MUSCLE AND LIGAMENT SURFACE RECONSTRUCTION BY DIGITAL STEREOPHOTOGRAMMETRY

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INTRODUCTION

Soft tissue (muscles, ligaments) 3D morphology reconstruction, including extraction of muscle and tendon fibre topology and attachments are presented as a software pipline in this paper. It contains 3D reconstruction of dissected soft tissues as alternative to high resolution MRI that shows some limitations when whole specimen body has to be scanned. This paper proposes a method using stereophotogrammetry on the basis of digital cameras allowing soft tissue data collection and maintaining anatomically-correct results.

METHODS

The software pipeline used in this paper is an advanced modification of a previously reported [1] approach dealing with similar data collection. The method was based on an image recognition toolbox and was validated by processing simultaneous poses of calibrated clusters made of coloured balls and pins attached to a 3D digitizer (Platinum FaroArm© 4ft., accuracy = 0.013mm). Three pre-calibrated digital cameras (Olympus SP-500UZ, 6 mega pixels) allowed a reconstruction accuracy about 1 mm for the captured volume (0.5x0.5x1.0m^3). Prior to dissection, a specimen has been fully CT-scanned to obtain bone 3D models. During specimen dissection, pins with colored heads (COHs) were inserted in muscles and ligaments to characterize muscle and ligament fibre path, musculo-tendinous junctions, origins and insertions (Figure 1). CHO data registration to the 3D bone models occurred using technical frames including reflective markers and aluminium balls inserted into the bones for better accuracy (TF) rigidly attached to the bones [2] (Figure 2). Once registered, CHO information was reconstructed in 3D together with the bone models (Figure 3). Muscle and tendon fiber length and pennation angles were evaluated after piece-wise linear approximation of the reconstructed points. The method has been applied on an entire human body.

RESULTS AND DISCUSSION

Figures 1 to 3 show the pipeline steps for soft tissue reconstruction. Starting from image data captured by 3 digital cameras (Figure 1), registration of CHO data to bones (Figure 2) and CHO reconstruction were done. Final results were visualized and stored in LhpBuilder [3] (Figure 3). Each muscle was reconstructed in laboratory and CT scan joint poses to get result of direct measurements and after soft tissue transformation for muscle and ligament fibre path and musculo-tendinous junctions. A total of near 250 muscle and ligament surfaces were reconstructed. The main drawback of the method is the lack of automated pin recognition that must be performed semi-automated.

Figure 1: TFs (right scapula, humerus, radius) and colored pins captured by digital camera for biceps brachii (caput longus) muscle.

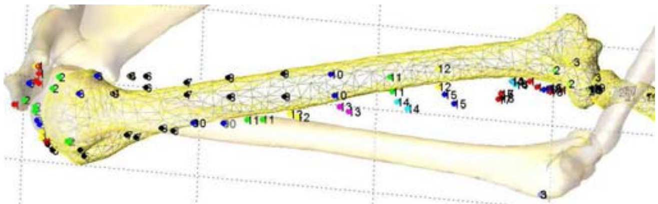

Figure 2: Registration of CHO data to bone models.

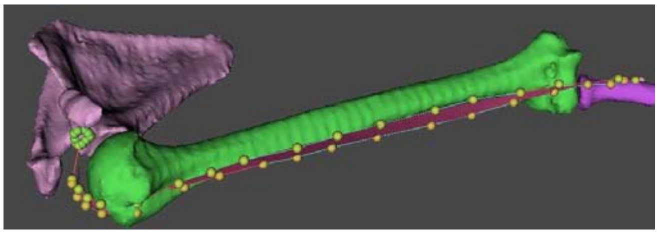

Figure 3: Final reconstruction and visualization in LhpBuilder.

CONCLUSIONS

The accuracy reached by the proposed system is satisfactory for further soft tissue and musculo-skeletal modelling. The main drawback of the approach is the time for specimen preparation (dissection and pin insertion) and semi-manual pin recognition. Benefits are the low-cost, reasonable accuracy and reproducibility of the final result due to the stored original image data.

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