Occupant Modelling for Impact Biomechanics

Injury Prediction in Railway Vehicles

by

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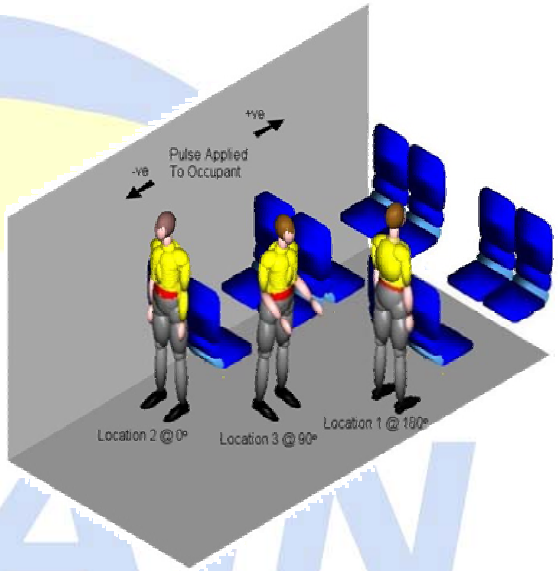
Railway Occupant Biomechanics versus Road Vehicle Occupants



Seating Position:

- Front facing seating positions.
- Side facing seating positions.
- Standing passengers
- Out-of-position occupants (???).

Vehicle Interiors:

- Tables between seats.
- Poles and rails.
- Seats without structural energy absoption.

Restraint and Protection Systems:

- No restraint systems are used.
- No devices such as air-bags.
- Seats/furniture without structural energy absoption.

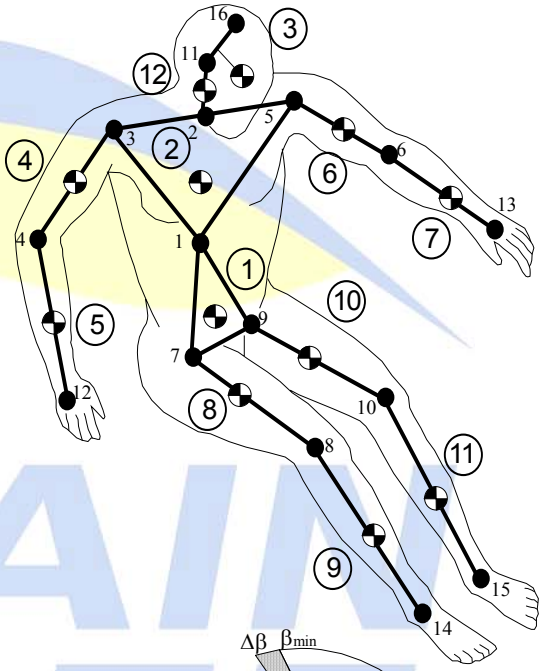
Biomechanical Models for Impact

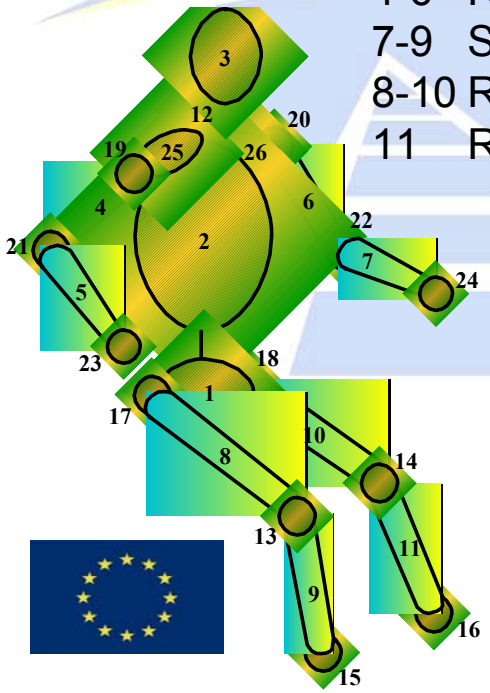
Biomechanical Characteristics

12 Rigid bodies

29 degrees-of-freedom

Joint	Type	Description
1	Spherical	Back, (12th thoracic and 1st lumbar).
2	Spherical	Torso-Neck (7th cervical + 1st thoracic)
3-5	Spherical	Shoulder.
4-6	Revolute	Elbow.
7-9	Spherical	Hip.
8-10	Revolute	Knee.
11	Revolute	Head-Neck, (at occipital condyles).



