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LOAD EVALUATION BY DIGITAL MAN MODELS – A RADICAL NEW 3 D-APPROACH REALIZED BY RAMSIS

P. Schaefer, H. Rudolph, W. Schwarz
P. Schaefer: Lehrstuhl für Ergonomie Technische Universität München, Germany

A radical new approach was realized to integrate load evaluation into digital man models. The idea is to envelop articular strength-vectors by spacial bodies suggesting potatoes. A total of 244 articular „Moment-Potatoes" was recorded at 34 body joints. „M-Potatoes" allow not only efficient „virtual load evaluation" but possibly provide also a base for autonomously moving manikins.

COMPUTER MANIKINS

Modern CAD Tools provide early approaches to reality at low costs. These virtual realities usually need some integration of man for a first check of useabilty and safety. That´s a major driver for digital man models like RAMSIS, SAFE WORK, JACK etc.

LOAD EVALUATIONS – WHY?

Unfortunately load manipulations generally continue to be a serious health risk. Additionally perceived discomfort is increasing with growing loads. To promote both safety and sales designers are trying to reduce physical loads as far as possible. In particular they are to ensure that there is no man-machine interaction exceeding any kind of human load limits.

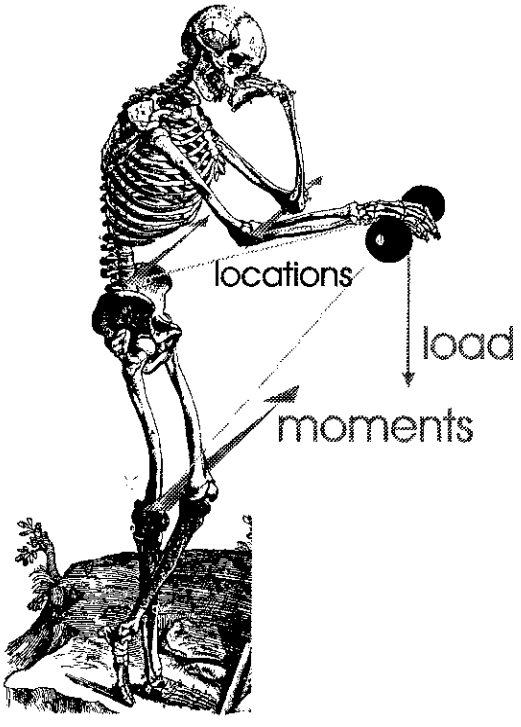

Fig.1 Generation of local moments

TRADITIONAL LOAD RATING PROCEDURES

In the past a wide variety of load rating procedures has been established to provide reliable load limits (e. g. NIOSH, CEN, ISO, etc.). These traditional procedures had not been designed to be built into digital man models. They do not realize the powerfull potentials now available by such models.

NEW APPROACHES

Digital man models are able to trace down postures and movements of the human operator. They do translate the operator´s real body postures into explicit spacial geometry.
Such full size geometric representation allows

- ✧ precise information about actual body postures – load limits largely depend on body postures – and
- ✧ precise calculations of local loads at relevant body joints.

These are the roots of Local Load Analysis presented in this paper.

LOCAL LOAD ANALYSIS

The basic ideas of Local Load Analysis are easy to realize (s. Fig. 1):

① find articular moments as a result of external and internal loads and
② compensate those articular loads by active moments produced by our own local muscular systems to ensure posture stability.

OBJECTIVES

To make Local Load Analysis work local physical strength at all major body joints should be available. In particular we are interested in articular moments represented by spatial vectors.

„M–POTATOES“

Muscular moments are drawing up “vector bunches” at all body joints:

- ✧ depending on given joint-characeristics these vectors may be pointing radially into all spatial directions like stings of a hedgehog or they may be reduced to planes or to simple lines;
- ✧ moment-vectors are limited by human physical capacity.

All varieties of muscular moments are embodied by spatial, plain or linear envelops – these are non geometric and may suggest the shape of potatoes.

EXPERIMENTAL APPROACH

Comprehensive sampling of „M-Potatoes“ may be a never ending task. Fortunately we managed to reduce experimental work dramatically by three simple approaches:

① „Basic moments“
Generally physiology leaves only 2 ways to move our body elements: flexions and torsions. This recommends a 4 step program:

- ✧ sample flecting moments produced by circumducting but isometric „motions“. This first step yields „cross-sections“ of „M-Potatoes“.
- ✧ rotate body elements in the same isometric way. This results in 2 torsional moments in opposite directions and perpendicular to above „cross-sections“.
- ✧ Combine flecting and torsional moments to put up supporting frames of „M-Potatoes“.
- ✧ „planke“ finally these frames by elliptic elements to obtain „natural“ approximations of „M-Potatoes“.

