# Conversion of Gait data into OpenSim

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**Abstract -** *Dynamic simulations of movement allow one to study neuromuscular coordination, analyze athletic performance and estimate internal loading of the musculoskeletal system. Simulations can also be used to identify the sources of pathological movement and establish a scientific basis for treatment planning. OpenSim is freely available software used to calculate the muscle forces. OpenSim provides a platform on which the biomechanics community can build a library of simulations that can be exchanged, tested, analyzed, and improved through a multi-institutional collaboration. The work deals with the solution of the inverse kinematic of the lower extremities of the musculoskeletal system of man on the basis of marker motion capture system and dynamic model obtaining in the software package OpenSim. As a means of studying the gaits used motion capture system and software platform OpenSim.*

***Key Words***:  **OpenSim, Gait analysis, Dynamic Simulation, Inverse Kinematics, Muscle.**

## 1. INTRODUCTION

Musculoskeletal modeling and simulation are more likely to cure the pathology and decrease the cost of treatment by showing the result of cause and effects relationships in neurological and musculoskeletal impairments. Many elements (muscles, joints, and segments) of musculoskeletal are required to enable coordinate movement. Scientists who studied human movement have described many data to show the relationships between muscles and bones, and motion of joints[1]. As with Experiment alone, it's hard to calculate the forces generated by muscles. For example, from electromyography (EMG) in gait analysis tells when the muscle is activated but it cannot tell what the force generated in muscle is. So for that, there are many commercial software available like Anybody, BOB(Biomechanics of Bodies)[3],etc. and open source software OpenSim. OpenSim Software is available at free of cost.

It allows users to build their own model for simulating and analyzing the musculoskeletal system. It is one of the major applications from Simbios, an NIH (National Institute of Health) Center for Biomedical Computation at Stanford University. OpenSim models can be designed using C++ language or scaled the already existing model by recorded the movement data using gait analysis. It is the upper version of SIMM tool as OpenSim has more capability than SIMM. As there are other commercial packages like Anybody, Visual 3-D,etc. through which we can find muscle forces, but they don't provide full access to the core code, and OPENSIM provide full access to its core code by which capability of OpenSim can be further increased according to researcher need Researchers are using OpenSim to design many orthotic devices like to see the Effect of Knee Bracing on Lower-Limb Muscle Forces[4], analyze the human movement using OpenSim, etc. As it makes easy for a user to check what will be the effect on muscle by changing the parameter of the device in coding.

## 2. Collection of Data

For a collection of data put the markers on the human body (healthy subject) according to gait lab protocol. I used PGIMER Chandigarh lab for data collection and used Helen Hayes protocol and put 18 spherical markers on subject to completely determine the rigid body position and orientation: 3 on trunk ( c7,r should and l should) , 3 on pelvis (r asis , l asis, sacrum ), 2 on each thigh (bar1 and knee1) , 2 on each shank ( bar2 and mall) and 2 on each foot ( heel and met). 4 of these markers are fixed on rigid bars. After placement of markers calibrate the BTS Gait system properly.



Figure 1- Front Marker Position and Rear Marker Position

## 3. Trails of Subject:

After Marker placement adds a new patient in BTS System and enters the Anthropometric measurements of subjects in a system which was measured with the help of Pelvimeter. Further standing trail of the subject has taken. The subject should stand in the middle of the lab without any body movement being happened so that all markers should be properly visible by cameras and then walking trail has taken. The subject moved in a straight line with normal walking speed. No load has been placed on the subject. Take different trails of the subject and select the best trail for further processing of data. Gave the right ground reaction vector and left ground reaction vector in 3D track. All data was saved in the.tdf format in a given folder.

## 4. Conversion of Data:

i.          Tdf Inspector: Tdf inspector is a tool which convert data from .tdf file to .c3d (Coordinate 3D) file. Open the saved file (Standing file and different walking trails files separately) in Tdf inspector and convert it into .c3d format.
ii.         Mokka Software: It is an open source software easily analyzes the biomechanical data. Through this software, we can read or write .c3d files and easily convert them into many other formats. Open the .c3d file in Mokka Software and convert the file into a.trc (Track Row Column) file. When the file was opened in mokkasoftware, it shows the position of different force plate in gait lab and also its axis and position of different makers which placed on subjects. The .trc file is an input file for OpenSim for calculation inverse kinematics.
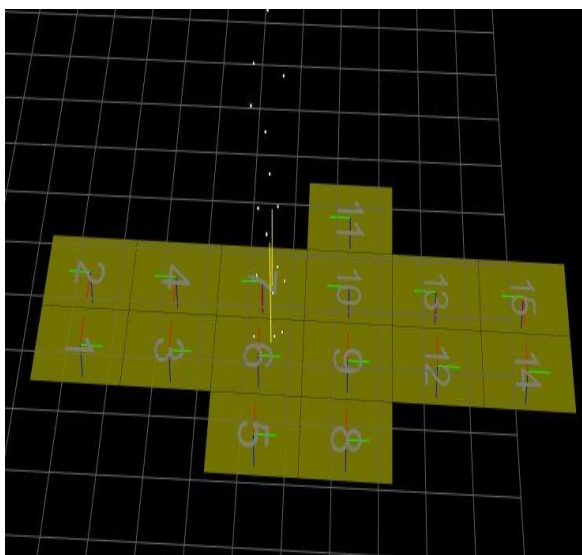


