Old	New	Speed up
Lower extremity MoCap	Inverse Dynamics			

Multiple surfaces gives more options



Acknowledgements

Ideas from:

- Lloyd, J., Roewer-Despres, F. & Stavness, I. Muscle Path Wrapping on Arbitrary Surfaces. IEEE Trans. Biomed. Eng. PP, (2020)

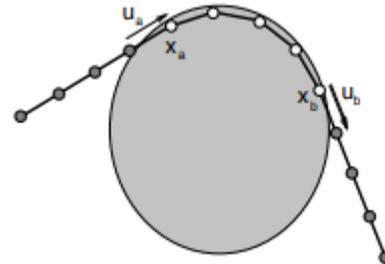
Conveniently, from (3), we see that \mathbf{K} is block tridiagonal:

$$\mathbf{K} = K \begin{pmatrix} -2\mathbf{I} & \mathbf{I} & & & \\ \mathbf{I} & -2\mathbf{I} & \mathbf{I} & & \\ & \mathbf{I} & \ddots & \ddots & \\ & & \ddots & \ddots & \mathbf{I} \\ & & & \mathbf{I} & -2\mathbf{I} \end{pmatrix} + \nabla \mathbf{f}_c \quad (5)$$

where $\nabla \mathbf{f}_c$ is a block diagonal matrix consisting of 3×3 blocks which are 0 for knots not in contact and $\nabla \mathbf{f}_{c,k}$ for knots that are. From (1) and (2), we have that

$$\begin{aligned} \nabla \mathbf{f}_{c,k} &= -K_c \mathbf{n}_k \nabla \phi(\mathbf{x}_k) - K_c d_k \nabla^2 \phi(\mathbf{x}_k) \\ &= -K_c \mathbf{n}_k \mathbf{n}_k^T - K_c d_k \nabla^2 \phi(\mathbf{x}_k). \end{aligned}$$

The last term, $-K_c d_k \nabla^2 \phi(\mathbf{x}_k)$, while small, is important to help achieve quadratic convergence in Newton's method.



This article has been accepted for publication in a future issue of this journal, but has not been fully edited. Content may change prior to final publication. Citation information: DOI 10.1109/TRIME.2020.3009922, IEEE Transactions on Biomedical Engineering

IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, VOL. X, NO. X, XXX XXXX

1

Muscle Path Wrapping on Arbitrary Surfaces

John E. Lloyd, François Roewer-Després, and Ian Stavness*, Member, IEEE

Abstract— Objective: Musculoskeletal models play an important role in surgical planning and clinical assessment of gait and movement. Faster and more accurate simulation of muscle paths in such models can result in better predictions of forces and facilitate real-time clinical applications, such as rehabilitation with real-time feedback. We propose a novel and efficient method for computing wrapping paths across arbitrary surfaces, such as those defined by bone geometry. **Methods:** A muscle path is modeled as a massless, frictionless elastic strand that uses artificial forces, applied independently of the dynamic simulation, to wrap tightly around intervening obstacles. Contact with arbitrary surfaces is computed quickly using a distance grid, which is interpolated quadratically to provide smoother results. **Results:** Evaluation of the method demonstrates good accuracy, with mean relative errors of 0.002 or better when compared against simple cases with exact solutions. The method is also fast, with strand update times of around 0.5 msec for a variety of bone shaped obstacles. **Conclusion:** Our method has been implemented in the open source simulation system ArtiSynth (www.artisynth.org) and helps solve the problem of muscle wrapping around bones and other structures. **Significance:** Muscle wrapping on arbitrary surfaces opens up new possibilities for patient-specific musculoskeletal models where muscle paths can directly conform to shapes extracted from medical image data.

Index Terms—Biomechanics, musculoskeletal modeling, muscle wrapping, real-time simulation, signed distance field, geodesic.

I. INTRODUCTION

MUSCULOSKELETAL simulations are increasingly being used to quantify the neuromuscular activity in a range of clinical applications including analysis of ankle [1] and shoulder [2] injuries and real-time control of prostheses [3], [4]. Line-based muscle models, represented as mass-

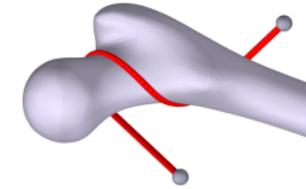


Fig. 1. Muscle strand wrapped around an arbitrary surface.

Simulation of thin strands and cables has been proposed in computer graphics studies for simulating cable-driven machines. These include adapted via point techniques [6], efficient cable-pulley mechanisms [7], frictional contact between wires and surfaces [8], and highly constrained cables that include both contact and routing through tunnels [9]. While primarily used for abstract mechanical systems, some of these approaches have been transferred to modeling musculoskeletal systems, notably for the musculotendon units in the hand [10].

The majority of muscle wrapping approaches in musculoskeletal models, however, have been limited to obstacles described by simple analytic shapes (e.g., cylinders, spheres, tori) or smooth parametric surfaces. The use of smooth shapes makes it simpler to compute shortest-distance paths and ensures smooth path evolution [11]. However, such approximations may have low fidelity with respect to the true obstacle surface, e.g. the humeral head and shaft are usually

