Research at

Human Engineering Research Laboratory (HERL)

Research Areas

1. Human System Engineering

Understanding the behavior and response of the human system applying engineering and technological concepts

Research areas: Medical/clinical engineering, Application in Human Physiology & health care, Biomechanics, gait analysis & posture, neuroscience & engineering psychology

2. Human factors Engineering

Application of this knowledge in design & development of systems and service

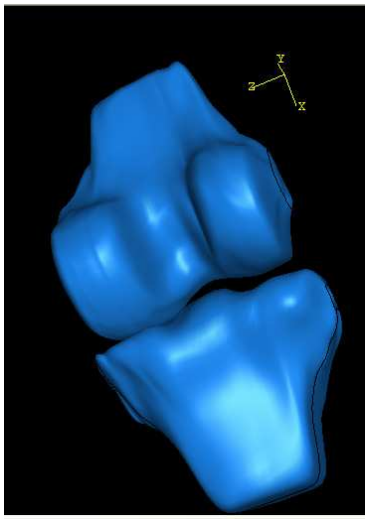
Research areas: Human factors, Product Design, Rehabilitation engineering for the disabled, Occupational health and safety, work and sports engineering, biosensor design

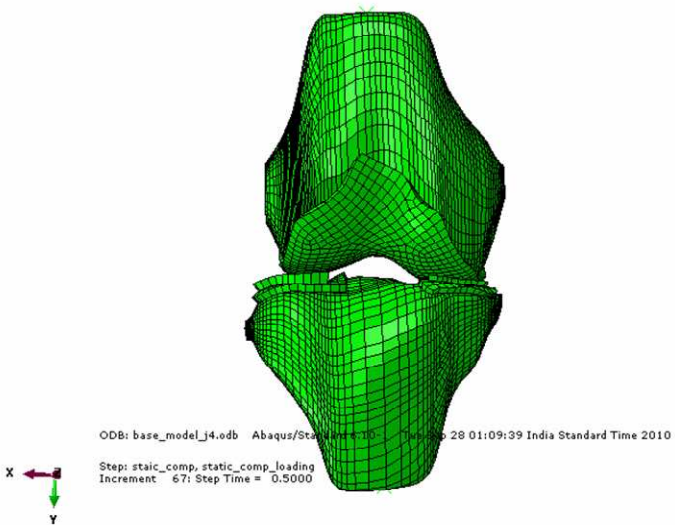
Ongoing Research areas are given below.

1. Constitutive modeling of skeletal joints and FE analysis:

- Image processing for bone segmentation and boundary extraction from 2D medical image
- Point with Curvature maxima at sub-pixel level for identifying anatomical landmarks
- 3D constitutive modeling of the joint
- FE analysis for studying contact behavior at the joint

Constitutive modeling of knee joint with Tibia, Femur, cartilage and menisci is developed from MRI images. Medical images are processed with image intensity adjustment, anisotropic diffusion and then edge detection. Option for manual correction is provided for better bone boundary extraction especially at the inhomogeneous intensity areas. Then this edge is filtered and further processed at subpixel level using cubic spline interpolation for curvature analysis. Then the point having curvature maxima irrespective of gradient direction is **identified as anatomical landmark**. This semi-automatic anatomical landmark extraction process **based on image processing is coded in Matlab2007**. This will help to quickly access the ethnic variation of Indian knee than the Caucasians. This method will also help to access any anatomical deformity in our musculo-skeletal system and in other systems through medical image data. This method also has been tested on x-ray data and produced a promising result. This work is now communicated in Elsevier journal.





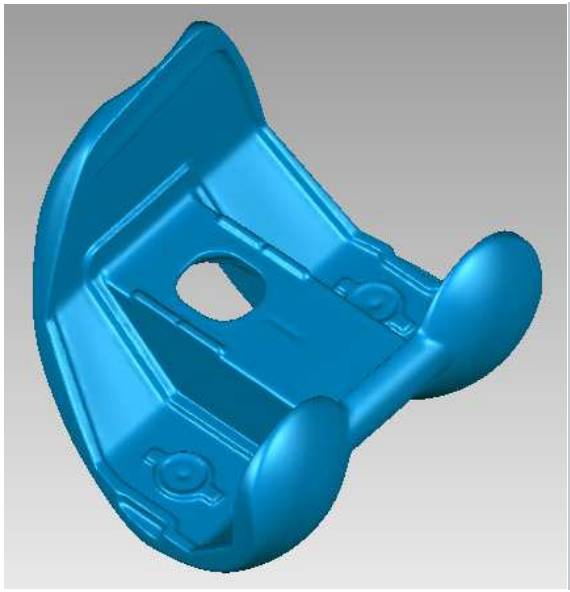
- Reverse engineering for extracting CAD parameters from scanned image in terms of point cloud data
- HEX Meshing of complicated CAD geometry

We have generated a CAD model of one TKR and then observed improper fitment of that TKR (Total Knee Arthroplasty) while fitting to the Indians through computer simulation model, which has been experienced by the medical practitioners but not studied properly.

