Development of three-dimensional face scanning system to perform anthropometric measurements

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Abstract—**In this paper, we present a system that must perform 3D reconstruction of objects using an hardware-software platform, it must have a considerable degree of accuracy due to our objective in the development of this system that is utilize it to security applications. It can be possible due to each human face has unique characteristics and points that give us anthropometrics measures that are unchangeable along aging factors. Considering this points, our system must besides implementing the 3D reconstruction, recognizes the facial standard, and finally performs the measurement of the distance between the points to make a correctly identification.**

Keywords— reconstruction 3D; Delaunay triangulation; Kalman filter; anthropometric measurements

I. Introduction

Nowadays, biometric systems broadcast had not great results in identifying people according to [1]. Thus, it show to be necessary an identification system using the face recognition methods, once the human face has anthropometric measurements unique to each person and that, even with the passage of time, such measures present a low degree of variation. This type of technology has great importance in airports, criminalistics' center, and institutes of public safety.

However, as described in Face Recognition Vendor Test published in [2], as with other reports, face recognition technologies most commercial suffer two problems. The first concerns the inter-class similarity like twins classes, and parent and child classes. Here, people have similar characteristics that make their discrimination difficult. The second, and most complexly important, is about intra-class variations, caused by changes in lighting conditions, change in position (i.e., three-dimensional orientation), and facial expressions. Positional variations have also a considerable disadvantage for recognition by performing comparisons between frontal face images and images of viewpoint exchanged. Additionally, the compensation of facial expressions is a hard task in 2D approaches, because it alters significantly the appearance of the face image.

The state-of-the-art of facial recognition is interesting, once it contains works that aim to solve problems related this challenge. Most of these works use intensively face images for recognition or authentication, called 2D model-based techniques. A second family of recent work, known as 3D model-based techniques, explores the three-dimensional shape of the face in order to mitigate some of these variations.

According to [3] the identify recognition through the human face is a manual process performed by humans, who perform a range of procedures including tests, reviews and comparisons of images from a database, which consists of photographs, recordings videos, as well as identification documents. This task is slow, requires professionals with expertise in image processing, human anatomy and statistical analysis, and it brings a subjective evaluation.

Our purpose with this project is to automate the identification process allowing conduct a reconnaissance quickly with a high degree of accuracy. To reach that, we are developing a hardware-software platform that enables the capture of an individual anthropometric measurements. With this system it is possible to examine as a principle, the Brazilian human phenotype with evaluations commensurate on the area of research and may be placed at the service of identifying institutes.

II. Methodology

Our approach to capture anthropometric measurements is based on three-dimensional surfaces of faces. Therefore, research on surface reconstruction from point cloud emerge by the need to improve and refine the data from a hardware-software platform based on computer vision, which generates three-dimensional digitized models of surfaces.

A. Data acquisition and filtering

In the process of acquiring the point cloud is common the occurrence of noises which are produced both by the acquisition device, and the environment. These noises affect the connectivity relationships among points, and consequently affect the 3D reconstruction. Thus, it is clear the need to develop point cloud filtering techniques so that the resulting sample is more suitable than the original cloud of points for specific application. A fundamental problem in the restoration of a noisy sample is noise removal without loss of details.

Initially filters are developed based in KALMAN filter on MATLAB which are later transcribed into C language and used to attenuate noise produced in point clouds captured by 3D device system. The use of filters allows the elimination or mitigation of interference that are collected in the acquisition process and impair remarkably the rebuild the surface when it is displayed in three dimensions.

B. Reconstruction of 3D surface

The reconstruction of 3D surfaces can be accomplished in two ways: one is to utilize a point cloud generated by a device and organize these samples. The second is to use samples from 2D images, trying to fit three images and recompose a 3D object.

The 3D reconstruction from point cloud uses techniques of rebuilding surfaces that organize the point cloud. These techniques make use of meshes to subscribe trajectories measured on the 3D image. There are several techniques for solving the problem of reconstruction of surfaces, so that the choice of method is based on the characteristics of the form in which they can arrange the point cloud. In this article, it is proposed the spatial decomposition approach, which consists, firstly, obtain the Delaunay triangulation of the set of input points to then remove a set of simplexes in order to obtain an approximation of original surface, as shown in figure 1.

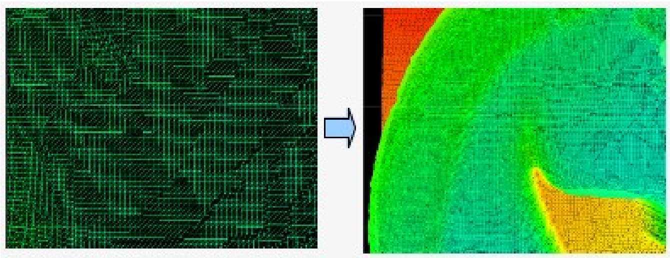

Figure 1. Surfaces at 3D mashes.