Figure 2-Force Plates position and marker position shown in Mokka Software

## 5. Format of .trc file

The .trc files which have gotten from Mokka Software opened in notepad++ and saw the name of markers. As the name of markers shown in .trc file and name of markers used in OpenSim model2354 are not same so change the name of markers in the.trc file according to OpenSim model2354 marker position and also defined new marker in OpenSim model2354 according to Helen Hayes protocol.

## 6. Scaling

Open the model2354 in OpenSim and use the scale tool. The scale tool changes the measurements of the model so that it matches a particular subject as closely as possible. The process of Scaling is by comparing the marker position in experimentation to virtual marker position placed on the model in a.trc file.
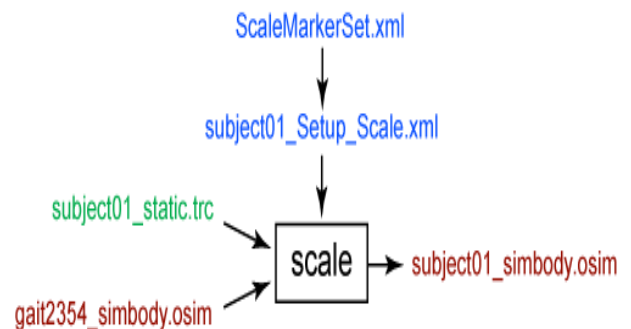


Figure 3- Files for Scaling

Make a Setup_Scale.xml file for scaling. Load this file in Scale tool then model scaled according to the scale factor.
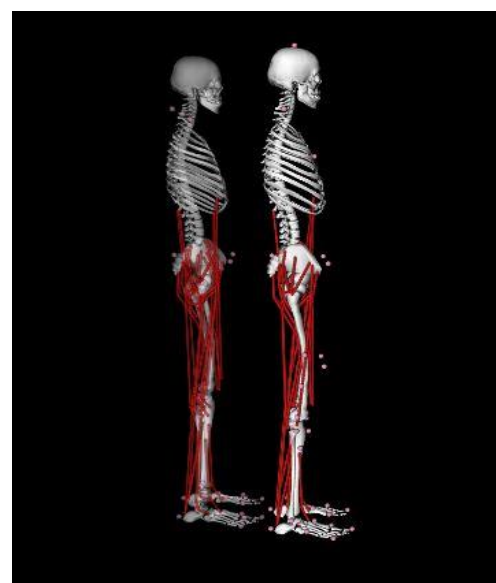


Figure 4-Scaled Model of as subject height is more than given model

## 7. Inverse Kinematics

The Inverse Kinematics (IK) Tool runs through each time frame of experimental data and re-arrange the positions of the model in a pose that "best matches" experimental marker and coordinate data for that time step.



Figure 3- Inverse Kinematics

For inverse kinematics tool scaled model file and walking.trc file required as input and as output got Walking_IK.mot (motion). In this .mot file contains the joint angles calculated by IK. While calculating IK OpenSim gave marker error which tells the distance between an experimental marker and the corresponding marker on the model (Virtual marker) when it is positioned using the generalized coordinates computed by the IK solver. In IK weight has associated with each marker, specifying how strongly that marker's error term should be minimized. It best matches the weighted least Square equation. The .mot file gave the joint angles in degrees. After .mot file plot the result of various angles of joints in OpenSim.
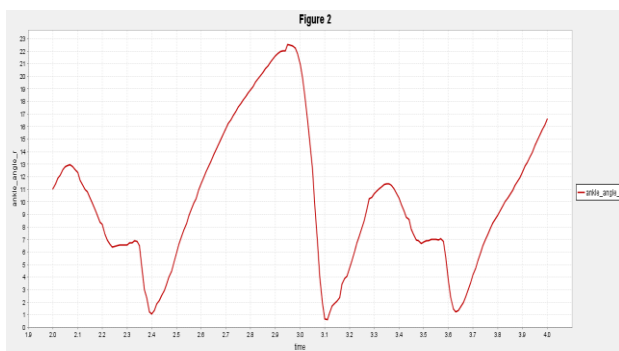


