Influence of Pose on 3-D Shape Classification: Part II

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Influence of Pose on 3-D Shape Classification: Part II

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ABSTRACT

Last year we presented the influence of pose on three-dimensional (3-D) shape classification in the context of a repeatability study. Meaning, that the subjects are repeatedly scanned 10 times and they attempt to assume the same pose each time. It was shown that changes due to a slight pose modification had no detrimental effects for shape classification. This paper discuss a second set of experiments, designed to test the stability of the geometric search engine in more extreme cases. The pose of the subjects between the scans are modified substantially, with an increasing amount of differences compared to the CAESAR protocol. Experimental results will be presented and discussed.

INTRODUCTION

The Visual Information Technology Group from the National Research Council of Canada has developed a software tool system called Cleopatra that can automatically describe the shape, scale and color distribution of a large set of 3-D shape files. The information about each object is written in a descriptor. The descriptor is very compact: the size ranges from 200 to 400 bytes depending on the complexity of the object's shape. The size of the descriptor is independent of the original file size. The 3-D shape files can come from a computer software package (such as CAD, CG,.....), a 3-D digitizer or any other vision and rendering system. They can represent a museum object, a mechanical part, a human or even a scene.

The color involves the color distribution, the texture and the materials description of the object, subject or environment. In this paper, we will not consider the color for relevant accurate classification, due to the fact that the color files in the CAESAR project have no calibration. Rather the CAESAR color files are used to help visualization of the 3-D data, and are not intended for metric objectives. The number of objects can easily reach 100,000 without compromising the system performances. The system can handle local databases and distributed databases like the Internet. It can be deployed on our own custom made object oriented database or on a commercial object-relational database like Oracle8 and Oracle8i. The search engine can run as a stand-alone application or on an application server. In the later case, the search engine can be accessed from anywhere over the Internet. From the user point of view, a 3-D model can be analyzed in three different ways based on the scale, shape or color. The scale is simply the size or dimension of the object. Even if the size is a very simple characteristic, it is a powerful one for discrimination in large 3-D shape databases.

The shape is related to the 3-D geometrical appearance of the object. It can be analyzed at three levels: local, regional and global depending on the relative size of the object's region described. The shape can be analyzed from two perspectives: the model is viewed as a set of surfaces, or as a volume. The geometric data of the CAESAR project are, on the other hand, highly accurate, and the measurement information obtained from these files is needed by the end users of such databases. In order to evaluate the sensitivity of the classification process of the 3-D database management, we present here the results of two series of tests related to the influence of pose.

The first test of the classification performances was made with two subjects (a male and a female) which are repeatedly scanned ten times, at different measuring sessions. The subjects attempt to take the same pose each time. It is assumed here that normal daily variations in the subjects body shape is negligible in comparison to their pose variations. Initial results of this test have been presented [1], along with the classification algorithms, which are based on wavelets and multi-scale shape invariants [2-5]. A repeat is done here with additional subjects in the database. It is important here to evaluate if the size of the database has an influence on the classification properties of the software. The second test of the classification performances was also made with two subjects (a female and a male) which were repeatedly scanned, at different measuring sessions, with an increased amount of posture differences compared to the CAESAR protocol [6]. What is important here is to find a value for a difference in posture which will alter the classification properties of the software.

1. **SAME POSTURE REPEATED SCANS**

The CAESAR database has increased in size since last report. Last year's results were done on a database of 262 subjects (The Los Angeles site). It was shown that small variation in posture had no detrimental effect in shape classification. The same subject was retrieved first no matter the small variation in posture (around a cm). The database has now increased to about 900 subjects , the LA site, Detroit, Ames and Ottawa.

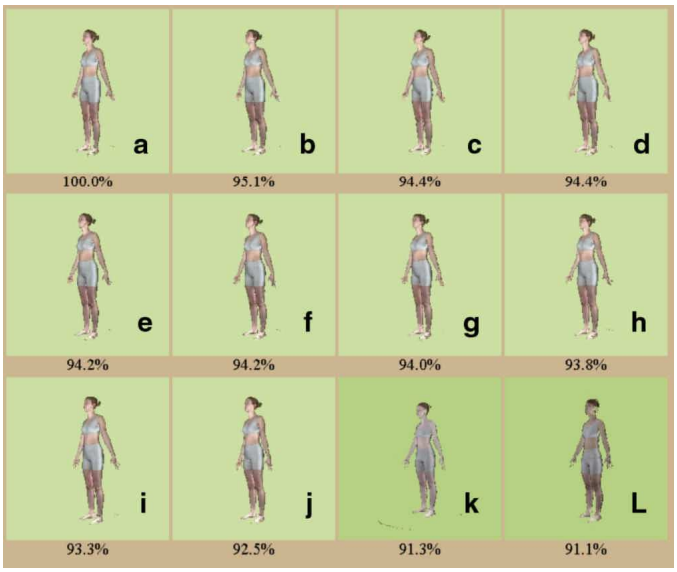

Fig. 1. Female subject testing. Results of shape classifications for small posture variations (around 1 cm) and an increased database size (900 subjects).

