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Quantitative Analysis of Camera Setup for Optical Motion Capture Systems

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Abstract : Biomechanics researchers commonly use marker-based optical motion capture (MoCap) systems to extract human body kinematic data. These systems use cameras to detect passive or active markers placed on the subject. The cameras use triangulation methods to form images of the markers, which typically require each marker to be visible by at least two cameras simultaneously. Cameras in a conventional optical MoCap system are mounted at a distance from the subject, typically on walls, ceiling as well as fixed or adjustable frame structures. To accommodate for space constraints and as portable force measurement systems are getting popular, there is a need for smaller and smaller capture volumes. When the efficacy of a MoCap system is investigated, it is important to consider the tradeoff amongst the camera distance from subject, pixel density, and the field of view (FOV). If cameras are mounted relatively close to a subject, the area corresponding to each pixel reduces, thus increasing the image resolution. However, the cross section of the capture volume also decreases, causing reduction of the visible area. Due to this reduction, additional cameras may be required in such applications. On the other hand, mounting cameras relatively far from the subject increases the visible area but reduces the image quality. The goal of this study was to develop a quantitative methodology to investigate marker occlusions and optimize camera placement for a given capture volume and subject postures using three-dimension computer-aided design (CAD) tools. We modeled a 4.9m x 3.7m x 2.4m (LxWxH) MoCap volume and designed a mounting structure for cameras using SOLIDWORKS (Dassault Systems, MA, USA). The FOV was used to generate the capture volume for each camera placed on the structure. A human body model with configurable posture was placed at the center of the capture volume on CAD environment. We studied three postures; initial contact, mid-stance, and early swing. The human body CAD model was adjusted for each posture based on the range of joint angles. Markers were attached to the model to enable a full body capture. The cameras were placed around the capture volume at a maximum distance of 2.7m from the subject. We used the Camera View feature in SOLIDWORKS to generate images of the subject as seen by each camera and the number of markers visible to each camera was tabulated. The approach presented in this study provides a quantitative method to investigate the efficacy and efficiency of a MoCap camera setup. This approach enables optimization of a camera setup through adjusting the position and orientation of cameras on the CAD environment and quantifying marker visibility. It is also possible to compare different camera setup options on the same quantitative basis. The flexibility of the CAD environment enables accurate representation of the capture volume, including any objects that may cause obstructions between the subject and the cameras. With this approach, it is possible to compare different camera placement options to each other, as well as optimize a given camera setup based on quantitative results.

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