The new Glasgow-Maastricht AnyBody foot model

Sylvain Carbes
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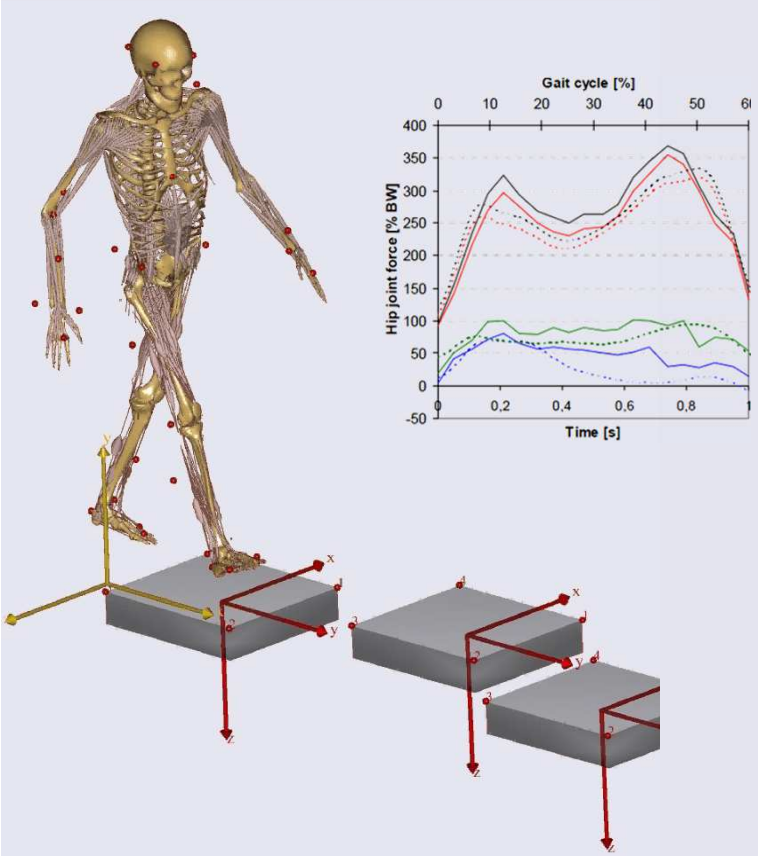
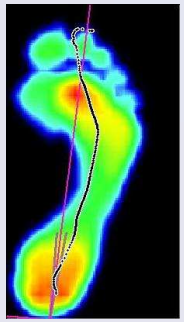
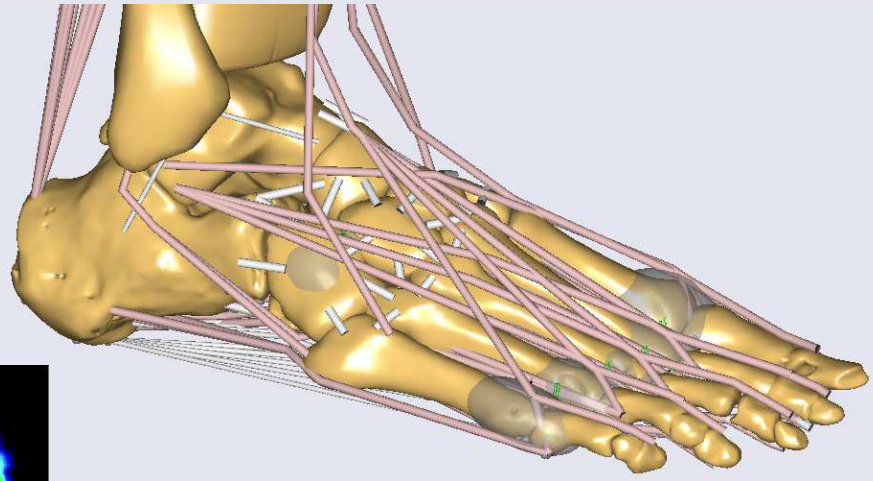
The web cast will start in a few minutes….



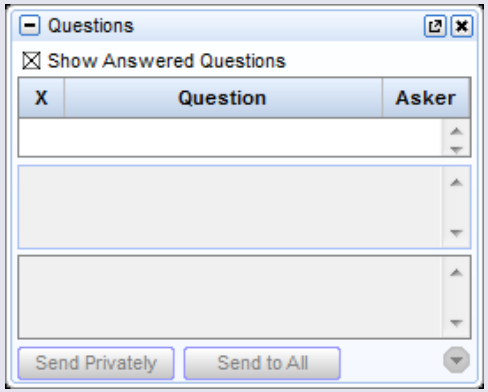




ANYBODY TECHNOLOGY

Agenda & Presenters

- Who and what is AnyBody?
- Why a foot model?
- Foot model
- Validation
- Live demonstration
- Applications of the model
- Q & A



Sylvain Carbes
(Presenter)

Arne Kiis
(Host/Panelist)

Amir Al-Munajjed
(Panelist)