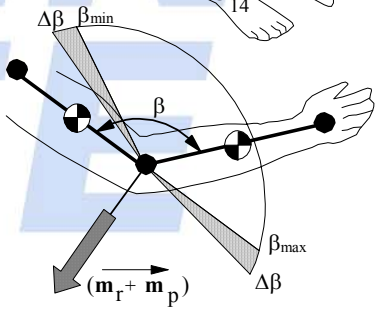


Contact Surfaces

The contact surfaces are used to describe the occurrence of contact.

Contact surfaces are defined by an ellipsoid.

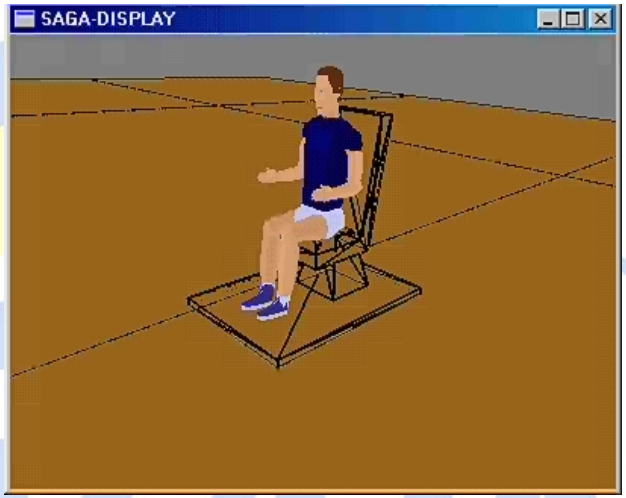
One or more ellipsoids define each segment



