Point-Cloud Spread for the
Measurement of Postural Contraction and Expansion

Brief Technical Report

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Introduction

In the analysis of video images, the contraction and expansion of the human body has been measured by a "Contraction Index", or CI. This name has been given to measures that approximate the silhouette of a subject in the picture. The measures that have been used as CI are for example the minimum bounding rectangle or the eccentricity of an inscribed ellipse (Camurri et al., 2003). In the analysis of marker-based motion capture (resulting in point-cloud data), also the minimum bounding rectangle has been used as a measure of CI (Burger & Toiviainen, 2013; Luck et al., 2014). Another way of obtaining a CI is to compute the sum of distances between each point and the centroid (Fenza et al., 2005; Dahl & Visi, 2018). However, these measures fail to accurately quantify the contraction and expansion of the human body, due to their geometrical properties.

In this report the sum of the distance between each point with all other points is proposed as an accurate measure for postural expansion and contraction. The proposed measure is compared with measures mentioned above. For simplicity, in the rest of this report the extent of contraction or expansion of a point-cloud is referred to as “spread”.

Method

Four distinct hand-crafted postures are used as key examples. These postures are encoded as point-cloud data and the points are joined with straight lines to visualise them as anthropomorphic skeletons (Fig. 1). They are ordered from less expanded (more contracted) to more expanded (less contracted), starting with posture A. Only the arms have been manipulated. It should be evident that B is more expanded than A. The rationale for the order of B to D is the distance between the farthest points of the manipulated limbs, to their respective closest point on the body, which may be a point of the cloud (i.e., a marker) or a point in the line connecting two points of the cloud. In Fig. 1, this distance is shown with dotted lines. For posture B the distance is roughly two times the half of a forearm. In the case of posture C, the distance is roughly two times a forearm. In the case of D, the distance is roughly two times a full arm.

For each posture three measures were computed: sum of all distances between points, sum of the distance between each point and the centroid, and the minimum bounding rectangle. The source code of the program is provided in the Appendix. In this comparison, what is of interest is not the resulting values but the ranking of the resulting values for each measure. The correct ranking is A, B, C, D, from low to high.

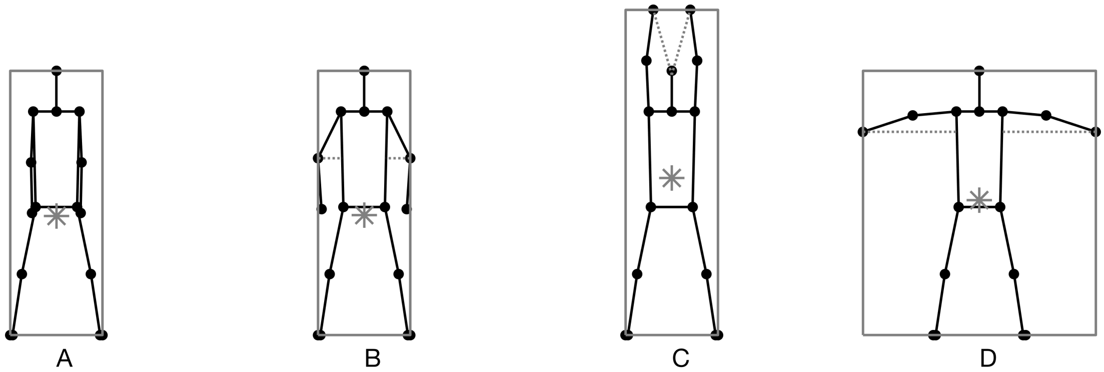

Figure 1: Example postures ordered from less to more expanded, left to right.
Also the minimum bounding rectangle (solid gray line) and the distance from farther to closest points not in the same limbs (dotted gray line).
The centroid is indicated with an asterisk.

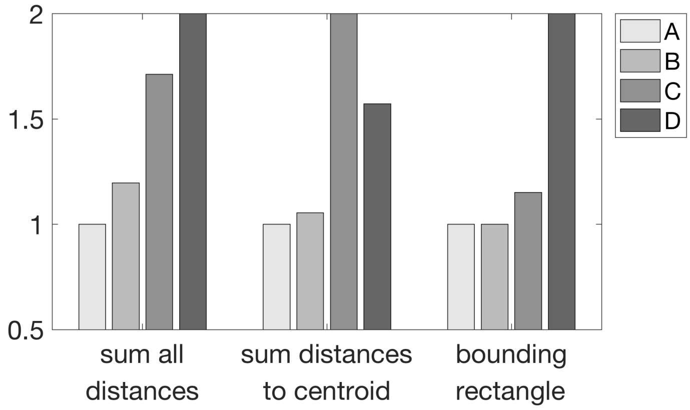

Figure 2: Measurements of the examples in Fig. 1

Results

Figure 2 shows the measurements for the example postures. The values have been rescaled for each measure so that the minimum is 1 and the maximum is 2. The bar chart shows that the sum of all distances reflects the correct ranking. The sum of the distances to the centroid results in postures A and B having correct ranks, but posture C having a higher rank than D. Conversely, the bounding rectangle correctly reflects the ranks of C and D but fails to capture the difference between A and B.

Conclusion

This report shows a comparison of three measures for postural expansion or contraction of the human body represented by point-cloud data. The measures evaluated are the sum of all distances between points, the sum of the distance between each point and the centroid, and the minimum bounding rectangle. Only the first measure correctly reflects the expansion or contraction of the body, which is in fact the extent to which the points are separated, or “spread”. This is a preliminary assessment with only a few synthetic examples. Further research should consider a comparison using a variety of motion-captured data and perceptual assessments of a number of raters enough to provide substantial statistical power.

References

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Appendix

Matlab source code reproducing the data and results in this report may be found at
https://gitlab.jyu.fi/juigmend/matlab-miscellaneous
under "mcspread".