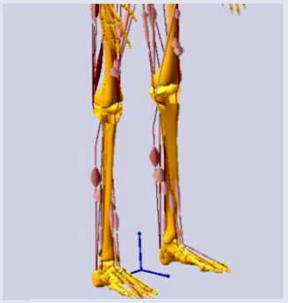
ANYBODY
TECHNOLOGY

AnyBody Technology

- Software licenses
- Consulting
- Training
- Support
- US Office
- AnyGait

2002

2006



2010

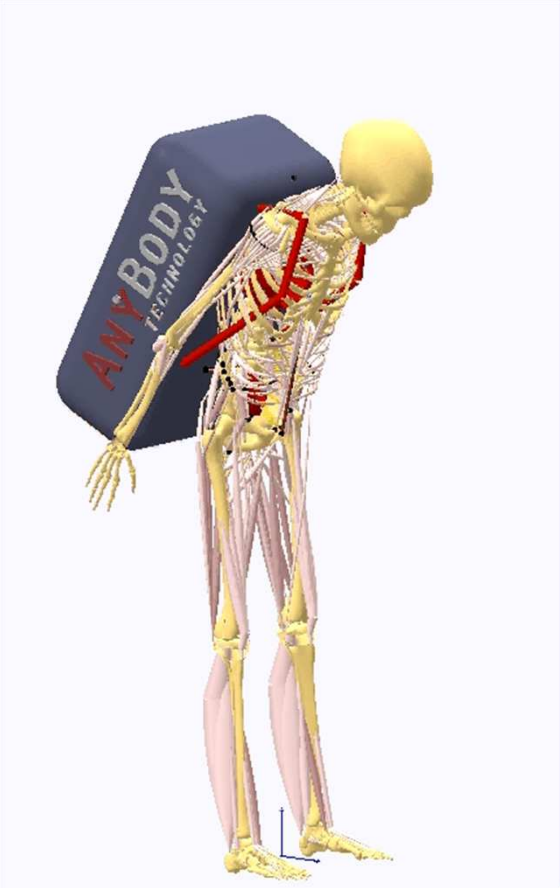
2011

2012

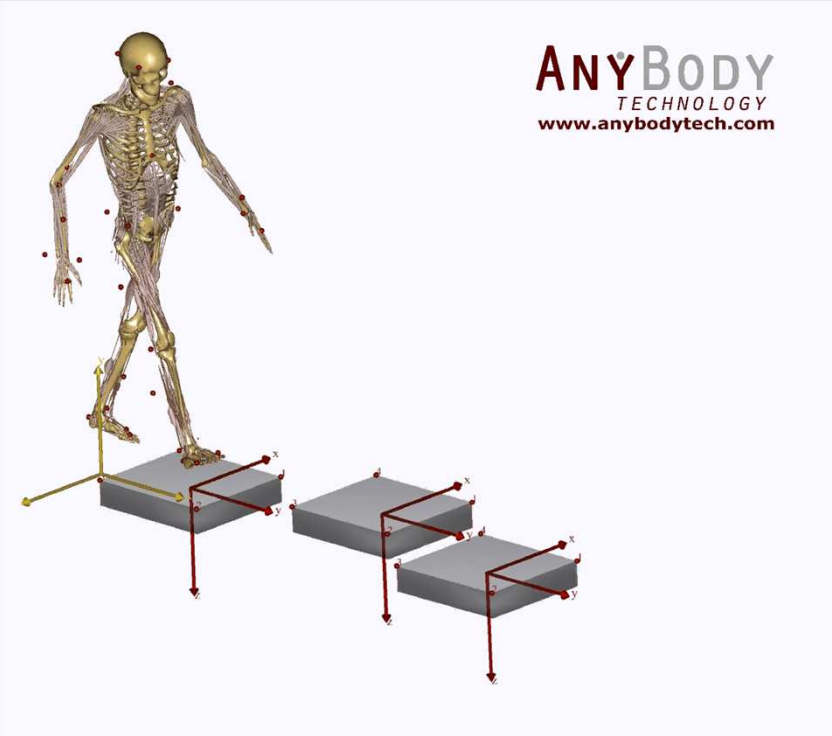
ANYBODY TECHNOLOGY

AnyBody Modeling System

- Developed in-house for musculoskeletal analysis
- Self-contained system
- Interfacing to
  - motion capture
  - image-based bone and muscle data
  - finite-element software
  - CAD software
  - office systems
- Open body model
- Broad and deep model validation
- API for imbedded use

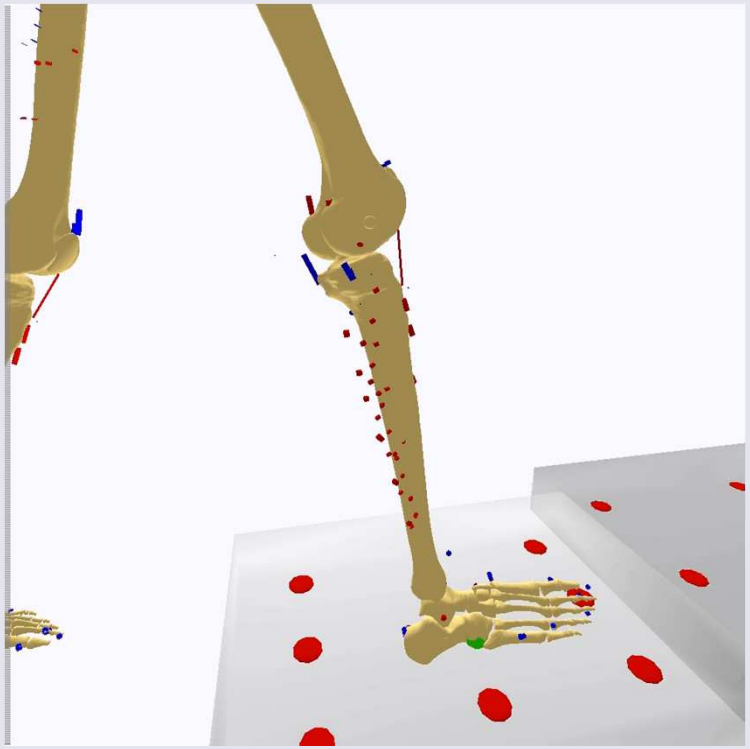


AnyBody Modeling System



Motion & ext Forces as Input:

- Motion Capture (Vicon, Qualisys...)
- Joint Angle Input

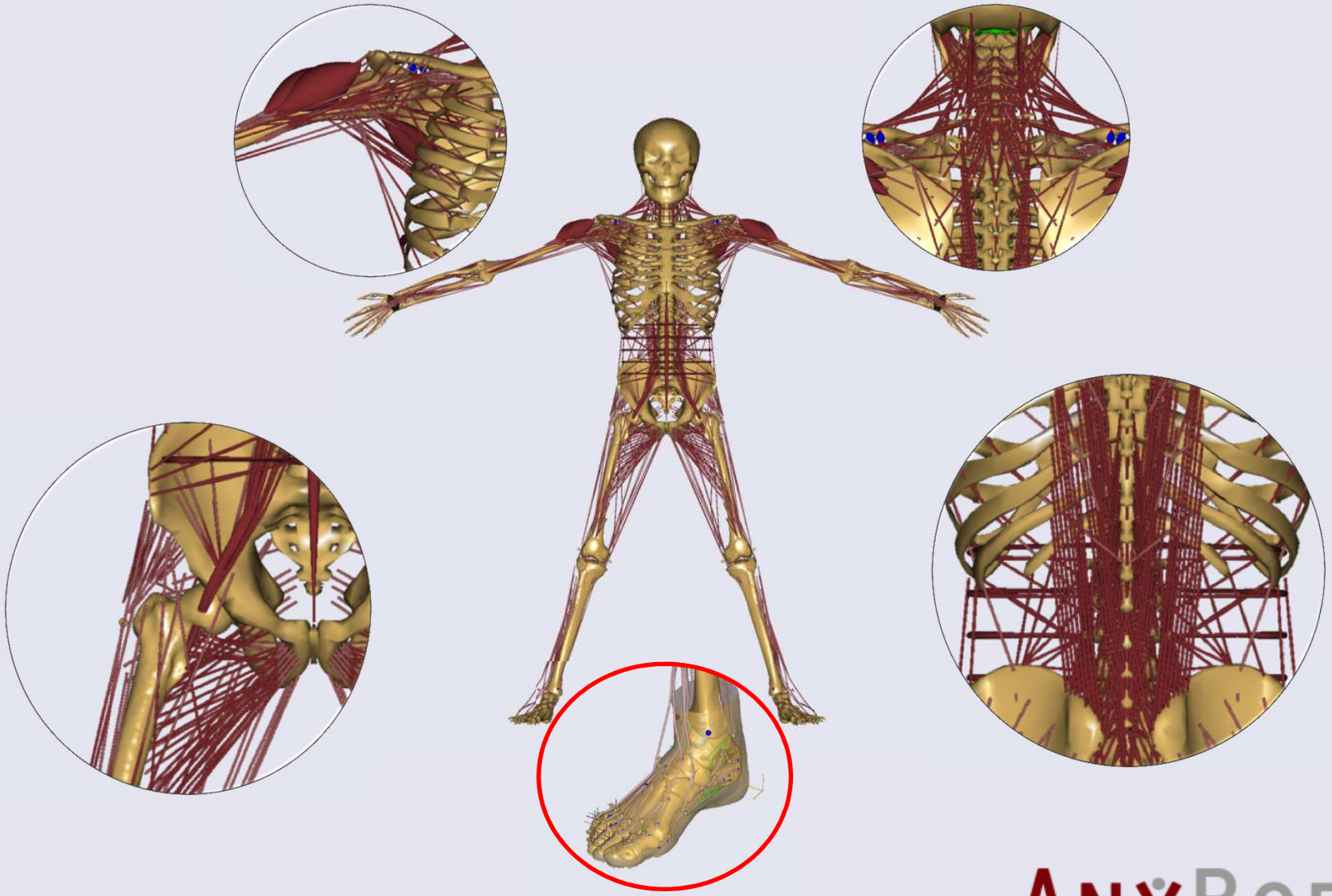


Forces as Output:

- Muscle Forces (activations)
- Joint Reaction Forces

ANYBODY
TECHNOLOGY

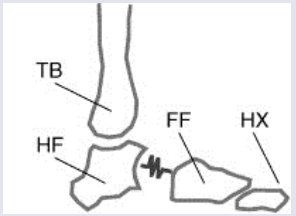
The AnyBody Managed Model Repository™



AnyBody TECHNOLOGY

Why a foot model?

- Develop ankle/foot and foot orthoses personalized for better fit and comfort and functional performance.
- A detailed human musculoskeletal body model is avaiable for all body parts except the foot.
- Only simple foot models with 1-5 bone segments are available (Oxford Foot Model).



