AN INNOVATIVE TOOL FOR GENERATING NUMERICAL MODELS OF THE HUMAN FOOT – A NEW AGE OF TAILOR MADE RUNNING SHOES?

[2]E. Dejuniat, [1]E. A. C. Johnson, [1,2]P. G. Young
[1]School of Engineering and Computer Science, University of Exeter, Exeter, UK Email: e.a.c.johnson@ex.ac.uk
[2]Simpleware Ltd, Innovation Centre, Rennes Drive, Exeter, UK. Email: p.young@simpleware.com
Web: www.simpleware.com

INTRODUCTION

The human foot is a complex, multifunctional system that serves as the primary physical interaction between the body and the environment during gait and understanding the impact mechanics during human motion is important for research in motion analysis and footwear design. Many fundamental and applied human motions are influenced by complex deformations, internal stresses and shock waves of the foot skeletal system but it is difficult to directly examine the relationship between foot structure and function *in vivo*.

A new technique is emerging in the advancement of motion analysis and image processing. The ability to automatically convert any 3D image dataset into high quality meshes, is becoming the new *modus operandi* for studying the mechanical loading of complex structures. Novel proprietary techniques have been developed for the automatic generation of volumetric meshes from 3D image data including image datasets of complex structures composed of two or more distinct materials at resolutions down to the sub-micron level. The techniques guarantee the generation of robust, low distortion meshes from 3D data sets for use in finite element analysis (FEA). Such a model could generate simulations of normal and pathological foot behaviour.

The purpose of this study was to develop a complex skeletal model for finite element analysis of physical exercise, sports injury and footwear design.

METHODS

Magnetic Resonance Image (MRI) scan data was obtained from the Medical Physics department of the University of Exeter. The original scan had a plane resolution of 0.75mm and a slice-to-slice separation of 0.75mm. A first generation finite element (FE) model of the foot, that had been preliminarily validated against cadaveric data, was developed (Figure 1) using an in-house software package, Scan IP™ [1]. The model consisted of 26 foot bones (including the distal tibia and fibula), 51 ligaments (including the plantar aponeurosis) and the plantar soft tissue (flesh).

Material properties of each tissue structure were assigned to the model and appropriate loading conditions according to the mass of a 70kg human, were introduced thus imitating the impact of the weight on the articulations.

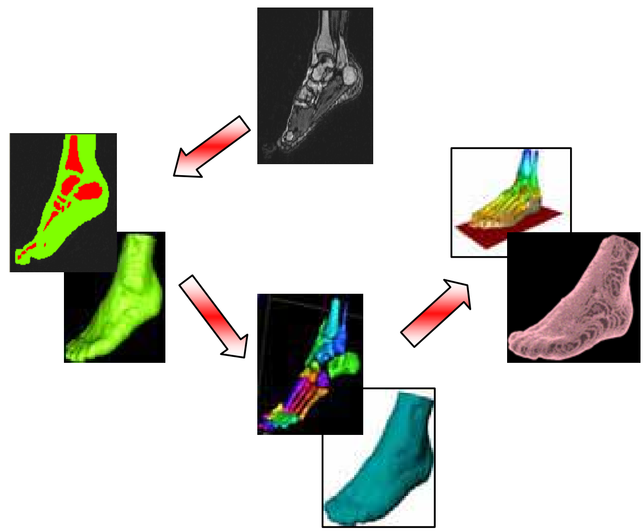

Figure 1: Development of the model from MRI scan to numerical (FE) model

RESULTS AND DISCUSSION

The aim of the study was successfully achieved in the development a high quality, complex mesh of unprecedented sophistication for use in FE analysis. The model is true to form and patient specific which opens the door to a vast array of applications in biomechanics. Parametric analyses can be performed to explore the function of different regions of the foot. Various treatment strategies could be simulated to quantify their efficacy in treating foot pathology. In addition to the obvious potential for sports injury and physical exercise analysis, it leads the way to mass customization of subject specific products such as running shoes or football boots.

REFERENCES

1. Simpleware Ltd. www.simpleware.co.uk