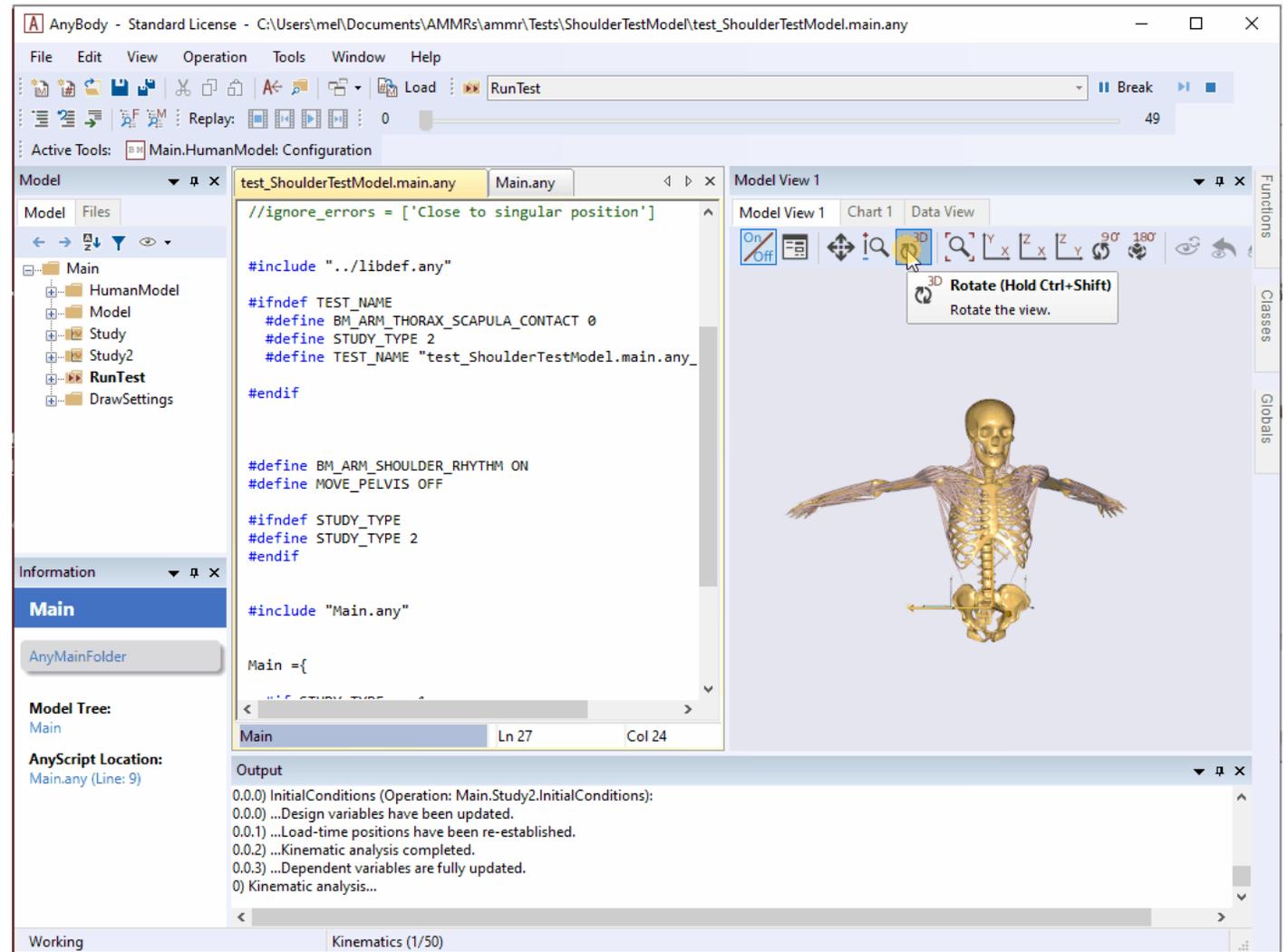
Improvements to user interface

Smoother model view when running simulations

Model view persists across reloads

New hierarchical model view

New reference manual



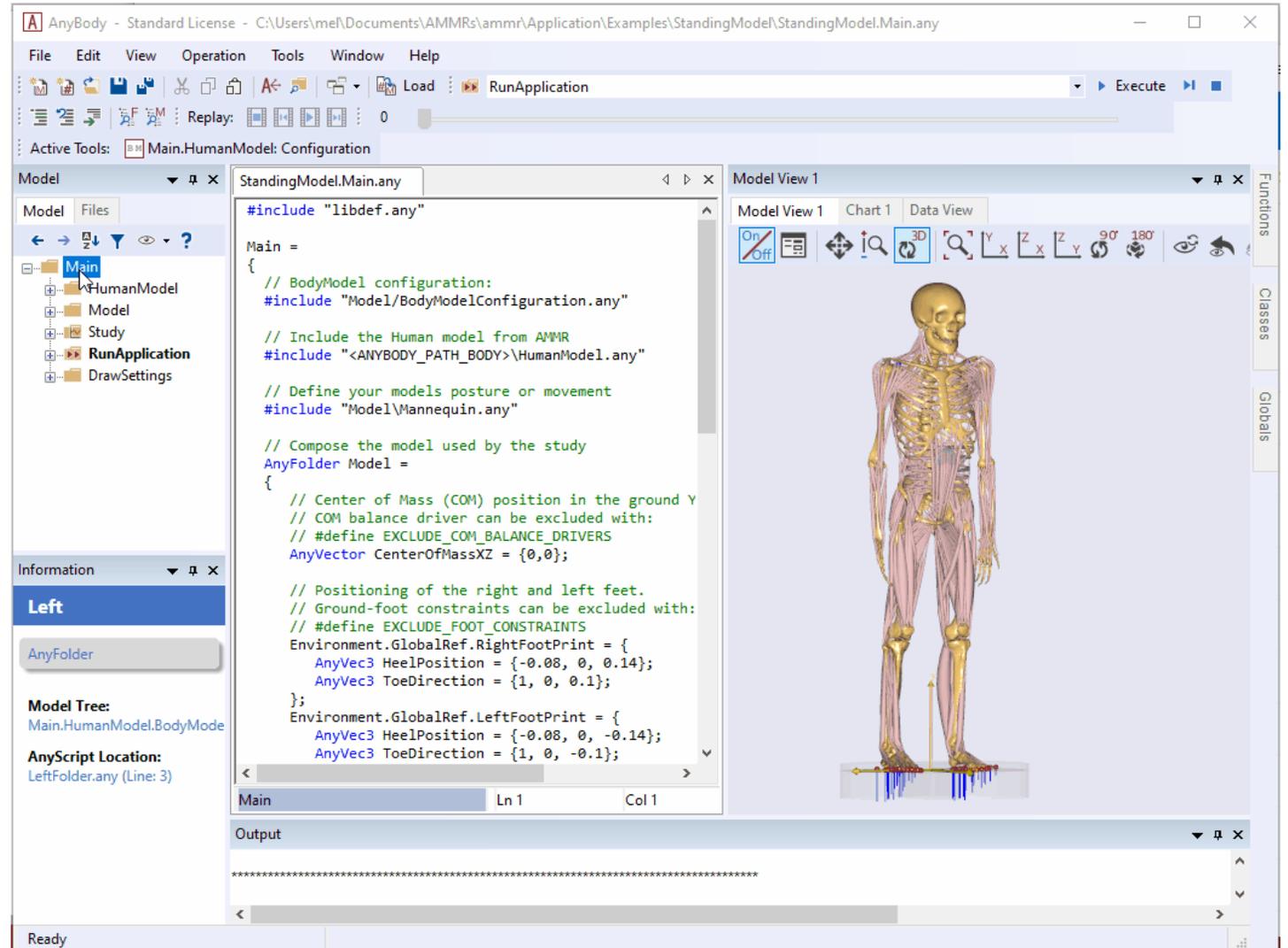
Improvements to user interface

Smoother model view when running simulations

Model view undo/redo/persistence

New hierarchical model view

New reference manual



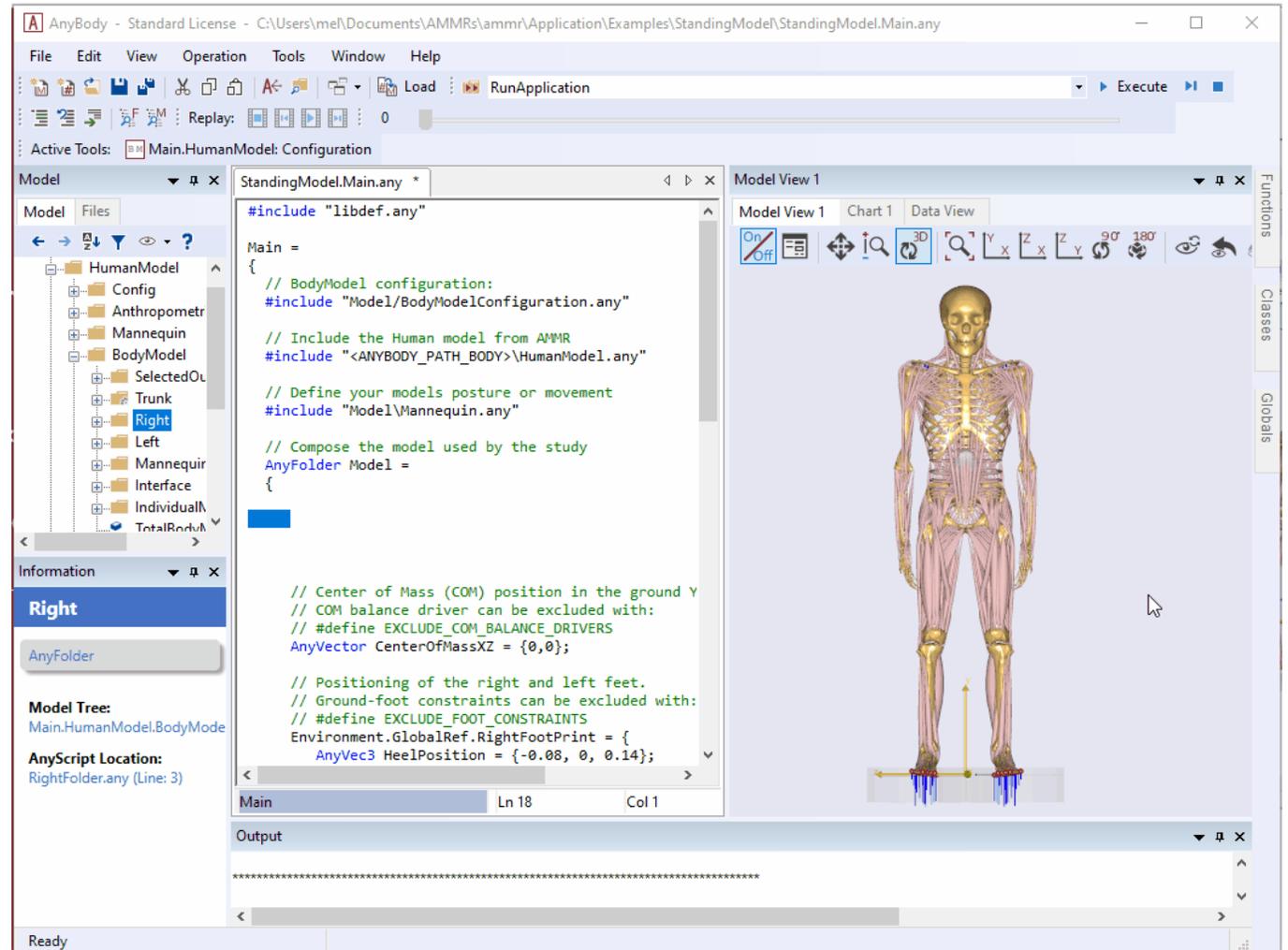
Improvements to user interface

Smoother model view when running simulations

Model view persists across reloads

New hierarchical class tree

New reference manual



Improvements to user interface

Smoother model view when running simulations

Model view persists across reloads

New hierarchical class tree

New reference manual

The screenshot shows the AnyScript Reference Manual application. On the left is a hierarchical class tree with categories like Mechanical Objects, Drawing and Styling Objects, and Studies and Operations. The main area displays the documentation for the **AnyRefNode** class. It includes the following information:

- Type:** Creatable
- Base Class:** **AnyPositionedRefFrame**
- Description:** The reference node is a reference frame rigidly attached to another one. Thus, its position and orientation are specified relatively to its owner. The node's angular velocity and acceleration are the same as the owner's (global representations).
- Object Members:** A table of optional-initialization members.

Class	Name	EvalMoment	Description	Default Value
AnyDrawRefFrame	viewRefFrame	Const		
AnySwitchVar	viewRefFrame.Visible	RuntimeVar	Visibility setting, which specifies default visibility of the object.	Of
AnyVar	viewRefFrame.Opacity	RuntimeVar	Opacity setting, which specifies default opacity of the object.	1.0
AnySwitchVar	viewRefFrame.Pickable	RuntimeVar	Switch for whether the AnyDrawObject can interacted with by clicking it in a model view.	Of



The screenshot shows the AnyScript Reference Manual web browser interface. The page title is **AnyRefNode**. It features a clean, modern design with a navigation sidebar on the left and a main content area. The sidebar includes a search bar, a 'Reference Manual' section, and a list of navigation links. The main content area displays the following information:

- ANY REFERENCE** logo
- AnyRefNode** title
- Type:** Creatable
- Parent class:** AnyPositionedRefFrame
