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Matching Fabric Based on Wavelet Kernel Signature (WKS) and Drape Indicators ⋆

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Abstract

The drape performance of the fabric is an important part of the fabric style, as well as a special expression of the structural parameters and mechanical properties. The comprehensive drape performance of fabric can support fabric matching. This study was conducted to match fabric based on 3D triangular meshes of draped fabrics. Firstly, the three-dimensional (3D) point cloud of draped fabric was scanned with a self-built 3D scanning device followed with triangulation. Secondly, three drape indicators, i.e., drape coefficient, the number of fabric drape nodes, and the solid rate of a draped fabric was extracted, as well as the wavelet kernel signatures (WKS) of triangular meshes. The WKS of vertices on the 3D boundary was selected and clustered into different classes with K-Means. With the cluster centers, the WKS of vertices on the boundary was encoded into a vector with a fixed length. Finally, two methods for matching fabrics were proposed based on WKS+DR and a vector consisting of three drape indicators separately. The results show that WKS+DR outperforms the vector consisting of drape indicators in characterizing the drape configuration details of a draped fabric. The accuracy of the method based on WKS+DR could reach 89.6%. The fabrics obtained with this method are close to the matching fabrics in both drape-ability and details of a triangle surface.

Keywords: Fabric Matching; Draped Fabric; Triangular Mesh; Wavelet Kernel Signature (WKS)

1 Introduction

The drape performance of the fabric is an important part of the fabric style. In one aspect, drape performance depends on the mechanical properties, structural parameters of fabric as well as the environmental factors [1]. In another aspect, drape performance is also an expression of the structural parameters and mechanical properties of fabrics [2]. That is, drape performance could be though as an implicit function of fabric parameters. Therefore, drape performance could provide significant guidance for fabric comparison and matching.

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The research object of fabric drape may be a two-dimensional top-view image [3] or a three-dimensional point cloud model. A two-dimensional image of a draped fabric is easy to obtaining and analyzing, while 3D models contain more information than two-dimensional images. With the development of 3D scanning technology, the cost of 3D modeling of draped fabrics has been significantly reduced, which results in the rapid development of studies about 3D models of draped fabrics. However, so far, most of the research on the three-dimensional modeling of the draped fabrics have been focusing on the acquisition of 3D point clouds or triangular meshes of the draped fabrics. For example, Wang et al [4] identified the contour line information in the panoramic raster image, located the grating stripe, and obtained the height of the space where the grating stripe is located. With this method, a three-dimensional image of the specimen's draping morphology is constructed with a bi-cubic Bezier surface. Mah et al [5] captured 3D images of fabric drape through a 3D body scanning and studied the distribution of air gaps between the draped fabric and the outside edge of a cylinder. Hu et al [6] proposed a simple effective method that can reconstruct and measure the fabric drapes with a smartphone. The breakthrough of their study lies in the simple approach of obtaining the 3D point cloud of fabric drape. These reports mentioned above show that there is little research on the comparison of comprehensive drape performance. The reason lies that fabric performance contains not only the drape ability but also the drape configurations. Besides, the result of the fabric drape is discrete. Niwa et al [7] tested 145 fabrics for the female dress and 138 fabrics for the male shirt. The result revealed that the same fabric could possess different DRs under the same experimental condition and different drape times. For the variance of fabric drape, Kenkare et al [8] pointed out that fabric drape is dependent on structure parameters, mechanical properties, and the environment. Besides, these factors were depended on other factors. Therefore, fabrics do not fall in the same con?guration each time they drape.

However, there is a factor that we cannot ignore. The structure of the fabric determines the properties of the fabric. Although there are discrete drape results for the same fabric under the same experiment condition, the local deformation of a draped fabric may be stable. Therefore, we can infer the fabric performance with the local deformation. How to describe the local deformation of a triangular mesh? Inspired by the corresponding and analysis of 3D shapes, we proposed to analyze the 3D triangular mesh of a draped fabric with a wavelet kernel signature (WKS). WKS is a three-dimensional shape descriptor. It performs great in distinguishing 3D shapes. Mathieu Aubry et al [9] have experimentally proved that WKS is more effective in analyzing 3D shapes than other types of 3D shape descriptors, such as Fourier descriptors (FD), 3D Rotation Invariant Local Binary (3D LBP), 3D scale-invariant feature transform feature vector (3D SIFT) and heat kernel signature (HKS).

In this study, we obtain the 3D point cloud of draped fabrics followed with surface reconstruction. Then the WKS of a draped fabric is calculated and encoded into a vector. A new method was proposed to match fabrics, i.e., matching fabric with the encoded WKS as well as DR. In the comparison experiment, a vector consisting of three drape indicators was used to match fabrics. At last, the two methods are compared and analyzed [10].

2 Material and Methods

The pipeline of matching fabric based on WKS+DR is shown in Fig. 1.

As shown in Fig. 1, the step of "fabric scanning" refers to obtaining the 3D point cloud of a