JOURNAL OF PURE AND APPLIED MICROBIOLOGY, Aug. 2015. Vol. **9**, p. 111-116
SPECIAL ISSUE ON RECENT RESEARCH CHALLENGES IN BIO-MEDICAL APPLICATIONS

Ergonomic Analysis of Human Knee Joints during Manual Material Handling Using Soft Computing Techniques

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(Received: 10 April 2015; accepted: 16 May 2015)

Manual Material Handling like lifting is risk to many and considered the cause of back pain and other joint impairments. This problem leads to increased worker compensation and loss of productive man-hours. Approximately one third of all jobs in industry involve Manual Material Handling. Low back pain is one of the most prevalent and costly work related injuries. A finite elements model studies about the analysis of stresses on all Human knee joints. The analysis has been proposed to develop using Image processing techniques soft computing like MAT Lab and ANSYS. The effort to be taken for in vivo and in vitro data collection and analysis are reduced considerably in the finite element modeling. A biomechanical model has been proposed to develop for optimizing the lifting posture for minimum effort. The model may also be used to predict the lifting capabilities of individuals. The study can be extended to include the loading of the muscles.

Key words: Magnetic Resonance Imaging, Human Joints, Finite Element Modeling, ANSYS, Image Processing.

Human knee joints during manual material handling are one of the most important and most complex joints problems in the human body. The knee joints must support the whole weight of the body and strain. As a result of every action and motion manual handling occurs in almost all working environments, through workers in construction, agricultural hotels and restaurants are most likely to be expressed to heavy loads.

As a research subjects, the human joints has been thoroughly studied and still attracts the interest of researchers to do research over beyond their work. All the researchers had analyzed the motion activities. Lifting is considered to be a major cause for low back pain, human joints paints & spiral injuries. A biomechanical model has been proposed to develop for optimizing the lifting postures for minimum effort.

Literature survey

[1] T. Lenzi, M.C. Carrozza, and S.K. Agrawal Member, IEEE -2013. The human locomotors adaptation to the action of assistive exoskeletons that provide additional torque at the user's hip, with the goal of reducing the muscle activity during gait while still allowing users to control their joint kinematics.

A muscle effort reduction during walking may be desirable for many persons. Several pathologies can decrease the walking ability of affected persons by reducing their.

[2] Fari Muhammad Abubakar, November-2012 Image is formed in the eye and in the camera by the amount of illumination reflected by an object. In computer vision, image processing is any form of signal processing for which the input

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is an image, such as photographs or frames of videos. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image.

[3] Nitin B. Ukunde, Dr. Sanjv K. Shrivastava, Sheetal N. Ukunde September 2012 I mage segmentation refers to partitioning of an image into several disjoint subsets, where each subset corresponds to a meaningful part of the image. As image segmentation is often an integral part of many large vision problems, its quality influences the performance of the whole system. Most commonly used approaches for image segmentation are threshold techniques, edge-based methods, region-based techniques and connectivity-preserving relaxation methods Irrespective of the choice of approach, the complexity lies in formulating prior knowledge into the segmentation process.

[4] Faten Abu Shmmala#1, Wesam Ashour , January, 2013 Image processing is very attractive field, mostly image segmentation. Image segmentation refers to the process of partitioning a digital image into multiple segments. To locate tumors and other pathologies, measure tissue volumes, computer-guided surgery, diagnosis, treatment planning and study of anatomical structure or for locating objects in satellite images and it can be used for face and fingerprint

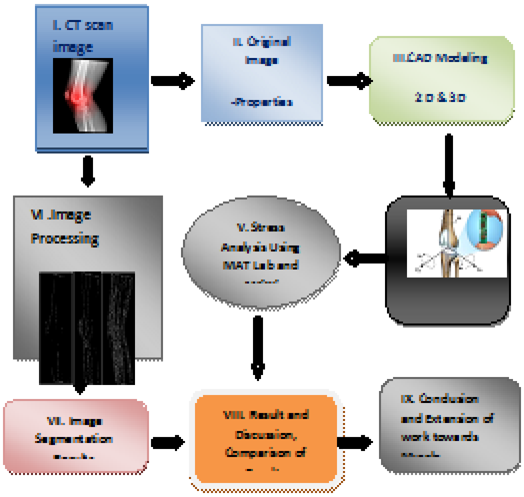

Fig. 1. Block Diagram of Sequential Work

recognition, traffic control systems and brake light detection and machine vision. Several general-purpose algorithms and techniques have been developed for image segmentation.