Figure 4-Ankle_angle_r

## 8. Inverse Dynamics

The Inverse Dynamics (ID) Tool used to find net forces on each segment and torques at each joint. For this external load file (_grf.xml) is required. This file needs how ground reaction forces, Center of Pressure and torque on the right

and left varies with time. The file should be in the proper format as given in OpenSim example and data for this file was collected from BTS Analyzer software. From Analyzer Software export the forces, moments and center of pressure of right and left foot separately. These files export in .txt files and then made a program in Excel to directly combine all these files and save them in the format of the file as _grf.mot.
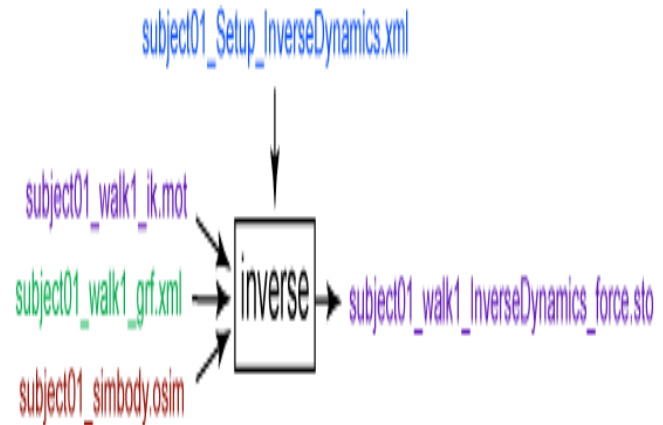


Figure 5-Files Required for Inverse Dynamics

The output of Inverse Dynamics is in a.sto format which gives the forces in different segments of the body with time while walking.
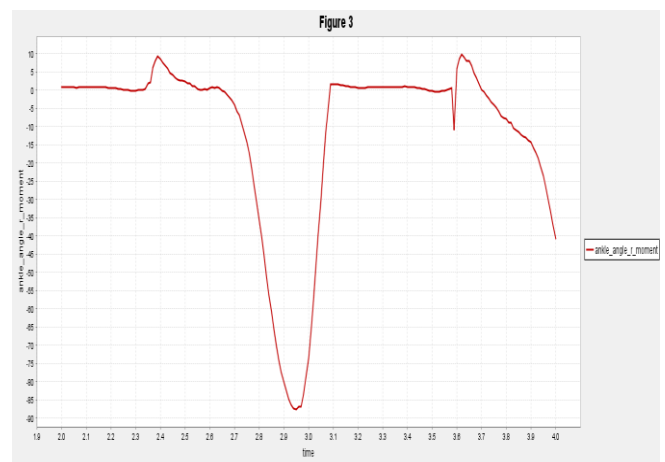


Figure 6-Ankle_angle_r_moment varies with time

## 9. Static Optimization

For analyzing the muscle force, static Optimization has to do. It is the next level of Inverse Dynamics that further distribute the net joint moments into muscles forces at each instant of time. For calculating muscles force, we need input files as shown in fig-9. All these files generated by doing above processes. Easily we calculate muscle force with the help of OpenSim as for other software's it's a tedious work or may be impossible.
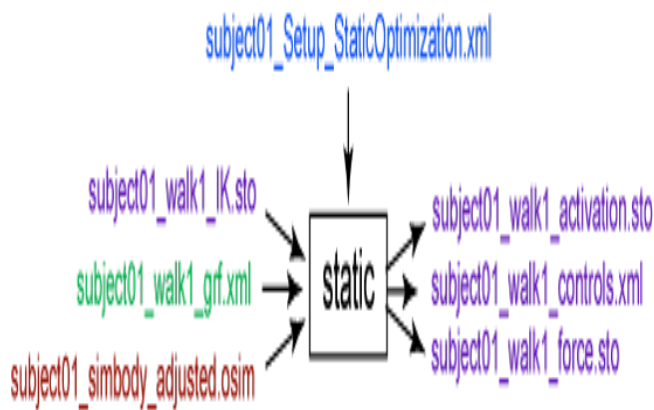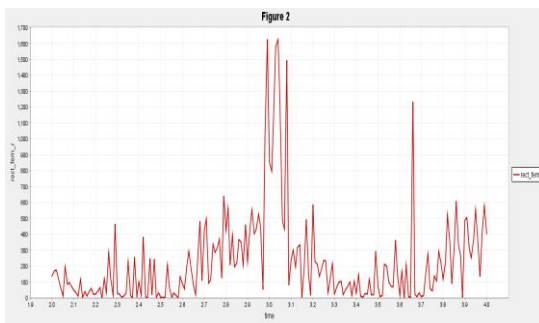
Figure 7- Files for Static Optimization



Figure 8 - Muscles Forces for Rect_fem_rmuscle force

## 10. Discussion

The most important finding of this paper is that how to generate files as input files for OpenSim and how it can be used to find muscle forces. As it is open source software so many researchers are using this software than others and also it provides an online community where models can be shared, and any problem related to this can be discussed. Through this many orthotic devices can be designed like AFO, knee support and can analyze various load effect on human movement and muscles force. This software can be used to improve the activity or motion of athletics.

## 11. References

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