- Description:** The reference node is a reference frame rigidly attached to another one. Thus, its position (sRel) and orientation (ARel) are specified relatively to its owner. The node's angular velocity and acceleration are the same as the owner's (global representations).
- Examples:** A code block showing how to create a node in an AnyFixedRefFrame.
- Optional initialization members:** A list of members with their descriptions and default values.
- Denied-Access members:** A section for members that are not accessible.

```
AnyFixedRefFrame G1bRef = {
  AnyRefNode Node = {
    sRel = (0.1, 0, 0);
    viewRefFrame.Visible = On;
  };
};
```

viewRefFrame = {}	Drawing object that renders the reference frame.
viewModes = {}	Drawing object that renders the segment's nodes.
sRel = (0.0, 0.0, 0.0)	Relative position vector.
ARel = ...	Relative rotational transformation matrix (see class ...)

Documentation: Reference Manual

- Quick search
- Type/parent/child links
- Examples/snippets for some classes
- Class member descriptions
- More info on Classes/functions

The screenshot shows a web browser displaying the 'AnyRefNode' page in the 'AnyScript Reference 7.3.0 documentation'. The page layout includes a sidebar on the left with a search bar and navigation links, and a main content area on the right. The main content area is divided into several sections: 'Description', 'Examples', and 'Optional initialization members'. The 'Description' section explains that the reference node is rigidly attached to another one. The 'Examples' section provides a code snippet for creating a node in an AnyFixedRefFrame. The 'Optional initialization members' section lists properties like viewRefFrame, viewNodes, and sRel.

ANY REFERENCE

Quick search Go

Reference Manual

API

- Class reference
- Function reference
- Globals reference
- Environment variables
- Errors, warnings and messages

Language

- AnyScript™ language
- The preprocessor
- Inside the AnyBody Modeling System
- Technical notes

Demo examples

Other resources

← Back to all manuals

AnyRefNode

Type: Creatable
Parent class: AnyPositionedRefFrame

Description

The reference node is a reference frame rigidly attached to another one.

Thus, its position (sRel) and orientation (ARel) are specified relatively to its owner. The node's angular velocity and acceleration are the same as the owner's (global representations).