Biomechanical Models for Impact

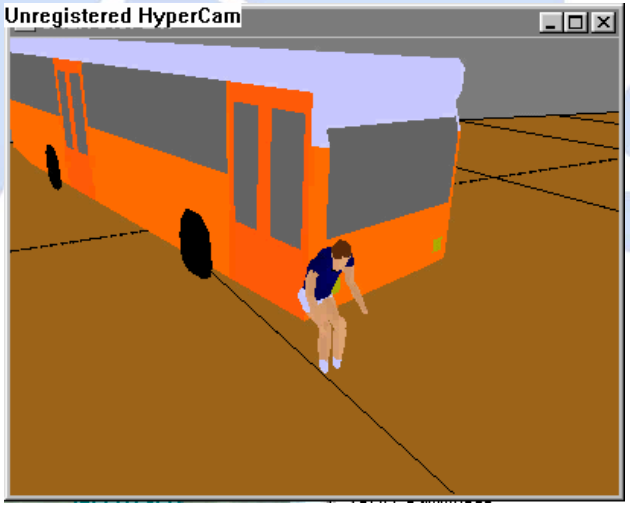
Road Vehicle Applications

- Restrained occupant

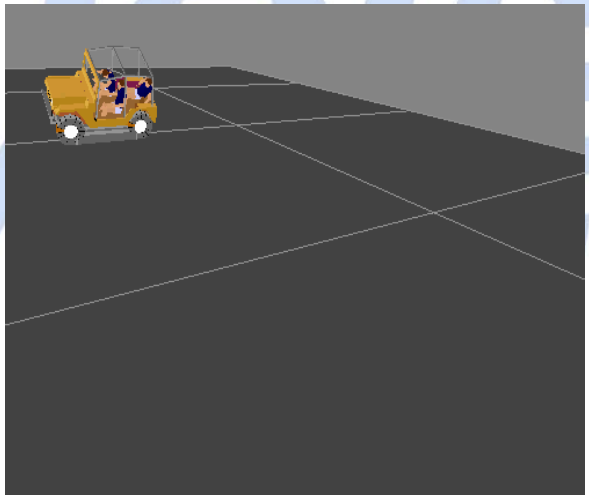


Complex Application Cases

- Pedestrian sidesweep

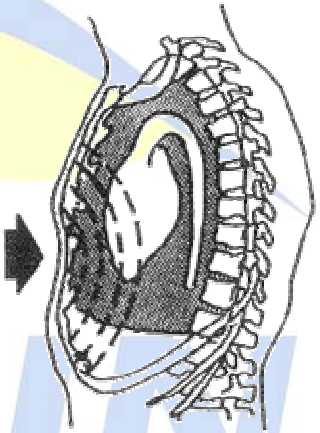


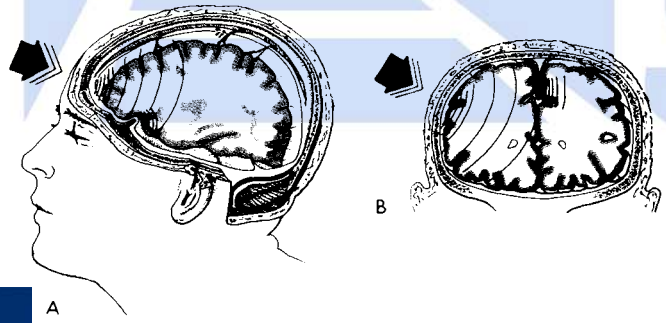
- Vehicle rollover

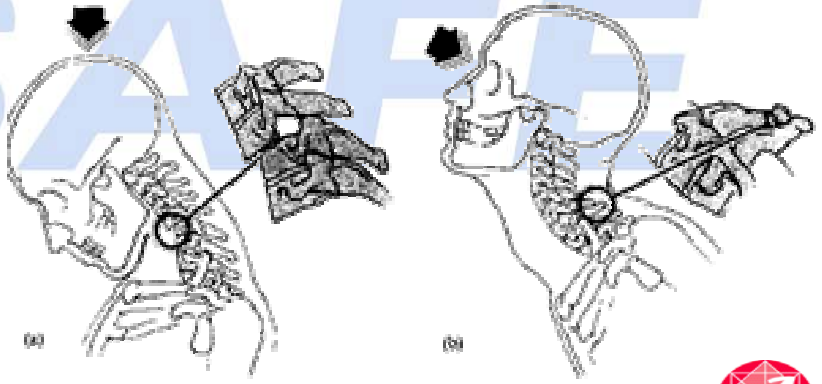


Injury Biomechanics

- Response of the brain within the skull to frontal and lateral head impact
- Downward impact on the head can flex or extend the neck with the potential for fracture-dislocation of the vertebrae and damage to the spinal cord
- Compression of the chest or abdomen cause injury if the elastic tolerances are exceeded
- Impulsive shock cause shock waves that may lead to injury if the viscous tolerances are exceeded
- Excessive acceleration leads to tearing of the internal structures

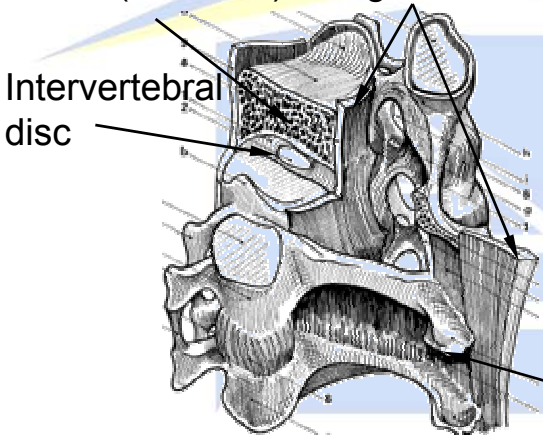






Modeling Requirements for Railway Vehicle Occupants

- Important to model muscle voluntary contraction
- Important to have more detailed human body for injury prediction