C. Detection and description of local resources in images using SIFT

Considering the mitigating factors to the method of facial recognition, we search a mechanism that can perform this comparison using a computer algorithm. In the development of this tool, one of the greatest challenges is the identification process of an individual by the facial features which should be performed differently for each image, considering factors lighting, environment and other that might distort the identification. Knowing that, to accomplish this step successfully, the method will be used SIFT (Scale-Invariant Feature Transformation) and their resources for the purpose of conducting the identification of anthropometric points.

To reach the acquisition of anthropometric points from 3D surface the algorithm uses SIFT, which was initially developed by David Lowe [4]. This algorithm consists in extracting invariant features from images, in other words, in the case of human faces would be defined by specific points in anatomy, which do not vary over the course of age and other biological factors. Knowing this, these points will be used to perform a reliable matching among different views of an object or scene. These characteristics should not vary with rotation or scale of the image in the same way that must remain in operation even after illumination changes and adding noise to the image.

Basically the main goal of the algorithm, considering its apply for anthropometric measures, must be finding a bottom line, and this finding neighboring points whose Euclidean distance is minimal for the description of a vector invariant and repeat the procedure for each new point until be capable of generating a mask of points. After performing the capture of the face invariant key points, performs a comparison with a database test, which has some points to compare previously stored the greatest number of features and it can perform an identification.

III. EXPERIMENTS AND EVALUATIONS

According to the proceedings that were described on methodology, it was performed the following test-case. As it can be observed in figure 2, an human face, was properly scanned and then it was created a mesh of points, based on it. The next step was apply the triangularization method, it is important to be careful to the mesh resolution, it must have the largest number of iterations to make the 3D reconstruction obtained by the software the closest from the real object.

Figure 2. Scanned face.

In figure 3, it can be seen that the steps of data acquisition, noise filtering and finally the 3D reconstruction were done and successful realized according to what has been proposed.

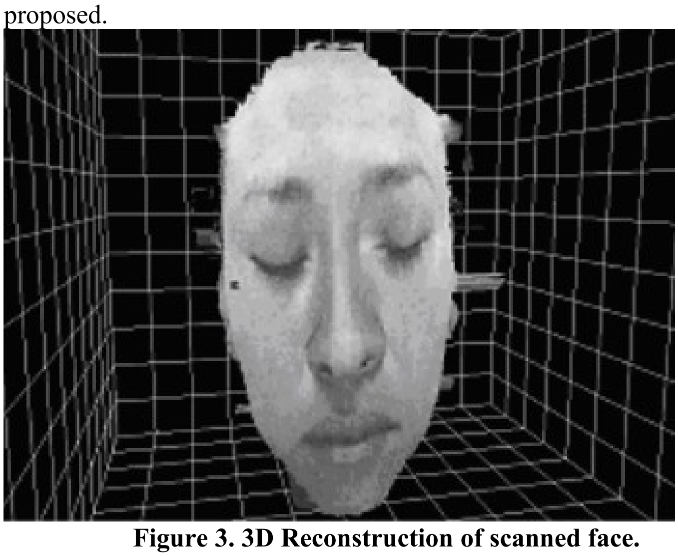

Figure 3. 3D Reconstruction of scanned face.

In figure 4, we did a measurement on 3D surface. The value obtained by measurement consider many factors that aim to reach a minimal error between the 3D reconstruction and original face.

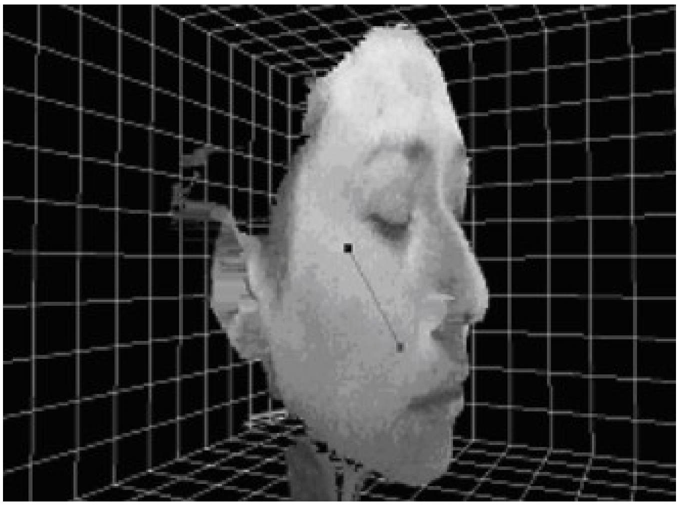

Figure 4. Measurement on 3D surface.

Analyzing the results found it can be concluded that the applications from 3D reconstruction are useful for security due to the possibility of improving the system to make it capable of measure the distance between a few specific points that are unchangeable and different from each person.

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