Examples

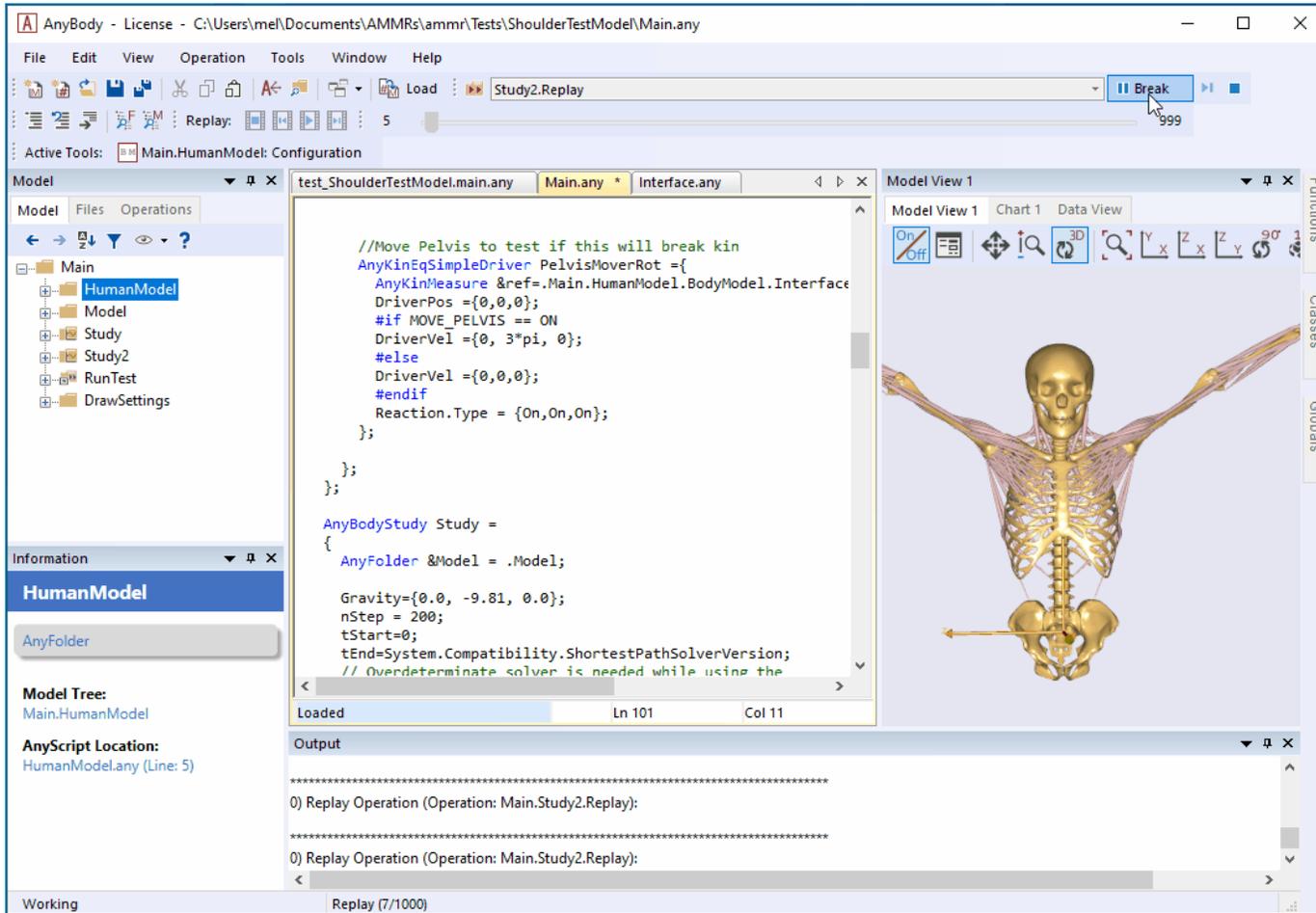
Here is simple code block to create a node in a AnyFixedRefFrame which is typically used to define the global coordinate system. The AnyRefNode can also be embedded in any child objects of AnyRefFrame (e.g. AnySeg, AnyRefNode).

```
AnyFixedRefFrame G1bRef = {
  AnyRefNode Node = {
    sRel = {0.1, 0, 0};
    viewRefFrame.Visible = 0n;
  };
};
```

Optional initialization members

viewRefFrame = {}	Drawing object that renders the reference frame.	+
viewNodes = {}	Drawing object that renders the segment's nodes.	+
sRel = {0.0, 0.0, 0.0}	Relative position vector.	+

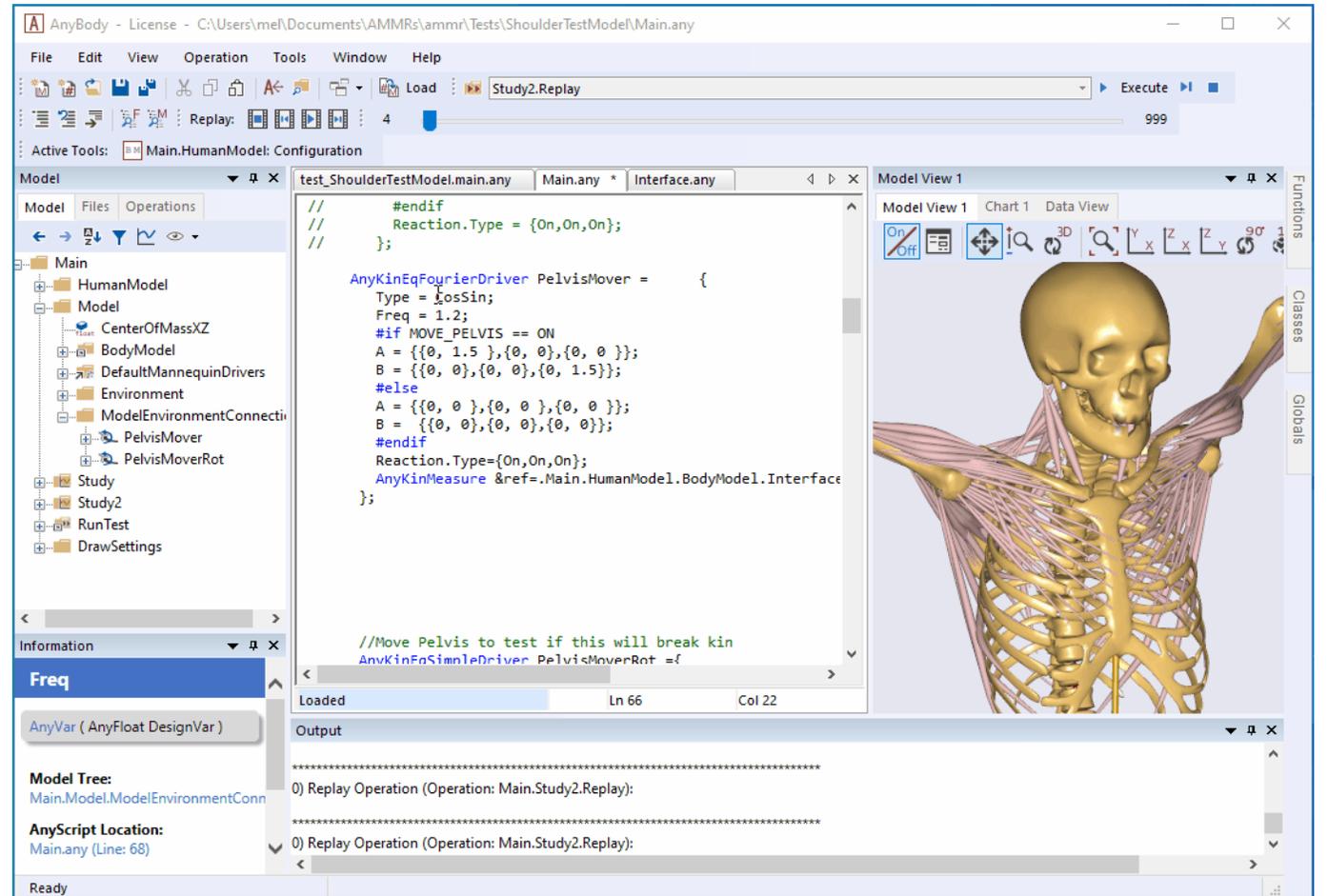
New reference manual



- In the help menu:
 - Help->Reference Manual

New reference manual

- By pressing F1:
 - In the model tree: selected objects
 - In the editor: cursor on class or functions.



What else has changed in AnyBody?

AnyBody Release notes

AnyBody, v.7.3.0 (07-07-2020)

AnyBody, v.7.3.0 provides several new features and minor updates. Many of these are supporting the new version of the AnyBody Managed Model Repository, AMMR v.2.3.

The installed version of AMMR is now version 2.3, which includes many improvements and new examples. For example, a large-scale gait MoCap example, and a new graphical interface (plugin) to scale models based on statistical data. In addition, numerous issues have been fixed and improved throughout the model codebase. Please see the AMMR documentation for a full changelog (<https://anyscript.org/ammr-doc/changelog.html>).