- In order to study the inside biomechanics of the foot a highly detailed model is required.
- The Glasgow-Maastricht foot model is a fully detailed model with all 26 bones of the human foot and the corresponding joints. It also includes all intrinsic and extrinsic muscles, and major ligaments.

ANYBODY TECHNOLOGY

The people involved

- Developed by AnyBody Technology in cooperation with the Glasgow Caledonian University and University Hospital Maastricht, which provided data such as gait trials and CT scans.

- The work is part of the *A-FOOTPRINT* project: www.afootprint.eu
  (funded by the European Commission Framework 7 Programme, under the Nanosciences, Nanotechnologies, Materials and New Production Technologies theme, Grant Agreement Number: NMP2-SE-2009-228893)

SEVENTH FRAMEWORK PROGRAMME

a-footprint

GCU Glasgow Caledonian University

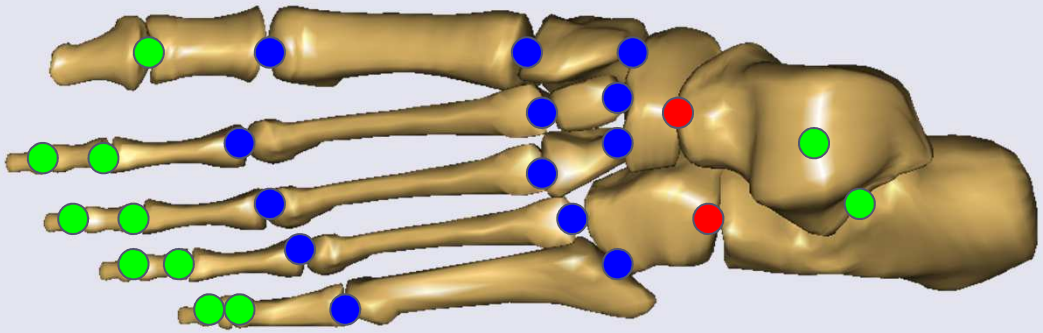
Maastricht UMC+ azM | Maastricht University

ANYBODY TECHNOLOGY

Foot model structure – bones and joints

- 26 segments, including all the bones.
- 26 idealized joints of type revolute, universal or spherical.
- Data from literature:joint type, location and orientation

  (Winson et al. 1995, MacWilliams et al. 2003, Arampatzis et al. 2003, Magee 1997, ...)



Revolute joints

Universal joints

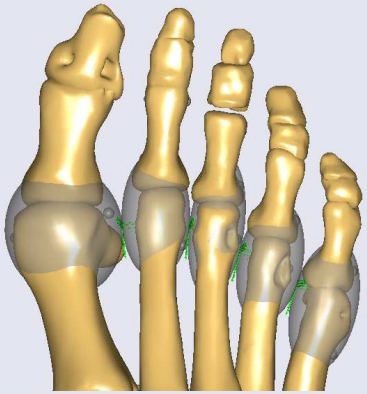
Spherical joints

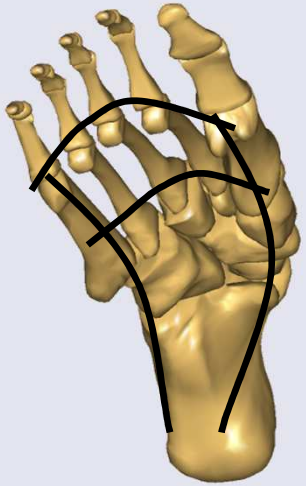
ANYBODY TECHNOLOGY

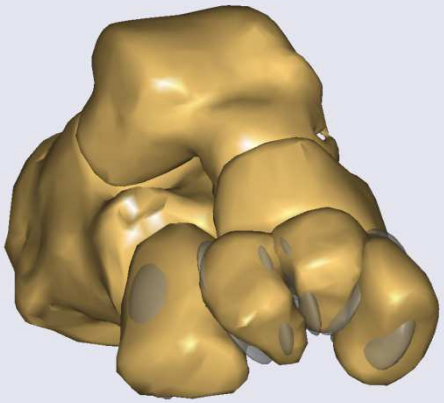
Foot model structure – additional kinematic features

More advanced kinematic constraints (KC) are also added in order to better represent the complexity of the foot kinematic. KC decrease the number of DoF and makes the model easier to use:

- Tarsal bones lateral contact
- Metatarsal heads lateral contact
- Arch curvature (metatarsal transverse, tarsal transverse, longitudinal medial, longitudinal lateral)

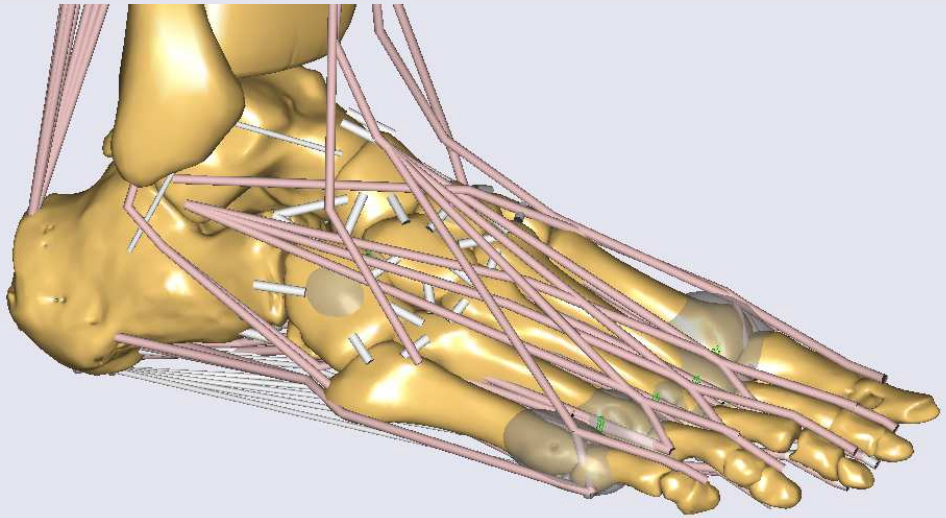


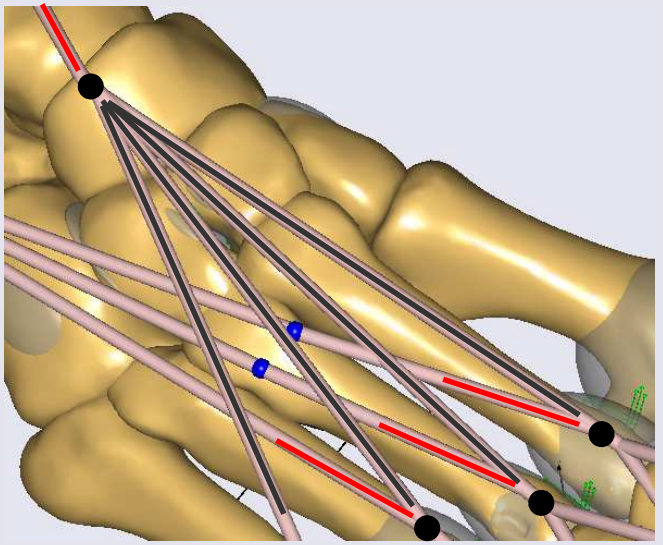




ANYBODY TECHNOLOGY

Foot model structure – muscles and ligaments





• Intrinsic and extrinsic muscles modeled, including complex structures like tendons spliting and blending.

• All major ligaments included

• Data from literature: origin/insertion, mechanical properties

(Lachowitzer et al. 2007, Kura er al. 1997, Funk et al. 2000, Wright 1964, ...)

