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 area of the minimum bounding rectangle or the eccentricity of an inscribed ellipse (Camurri et al., 2003, Glowinski et al., 2011). In the analysis of marker-based motion capture (resulting in point-cloud data) also the minimum bounding rectangle may be used as a measure of CI (Burger & Toiviainen, 2013), although it has to be expanded to a three-dimensional cuboid. Another way of obtaining a CI is to compute the sum of distances between each point and the centroid (Dahl & Visi, 2018; Fenza et al., 2005). Yet another CI, that has been used for marker-based motion capture data, is the convex hull (Ajili et al., 2019; Hachimura et al., 2005; Hartmann et al., 2022). However these measures, due to their geometrical properties, fail to accurately quantify the contraction and expansion of the human body.

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 the 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

Eight distinct hand-crafted postures projected onto a plane 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. These postures are organized in two sets. The first set comprises frontally projected postures (Figure 1), ordered from less expanded (more contracted) to more expanded (less contracted), starting with posture A. Only the arms have been manipulated, except for posture C that also has the head tilted to one side. The postures of the second set are projected laterally (Figure 3), ordered from more expanded to less expanded starting from posture F. Both postures G and H have the same height.

For each posture four measures were computed: sum of all distances between points, sum of the distance between each point and the centroid, area of the minimum bounding rectangle, and the convex hull. 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 for frontally projected postures is A, B, C, D, E, from low to high; for laterally projected postures it is F, G, H, from high to low.

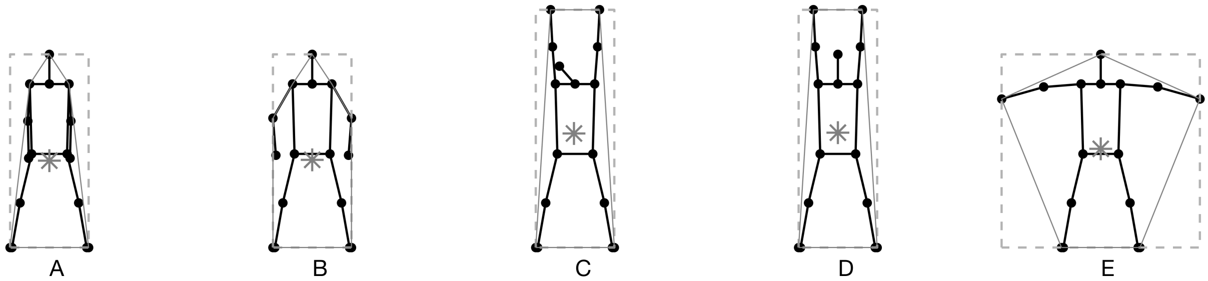

Figure 1: Frontally projected postures ordered from less to more expanded, left to right.
Also the minimum bounding rectangle (segmented gray line) and the convex hull (solid gray line).
The centroid is indicated with an asterisk.

Results

Table 1 and Figure 2 show the measurements for the frontally projected postures. The values have been rescaled for each measure so that the minimum is 1 and the maximum is 2. The sum of all distances reflects the correct ranking, capturing the subtle difference between postures C and D. The sum of the distances to the centroid results in postures A and B having correct ranks, but postures C and D having higher ranks than E. Conversely, the bounding rectangle correctly reflects the ranks of A and E but fails to capture the difference between A and B, and between C and D. Similarly, the convex hull correctly reflects the ranks of most postures, failing to measure the difference between C and D.

Table 1: Rescaled measurements for frontally projected postures (Figure 1).

	A	**B**	**C**	**D**	**E**
sum of all distances	1	1.2	1.74	1.75	2
sum of distances to centroid	1	1.05	1.97	2	1.57
bounding rectangle	1	1	1.15	1.15	2
convex hull	1	1.17	1.34	1.34	2

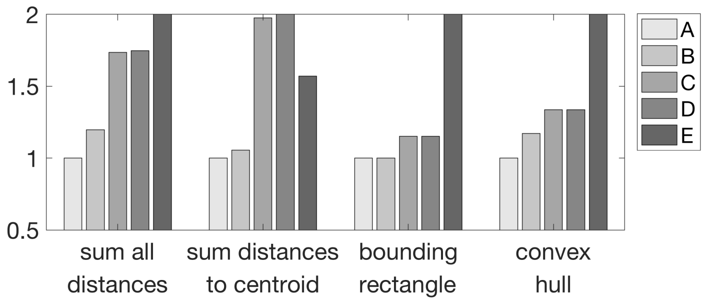

Figure 2: Measurements of the frontally projected postures (Figure 1 and Table 1).

Figure 4 shows the measurements for the laterally projected postures. The values have been rescaled in the same way as for the frontally projected postures. Both the sum of all distances and the sum of the distances to the centroid reflect the correct rankings. The opposite and thus incorrect ranking is displayed both by the bounding rectangle and the convex hull.

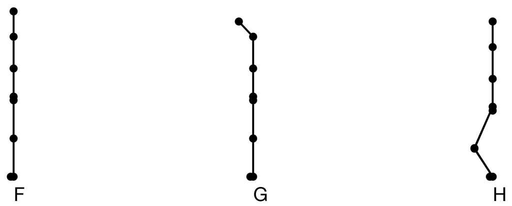

Figure 3: Laterally projected postures ordered from more to less expanded, left to right.

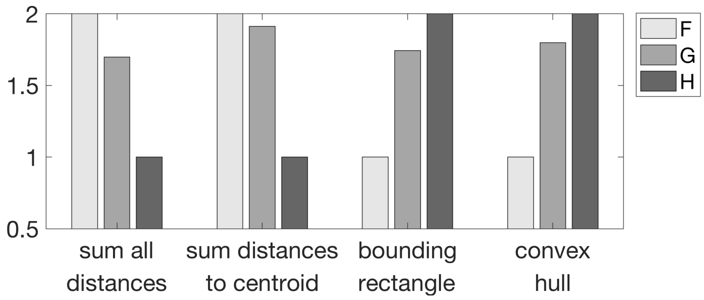

Figure 4: Measurements of the laterally projected postures (Figure 3).

Conclusion

This report shows a comparison of four 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, the area of the minimum bounding rectangle, and the convex hull. 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 in two dimensions and perceptual appraisals made by the researcher. Further research should consider a comparison using a variety of motion-captured three-dimensional data and perceptual assessments of corresponding pictures given by 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".