AnyBody, v.7.3.x installs separately from previous versions of AnyBody.

New features:

- **AnyScript Modeling Language:**
 - AnyKinMeasureQuadComb is a new so-called kinematic combination measure. It derives from AnyKinMeasureLinComb that provides a linear combination of other kinematic measures.



AnyBody - Standard License - C:\Users\me\Documents\AMMR\ammr\Application\MocapExamples\Plugin-gait_Simple\FullBody_GRFPrediction.any

File Edit View Operation Tools Window Help

Model View 1

Model View 1 Chart 1 Data View

Model View 1 On/Off 3D

Functions Globals Classes

Ln 1 Col 1

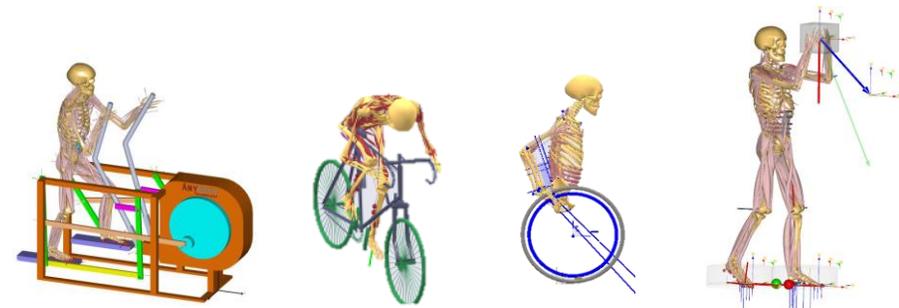
Ready

Help

- AnyBody Assistant...
- Tutorials
- AnyScript Reference
- AMMR Documentation
- Online documentation ...
- Demo...
- Check for Updates...
- Registration...
- License Agreement...
- Release Notes
- About AnyBody...

Model repository

WHAT IS NEW IN AMMR 2.3.0/2.3.1



Model Repository (version 2.3.1)

- Development since 2.2 (last December)
 - 90+ pull requests / 350 commits
 - Many contributions from users on GitHub.
- New model examples and improved body models
- Many fixes and tweaks to performance and robustness

AnyBody Managed Model Repository

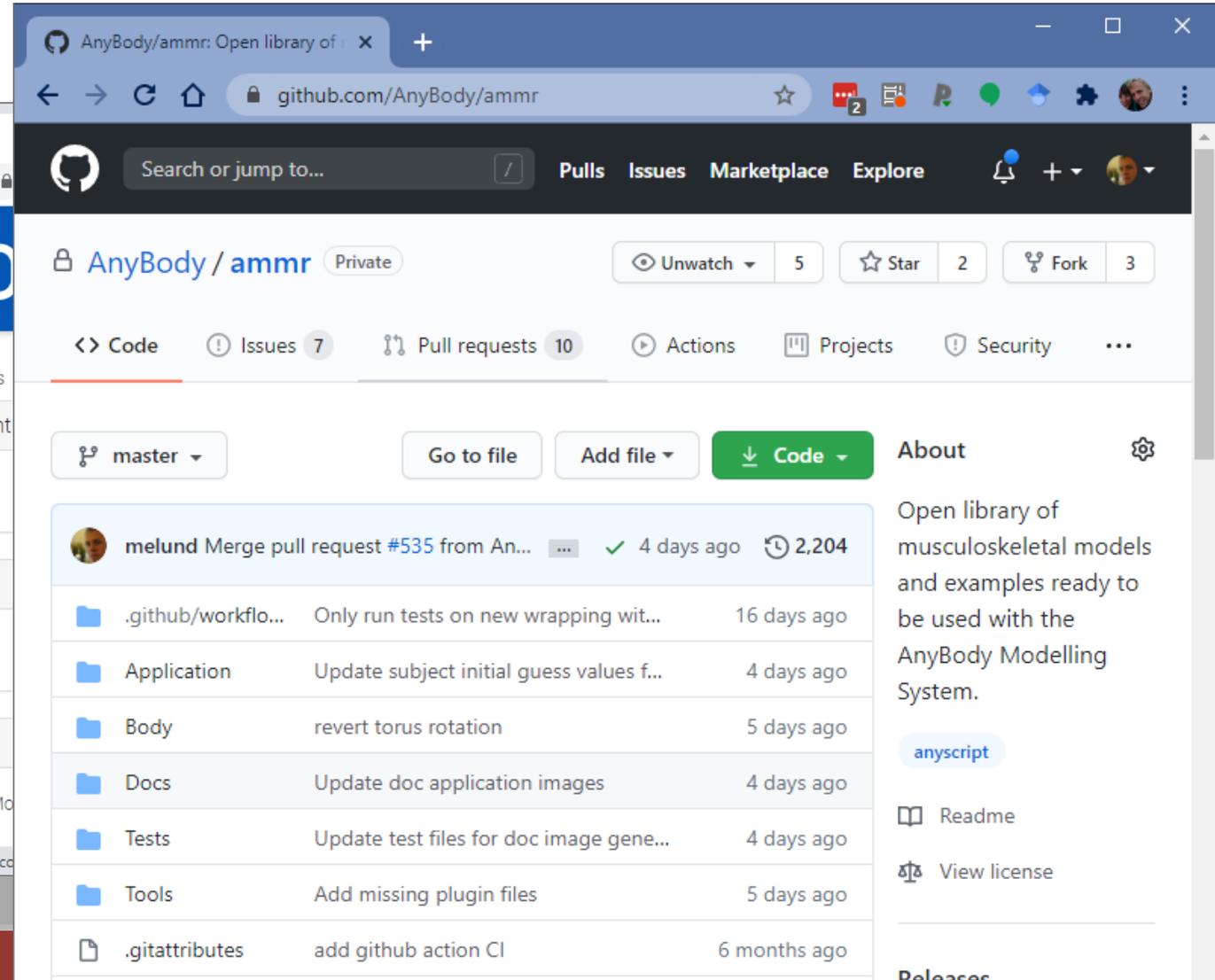
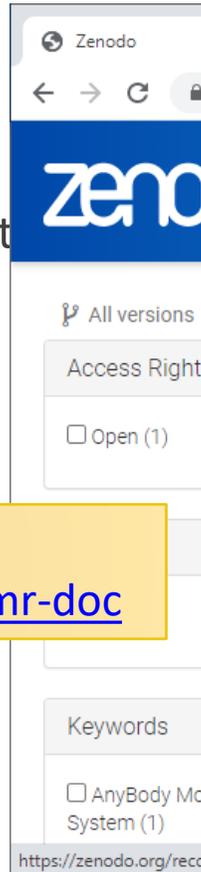


How to get the model repository...

- Bundled with AnyBody
 - Unpack a version from the AnyBody Assistant
- Archived on Zendo
- From our internal development repository on GitHub

Apply for access here:

<https://github.com/AnyBody/ammr-doc>



What is new?

