Release notes AMMR1.5

Introduction

This release of AnyBody Managed Model Repository (AMMR) introduces several new applications

- Examples/LegPressMachine
- Examples/BikeModelTD
- Examples/THA-KneeBendDemo
- Beta/TKA-KneeBendDemo

Additionally it contains the new AnyGait model which is a new powerful and easy-to-use application to analyze motion capture trials from gait labs in a laboratory or clinical environment.

It also contains a major restructuring of the LegTD model.

The models run with the AnyBody Modeling System (AMS) ver. 5.2

AnyGait

AnyGait is a new powerful and easy-to-use application to analyze motion capture trials from gait labs in a laboratory or clinical environment. Using a new graphical user interface it enables existing gait lab personnel to process trial data in the AnyBody Modeling System.

- Processing of trial data according to lab standards
- Automated optimized fitting of model to subject
- New functional insight from model with unprecedented level of detail
- Output data customized to fit lab, application, or patient group
- All model details accessible for skilled users

Input data: AnyGait requires motion capture including ground reaction forces for input in the form of C3D files. Height and weight of the subject is also needed. A set of standard set-ups is available for use with leading MOCAP and force plate vendors.

Results/Output: AnyGait is pre-setup to deliver important results in a condensed and easy-to-read form. The default output contain joint angles of ankle, knee, and hip, joint reaction forces of ankle, knee, and hip, and muscle activity of major muscle branches. Outputs can be selected and customized to meet the needs of laboratory, application, or patient group.

Graphical user interface: The application runs inside the AnyBody Modeling System which enables the skilled user to access and modify all features of the model. Less skilled users who mainly process gait lab data use an intuitive graphical user interface which shields them from the modeling details.

Please refer to the AnyGait Manual in the AnyGait folder for further details.

Applications:

All applications have been equipped with an ANYBODY_PATH_BODY statement; this makes it easy to run an application with different versions of the body repository. Additionally there are multiple other statements for setting ToolBox, Output paths etc. All models come with predefined paths which can easily be changed.

THA-KneeBendDemo (new model)

This model simulates a knee bend for a body model with a total hip (THA) using:

- either an ideal spherical joint with joint reaction forces
- or force dependent kinematics and a contact model.

In this model, the hip joint is excluded from the AnyBodyStudy and a new hip joint with a THA is included with an Acetabular Cup and a Femoral Component. The model is setup to run either with an ideal spherical joint and joint reaction forces or using force dependent kinematics in the 3 translational degrees of freedom and calculating surface contact force between these implants.

Beta/TKA-KneeBendDemo (new model)

This model demonstrates how to replace the knee joint by a contact model using a total knee arthroplasty for a knee bend model.

The model is performing a knee bend, which is driven by positions of the hip and foot and ground reaction forces added from external sources. The knee joints (tibial femural joint and patella femural joint) from the standard repository body are excluded from the inverse dynamic study and a new joint is implemented using force dependent degrees of freedom (DOF). The forces in the knee joint are provided by a contact force between a femoral and a tibial implant (defined into medial and lateral part), contact forces between the femoral implant and the patella as well as ligament forces from medial and lateral collateral ligaments and posterior cruciate ligament (PCL) and muscle forces. For computational reasons, the demonstration model was reduced to simulate only one leg.

LegPressMachine (new model)

This is a new model illustrating a leg press exercise. Additionally, the model demonstrates the use of the SolidModeling Class Template in the ToolBox.

BikeModelTD (new model)

This is a model is a new BikeModel using the LegTD. It also applies the new gluteus wrapping surfaces that has been released as an optional beta-release) feature in the LegTD model.

StandingModelScalingDisplay

The model has been reorganized to use the LegTD. This is done to facilitate introduction of an optional custom scaling for individual bones. The model now forms the basis of a new tutorial on subject specific scaling.

GaitLowerExtremityModel

The ‘Motion and parameter optimization’ part of the model has been restructured. This was done to avoid referencing the entire HumanModel folder in the study section. The model now follows the convention used by the other example models.

The model has been updated with a new way for setting the timeframes for the calculation; this can be seen in the ModelSetup.any file. A file named ExtraDrivers has been added it can be used for driving if no makers for the upper body have been recorded.

GaitFullBodyModel

Same updates as in GaitLowerExtremityModel, and neck motion have been included into the motion optimization.

Body

All body parts have been equipped with pre-made studies to calculate the joint strength for each individual DOF and to find the moment arms for all muscles. This makes it easy to calculate joint strengths and see moment-arms. This can be enabled in the BodyPartSetup.any file, with the switches:
#define EVALUATE_MOMENT_ARMS 1
#define EVALUATE_JOINT_STRENGTH 1

Scaling

New scaling law ScalingCustom.any has been included making it easy to apply and create subject specific scaling using linear, RBF, and combinations of transforms for individual bones. As a consequence all scaling laws have been reworked to allow easier inclusion of custom scaling functions. Lumbar and cervical spine segments now use individualized references to ScaleFunctions. This makes it possible to apply unique scaling laws for the particular segment. Please check the description of ScalingCustom.any or refer to the subject-specific morphing tutorial.

LegTD

The model has been restructured with the aim of make it easier to include new datasets into the model. Model parameters and model topology have been separated. The parameters for the model can now be found in the following new files:

- CadaverMuscleParameters.any: This file contains all muscle parameters
- CadaverParameters.any: This file contains all muscle attachment points, bony landmarks, points used for wrapping surfaces etc.