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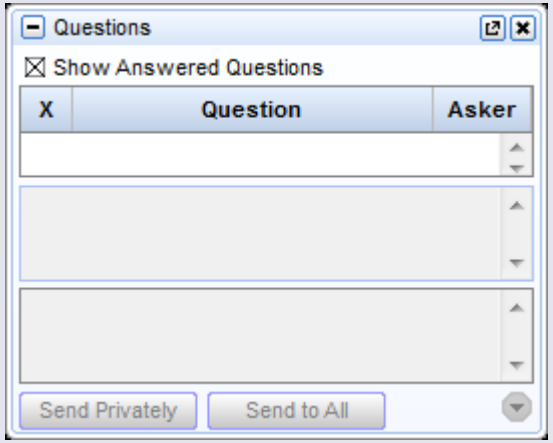
Foot model availability and documentation

Planned release date of Glasgow-Maastricht foot model:

- November 2012 as beta.

Detailed Documentation on:

- Joint types
- Ligaments
- Muscles
- Literature References (all data sources)



Keep an eye on our web sites for further informations:

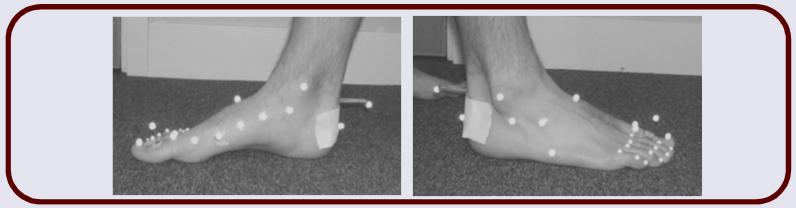
http://www.anybodytech.com/

http://www.anyscript.org/

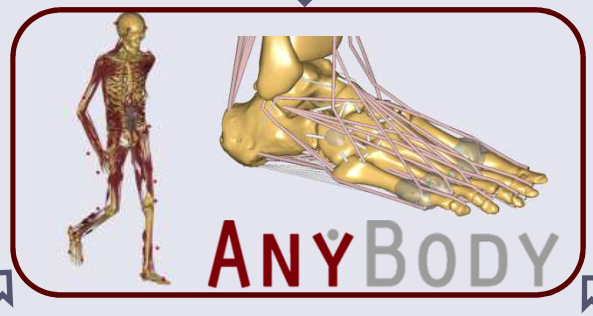
sales@anybodytech.com

ANYBODY TECHNOLOGY

Use of the Glasgow-Maastricht foot model

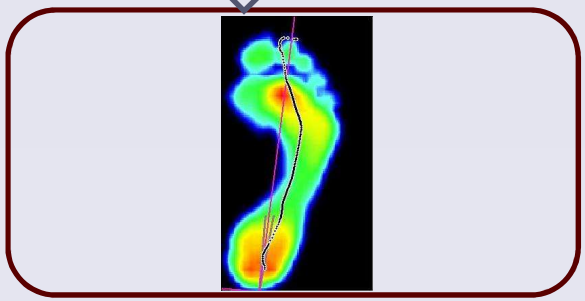


Motion: Mocap experiment

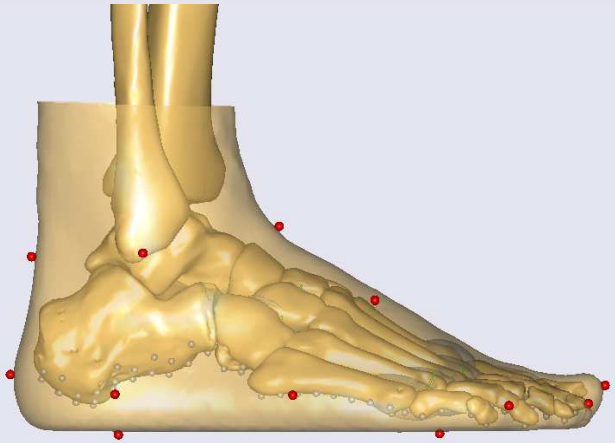


Patient geometry:
- Skin surface scan
- Bone CT scan

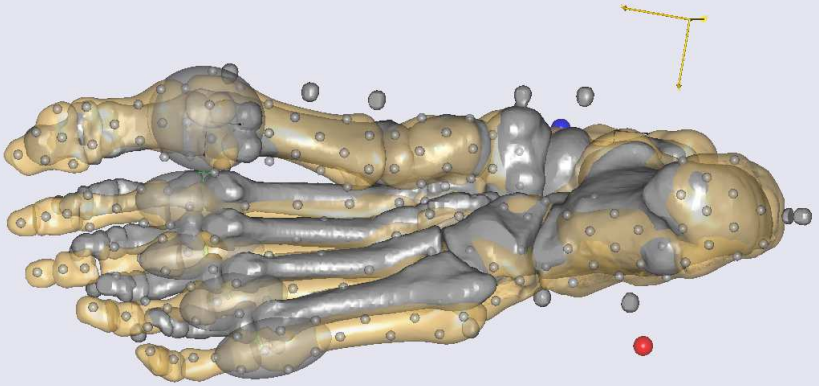
Boundary conditions:
- pressure plate only
- pressure plate + force plate

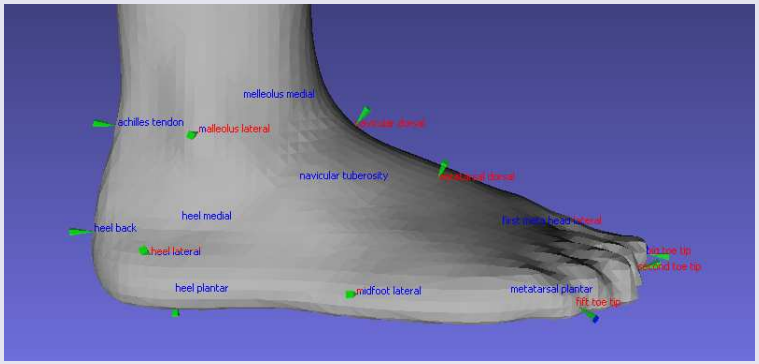


Scaling of the foot model

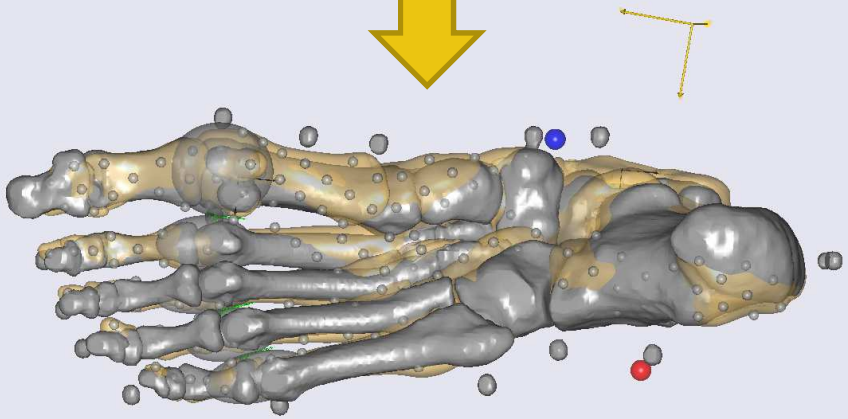


Original 16 skin landmarks on standard model.





Target 16 skin landmarks on patient's surface scan.