Problem identification

Lifting Material by Manual poses risk to many and considered the cause of Knee joint pain and other joint impairments. Knee Joint pain leads to increased worker compensation and loss of productive man-hours. One third of all jobs in industry involve Manual Material Handling (MMH). Lifting is said to be a major cause for low back pain, knee joints pain and spinal injuries. A finite element model to study and analyze the stresses on all Human Joints has been proposed to develop. A biomechanical model has been proposed to develop for optimizing the lifting posture for minimum effort.

Progression of work

Sequence of work followed by many stages like CT scan Image, Original Image properties of Input data, parameters, CAD Modeling of 2D and 3D Modeling, Stress analysis using MAT Lab, Image processing, Image Segmentations, Comparison of Results, Extension of work towards Muscles

Research methodology

CT Scanned Image from the medical Lab is taken as input data with their parameters. The input data is transformed to 2D and 3D modeling by using CAD techniques. Stress analysis using MAT Lab and ANSYS is applied to the output data. Image processing techniques identifies the exact image of both stressed and unstressed image between original CT Scanned image with 2D and 3D image. The images of different segments were taken as results. The results will be compared with original image so that the human joints problems can be analyzed in the human being. Human joints like wrist, elbow, shoulder, hip, knee, and foot joints can be analyzed with this methodology.

Mathematical modeling

Calculation of body mass index

Body mass index (BMI) is a measure of body fat based on height and weight that applies to adult men and women.

BMI = Weight (kg) / (Height) ^{2}

Examples 1: Someone who is 1.50 m and weights 50 kg has a BMI of

BMI Calculation = 50 / (1.5 x 1.5) = 22.2 <== This person is in the Normal category.

BMI Categories:

BMI	Weight Status
Below 18.5	Underweight
18.5 – 24.9	Normal
25.0 – 29.9	Overweight
30.0 and Above	Obese

The result falls in the overweight or obese range, and you have other risk factors, such as smoking, heart disease, diabetes, high blood pressure or high cholesterol, get busy navigating this site to learn how to make the necessary lifestyle changes! The CDC (Center for Disease Control) reports that losing even a small amount of your total body weight, somewhere between 5-10%, can help you lower your risk of serious health problems.

Lifting equations and its functions

Lifting Index (LI)

The term LI that provides a relative estimate of the level of physical stress associated with a particular manual lifting task. The estimate of the level of physical stress is defined by the relationship of the weight of the load lifted and the recommended weight limit.

The LI is defined by the following equation:

$$LI = \frac{\text{Load Weight (LW)}}{\text{Recommended Weight Limit (RWL)}}$$

Recommended weight limit

The RWL is defined by the following equation:

RWL = LC * HM *VM * DM * AM * FM * CM

Where;

LC Load Constant
HM Horizontal Multiplier
VM Vertical Multiplier
DM Distance Multiplier
AM Asymmetric Multiplier
FM Frequency Multiplier
CM Coupling Multiplier

Performance measure

The Peak Signal to Noise Ratio (PSNR) value can be calculated for the noisy image compared with the original image. The value of PSNR and MSE (Mean Square Error) is found out for this method experimentally.

$$MSE = \sum_{i=1}^{x}\sum_{j=1}^{y} (\| E_{ij} - F_{ij} \|)^2 / X * Y$$

Where Eb"ó is the original image and Fb"ó is filtered image. X, Y is the size of the image.

$$PSNR = 10 \log_{10} (255)^2 / MSE$$

Normalized image pixel value is 255, the value obtained are in the interval [0, 1].

