The VAKHUM Project

Virtual Animation of the Kinematics of the Human

DATABASE ACCESS (*in construction*):

http://www.vakhum.com

VAKHUM **project:**

http://www.ulb.ac.be/project/vakhum

The VAKHUM project has developed an interactive database of Human Kinematics for industrial, educational and research purposes. Users can access the database through a virtual interface and download high-quality data for their own applications, or take an online class on Functional Anatomy. The data analysis procedures used also provided important advances in solving theoretical problems.

Introduction

The study of the Human Kinematics is an important field, and many unknowns remain to be determined and explored. Currently, very little accurate data on Human Kinematics and Bone morphology is readily available.

Industrial and biomechanical researchers all need reliable data for their applications. One of the main goals of the VAKHUM project was to produce high-quality data according to a well-defined protocol, and to make this data available to users. Full documentation about the accuracy of the data is also to be available.

Kinematics is a typical dynamic 3D phenomenon yet textbooks can only describe it in a 2D manner. Useful information is then lost for the students. The VAKHUM project has used the above data to develop tutorials on Functional Anatomy. These tutorials will be integrated into a multimedia environment accessible via the Internet.

The potential fields -of- application are numerous:

- **industry** using virtual models for testing (e.g. car safety, prosthesis)
- **education** (e.g. training of medical and bioengineering students, retraining of post-graduate professionals)
- **fundamental research** (e.g. better understanding of human kinematics within biomechanics)
- **virtual worlds** (e.g. populating virtual worlds with accurate humans for the video game industry).

Morphological data

Morphological data of human bones was collected from medical imaging, mainly by computerised tomodensitometry (CT-Scan). This allowed construction of very accurate 3D bone models (Figure 1).

Several kinds of data will be available from the VAKHUM database. Not only raw data, but also both surface and finite-element models will be included. Surface models are useful for 3D animations and /or education, for example.

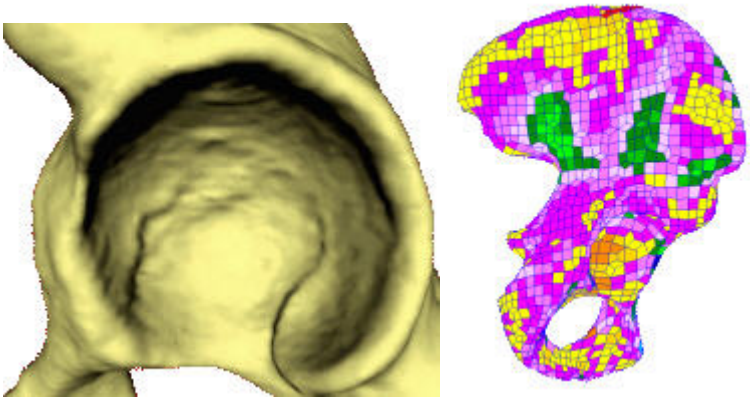
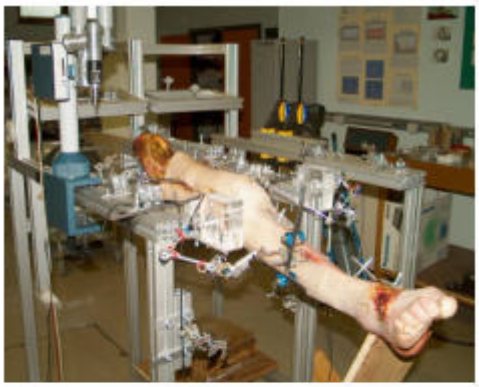


Figure 1. Left: Surface rendering of a 3D model of the acetabulum of an iliac bone. The image shows the great detail of the anatomical models. Right: Finite element models of the ileum. The various mechanical properties of the bone tissue, as derived from CT data, are represented as a colour-coded plot.

Finite elements meshes are used to simulate the deformation and the mechanical stresses induced within living tissues by performing different motor tasks.

They are essential in research, but also in clinical applications such as the evaluation of the risk of bone fracture, or the planning of complex musculo-skeletal surgery. Finite elements simulations are also useful to teach musculo-skeletal biomechanics.



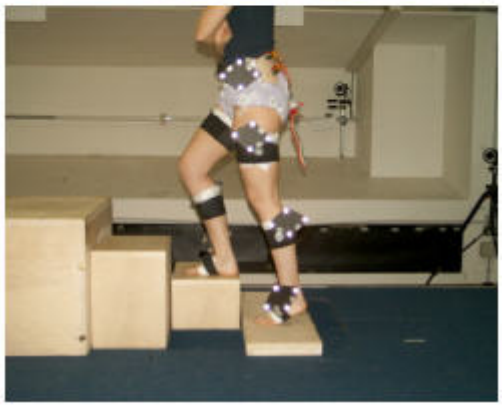


Figure 2. In-vitro electrogoniometry (top). In-vivo stereophotogrammetry (bottom).

Kinematics Data

Kinematics is the study of motion. As part of the VAKHUM project, the motion of the human lower limb was studied during several normal activities (walking, biking, stair climbing, stair descending, jumping).

Several techniques can be used to study a motion, each of them having its own advantages and disadvantages. For example, electrogoniometry (Figure 2, top)

can collect very accurate kinematics data at joint level. This data, associated with medical imaging within VAKHUM, brings useful information on human kinematics (Figure 3).