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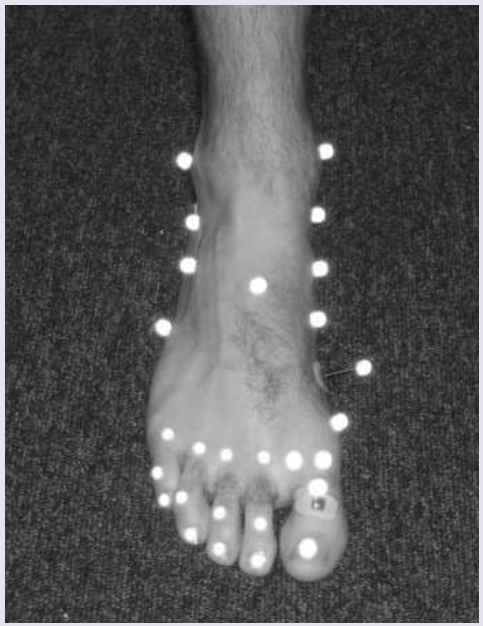
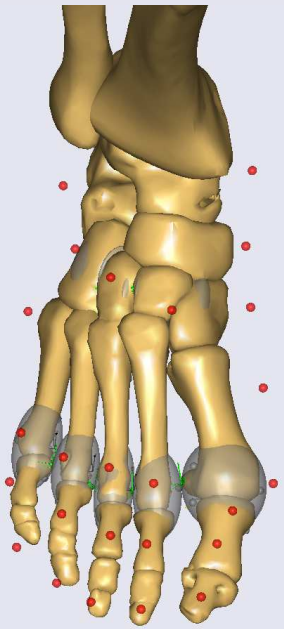
Use of the foot model – applying motion

- Motion applied using Motion Capture data.
- Foot marker protocol developed with Glasgow and Maastricht universities was used (containing 28 markers covering all the needed DoF)*.



Marker set on the experiment.

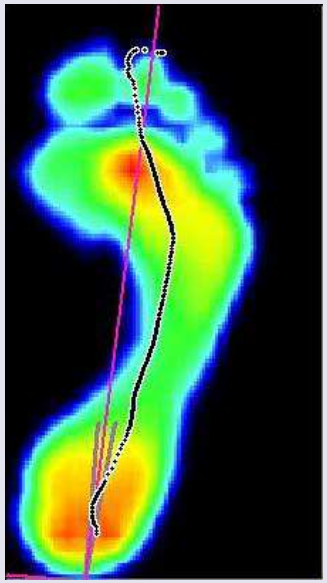


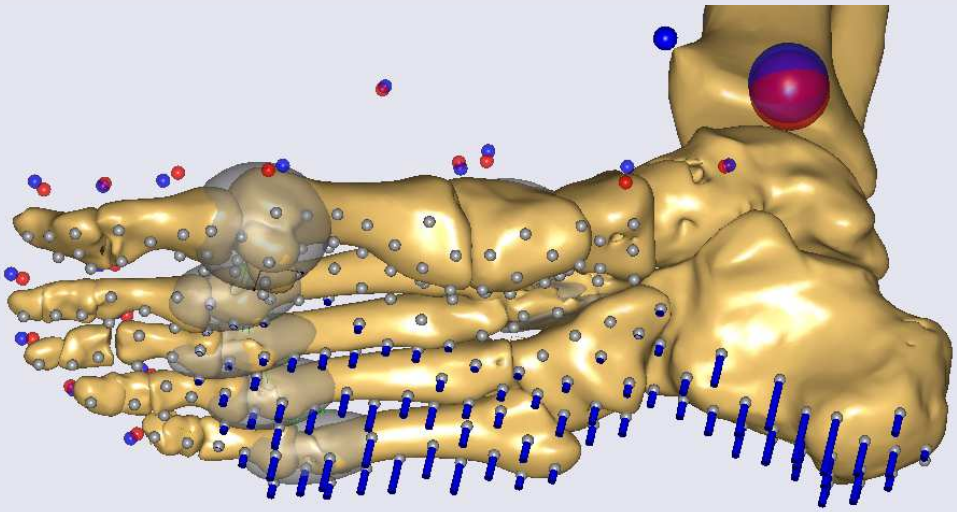
Marker set on the model.

*Oosterwaal, M., Telfer, S., Tørholm Christensen, S., Carbes, S., van Rhijn, L., Macduff, R., Meijer, K. & Woodburn, J. (2011), "Generation of subject-specific, dynamic, multisegment ankle and foot models to improve orthotic design: a feasibility study", BMC Musculoskeletal Disorders 12, 256.

ANYBODY TECHNOLOGY

Use of the foot model – applying boundary conditions (ground reaction force)





- Measured ground reaction force applied according to plantar pressure map.
- Series of time-varying 3D forces is computed and applied to all 26 segments.
- Pressure sensitive plate can be combined with a force plate for higher accuracy.

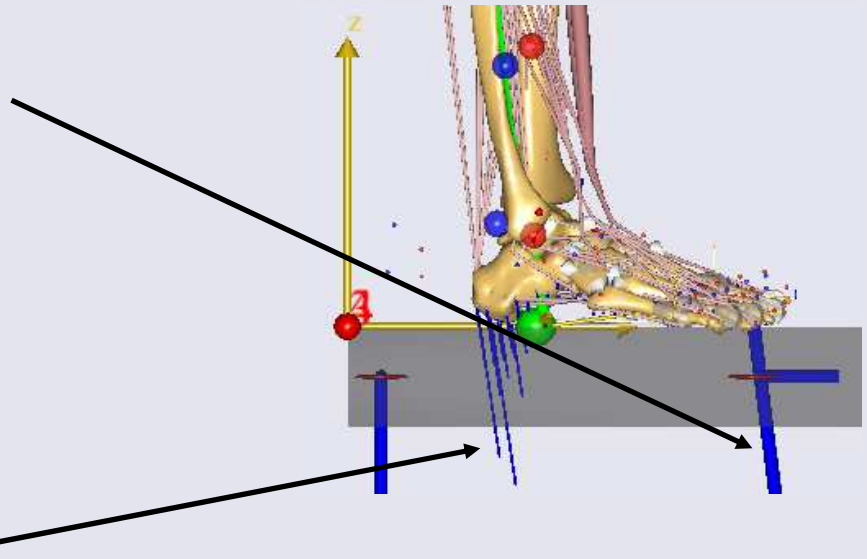
ANYBODY TECHNOLOGY

Use of the foot model – applying boundary conditions (ground reaction force)

Pressure plate + force plate

The force plate gives the direction of the resultant force.

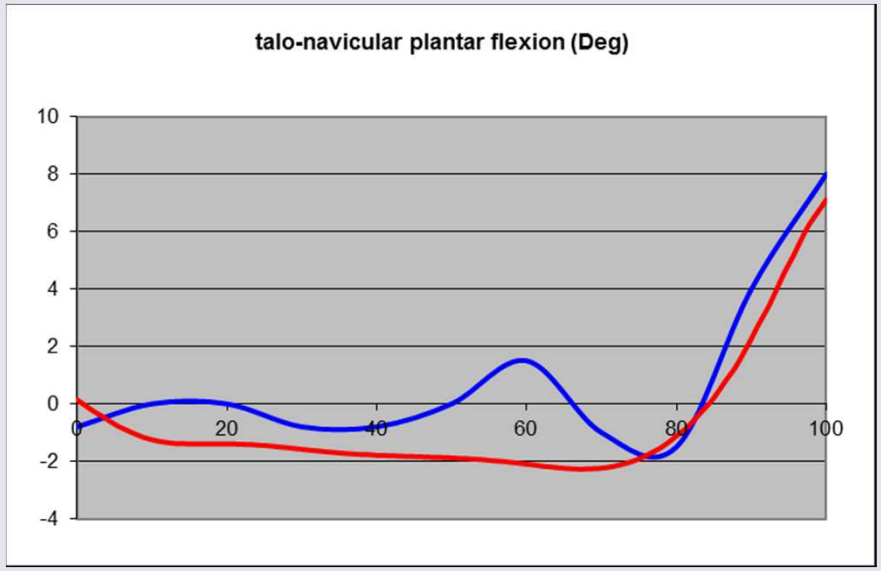
The pressure plate gives the distribution on the plantar surface.



