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DEVELOPMENT OF A CALIBRATION PROCEDURE FOR INTEGRATION OF DUAL FLUOROSCOPY AND MOTION ANALYSIS

Braden Mund[1], Gulshan Sharma[2], Gregor Kuntze[2], Adrienne Kline[3], Janet Ronsky[2+]
[1]Software Engineering, University of Calgary; [2]Mechanical Engineering, University of Calgary; [3]Mechanical Engineering, Indiana Institute of Technology
[+]jlronsky@ucalgary.ca

INTRODUCTION

Accurate quantification of in vivo effects of injury on joint mechanics is essential to identify movement abnormality and related joint pathologies such as osteoarthritis. Typically used Motion Analysis (MA) technologies for studying human gait and injury suffer from soft tissue movement artifact, which may prohibit identification of small but significant changes of joint motion. High-speed dual fluoroscopy (DF) systems such as the one at the Clinical Movement Assessment Laboratory, University of Calgary, provide movement-artifact-free, high-resolution (0.30-0.44°, 0.25-0.33mm) [1], in vivo bone kinematics during dynamic activities. Such systems however, represent a trade-off between high system accuracy and limited field of view (FOV~10 inch) [2] compared to MA systems. DF systems therefore typically provide information only for a single joint while MA systems may capture the whole body. This project worked toward the integration of traditional MA and state-of-the-art DF systems to provide high accuracy joint as well as lower limb kinematics. The aim was to create hardware and software solutions for the calibration of a DF system for integration with MA systems.

METHODS

A Plexiglas calibration frame (48” x 22”) with an integrated steel bead grid (95 x 41, 0.125″ diameter) was designed and built. The calibration frame pattern spanned the entire frame to allow easy identification of the pattern in the small FOV of the X-ray images. A unique braille design with letters for each row and column was implemented to support simple bead location identification and future automated procedures. Three sets of column identifiers were placed at the left, center, and right regions. This pattern was glued into the calibration frame using 0.125" diameter spherical steel beads. The DF 3D coordinates were determined by imaging a custom calibration cube and using a modified direct linear transform [3]. The calibration frame was placed on top of the treadmill and images were acquired by the DF system. A MATLAB program was developed to process the calibration frame images. A Hough Transform-based circle detection function was used for digitizing the beads in both images. The user then identified the bead ID’s in the X-ray images. Combining the X-ray image bead locations, the DF 3D coordinate system, and the calibration frame’s physical parameters, the planar equation for the treadmill location can be computed.

RESULTS

Figure 1 shows an image of the calibration device positioned on the treadmill, as well as the resulting X-ray images. The braille pattern was successful in allowing the user to identify the pattern and its beads.

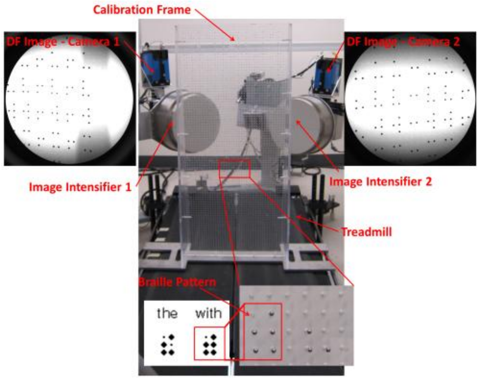

Figure 1. Calibration frame with corresponding X-ray images

DISCUSSION AND CONCLUSIONS

The calibration frame developed in provides information of the spatial location of the instrumented treadmill. This is instrumental for integrating the DF and MA systems. Without this calibration device, all joint movements are observed as floating in 3D space and information about the joint’s interaction with the ground is not accessible. Further, without systems integration, no knowledge is available for the interaction of multiple joints of the lower limbs, which contains critical information for biomechanical investigations of injury and disease. Future developments based on these methods will provide the planar equations of the treadmill to provide full systems integration.

REFERENCES

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