Image Pre-Processing fractured image (Filters)

Linear filter, Weiner filter, Mean filter

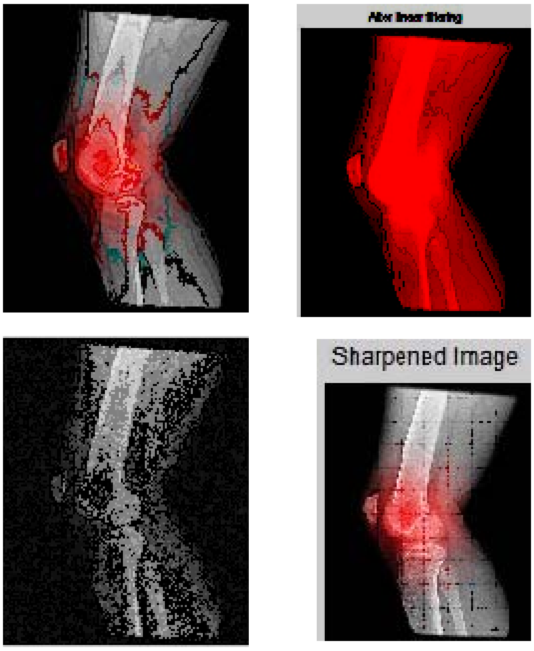

Fig. 2. Different type's image filters

Table 1. Performance Measure of MSE and PSNR

Sl. No	Types of Filter	MSE (Mean Square Error)	PSNR value (Peak Square Noise Ratio)
1.	Weiner filter	5.45	30.05
2.	Linear filter	1.75	31.22
3.	Mean filter	1.01	51.85

Segmentation

Canny edge Detection, Prewitt edge Detection, Robert edge Detection, Sobal edge Detection

Edge Detection Techniques can be done using this gradient magnitude for fractured image:

$$|S| = \sqrt{(E_{ij})^2 + (F_{ij})^2}$$

Where ÐSÐ is the Gradient magnitude, Eb"ó is the size of original image and Fb"ó is the size of edge detection final image

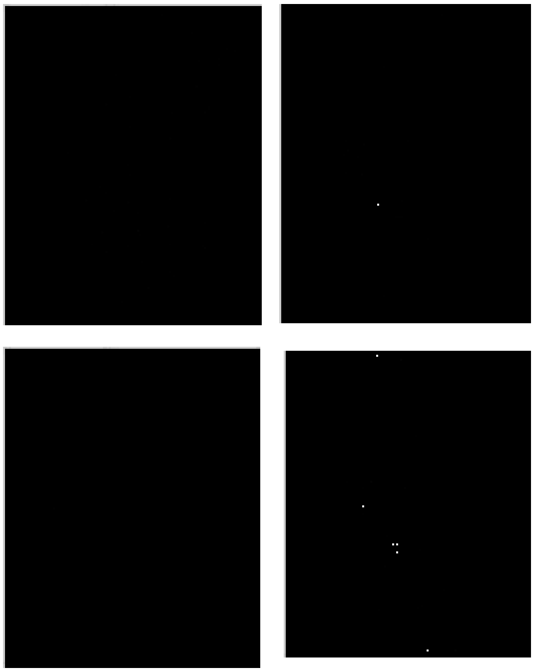

Fig. 3. Performance results of different Edge detection

Fig 3. Performance results of different Edge detection, Performance Evaluation of fractured image with different Edge Detection

Sl. No	Different types of Edge Detection	Edge Detection Rate
1.	Canny edge Detection	56.75
2.	Prewitt edge Detection	28.24
3.	Robert edge Detection	27.56
4.	Sobal edge Detection	31.61

Ansys modeling

ANSYS is a complete FEA simulation software package developed by ANSYS. A finite element model is used to study about the stress of human joints. After the completion of image filtering and edge detection stress is applied to the image. The exact material of the image is used for stress analysis. A Biomedical model has been used for optimizing the lifting posture for minimum efforts. This model is also used to predict the lifting material in every individual human being. This study can be extended for loading of muscles.

Material Properties of Human Bone

Young's Modulus: 105 MPa
Poission's Ratio: 0.45
Density: 1550 kg/m3
Mesh Type: Coarse

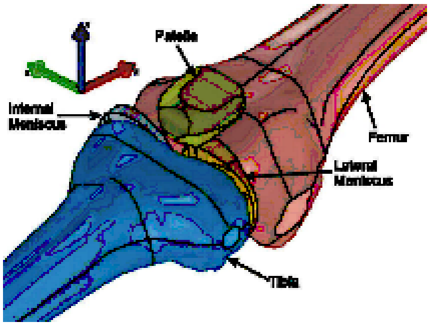

Fig 7.1: 3D Geometric Modeling

Computation Modeling

Computation model of our research is build using finite element system ANSYS 10.0. To get accurate solution it is necessary to create partial models as geometric model, material model, finite element model and loading material.