ANYBODY TECHNOLOGY

Validation – RoM/ joint angles

— Predicted by AnyBody — Measured by bone pins*

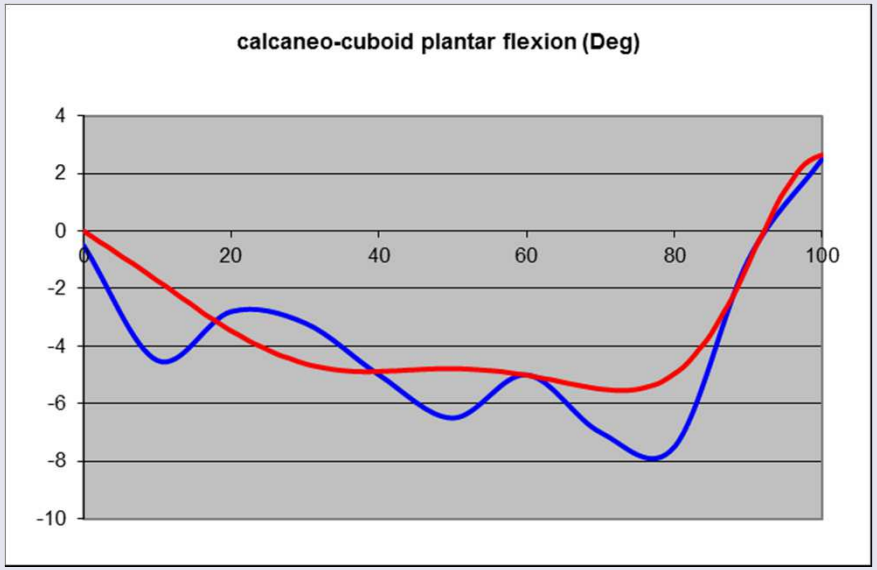


Predicted by AnyBody:

9 Deg

Measured by bone pins :

10 Deg



Predicted by AnyBody:

8.5 Deg

Measured by bone pins :

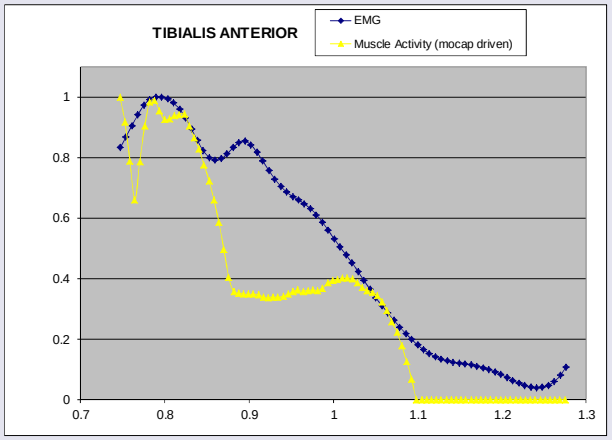
10.5 Deg

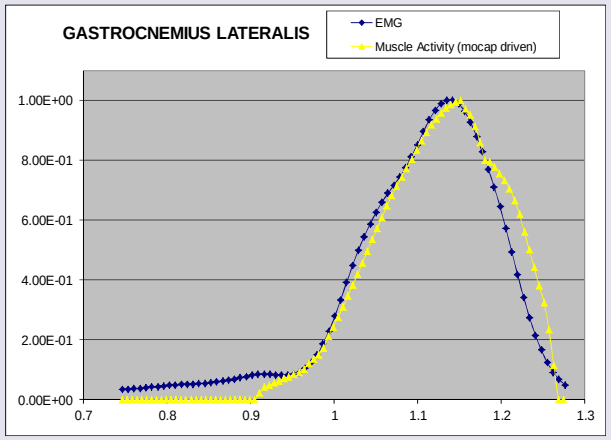
*Data reprinted from:

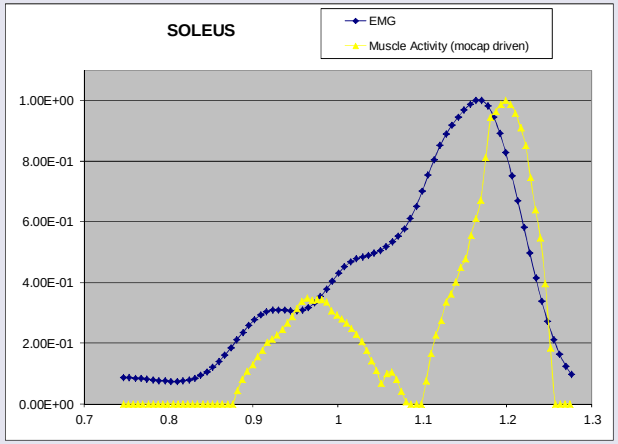
Lundgren et al. (2008). Invasive in vivo measurement of rear-, mid- and forefoot motion during walking.