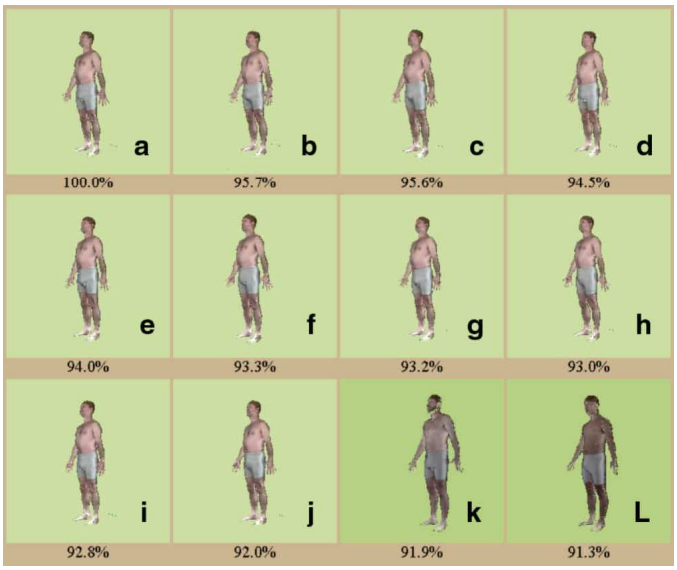

Fig. 2. Male subject testing. Results of shape classifications for small posture variations and an increased database size (900 subjects).

Figure 1 and Figure 2 show the results of small posture variation using an increased database (900 subjects). As expected, the classification is not altered by an increase of the number of subjects in the database. Note here that the background for the test cases have been lighten in order to better visualize the classification results. All 10 variations of the test subjects are retrieved first (1a to 1j), then the closest subjects in the CAESAR database (1k and 1L which have darker background). We expect the robustness of the classification being higher as the subject's shape moves toward the edge of the human body shape distribution. In other words, as the subjects body shape are more unusual the effect of pose on shape classification is less. Indeed here we present results of testing using subjects which have body shapes close to the peak of the body shape distribution (i.e. at the center of the distribution which is densely populated).

2. CLASSIFICATION WITH POSTURE DIFFERENCES

In this series of experiments two different subjects, already scanned and integrated in the database (the Ottawa site) were selected to be repeatedly scanned with their arms and legs substantially different of the CAESAR posture. At first the subject assumed a posture which is off by about 10 cm, either the position of hands or feet and both, which we call intermediate differences. Then a totally different posture was scanned, with the arms laying way in front of the subject (see Fig. 3a) and with the arms way back (see Fig. 3c). The most extreme case being a combination of arms posture changes with a large change in legs posture, which we called extreme differences.

Figure 3 shows such a result where arms and legs postures are substantially different from the CAESAR protocol (more than 20 cm).

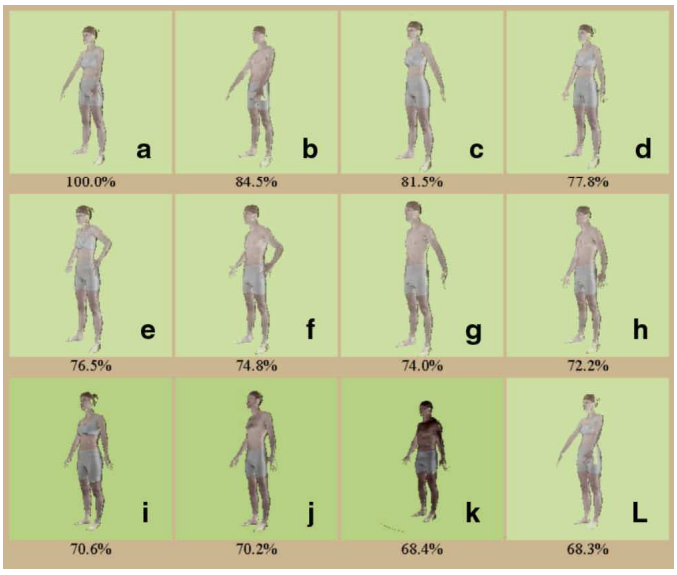

Fig. 3. Extreme posture differences cluster outside the CAESAR subjects.