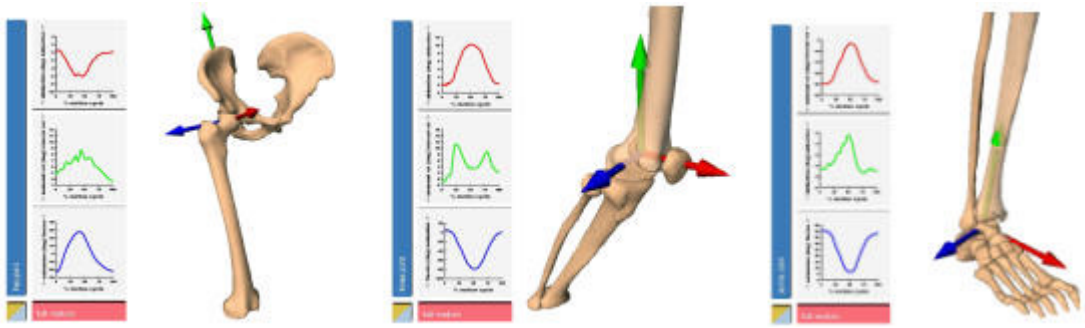


Figure 3. Joint kinematics. Studies of the joint kinematics for the hip (left), knee (middle) and ankle (right). Motion curves are displayed around each anatomical axes.

Unfortunately, electrogoniometry is difficult to use to study full-limb motion, so motion-capture devices using stereophotogrammetry (i.e. video cameras) have been used to study the absolute position and orientation oflower limb segments and relative angular displacement the relevant joints by tracking skin markers attached to volunteers during various activities (Figure 2, bottom).

Combining both in-vitro electrogoniometry and in-vivo stereophotogrammetry to animate 3D models collected from medical imaging produced several innovative features (Figure 4). The new techniques allowed not only a combination of different data sources, but also a comparison of results obtained from different protocols, which currently poses an accuracy problem in biomechanics owing to a lack of standardisation. Furthermore, the 3D models produced by VAKHUM are fully documented and established according the available guidelines from the International Society of Biomechanics (ISB).

Figure 4. Realistic simulation: three steps of a motion showing the lower limb skeleton rising from a chair.

Knowledge on joint functions has also been collected and is directly available through tutorials.

Tutorials on Functional Anatomy

Several partners within the consortium are responsible for Anatomy classes in their institutions. VAKHUM produced multimedia tutorials from

the data collected throughout the project. Different tutorials on Functional Anatomy have been written for both medical and bioengineering students. Such previously unobtainable materials are attractive to post-graduate professionals for re-training. The multilingual audiovisual tutorials can be selected from the database according to the profile of the user.

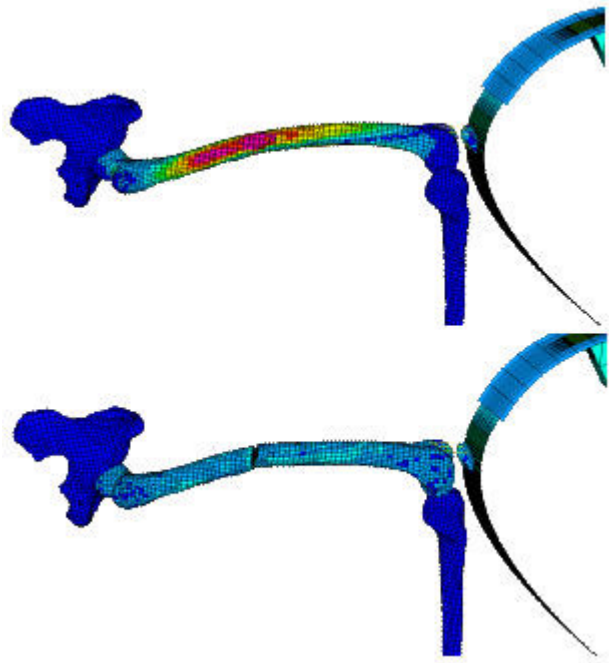


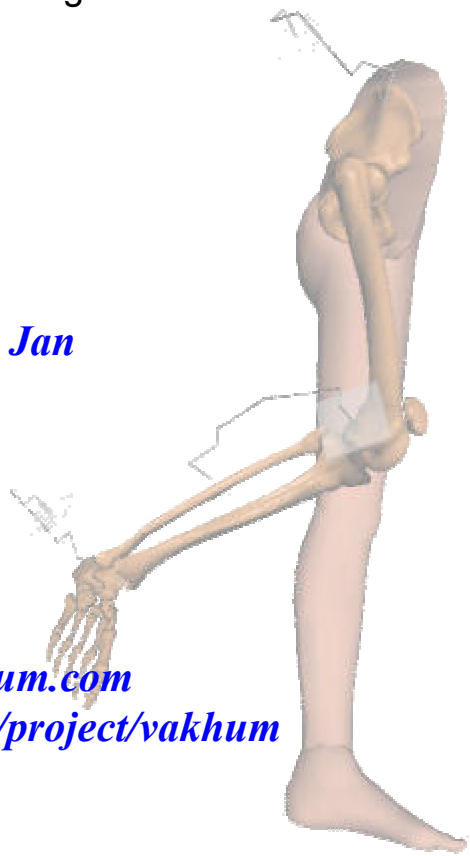
Figure 5. Virtual animation is used to simulate the distribution of pressure exerted on the femur when colliding with the dashboard of an automobile, and to determine the exact area where a bone fracture will occur.

Industrial Applications

The VAKHUM data allows industries to start their own applications from objective, validated and trustworthy data source. VAKHUM has already been used to simulate skeleton behaviour within an automobile safety environment (Figure 5).

Perspectives

VAKHUM has concentrated on collecting data about lower limb morphology and kinematics. In the future, other body segments will be processed as well the experimental protocols that have had their efficiency and effectiveness during the first stage of VAKHUM.



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💻 Websites

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