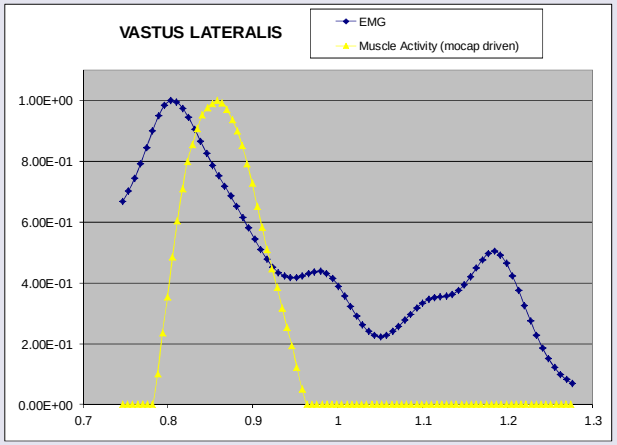
ANYBODY TECHNOLOGY

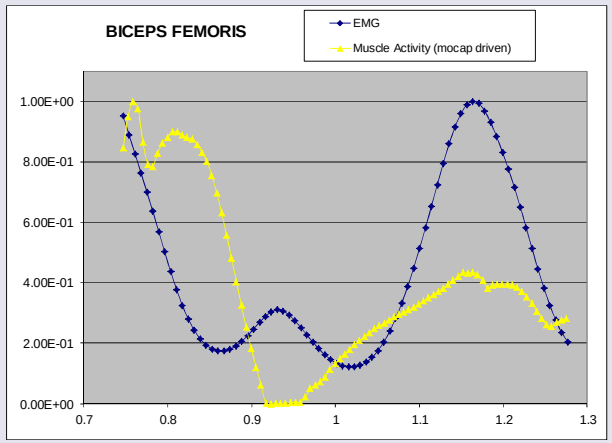
Validation - EMG





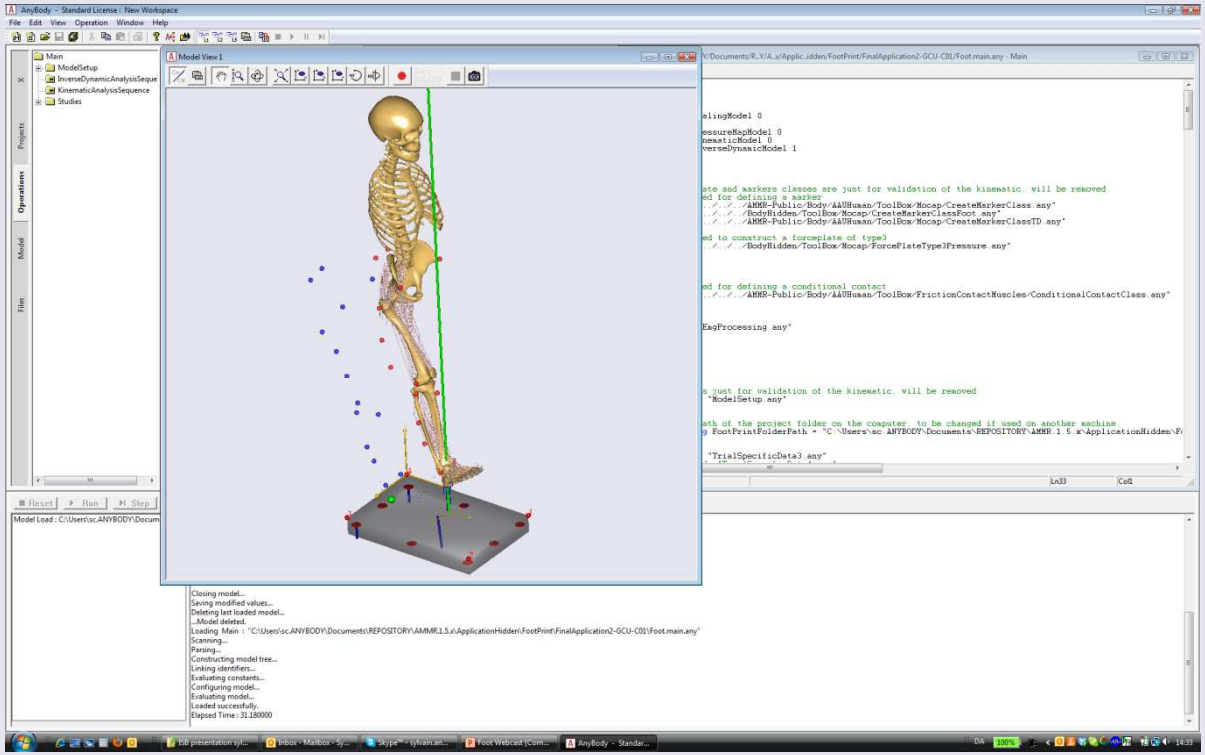






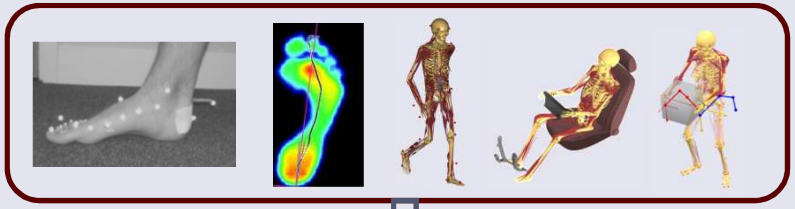
ANYBODY TECHNOLOGY

Live demonstration

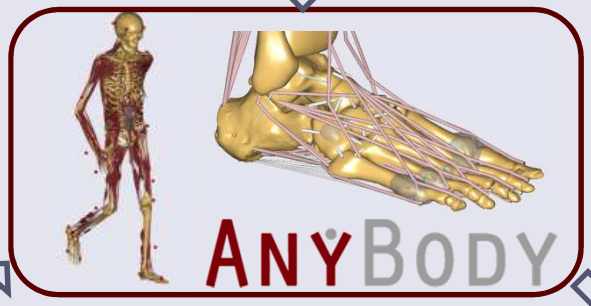


ANYBODY TECHNOLOGY

Applications of the model: patient specific FE load case



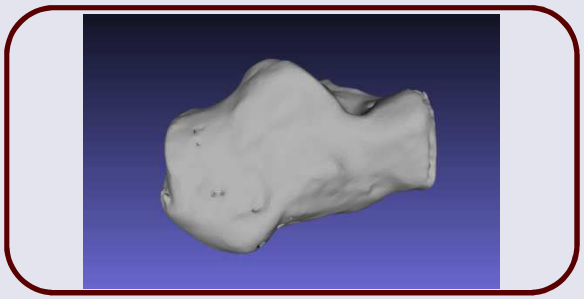
Activities of daily living



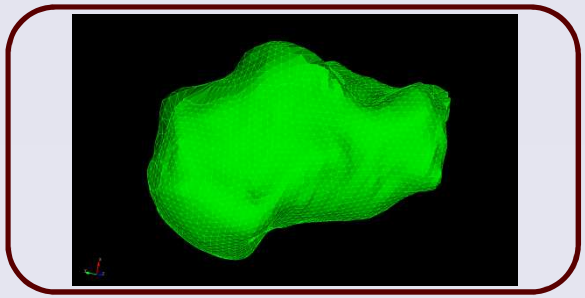
Patient information

Model information
Boundary conditions

Boundary conditions



FE-model



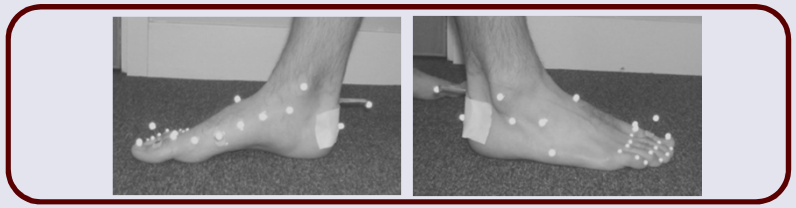
See also : The New Release of the AnyBody Modeling System, version 5.2 (Amir A. Al-Munajjed, 28. June, 2012)

Applications of the model

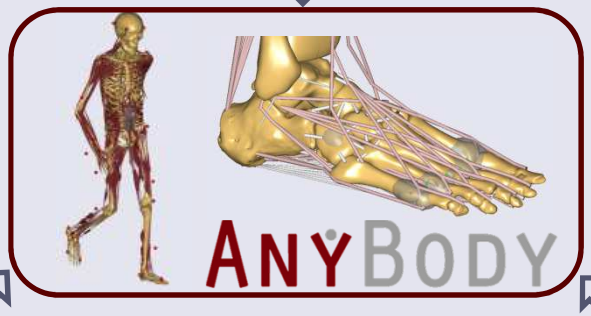
- Orthopaedics and Trauma Surgery
  - Fracture fixation plates
  - Joints
  - Helix fractures
- Shoe and Insole development
- AFO (ankle foot orthotics)
- Exoskeletons
- Gait Applications

ANYBODY TECHNOLOGY

Work in progress

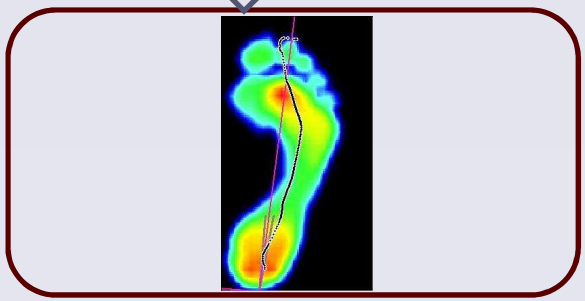


Motion: Mocap experiment

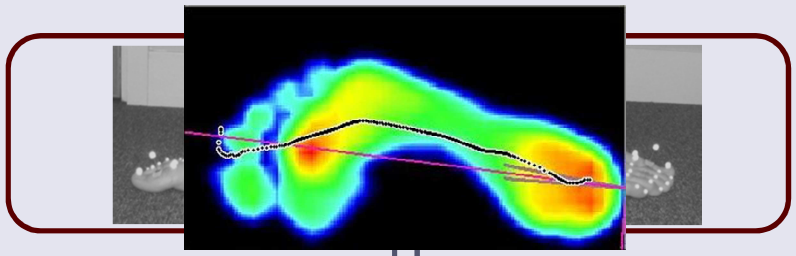


Patient geometry:
- Skin surface scan
- Bone CT scan

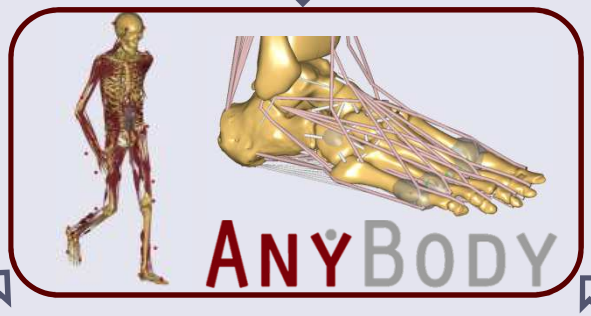
Boundary conditions:
- pressure plate only
- pressure plate + force plate