Computer Tomography at SRM University Hospital born was used. From these CT sections bones and soft tissues were separated. The bone edges were detecd using filtering and segmentation. Separated section were exported as a *.iges file format to the finite element system ANYSYS.

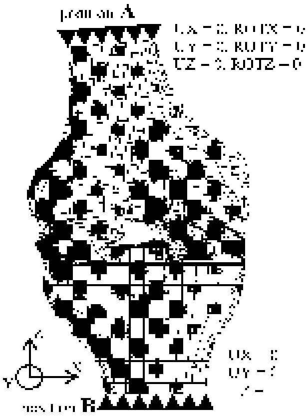

Fig 7.2. Loading Model

Mechanical Properties of cartilage

The Stress-Strain Relationship is represented by {ó} = [D] {å}
where: {ó} = stress vector = [óx óy óz óxy óyz óxz]T
[D] = elasticity or elastic stiffness matrix or
Stress-strain matrix {å} = total strain vector = [å x å y å z å xy å yz å xz]T

Table 3. Mechanical Properties of cartilage

Age (Yrs)	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80
Strength (Mpa)	4.5	4.5	4.4	4.2	3.5	2.5	1.5	1.3
Maximal Strain(%)	31	28	25	25	20	16	11	9

The principal stresses (ó1, ó2, ó3) are calculated from the stress components by the cubic equation:

$$[D_{x-y-z}]^{-1} = \begin{bmatrix} 1/E_x & -\nu_{xy}/E_x & -\nu_{xz}/E_x \\ -\nu_{yx}/E_y & 1/E_y & -\nu_{yz}/E_y \\ -\nu_{zx}/E_z & -\nu_{zy}/E_z & 1/E_z \end{bmatrix}$$

$$\begin{vmatrix} \sigma_x - \sigma_0 & \sigma_{xy} & \sigma_{xz} \\ \sigma_{xy} & \sigma_y - \sigma_0 & \sigma_{yz} \\ \sigma_{xz} & \sigma_{yz} & \sigma_z - \sigma_0 \end{vmatrix} = 0$$

where: óo = principal stress (3 values) The three principal stresses are labeled ó1, ó2, and ó3. The principal stresses are normal

stresses, acting on principal planes on which the shearing stresses are zero, and are calculated by using the existing six normal and shearing stress components óx, óy, óz, ôxy, ôxz, and ôyz. The principal stresses are ordered so that ó1 is the most positive (tensile) and ó3 is the most negative (compressive).The stress intensity óI is the largest of the absolute values of ó1- ó2, ó2-ó3, or ó3 - ó1.

Finite Element Results

The stress and strain analysis solved using Finite element Model. The modeling and finite element analysis of knee joint is carried out using ANSYS 10.0 of different loading conditions at various persons weight from 50 to 80 kg.

Table 4. Condition 1: Vertical force due to person's weight acting on knee-joint.

Input Parameter		Output Parameter			
Weight)	Force in (N)	Stress at various angles in(MPa)			
in (kg	Fy=mg	0º	45º	90º	120º
50	490	1.78	1.56	2.02	3.01
60	588	1.93	1.87	2.5	3.69
70	686	2.47	2.18	3.21	4.27
80	784	2.75	2.50	3.61	4.88

Table 5. Condition 2: Force is acting on all the three Fx, Fy, Fz direction during walking.

Input Parameter				Output Parameter			
Weight in (kg)	Force in (N) Fy=mg			Stress at various angles in(MPa)			
	Fx	Fy	Fz	0º	45º	90º	120º
50	130.6	490	98.0	12.37	11.94	17.81	19.31
60	156.8	588	117.6	14.14	13.36	21.03	24.15
70	182.9	686	137.2	17.60	16.72	23.11	27.90
80	209.0	784	156.8	19.78	19.11	26.31	30.82

Table 6. Condition 3: Force is acting on all the three Fx, Fy, Fz direction during running or climbing.