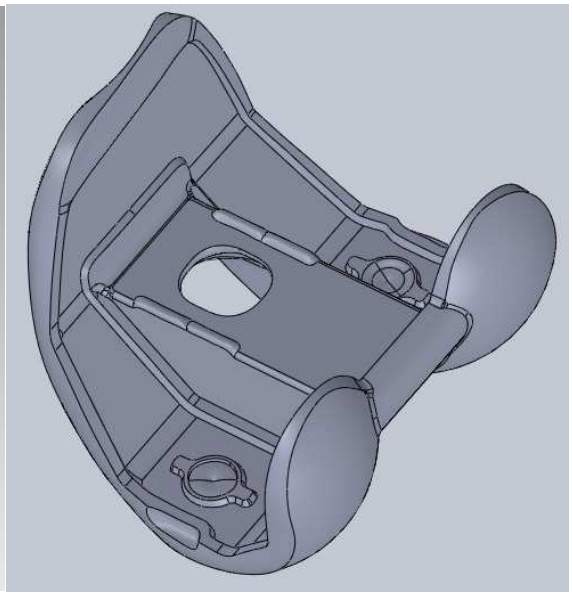
Stress-strain analysis shows contact behavior at the joint during different loading conditions at different posture.

Further study on more subjects is required to study ethnic variations in different joints.

Stress-strain analysis on other different human joints



Point cloud data

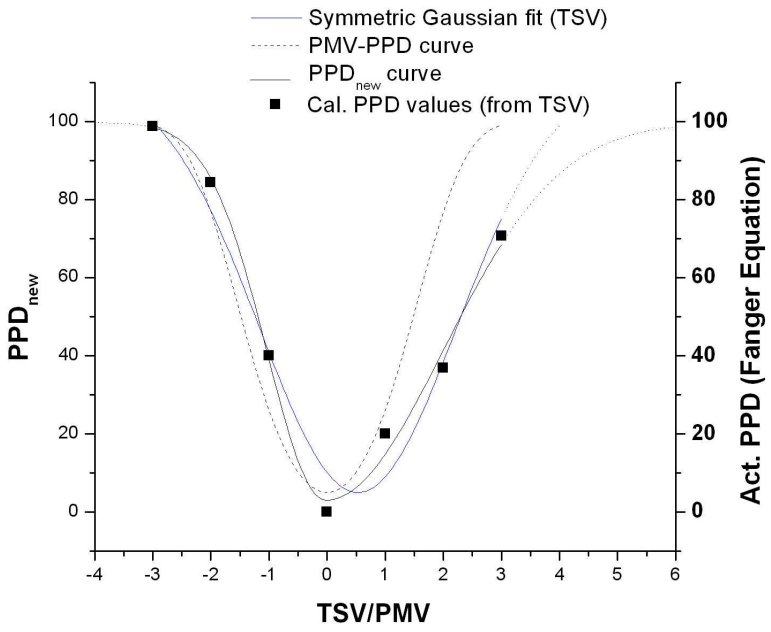


CAD model

2. Study on Thermal comfort for Indians (experimental & computational)

A. Modeling of Thermal sensation response of Indians

Thermal sensation deals with how we feel thermally (viz. hot, cool etc.) our ambient environment. ASHRAE has proposed the relationship between PMV (Predicted Mean Vote, a quantitative measure of thermal sensation based on ambient parameters and subjective parameters) and PPD (Predicted Percentage Dissatisfaction, a quantitative measure of percentage of people dissatisfied with the thermal condition) follows a symmetric thermal response curve between hot (PMV - 0 to +3) and cold ambient temperature (PMV - 0 to -3).For the first time, from this study, it has been shown that Indians are more hot adaptive (i.e. slow response curve in hot region) than the cold environment, due to the tropical adaptation. This work is published in 2 Elsevier journals.



B. Assessment of Thermal sensation response of Indians

Effects of ambient humidity, subjective thermal responses are being studied for Indians in their thermal sensation response while working in different occupational set-up, which are not well reported in the literature.

This study is being conducted both using computational (CFD) and experimental studies.

