CALCULATING ANATOMICAL LEG STRUCTURES FROM SURFACE CONTOURS

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INTRODUCTION

The analysis of objective movement parameters plays an important role in clinical diagnoses. State of the art motion analyzing tracks reflecting markers fixed on the skin over anatomical landmarks. When using such systems however, no information about the surrounding surface structures is available. Therefore, the purpose of this project is the development of a system able to reconstruct anatomical structures from the scanned surface volume of the lower leg under dynamic conditions. It was shown that a surface analysis of the back shape could be performed using white light raster line projection (Frobin&Hierholzer 1981, Drerup&Hierholzer 1987).

To achieve a system with the capacity to analyze the full volume of the lower extremities two main changes have to be developed. First, is the synchronization of four camera projection units and second, is to change from white light to laser light line projection.

The goal of the following pre-study is to evaluate the shape of the lower extremities using white light rasterstereographic technique to find surface areas which represent bony structures for the reconstruction of a musculo-skeletal model.

METHODS

The surface contour of the lower leg was analyzed using the formetric® system (DIERS International, Germany). This system consists of a commercial slide projector and a fire wire camera which were mounted in a constant geometrical order. The maximum analyzing frequency is 15 Hz.

The method of rasterstereography is based on the curvature analysis of horizontal light lines which are projected onto the legs and stored as a video image. Transforming the light lines into a 3D-point cloud, the shape of the leg can be comprised of concave, convex and saddle shaped areas (Fig.1).

Five subjects participated in this pre-study. They were positioned in front of the recording system and performed slow knee bending during normal stance. The surface structures were scanned from an anterior, posterior and sagittal view separately. Black markers were fixed on significant anatomical landmarks, like the patella, tibial tubercle, the malleolus and the head of the fibula, for comparison with the previously palpated positions. Due to limitations of the measuring volume, the pelvis could not be analyzed. As an orientation, markers were placed 15cm beneath the spinea iliaca anterior and the trochanter major.

RESULTS AND DISCUSSION

From the sagittal view the lateral malleolus are a rather prominent landmark detectable in every subject. Looking at the knee, the patella can be detected as a prominent convex area from the frontal view and is also detectable from the

lateral view (Fig. 1). At the shank, the maximum curvature of each horizontal line can be marked and linked vertically. This however, does not represent the line of the tibia due to the fact that the m. tibialis ant. obscures the tibia. As a further landmark, visible from the frontal view, the tibial tubercle is represented by a change from a convex to a saddle shaped area. As already mentioned, no significant landmarks can be detected from the thigh, neither from the frontal nor from the sagittal view. In this case alternative points must be marked manually to get the line passing the iliac spine or the trochanter. Thus a calculation of the angle in the anterior posterior and the medial lateral plane is possible.
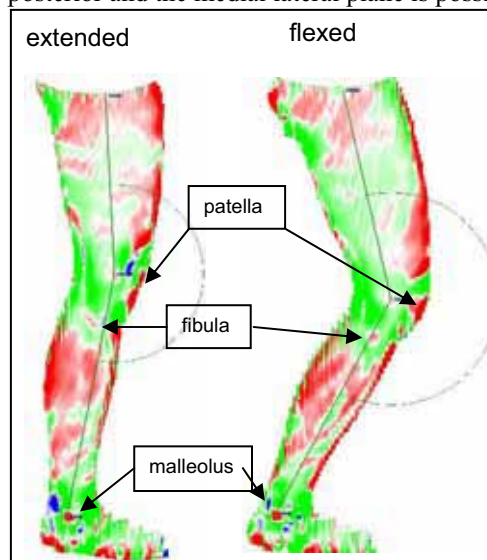
Figure 1: Image example from a sagittal view. The arrowed parts represent the detected landmarks.

CONCLUSIONS

It could be shown, that lower leg anatomical landmarks are detectable using this technique. The detection of these landmarks allows the computation of segments representing the anatomy of the lower extremities in 3D. Limitations must be seen that a movement sequence could only be analyzed from one view. The development of a four camera laser light based system, however, should solve this problem.

REFERENCES
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