A NUMERICAL METHOD FOR DETERMINING IDEAL CAMERA PLACEMENT

[1] Joseph D Gardinier, [1]Kurt Manal
[1]Center for Biomedical Engineering Research, University of Delaware

INTRODUCTION

Data piloting is important to ensure accurate coordinate data and to minimize camera drop-out. Camera drop-out occurs when a marker fails to be imaged by a camera; often due to marker merging and occlusion. In this paper, we present the conceptual framework of a numerical method for determining where video cameras, if placed, would have an occluded or a merged view of the markers. Experimental data are used to demonstrate the efficacy of the method as an effective tool to complement existing data piloting procedures.

METHODS

The method is best described by considering two markers within a motion capture volume. The motion capture volume is a subspace of a larger laboratory volume, both of which are defined by 4 walls, a floor and a ceiling (Figure 1). The apex of a cone is set at the midpoint between the markers, opening in the direction of one of the markers, and encircling its perimeter exactly. The cone continues outward, intersecting the walls, floor or ceiling of both volumes. A camera placed within this cone will have an occluded or merged view of the markers. This process is expanded to every possible marker pairing and at every point in time. Regions of intersection are displayed graphically to portray problematic camera locations. An exemplar graphical display is shown in Figure 1. The darker the shade of gray, the more frequently a camera in that location will drop-out. The method was tested using 3 video cameras positioned symmetrically as depicted by the circles in Figure 1 (Experiment 1). Markers were placed on the right leg and shoe of a subject using a modified Helen Hayes marker set. The distance between select markers was determined from data collected during a standing reference trial, and subtracted from distances measured during walking as an estimate of error due to camera drop-out. Note that camera 3 was initially positioned in a problematic location. In a second experiment, camera 3 was moved to a more favorable location (square in Figure 1) and the distance between the markers was computed once again.

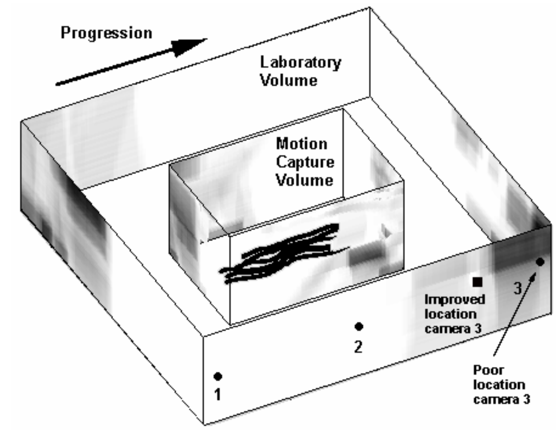

Figure 1: Gray regions depict problematic camera locations. The numbers identify the cameras. The black lines within the motion volume are marker trajectories.

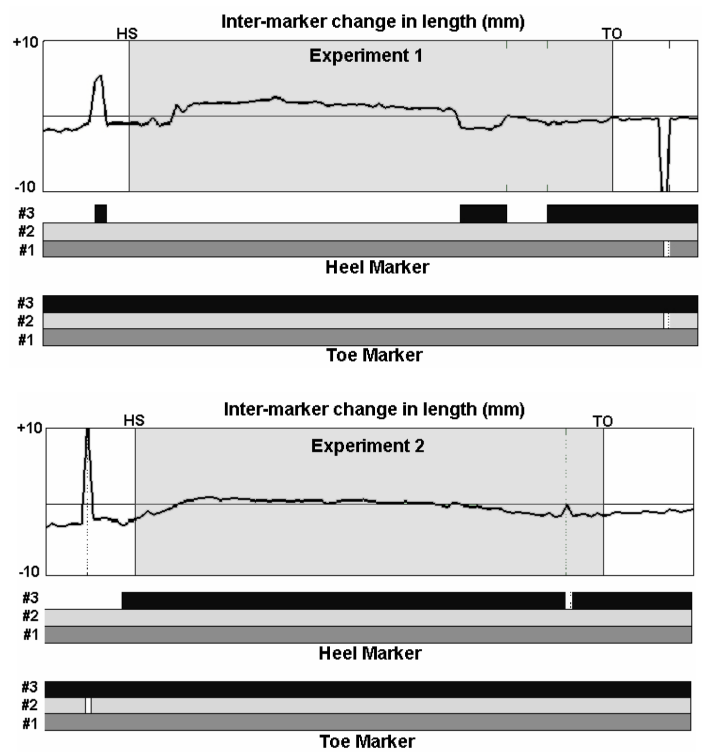

Figure 2: Errors due to camera drop-out when camera #3 was located in a bad region (Experiment 1). The bar graphs indicate which cameras contributed to the spatial location of the markers. Cameras are identified as #1 - #3. HS = heel strike, TO = toe off. In contrast, the errors are smaller in experiment 2 when camera 3 was moved to a better location. Notice how camera 3 contributed to the location of the heel marker in all but 1 video frame.

RESULTS AND DISCUSSION

Only results for markers over the heel and toe are reported. The change in the distance represents errors due to camera drop-out since markers on the shoe are not subject to soft tissue error. Notice the large interval during stance in Experiment 1 when only cameras #1 & #2 contributed to the spatial determination of the heel marker. In contrast, camera 3 exhibited minimal drop-out and only small errors were noted during experiment 2.

CONCLUSIONS

The method can be used to assist data piloting. It affords an objective and practical solution to minimizing errors associated with camera placement.

ACKNOWLEDGEMENTS

Supported by NIH RR16458