

## VISUALIZATION OF HUMAN MOTION USING PARAVIEW-OPEN SOURCE SCIENTIFIC VISUALIZATION

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### ABSTRACT

*Gait analysis typically includes measurements of motion, ground force, foot pressure, and muscle activation patterns. This information can be presented in Binary or ASCII data file types. Binary files are generally used to store "raw" recorded data, and require a commercial software for data visualisation. On the other hand, an ASCII text file basically presents just a plain text (often used for exported data in gait analysis), which can be displayed in many programs, such as text editors, spreadsheets, etc.. This work presents a procedure developed for the visualization of gait analysis data recorded in ASCII data file type, in particular marker positions and ground force reaction. Data preparation was performed using programs written in C++, whereas the open source scientific visualization software ParaView was used for subsequent visualization. Apart from motion visualization, procedure can be used for detailed analysis of human gait (velocity and acceleration of markers, bone angles, pressure distribution on foot, etc) and as a utility for determination of boundary conditions for subsequent numerical analysis (e.g. stress analysis of bones).*

**Keywords:** human motion, gait analysis, visualization, ParaView, C++ programming

### 1. INTRODUCTION

Gait analysis is the systematic study of human walking, augmented by instrumentation for measuring body movements, body mechanics and the activity of the muscles [1]. In individuals with conditions affecting their ability to walk, gait analysis may be used to make detailed diagnoses and to plan optimal treatment. Besides this, usage of gait analysis is constantly spread to the different fields of biomechanics, optimisation of specific movements in sports activities, for determination of boundary conditions for subsequent numerical analysis, movie industry, etc..

Modern gait analysis systems allow large amounts of data to be recorded. These data could be stored in Binary or ASCII file type. Binary files have many advantages including file size, speed of writing and reading, efficiency, but cannot be read or written without a "specification" of the file's content. This means that vendor of a system can choose to keep the format "proprietary". Therefore, in order to open and visualize the data a vendor-supplied program must be used. On contrary, the term "ASCII file" refers to a "text" file that is easily readable (it only contains the letters a-z, numbers, carriage returns, and punctuations marks), and can be displayed in many available programs (text editors, spreadsheets, etc.).

The aim of this paper is to present a new procedure for visualization of the gait analysis data of a human motion using an open-source software, rather than expensive commercial alternatives [2-4]. The procedure includes extraction of the marker positions and ground force reactions data from an ASCII file, then data preparation using C++ programs which creates series of VTK (Visualisation Toolkit) files [5] that can be imported into scientific visualization software ParaView [6].

ParaView is an open source program for parallel, interactive, scientific visualization. It uses three basic steps to visualizing data: reading, filtering, and rendering. First, data must be read into ParaView in an adequate file format. Next, in order to manipulate the data in different ways the data must be filtered, with more than a hundred filters available [7]. Finally, a viewable image is rendered from the data.

## 2. METHODS

For kinetic and kinematic analysis of a healthy 30-year-old male subject's gait, the CODA mpx 30 system was used. Markers were placed on the medial aspect of the first metatarsophalangeal joint (MTPJ) and the lateral aspect of the calcaneum, the fifth MTPJ, ankle, knee and hip of the left foot (Figure 1). The subject made five „dummy“ walks along the walkway in the laboratory and on a sixth walk was asked to walk over the force plate so that the Fx, Fy, and Fz ground reaction forces were obtained. The gait analysis and data extraction were performed at Central Remedial Clinic in Dublin [8].

Collected data, markers positions and ground reaction forces, were initially saved into separated sheets of an XLS file (Microsoft Excel file format). Since the XLS type files cannot be directly read into ParaView, the process of data preparation had to be performed. Firstly, the necessary data (time steps and values of different marker positions) were extracted from the XLS file and saved into tab-delimited file type (.txt file). The same process was also performed for ground reaction forces. Secondly, two C++ programs were written to prepare extracted data in form of the VTK data model which ParaView can read, as presented in [9-10].