Highlights:

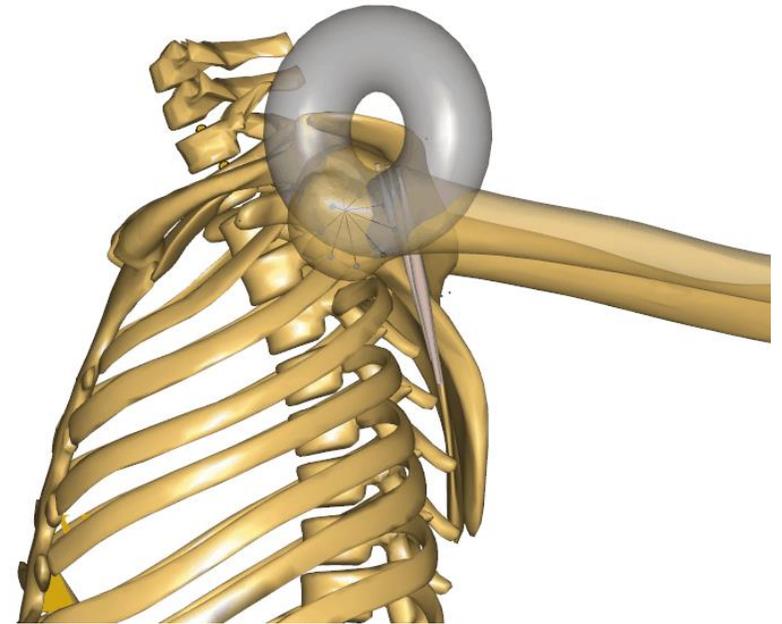
1. Improved shoulder rhythm and shoulder wrapping
2. New full body Gait MoCap model
3. New statistical scaling plugin.



Shoulder improvements

- Updated shoulder rhythm
 - De Groot, J. H. *The shoulder: a kinematic and dynamic analysis of motion and loading.* (1998)

- Wrapping improvements many shoulder muscles.
 - Example: Teres minor and torus wrapping



Note: Still room for improvements to shoulder rhythms

Non-linear relationships can be implemented with the class: [AnyKinMeasureQuadComb](#)

New full body “ADL” gait mocap model

Large pre-configured full body MoCap example

- 50 subjects/1193 trials
- 5 walking speeds

“Rehazenter adult walking dataset”

- Open license - creative commons (CC BY 4.0)
<https://doi.org/10.1038/s41597-019-0124-4>

The screenshot shows a web browser window with the following content:

- Browser tabs: Zenodo, ANY Becom, GitHub, A multi
- Address bar: [nature.com/articles/s41597-019-0124-4](https://www.nature.com/articles/s41597-019-0124-4)
- Page title: scientific data
- Navigation: Explore our content, Journal information
- Breadcrumbs: nature > scientific data > data descriptors > article
- Metadata: Data Descriptor | Open Access | Published: 03 July 2019
- Article title: **A multimodal dataset of human gait at different walking speeds established on injury-free adult participants**
- Authors: Céline Schreiber & Florent Moissenet
- Publication info: *Scientific Data* 6, Article number: 111 (2019) | Cite this article
- Metrics: 6195 Accesses | 1 Citations | 23 Altmetric | Metrics
- Section: **Abstract**
- Abstract text: Human motion capture is used in various fields to analyse, understand and reproduce the diversity of movements that are required during daily-life activities. The proposed dataset of human gait has been established on 50 adults healthy and injury-free for lower and upper extremities in the most recent six months, with no lower and upper extremity surgery in the last 6 months. Participants were selected to be injury-free and healthy at the time of data collection. Participants were selected to be injury-free and healthy at the time of data collection.

New full body “ADL” gait mocap model

Large pre-configured full body MoCap example

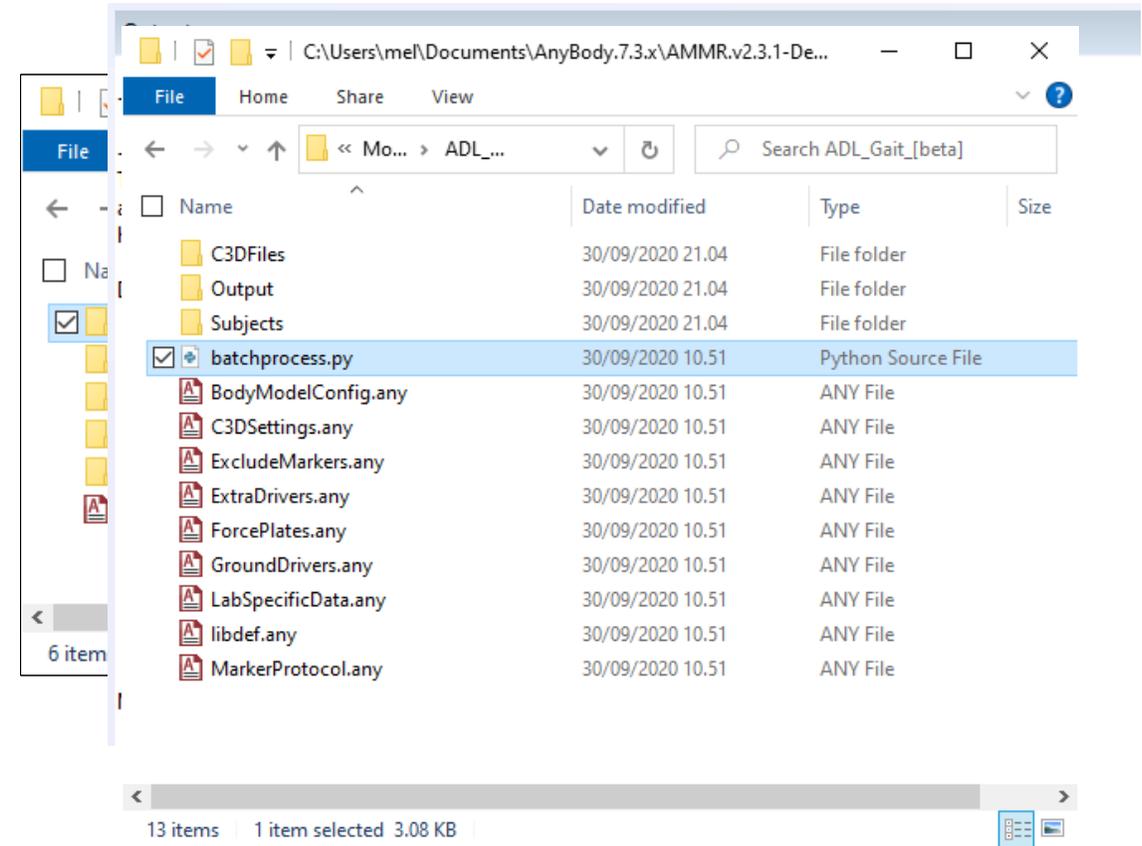
- 50 subjects/1193 trials
- 5 walking speeds

“Rehazenter adult walking dataset”

- Open license - creative commons (CC BY 4.0)
<https://doi.org/10.1038/s41597-019-0124-4>