The Model allows for a new definition of the knee joint and ankle joint based on bony landmarks. This is enabled by setting the flag #define `BONY_LANDMARK_DEFINED_JOINTAXIS`. With this feature, the model no longer behaves as the original Klein-Horseman dataset, however, the feature is useful in for selecting cases where the musculoskeletal models are scaled based on a standing reference trial. This feature is for example used in the AnyGait application. The ankle joint follows to new estimated medial and lateral bony landmarks (MedialAnkleAxisMarker, LateralAnkleAxisMarker) that better represents where markers would be placed in gait lab experiment.

Additionally multiple changes have been made:

- Scalable joint axis. All joint axes are now parameterized with control points which move with the scaling/morphing of the leg. The axis follow the Klein-Horseman joint axis definition with standard linear scaling

- The hip joint rotation sequence recommended by the International Society of Biomechanics (ISB) for has been implemented. However, with one exception, zero degree hip flexion is set to be the neutral anatomical position, which is not the case for the ISB joint coordinate system. The old sequence can be reactivated by setting the flag #define USE_AMMR14_HIP_ROTATIONS
- New wrapping surface has been added GluetusMaximusSuperior and GlutetusMaximimusInferior. The wrapping surfaces are default switched off, but can be included with the switch GLUTEUS_MAX_WRAPPING_BETA in the BodyPartSetup.any file. An example of its use can be seen in the new application named BikeModelTD.
- New via points for Gastrocnemius lateral1 and medial1 have been added.
- New wrapping surfaces for vastus and rectus femoris muscles have been added.
- The model has been updated to allow non-linear scaling. This has been done by numerous changes:
    - Redefining the wrapping surfaces, so that they are controlled by points located on the bone surface.
    - Introduction of the variables (sRelUnscaled, ARelUnscaled) to the joint ref nodes. These variables define the un-scaled position and orientation of the joints. This is done, so other parts of the model can get the un-scaled values here, without having to know if the joints are based on bony landmarks or the original joint axis from the dataset. These values can also be found in the CadaverParameters.any file.
    - Patella tendon length is now scaling with the overall leg length. Before it used the y component scale matrix in shanks scale function. This matrix does not exist when using RBF scaling.
- Added -24 deg rotation to the scaling function of the pelvis hipTD nodes. This should ensure that the all the muscles from the LegTD data set are correctly oriented in relation to the pelvic bone. This change was necessary after the rotation was removed from the ARel of the HipNode

- Changed naming of muscles branches to improve logic, the following muscles were changed:
    - VastusMedialisSuperior10Par to VastusMedialisSuperior6Par
    - VastusMedialisSuperior9Par to VastusMedialisSuperior5Par
    - VastusMedialisSuperior8Par to VastusMedialisSuperior4Par
    - VastusMedialisSuperior7Par to VastusMedialisSuperior3Par
    - VastusMedialisSuperior6Par to VastusMedialisSuperior2Par
    - VastusMedialisSuperior5Par to VastusMedialisSuperior1Par
    - VastusMedialisMid4Par to VastusMedialisMid2Par
    - VastusMedialisMid3Par to VastusMedialisMid1Par
    - VastusLateralisSuperior8Par to VastusLateralisSuperior2Par
    - VastusLateralisSuperior7Par to VastusLateralisSuperior1Par
    - AdductorBrevisDistal6Par to AdductorBrevisDistal2Par
    - AdductorBrevisDistal5Par to AdductorBrevisDistal1Par
    - AdductorBrevisMid4Par to AdductorBrevisMid2Par
    - AdductorBrevisMid3Par to AdductorBrevisMid1Par
    - SoleusLateralis6Par to SoleusLateralis3Par
    - SoleusLateralis5Par to SoleusLateralis2Par
    - SoleusLateralis4Par to SoleusLateralis1Par

- Added bony landmark based coordinate systems (anatomical frames) for the hip, knee, and ankle complex, for both in the proximal and distal segment. These coordinate systems are based on recommendations by the International Society of Biomechanics. (See ISB proposal by G. Wu, S. Siegler, P. Allard, C. Kirtley, A. Leardini, D. Rosenbaum, M. Whittle, D. D'Lima, L. Cristofolini, H. Witte, O. Schmid, I. Stokes. J. Biomech. 35(4):543-548, 2002)
    - Thigh.HipJointAnatomicalFrame
    - Thigh.KneeJointAnatomicalFrame
    - Shank.KneeJointAnatomicalFrame
    - Shank.AnkleJointComplexAnatomicalFrame
    - Foot.AnkleJointComplexAnatomicalFrame

Leg

The hip joint rotation sequence recommended by the International Society of Biomechanics (ISB) for has been implemented. However, with one exception, zero degree hip flexion is set to be the neutral anatomical position, which is not the case for the ISB joint coordinate system. The old sequence can be reactivated by setting the flag #define USE_AMMR14_HIP_ROTATIONS

Arm

Wrapping surface for Oleacron has been redefined to make use of the new five point fitting script which can be found in ToolBox/WrappingSurfaces

ToolBox

MOCAP

ForcePlateType2.any and ForcePlateType2AutoDetection.any: Changed the scale factor visualizing the ground reaction force vector. Automatic switch implemented to cover two data formats available for this type. In old Force Plate Type2 data, the origin of the force platform is different from that of recent systems. An AnyMessage is automatically created when its Origin has positive Z value.

SolidModeling

New tool for creating spheres, cylinders and box with correct shape and inertia properties.

WrappingSurfaces

New tool for fitting a cylinder using five points has been added, this is used for fitting wrapping surfaces.

FrictionContactMuscles

The visualization of the trigger cylinder has been changed to ensure it is always displayed correctly