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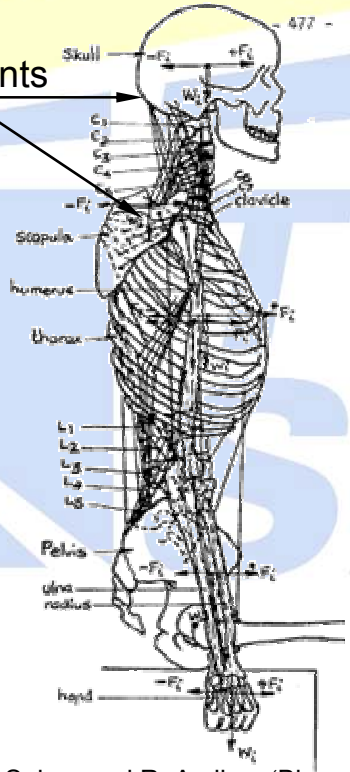
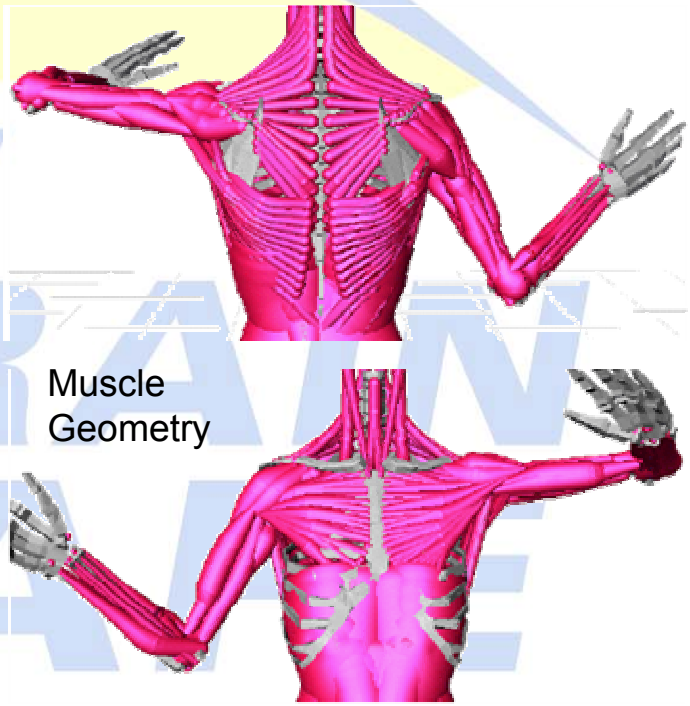


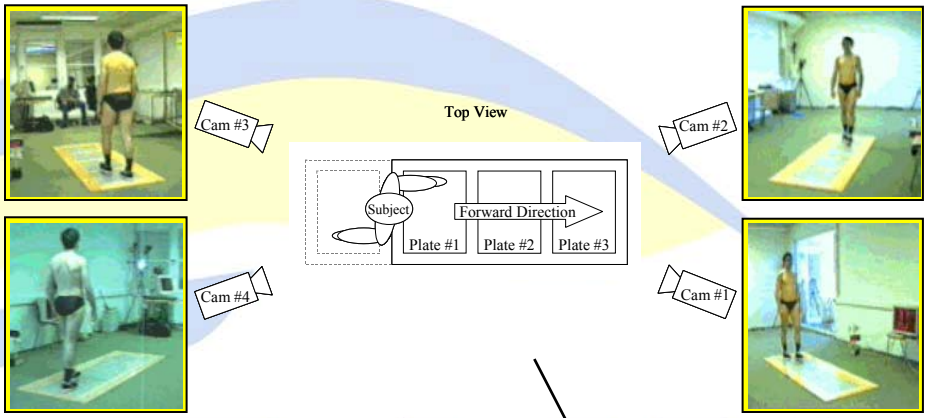
In: A. Seireg and R. Arvikar, 'Biomechanical Analysis of the Muscoloskeletal Structure for Medicine and Sports', Hemisphere Pub. Corp., New York, New York, 1989