Dataset must be downloaded separately

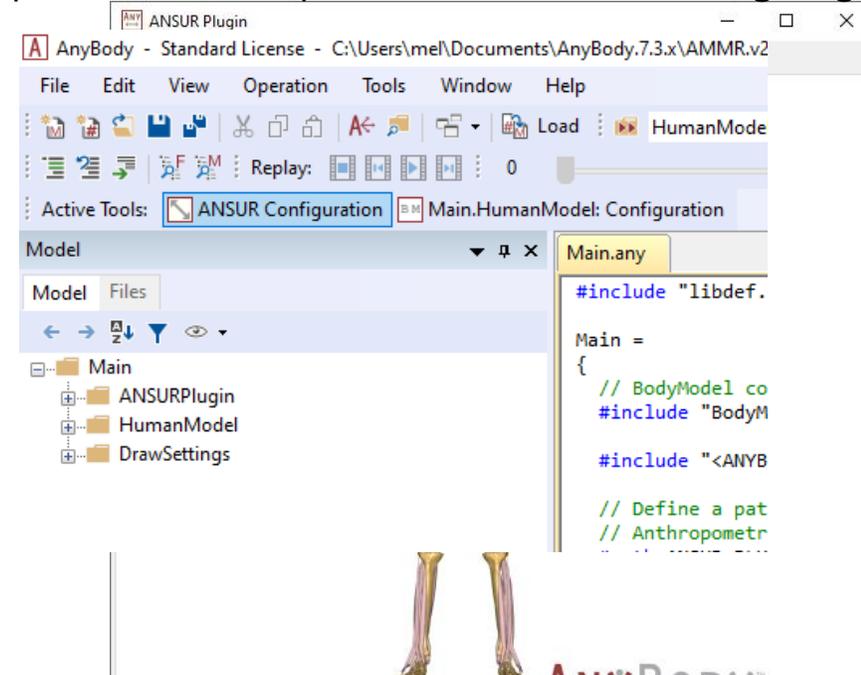
Scripts for batch processing everything



Statistical scaling plugin

- Small tool to create realistic model anthropometry/scaling
- Based on ANSUR anthropometric database
 - 1700 men / 2200 women

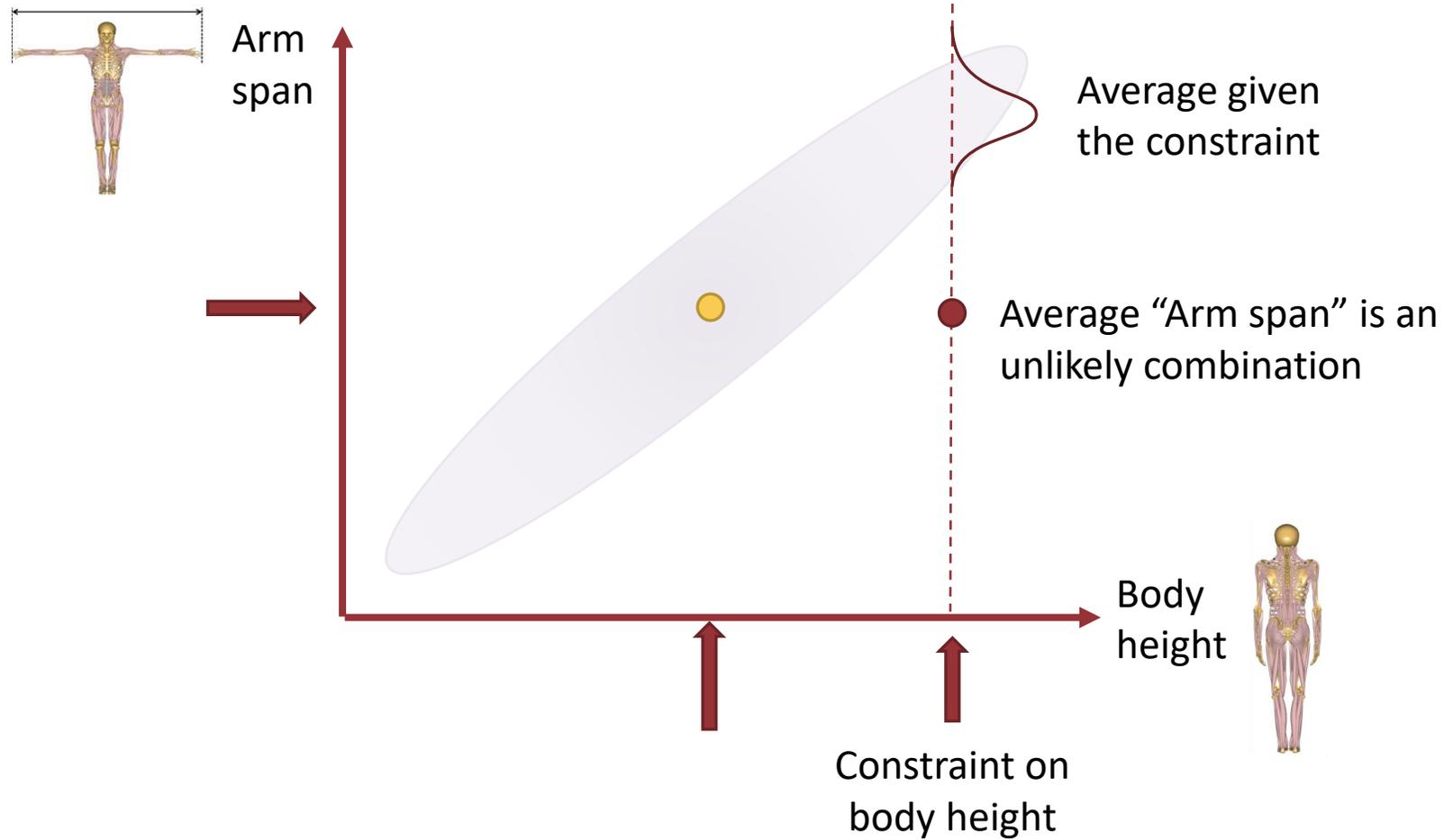
Application\Examples\StatisticalScalingPlugin



```
#include "<ANYBODY_PATH_AMMR>/Tools/Plugins/ANSUR_Plugin.any"

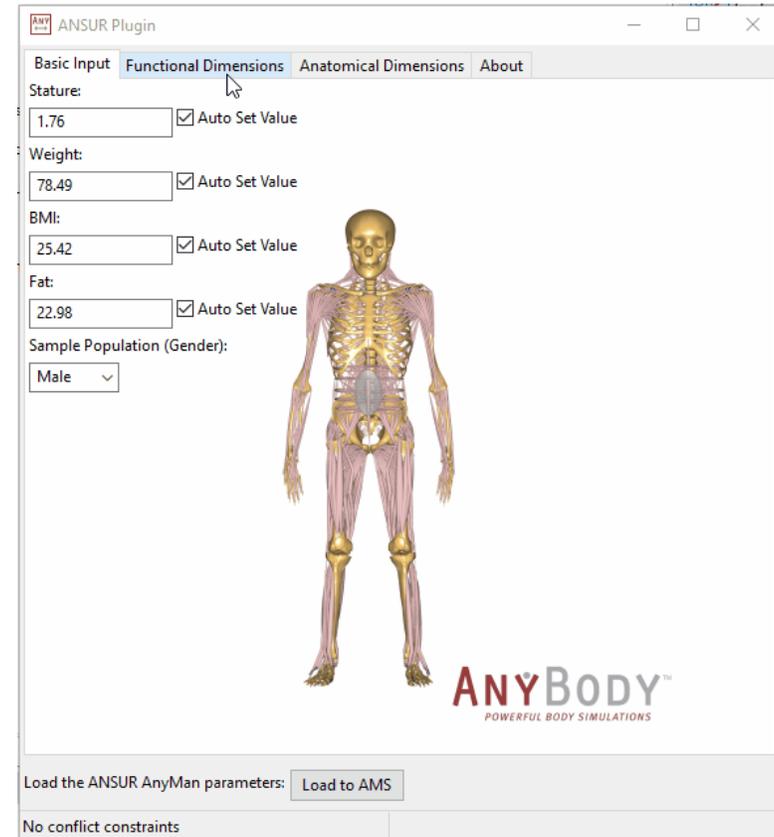
// Define a path variable so the plugin knows where to write
// Anthropometric information.
#path ANSUR_PLUGIN_ANYMAN_FILE "AnyMan_ANSUR.any"
#include "<ANSUR_PLUGIN_ANYMAN_FILE>"
```

Anthropometry is correlated



Statistical scaling plugin

- Small tool to create realistic model anthropometry/scaling
- Based on ANSUR anthropometric database



What else has changed?