② Synthetic distributions
There is a wide variation of muscular strength depending on target population characteristics such as age and gender. Our approach is to reduce measurements to a particular subgroup: females between 20 and 30 years. On the base of these subgroup data we are able to predict strength of any other target population optionally mixed in age and gender (synthetic distributions: Schaefer, 1997).

③ Percentile limits
Force limits should protect wide majorities from musculoscelettal disorders. Percentile approaches are exactly doing that kind of job.
The needs are:

- ✧ explicit definition of the percentage protected – e. g. 85%: this defines load limits by the 15 th percentile - and
- ✧ distribution functions of strength as given by „M-Potatoes“.

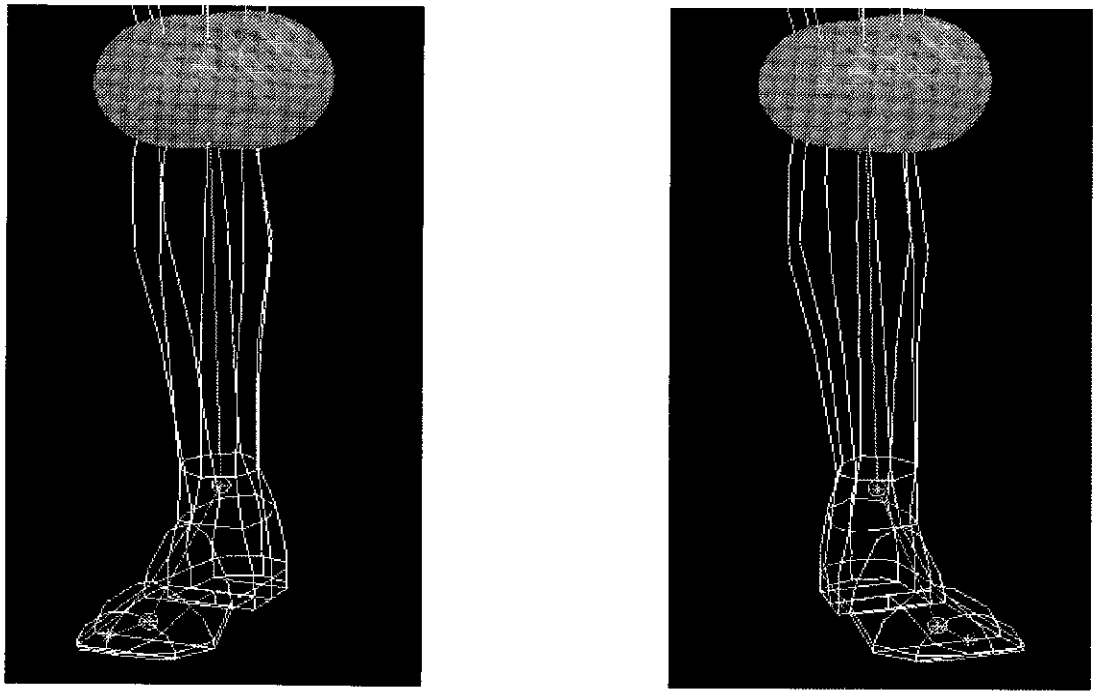

Fig. 2: „M-Potatoes“ of the knee

RESULTS

We found a variety of „M-Potatoes" ready to be integrated into digital man models:

- ✧ total body joints: 34,
- ✧ posture patterns: a spacing of 30 or 45 angular degrees at each joint,
- ✧ total „M-Potatoes": 244,
- ✧ data structures: „M-Potatoes" are described by data blocks each containing 14 elements,
- ✧ block elements: each block-element provides a pair of distribution parameters,
- ✧ distribution parameters: average moment and variance,
- ✧ total of subjects: 29 (maximum) young females (20 – 30 years).

Further computer animation reveals:

- ✧ „M-Potatoes" are following „their" joints when moving and
- ✧ „M-Potatoes" are changing shape with changing postures.

APPLICATIONS

Integrating „M-Potatoes" into digital man models opens at least 2 attractive fields of application:

① Load Evaluation
External loads may be easily evaluated – „good" loads produce moments completely accomodated by „M-Potatoes".
Our „M-Potatoes" are further designed in such a way that current CEN standardisation of force limits is easily applicable (prEN 1005/3).

② Autonomously moving models
„M-Potatoes" may allow some estimation of perceived discomfort – this could be a base to optimize movements of digital man models.

REFERENCES

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CONTACT

Peter Schaefer: Technische Universität München,
Lehrstuhl für Ergonomie, Boltzmannstr. 15,
85747 Garching, Germany,
Tel.: +498928915395; Fax: +498928915389
e-mail: schaefer@lfe.mw.tu-muenchen.de