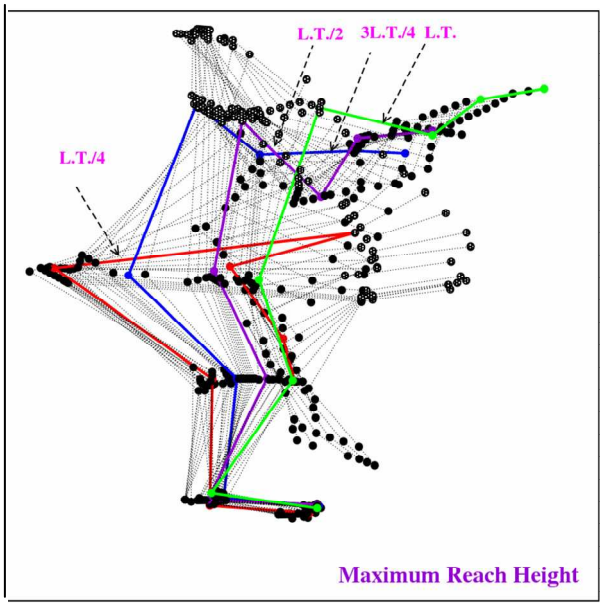
3. Human body joint biomechanics and Gait analysis:

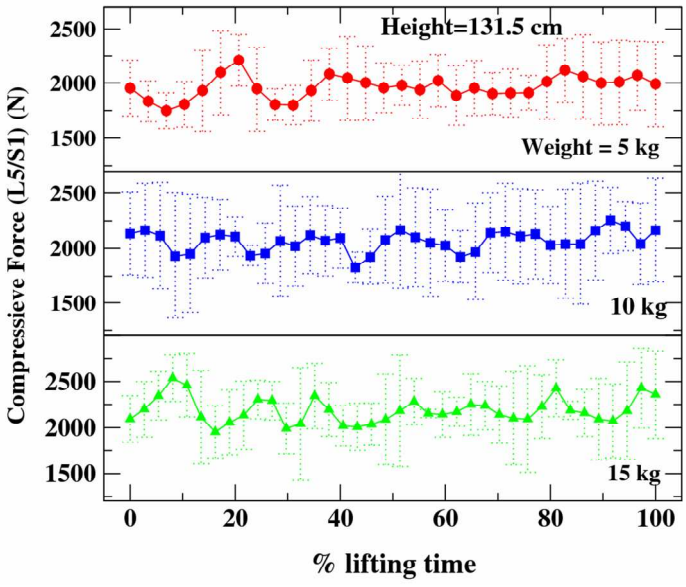
Calculation of different joint reaction force, moments and kinematics measurements in different postures will help in better understanding of both joint function and dysfunction, resulting in design improvements of devices such as joint arthroplasty systems and orthotic devices etc. Basic knowledge in musculoskeletal biomechanics is useful in a critical evaluation of current or newly proposed patient evaluations and treatments. Joint biomechanics study was done during manual load lifting and walking. This work is published as 5 journal articles.

We are interested to study joint biomechanics both in normal and clinical patient evaluations. We are having state-of-art laboratory set-up to perform extensive biomechanical study.

Examples of some previous works (Published in Journals)

- Peak strength measurement at field simulated postures towards job severity assessment
- Joint biomechanical analysis during manual load lifting
- Gait analysis
- Workload assessment during field activities
- Importance of interaction effects of different lifting multipliers in recommended load weight calculation





4. Muscle dynamics:

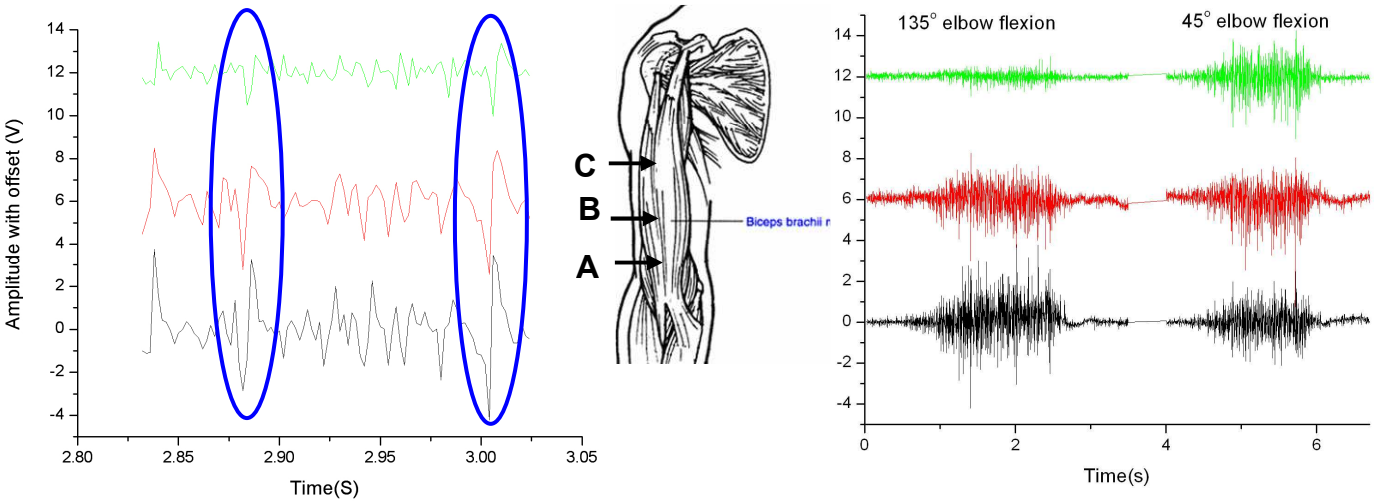
A. Understanding muscle fatigue during dynamic contraction:

In laboratory, subjects were asked to lift a weight till completely they exhausted and their EMG were collected for analysis.

- Digital Signal processing (DSP) on surface EMG signal during dynamic contraction (lifting)
- Consider EMG as stationary and linear signal to non-linear non-stationary signal and accordingly different signal processing techniques were adopted.
- both power spectral analysis, time-frequency signal analysis and non-stationary signal analysis were performed.
- Result showed non-linear and non-stationary signal processing techniques provide better estimating parameters than others. Wavelet results were also promising.

The preliminary results were presented in an international conference. **Further study on more subjects will help to understand muscle dynamics during dynamic contractions, where few publications are reported without proper interpretation.**

B. Study on muscle conduction velocity



5. Biosensor design:

A. Electronics:

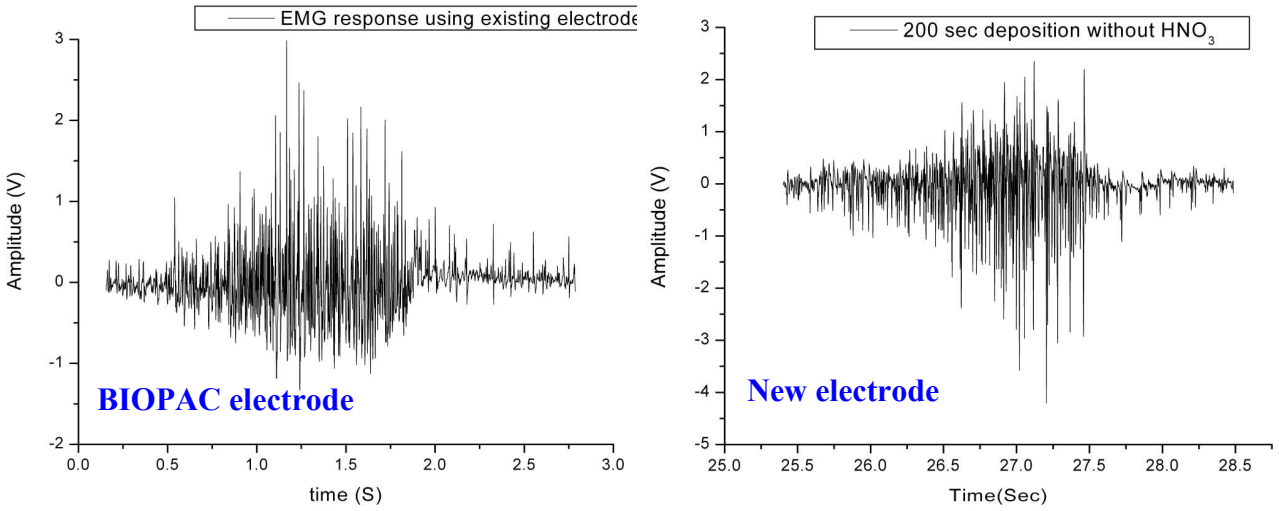
1. Recording heart and Lung sound to study cardio-pulmonary dynamics

2. PPG signal acquiring for measuring HR & respiratory rate

3. Body temperature sensing device

B. Others:

EMG electrode preparation by electro-deposition technique



Further study on packaging and development of actual biosensor with better human interface and study on human subject for understanding human response in different enviormental and clinical conditions

Similar other biosensor design and development and related human study

6. Heart rate variability analysis - ongoing

7. Product design for the challenged people and for better human interface.