A Framework for Visualizing Biomechanical Movement for Designers within 3D Modeling Programs

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INTRODUCTION

In the past twenty years the power of the computer has drastically changed the ability to visualize information. Architects and designers have adopted this technology for many aspects of their workflow, however, there is still much to be done. The only diagrams architects are legally bound to are those of the ADA Standards [1]. These diagrams are outdated sectional drawings of how people move within space. Current research similar to this give simplified iso-surface representations of reach envelopes that may be useful for the engineering profession [2], but are of little use towards a user understanding the movement. The purpose of this research is to project a methodology for advanced visualization and integration of biomechanical movements within computer aided design tools (Figure 1).

METHODS

The method for integrating biomechanical visualizations is split into two sections. One avenue of the methodology is with motion capture technology and the other is with a forward kinematic algorithm. A motion capture session recorded two actions, one of an arm envelope and another of a person sitting in a chair. The reach envelope was recorded in order to compare the forward kinematic model as well as the difference in computational costs associated with mesh visualizations. The recording of a person sitting in a chair was used as a more complex movement for visualization. For the motion captured movements a 'snapshot' of the human form was recorded in different resolutions in order to represent time in a single frame. A forward kinematic algorithm was applied to a premade skeleton in the software Autodesk MAYA. The algorithm created a point cloud of a reach envelope that was visually compared by an overlay with the motion capture data. The forward kinematic algorithm used a cylindrical reference to prevent plotting of a point within a persons body. The algorithm used a user given variable to adjust for the maximum joint angles.

RESULTS AND DISCUSSION

The two methods of creating the human movement are presented as point clouds and mesh surfaces. These methods represent a movement occurring over time in a single form. The findings show the two types of visualizations aid in design differently depending on the resolution of the movement. If a high resolution is used, the movement becomes a single envelope describing the domain of the movement whereas a low resolution gives a visual understanding as to how the human interacted with the chair. The kinematic algorithm was adjusted to the motion capture subjects' joint extents. The resulting point cloud accurately described the reach envelope (Figure 2). The efficacy of the visualization is checked against the computational load within the program. For this study the program Autodesk 3D Studio Max was used to compare the frames per second (FPS) of the viewing window of each type of visualization. The goal was to maintain a FPS above 15 (half the rate of video). While the mesh surface did extremely well, with an FPS of 155, the point cloud ranged from 4 FPS to 90FPS, depending on the way in which the points were represented (Figure 3).

CONCLUSIONS

These findings indicate the most feasible method for visualizing biomechanical movements in an understandable way is through mesh surfaces. The mesh surfaces described are unique to reach envelope visualization in that instead of a single iso-surface [3], the entire human form is represented. This method of visualization allows for a more thorough understanding of the biomechanics behind a reach envelope. The use of a kinematic model instead of motion capture data would still require a human manikin to create these visualizations. This combination proves extremely useful, as the user is able to clearly compare the result of the kinematic model to what they know about biomechanics. This can also further enhance the benefit of a kinematic model with its ability to reconfigure.

REFERENCES

1. 2010 *ADA Standards for Accessible Design*, Title II (28 CFR part 35) and Title III (28 CFR part 36). Department of Justice
2. Blanchonette P, 2010. *Jack Human Modelling Tool: A Review*. Air Operations Division, DSTO Defence Science and Technology Organisation, Australian Government Department of Defence, Australia.
3. Yang, J. (J. & Abdel-Malek, K. *Human reach envelope and zone differentiation for ergonomic design Hum. Factors Man*., Wiley Subscription Services, Inc., A Wiley Company, 2009, Vol. **19**(1), pp. 15-34