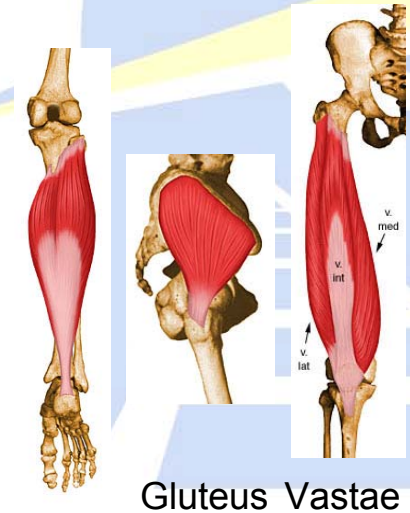


In: Walter Murial, '3D Modeling of the Human Upper Limb Including the Biomechanics of Joints, Muscles and Soft Tissues, Ph.D. Thesis, Ecole Polytechnique Federal de Lausanne, Lausanne, Switzerland, 1999

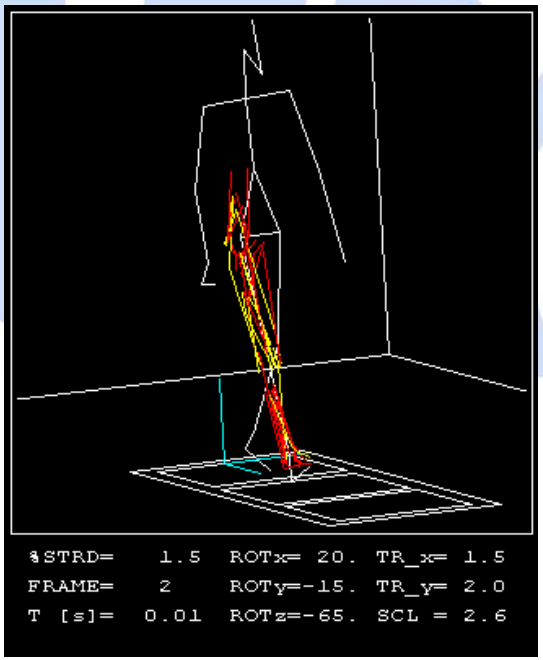
Muscle Forces Prediction

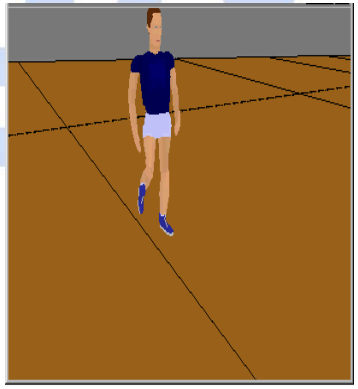
- Data Acquisition
- Motion reconstruction
- Muscle force sharing prediction





Soleus Gluteus Medius Vastae Family





Wish List For Biomechanical Models Features for Railway Passive Safety

Biofidelity:

- Detailed description of the anatomical segments.
- Realistic representation of the geometrical and material features of the body segments.
- Good model for the neck and trunk including bones, ligaments, spinal discs and joints
- Biofidelic muscle models that include reflexive and voluntary contraction.

Others:

- Improved Injury Indexes for the different segments of the human body.
- A testing program for railway vehicle occupants able to identify voluntary joint stiffening and voluntary muscle contraction.
- Better description of the geometrical and material features of the vehicle interiors.

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