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Personalised biomechanical models for intelligent orthotic design and optimisation

The A-FOOTPRINT project team provides some early insights on the development of personalised biomechanical models of the lower limb and foot

Two work packages in the *A-FOOTPRINT* project are currently developing patient-specific biomechanical models of lower limb and foot. These models will be used in the design optimisation and testing of personalised foot and ankle-foot orthoses. Researchers from ***Glasgow Caledonian University (GCU)*** and ***Maastricht University Medical Center (MAS)*** are recruiting normal healthy adult subjects and patients with a range of foot and ankle pathologies to undergo a series of foot examinations, anthropometric measurements, computed

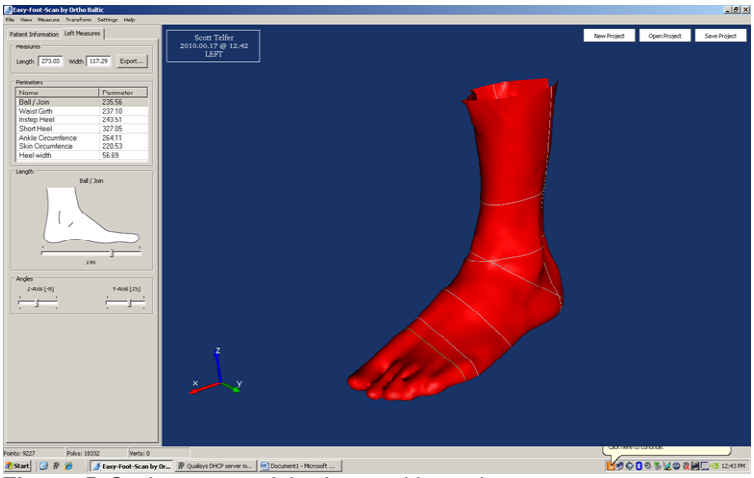

Fig 1. 3D Surface scan of the foot and lower leg

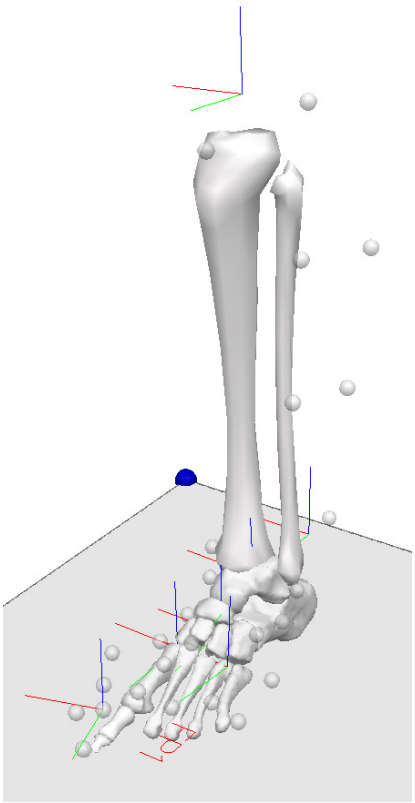

Fig 2. Motion capture foot and leg model

tomography (CT) imaging and three-dimensional (3D) gait analysis. The first step involves capturing the overall external and internal shape of the leg and foot as well as the detailed anatomy of the most important muscles and ligaments. The external foot/leg shape is pictured using a 3D laser scanning device, developed by ***Baltic Orthoservice (BOS)***, one of the SME partners in the *A-FOOTPRINT* project (Figure 1). The 3D shape of the bones of the foot and leg are reconstructed from images derived from CT scans using Mimics 14 (by ***Materialise (MAT)***) (Figure 3). The foot is a highly complex structure with multiple small bones, muscles and ligaments. Capturing the detailed movement and muscle action across multiple small joints during walking poses technical challenges to gait researchers. In the *A-FOOTPRINT* project, both ***GCU*** and ***MAS*** are providing this data by using clusters of cameras to track foot movement and sensors to simultaneously record muscle function. At the same time, the distribution of stresses on the plantar (sole) region of the foot is captured using a specialised pressure measurement system developed by ***RSscan INTERNATIONAL (RSS)***.