Input Parameter				Output Parameter	
Weight in (kg)	Force in (N) Fy=mg			Stress at various angles in(MPa)	
	Fy	Fj	Fc	90º	120º
50	490	2011.4	1606.3	135.32	128.31
60	588	2360.7	1857.2	162.04	174.23
70	686	2715.6	2113.7	243.76	208.41
80	784	3108.9	2448.4	389.13	322.37

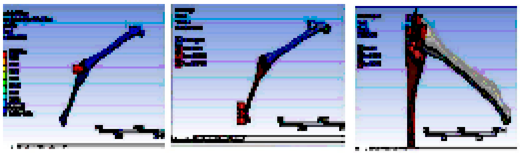

Fig 7.3. Finite Element Analysis Modeling

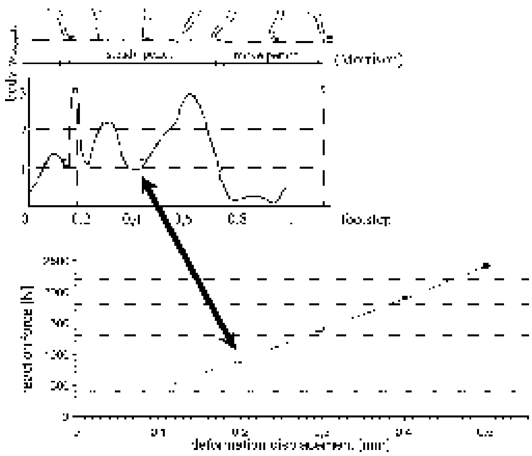

Fig 7.4. Force reaction during motion

Future extraction

The worker compensation will be reduced in the industry by using this Methodology and loss of productive man-hours will also be decreased. The future Study can be extended using loading of the muscles.

RESULT AND DISCUSSION

Loading behaviour of human knee joints using Finite element model is used to predict the proposed development. Image processing of Human knee joints like image filtering, image edge detection also be done. The effort is taken for the data collection and analysis to reduce multi fold in the finite element modelling. After the Completion of image filtering and edge detection the image is drawn by 2D and 3D CAD model. Stress is applied to that image by ANSYS model and the result is compared with the segmented image and also with the original image. The same work is extended to muscle in future work.

CONCLUSION

The load and results can vary from person to person as the size of bones, age, height, weight differs in each individual. So the load and stress analysis is advisable before lifting the material manually. The study of human knee joint shows the problems among human being by having joints paints using manual material handling. Lifting is more weighted things considered to be a major cause for low back pain, knee joints paints and spiral injuries finite elements model is used to study & analyses the success of all human knee joints using MAT Lab and ANSYS. The future study is extended to apply Load in the muscles.

REFERENCES

1. Matheel E. Abdulmunim1, Suhad M. Propose a Mixture Edge Detection Method for Infrared Image Segmentation, © 2012 British Journals ISSN 2047-3745.
2. Harris, M.D., *et al*.,Finite element prediction of cartilage contact stresses informal human hips. *J Orthop Res,* 2012; **30**(7): p. 133-9
3. K. Raja and A. Meena, Segmentation of Alzheimer's Disease in Pet Scan Datasets using Matlab, (0975 – 8887); 2012; **57**(10).
4. Fari Muhammad Abubakar , Study Of Image Segmentation By Using Edge etection Techniques, *International ournal of Engineering Research & Technology IJERT)*, 2012 **;** **1**(9): ISSN: 2278-0181
5. Nitin B. Ukunde, Dr. Sanjv K. Shrivastava, Sheetal N. Ukunde, Performance Evaluation of Image Segmentation Using Histogram and Graph Theory, 2012 **;** **2**(9): ISSN 2250-3153
6. M.M. Mirbagheri1,2 and K. Settle2 Neuromuscular Properties of Different Spastic Human Joints Vary Systematically Buenos Aires, Argentina, August 31 - September 4, 2010
7. Faten Abu Shmmala#1, Wesam Ashour#2, Color Based Image Segmentation using Different Versions of K-Means in two Spaces, Global Advanced (ISSN: 2315-5124), 2013; **1**(9) pp. 030-041.
8. Nareen Karnati, Ben Kent and Erik D. Engeberg Human Finger Joint Synergies for a Constrained Task Applied to a Dexterous Anthropomorphic Hand Bled, Slovenia, 2011.
9. Z. G. Zhang & S. C. Chan On Kernel Selection of Multivariate Local Polynomial Modeling and its application to Image Smoothing and Reconstruction # The Author(s) 2010.30 May 2010