Work in progress



Motion: from pressure



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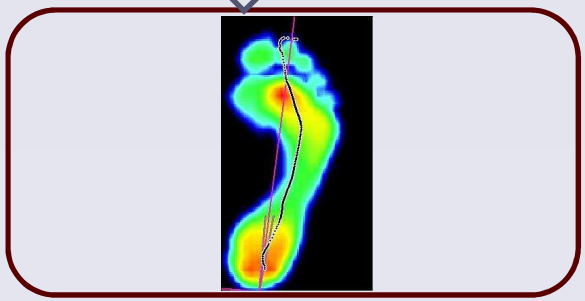
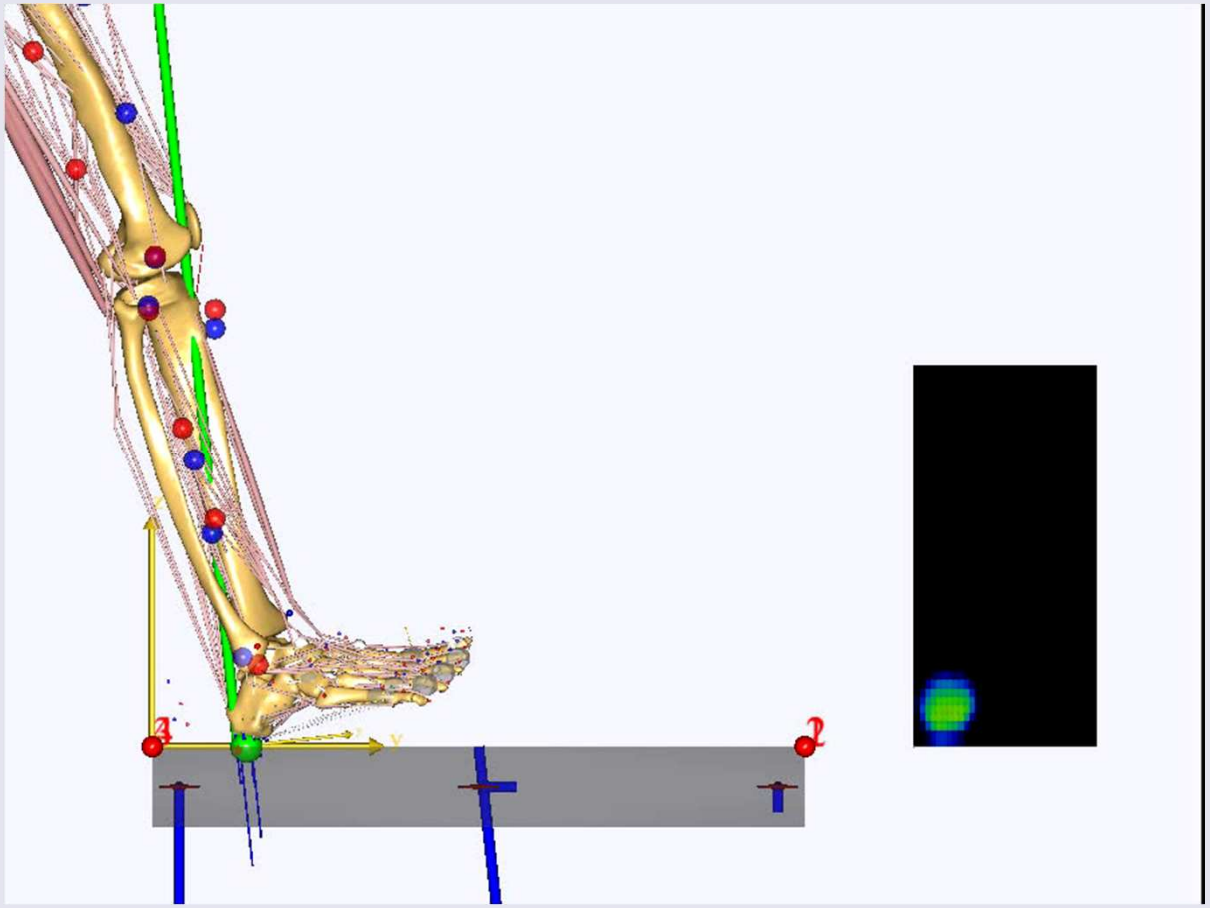


Results – motion generated by dynamic pressure



Work in progress

ANYBODY TECHNOLOGY

Summary

- A new detailed foot model has been developed
  - 26 kinematically seperate segments, intra-foot joints, muscles and ligaments
  - Providing detailed biomechanic information in the foot
  - Beta release planned November 2012
- Preliminary validation
  - Compared to in vivo Gait results
- Potential applications in shoe development, insole design, orthotics and foot ortopedics

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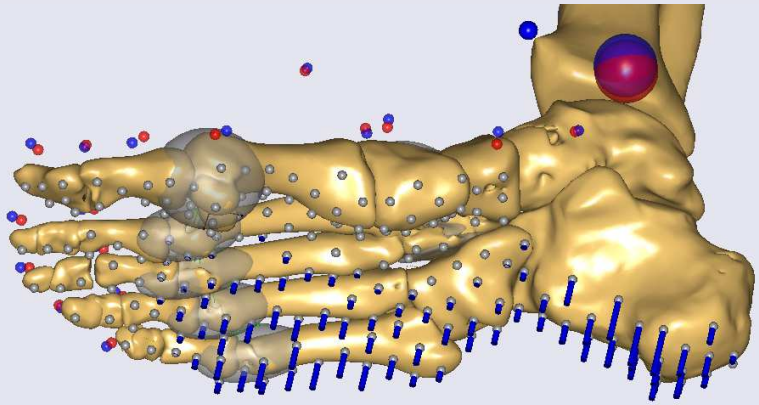
Q & A



Thank you for your attention!

www.anybodytech.com
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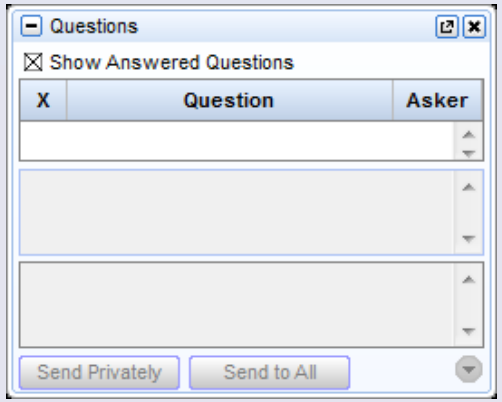

You can write your questions in the Q&A panel.

Don’t miss our next webcast:

- 17th Oct: SolidWorks2AnyBody: A new powerful SolidWorks add-in application to translate your CAD model into The AnyBody Modeling System
- 7th Nov: Orthopedic Applications in the Spine

Meet AnyBuddies at:

- 26-28 Sep: EORS, Amsterdam, Netherlands
- 23-26 Oct: DKOU, Berlin, Germany
- 02-04 Nov: AAHKS, Dallas, TX

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Publications

Sylvain Carbes, Søren Tørholm, Scott Telfer, Jim Woodburn, Michiel Oosterwaal, John Rasmussen, "A NEW MULTISEGMENTAL FOOT MODEL AND MARKER PROTOCOL FOR ACCURATE SIMULATION OF THE FOOT BIOMECHANICS DURING WALKING “, ISB 2011 proceedings

Oosterwaal, M., Telfer, S., Tørholm Christensen, S., Carbes, S., van Rhijn, L., Macduff, R., Meijer, K. & Woodburn, J. (2011), "Generation of subject-specific, dynamic, multisegment ankle and foot models to improve orthotic design: a feasibility study", BMC Musculoskeletal Disorders 12, 256.

And others here: http://www.anybodytech.com/publications.html

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