AnyBody Technology (ABT) and ***MAS*** are currently undertaking the musculoskeletal and orthotic modeling using the information described above. The models start as generic models,

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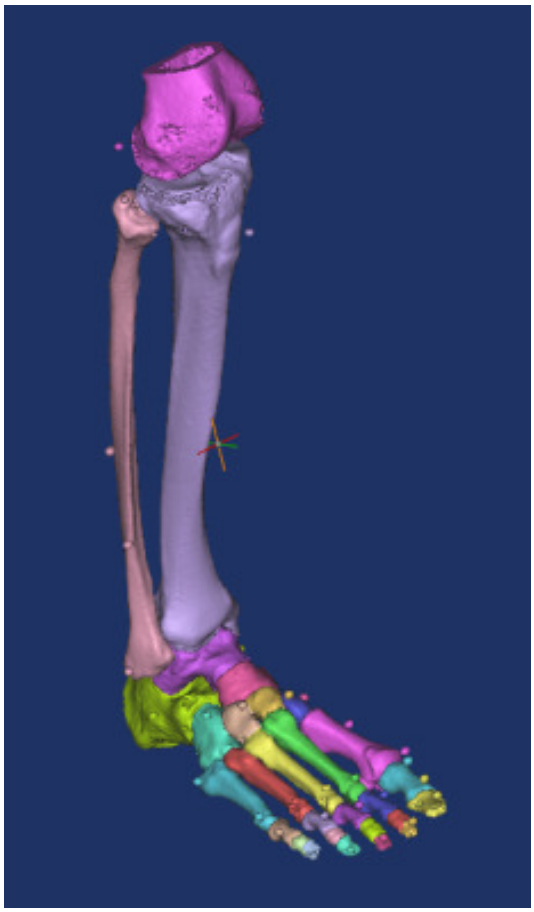

Fig 3. 3D leg and foot reconstruction from CT scans

which will then be scaled and refined, with a range of real-world foot and ankle pathological models added over time. The ***ABT*** team working with clinical and SME partners are also undertaking work to validate the models, and to assess the feasibility of driving the models using plantar pressure distribution data. Output data from the ABT modelling approach will also be used in by ***MAS*** in the MADYMO platform. This is a multi-body, finite-element software package will be used to predict motions and forces as well as tissue stresses and strains. This approach will be used to optimise or 'fine tune' the prototype orthotic designs developed by ***Materialise*** (***MAT***) and the ***University of Newcastle upon Tyne*** (***UNEW***).

The research work being undertaken in these two work packages is progressing very well. The UK clinical centre has gained ethical approval for subject and patient involvement and the first data sets have been collected and transferred to the relevant partners. The Dutch clinical centre will collect their first data sets once ethical approval has been granted. ***ABT*** have started the development of the generic foot model building in the individual bones, major ligaments and muscles from the anthropometric and CT data provided (Figure 4).

Over the following weeks and months the *A-FOOTPRINT* Consortium partners will start to gain new insights on the complex movement patterns and forces experienced in a highly complex structure that is the foot. Moreover, how disease processes and injuries determinentally alter function is urgently required to inform the design and manufacture of highly personalised orthotic devices.

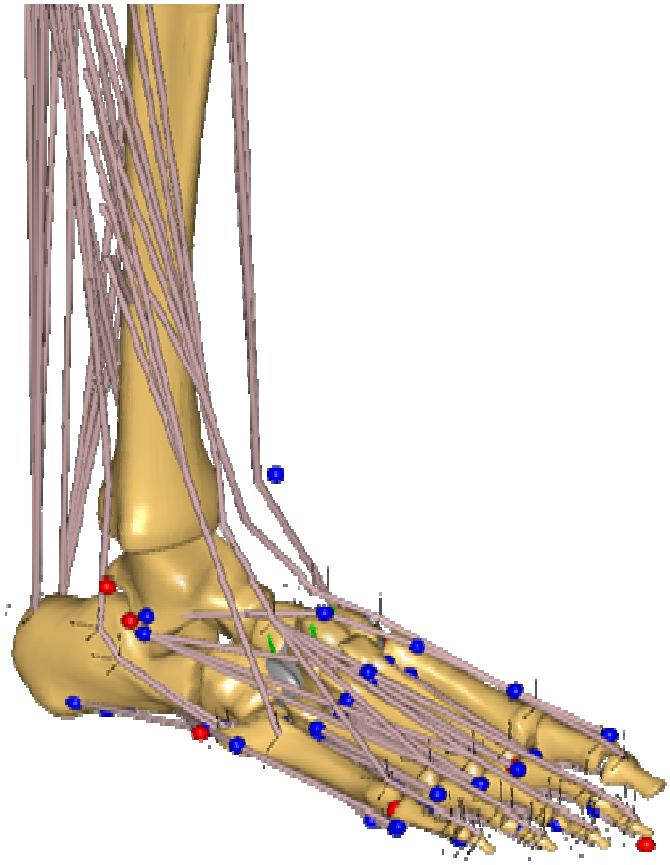

Fig 4. Preliminary foot model in the AnyBody Modelling platform

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