iEFFECT OF SILHOUETTE ACCURACY ON VISUAL HULL QUALITY

Guido Ascenso[1], Thomas Allen[1], Moi Hoon Yap[1], Simon Choppin[2], and Carl Payton[1]
[1] Manchester Metropolitan University, John Dalton Building, Manchester, M1 5GD, UK
[2] Sheffield Hallam University, City Campus, Howard Street, Sheffield, S1 1WB, UK

Markerless motion capture systems address many of the limitations of marker- and sensor-based systems: i) they are non-invasive; ii) they require less specialist hardware and therefore typically cost less; and iii) they are quick to set up. In biomechanics, a widely used markerless motion capture systems is the visual hull [1], which is a geometrically derived approximation of the volume of an object. To compute the visual hull of an object, a set of calibrated cameras are needed. On each camera plane, the object appears as a two-dimensional surface bounded by a silhouette. The first step in computing a visual hull is to extract these silhouettes from each image; the intersection of projections from the camera centre to each of the silhouettes is then used to define the 3D shape of the object. As many cameras are typically used (8-16), an automatic silhouette extraction algorithm is needed. Most authors who employ the visual hull use basic silhouette extraction algorithms [1-4], which do not work well if the background in the images is dynamic, as typical in sports settings. As it is logical to assume that more accurate silhouettes will lead to higher quality visual hulls, it may be that a markerless motion capture system based on the visual hull would struggle in challenging natural settings, unless more accurate silhouette extraction methods are used.

This paper aims to provide a qualitative answer to the question of how silhouette accuracy effects visual hull quality. For this purpose, the TempleRing dataset was adopted. The dataset contains 47 images of a plaster reproduction of the 'Tempio dei Dioscuri' temple, taken from 47 camera positions in a circle around the object. The experiment involved artificially reducing the quality of the silhouette in each image by a known amount, and visually inspecting the quality of the resulting visual hull. To reduce the quality of the silhouettes, a number of masks of size 10 x 10 pixels were applied to each silhouette (separately). Each mask was placed over a random patch of the silhouette, making sure that no two masks overlapped and that the distribution of masks was not the same for all silhouettes, so as to model only uniformly random—not systematic—silhouette inaccuracies. Each mask changed the values of the pixels of the silhouette it covered: if a pixel covered by a mask was originally labelled as background, the mask would label it as belonging

Corresponding author email: guido.ascenso@stu.mmu.ac.uk

to the silhouette; if it was originally labelled as belonging to the silhouette, the mask would label it as background.

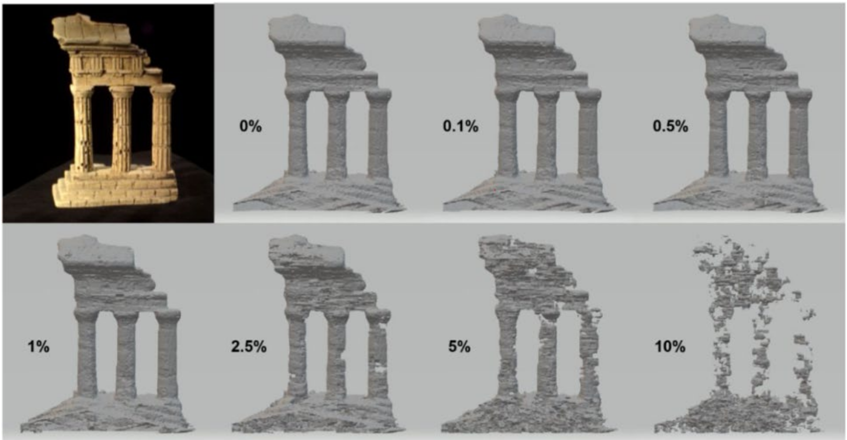

Fig. 1: *Qualitative interpretation of the effect of silhouette accuracy on visual hull accuracy. The top left image is one of the images in the TempleRing dataset. Every other image was obtained by reconstructing a visual hull from the TempleRing dataset using silhouettes that were altered by a percentage indicated by the number reported next to each figure.*

The analysis performed here was qualitative: though the silhouette errors were quantified in discrete intervals, the corresponding errors in visual hull reconstruction were evaluated by visual inspection. Fig. 1 shows a clear relationship between silhouette accuracy and visual hull quality, and indicates that silhouettes with errors exceeding 2.5% result in severely degraded visual hulls. These findings suggest that if the visual hull is to be used for the markerless motion capture of athletes in sports settings, which present backgrounds far more challenging than those present in the TempleRing dataset, basic background subtraction is unlikely to perform well, and instead a state-of-the-art algorithm for silhouette extraction should be used.

1. Laurentini, A., 1994. The visual hull concept for silhouette-based image understanding. IEEE Transactions on pattern analysis and machine intelligence, 16(2), pp.150-162.
2. Sheets, A.L., Abrams, G.D., Corazza, S., Safran, M.R. and Andriacchi, T.P., 2011. Kinematics differences between the flat, kick, and slice serves measured using a markerless motion capture method. Annals of biomedical engineering, 39(12), p.3011.
3. Abrams, G.D., Harris, A.H., Andriacchi, T.P. and Safran, M.R., 2014. Biomechanical analysis of three tennis serve types using a markerless system. British Journal of Sports Medicine, 48(4), pp.339-342.
4. Corazza, S., Mündermann, L., Chaudhari, A.M., Demattio, T., Cobelli, C. and Andriacchi, T.P., 2006. A markerless motion capture system to study musculoskeletal biomechanics: visual hull and simulated annealing approach. Annals of biomedical engineering, 34(6), pp.1019-1029.

Corresponding author email:
guido.ascenso@stu.mmu.ac.uk