Visualization of Local Movements for optimal Marker Positioning

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Abstract. Motion Capture has been adopted for the production of highly realistic movements, as well as for the clinical analysis of pathological motions. In both cases, a skeleton model has to be identified to derive the joint motion. The optical technology has gained a large popularity due to the high precision of its marker position measurements. However, when it comes to building the skeleton frames out of the 3D marker positions, significant local skin deformations may penalize the quality of the model reconstruction. In this paper we exploit a local fitting tool to visualize the influence of skin deformation on marker movements. Such a knowledge can in turn improve the layout of optical markers. We illustrate our viewpoint on motions of the upper-torso.

1 Introduction

Various motion capture technologies are used for measuring the movement of human beings either for animating virtual humans or analysing the movement per se (e.g. for sport performance or clinical context). Until now, the most successful technology is optical motion capture. This is due to its high precision measurement of little reflective markers, attached on some relevant body landmarks. In a production context, the movement of an artist is captured with two to eight calibrated cameras. For simple motions, the multiple views of markers allow the automatic reconstruction of their 3D position. Depending on the system, a static posture [1] or a special calibration motion (further referred to as the *gym* motion) is used to build or adjust a skeleton model. The skeleton model helps, in a second phase, to derive the angular trajectories of all the captured motions. In this second phase, the markers are generally assumed to be fixed in the coordinate system of a body segment. This assumption is weak for a body region undergoing large deformations, such as the shoulder. In this paper we exploit a recent tool for the analysis of local marker displacements (i.e. with respect to the underlying bones). This tool is designed to provide needed information for the skeleton fitting task, by highlighting marker sites that undergo important relative motion with respect to the underlying bones. It also helps to eliminate redundant markers and identify potentially interesting new marker locations.

The paper focuses first on the problem of skeleton identification for motion capture. Then it recalls our local fitting technique for deriving joint center from relative marker trajectories. The next section illustrates how it can be used to optimize the marker positioning of the upper-torso region. The conclusion summarizes the trade-offs regarding marker positioning and suggests new research directions.

2 Related Work

Identifying the correct location of human joint center from external information is a difficult problem. The most simple approach is to scale a standard human skeleton to the total height of a given person; needless to say, it requires some adjustments but it is sufficient for entertainment applications [2]. Within the same frame of mind, external anatomic features can be detected and exploited from a static 3D envelop captured by digital cameras [3]. However, the precision of these two approaches is very low.

Other promising techniques emerge from the field of video-based motion analysis [4]. In [5] an arm recorded with a stereo system is being tracked by fitting a model built out of ellipsoids to the data. This way, the skeleton fitting is concomitant to the motion tracking. In the longer term, one should be able to derive a generic model of the skin deformation from such data, thus paving the way to much more precise identification of the underlying skeleton movements.

Presently optical and magnetic systems prevail in motion capture as they offer the best compromise in terms of precision and overall cost (processing and human intervention). It is a standard working hypothesis in the literature to assume that the markers are rigidly linked to the underlying skeleton [6] (it is also reported for magnetic motion capture [7], [8]). However, the rigid body hypothesis causes important errors in the estimation of the joint kinematics. This was reported in [9] for marker-based systems or in [2] for magnetic systems. It is difficult to identify a better model for the local movement of the markers as it results from the combination of the inter-related movements of the bones, muscles, fatty tissues and the skin. Proposed solutions in optical motion capture are: carefully designing marker clusters [10], considering each marker separately [11], or allowing partial freedom of motion between the markers and the associated bones [12]. This latter work proposes a methodology based on an anatomic human model. The human model encompasses a precise anatomic description of the skeleton mobility associated with an approximated envelope. It has a double objective: by ensuring a high precision mechanical model for the performer, the tracking algorithm can predict the 3D location and the visibility of markers. This reduces significantly the human intervention in case of marker occlusion. The work described in the present article exploits the visualization features of a local fitting tool for which we recall the major characteristics in the next section (we refer the reader to [13] for full details).

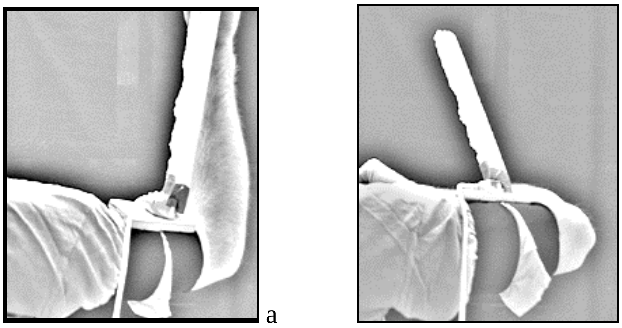

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Fig. 1: Orientation error between a strapped magnetic sensor and the underlying arm during axial rotation. A dedicated approach solving for this problem is proposed in [2] for magnetic motion capture

3. Building Local Frames

When looking for the position of the bones of a person, a first observation is that the relative distance of markers attached to one limb is almost constant. The biggest deviations occur when markers are attached on parts that suffer maximal deformation during the movement, as around the joints or on massive muscles (e.g. on the thigh). Our approach handles this context by decomposing the problem into two tasks: the partitioning of markers into rigid *cliques* and the estimation of joint centers. A *clique* denotes a set of markers where each member remains within a distance tolerance wrt all the other markers of the set. Mastering the partitioning and the joint center estimation allows us to visualize local marker trajectories and thus better understand the skin deformations

3.1 Partitioning Marker into Rigid Segment Set

In the following, we assume that we exploit a motion called the "gym motion", which highlights most of the body mobility with simple movements. The corresponding file of 3D marker locations is the input of the *partitioning* algorithm.

The partitioning algorithm computes the distances between markers at each frame of the gym motion (**Fig. 2**). It selects the biggest cliques for a given distance threshold. This condition defines a rigid segment set. The system may look for the expected number of partitions or the user can interactively tune this threshold (**Fig. 3**). In addition, we define the *attachment weight* of a marker to a segment as a normalized measure of the rigidity of its attachment to that segment. By default, all the attachment weights have a value of 1.0.

6 Acknowledgements

We thank our MOCA partner, ACTISYSTEM, for their help in providing test data files as well as our colleagues in LIG for their technical help. The MOCA project was sponsored by the European ESPRIT program. This work is also partly supported by the Swiss Federal Institute of Technology, Lausanne.

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