The most fundamental data structure in VTK is a data object. Data objects can either be scientific datasets such as rectilinear grids, or finite element meshes, or more abstract data structures such as graphs or trees. Datasets are formed of smaller building blocks: mesh (topology and geometry) and attributes. The first C++ program created series of VTK files (for different time steps), using "Polygonal Grid - Polydata" dataset and markers positions as input data. The second C++ program created series of VTK files, using "Rectilinear Grid" dataset and ground reaction forces as input data. Figure 1. shows a flowchart of the procedure for gait analysis data visualization using ParaView. When the process of data preparation was finished, series of VTK files were read into ParaView.

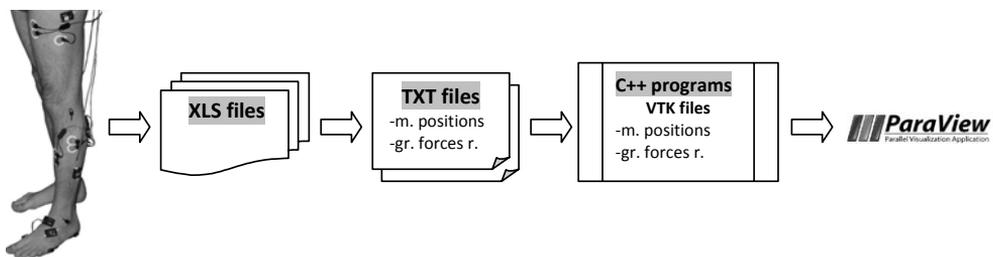


Figure 1. Flowchart of the procedure for the gait analysis data visualization using ParaView.

## 3. DATA VISUALIZATION WITH PARAVIEW

Once a set of data is read, ParaView automatically render it in *View*. Here, the *View* is simply a window that shows the data. There are different types of views, ranging from qualitative computer

graphics rendering of the data to quantitative spreadsheet presentations of the data values as text. User is free to change the view type, modify the rendering parameters of the data, and create a new view simultaneously.

Data set read into ParaView consisted of two modules: one for the data of markers positions, and the other for the ground force reactions data. Besides this, in order to better visualization of the data set, three built in filters were used: *Tube*, *Cell Centers* and *Glyph*. The *Tube* filter was used to create tubes around the “stick man” lines (visualization of the left leg), which obtained better visibility of the lines. In order to locate position of the resultant of the ground force reaction and preview its value in the legend, as well as the arrow on the ground surface (representing the direction of the ground force), *Cell centers* and *Glyph* filters were used. At the end of the visualization process, the result was a smooth movement of the “stick man” with the resultant of the ground force reaction for every time step (Figure 2).

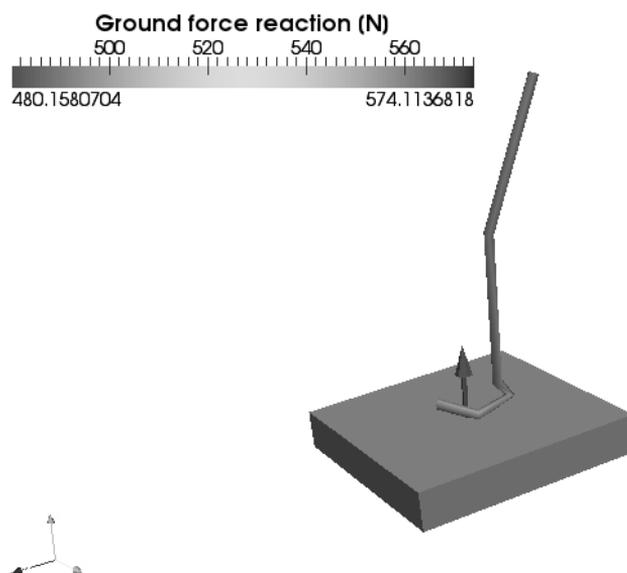


Figure 2. A sequence of visualization process of the gait analysis data using ParaView.

#### 4. CONCLUSION

A procedure for visualization of the gait analysis data recorded in *ASCII* data file type was developed. Instead of using commercial software solutions, an open source scientific visualization software ParaView was employed, along with developed C++ programs for data preparation in adequate file format. Tested data set showed good results which could be used for different purposes, from biomechanical experiments of human movement (velocity and acceleration of markers, bone angles, pressure distribution on foot, etc) to the adequate utility for determination of boundary conditions for subsequent numerical analysis (e.g. stress analysis of bones).

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