It shows that all extreme postures seems to cluster outside the range of subjects digitized and modeled following the CAESAR protocol. The results shows

clearly that all extreme cases (both arms and legs differences) are retrieved first.

In contrast, Figure 4 shows the results for intermediate postures changes (around 10 cm away from CAESAR protocol), yet it is much larger than the repeatability test done last year where differences were in the order of few cm (see Figure 1 and 2). Not only all the intermediate posture differences have been retrieved, but also the same subject in the CAESAR database is retrieved (see Fig. 4h).

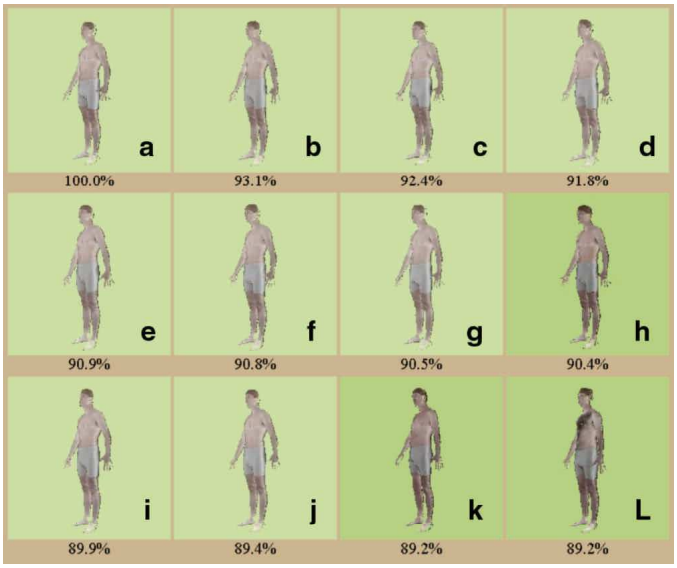

Fig. 4. Intermediate posture differences (around 10 cm away from the CAESAR protocol) are successfully retrieved.

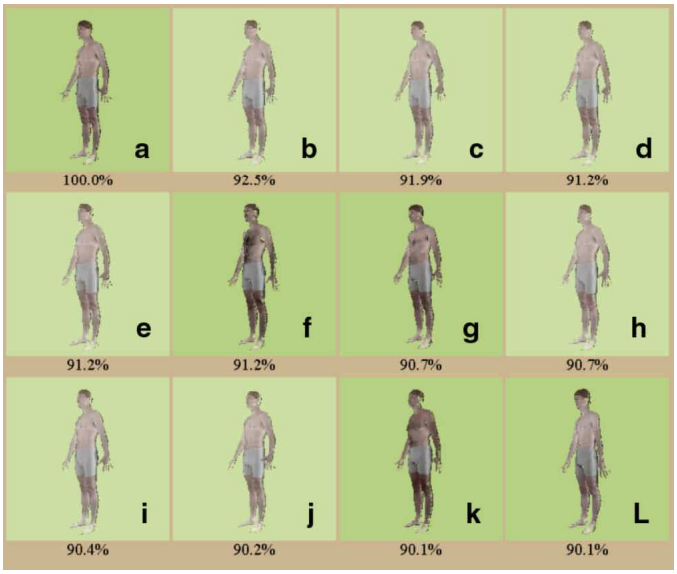

Fig. 5. The CAESAR subject file of the test subject is used for a search.

If we use the CAESAR subject file to do a search (see Figure 5), we then retrieved the same subject under smaller posture differences. Note that subjects retrieved and shown in 5f and 5g are very similar in shape to the subject under testing. This shows that for a populated area of the body shape distribution, there may be very similar body shape entering at the top of the classification within the subject's variation. The test subject and its "variations" show at the top of the classification list which is the basic objective of the classification tool.

3. CONCLUSION

The sensitivity of the shape classification tool Cleopatra has been tested with two series of experiments. The first one is a repeatability study which shows a clustering of the test cases at the top of the classification. The second one are experiments using larger differences in posture. It is shown that variation in posture as large as 10 cm in the position of the hand and the feet has minor effects on the classification properties of the search tool. For much larger differences the classification algorithm consider those shapes as "new" shapes and cluster them outside the main database. In other words, a larger difference produce an "other object" in the multidimensional classification space of Cleopatra.

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