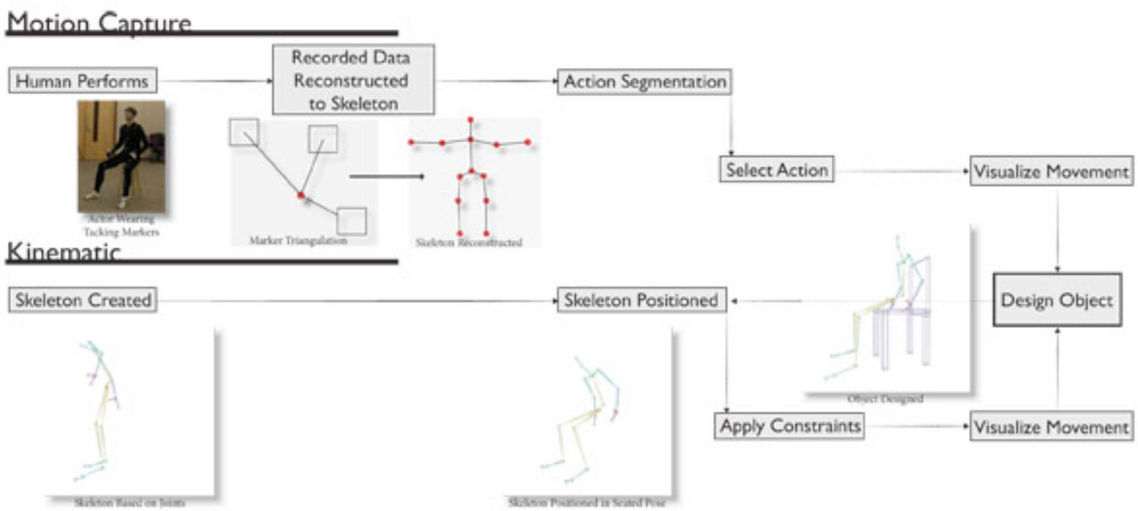

Figure 1: Motion Capture VS Kinematic Workflow for Designers

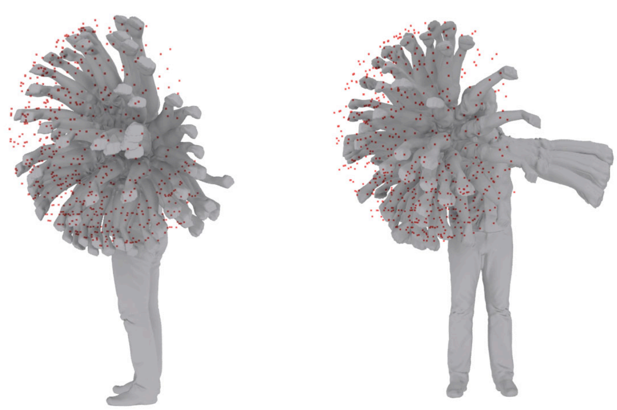

Figure 2: Overlay Comparison of motion capture mesh and kinematic point cloud

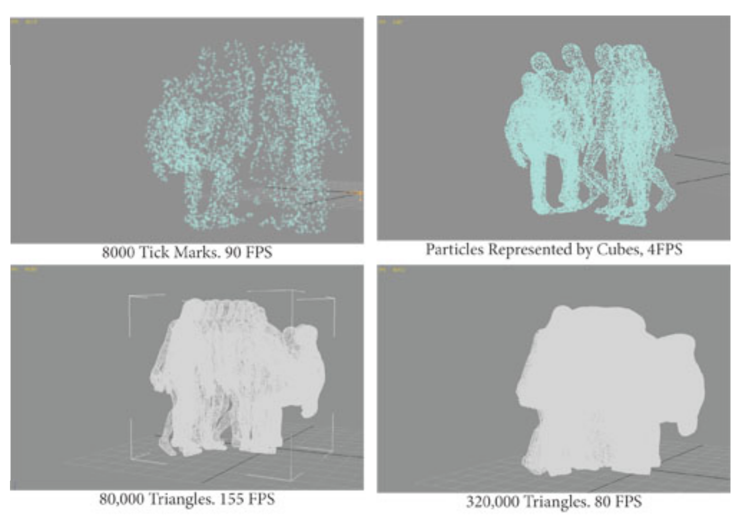

Figure 3: Frames Per Second (FPS) For varying resolutions of mesh and point clouds