- Improvements/bugfixes....
 - BVH marker protocol improvements -> triggers warning when using old models
 - Improvements to muscles/wrapping surfaces in many places
 - Stability improvements for MoCap models.

+40 different improvements/bug fixes

anyscript.org/ammr-doc

The screenshot shows a web browser displaying the 'Changelog' page for AMMR v2.3.1-beta. The page title is 'Changelog' and the version is 'AMMR 2.3.1 (2020-09-30)'. A DOI link is provided: DOI: 10.5281/zenodo.4023956. The page is divided into 'Added:', 'Changed:', and 'Removed:' sections. The 'Added:' section contains two bullet points: one about a new wrapping solver and another about a new wrapping ellipsoid for the triceps. The 'Changed:' section contains two bullet points: one about improvements to the 'ADL Gait' example and another about improving the shoulder rhythm. A code snippet is highlighted in green: `System.Compatibility.ShortestPathSolverVersion = 2; // 4 is default (new wrapping)`. The left sidebar contains a 'Table of Contents' with links to various documentation sections, including 'Changelog'.

www.anybodytech.com

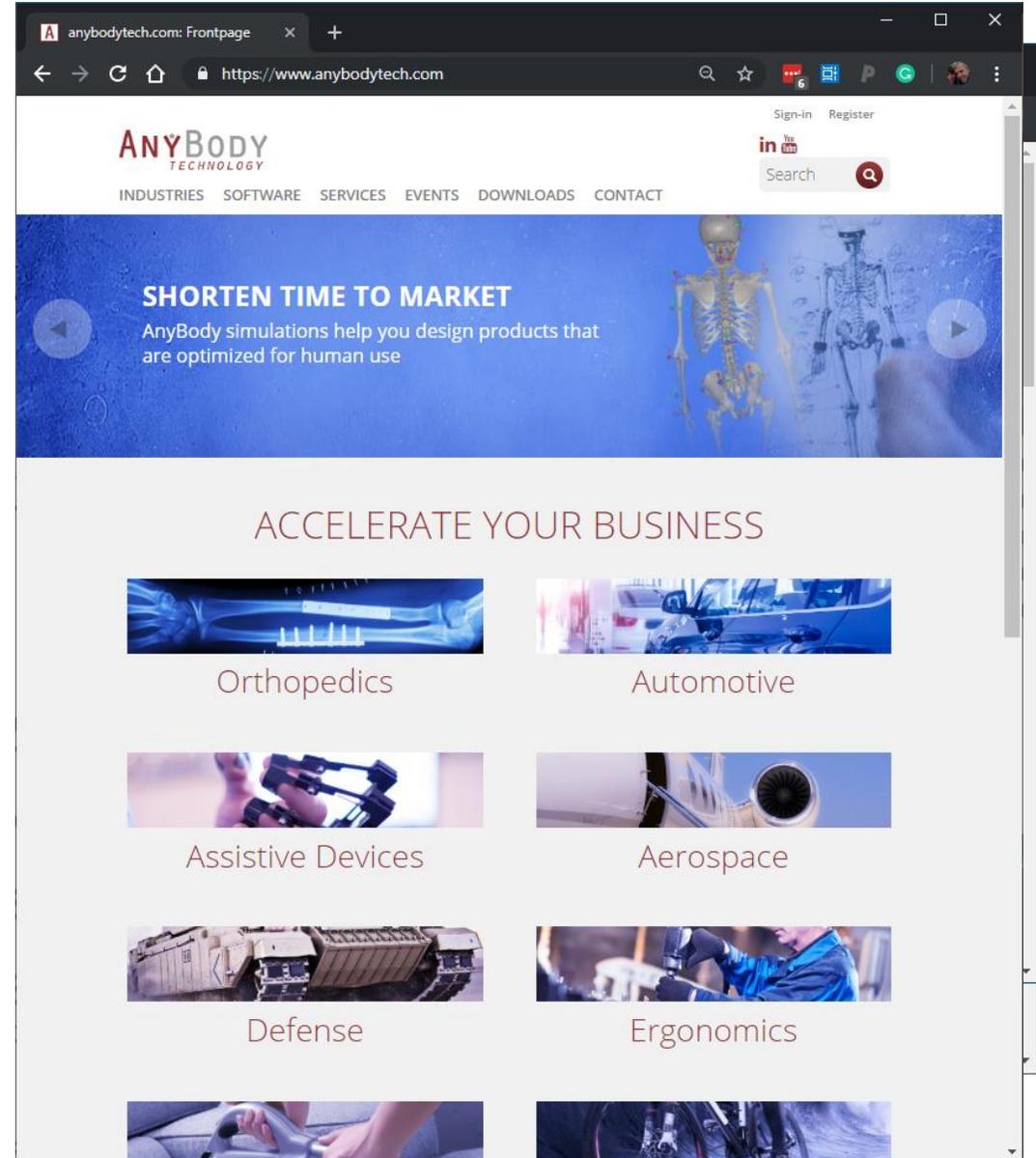
- Events, dates, publication list, ...

www.anyscript.org

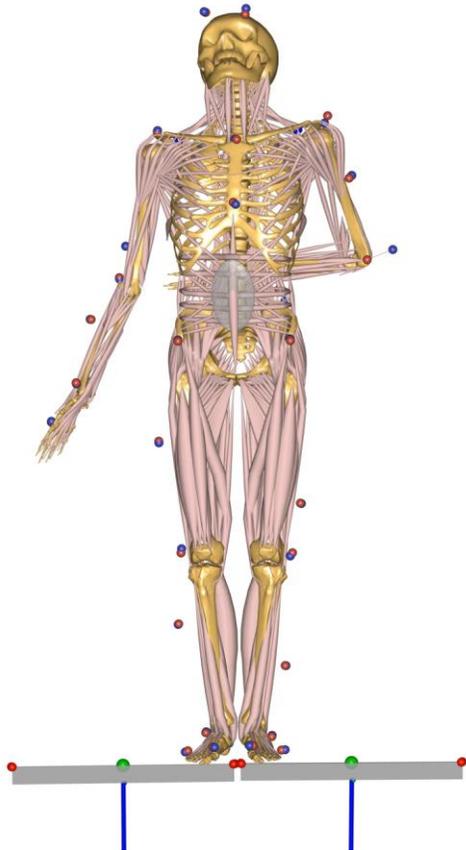
- Wiki, **Forum**, Repositories



Get in touch? sales@anybodytech.com



Time for questions:



AnyScript forum

https://forum.anyscript.org

ANYSCRIPT FORUM Sign Up Log In

all categories all tags **Categories** Latest Top

Category	Topics	Latest
Main Forum This is the category for discussion about the AnyBody Modeling System and problems with models	19 / month	Z Error when loading C3D model 1h Y Misalignment of robot joint and human joint 8h E Changing the TrailFileName with AnyPy Tools 21h Request for c3d2any.exe and gaitapplication2.exe 9d Node Orientation 9d
Announcements Big and small news AnyBody Modeling System, and Model Repository (AMMR)	2	
Blog comments This category is for collecting discussions from blog posts on AnyScript.org . Do not create new topics in this category. They are created automatically when people comment on blog posts.	1 / month	