

## *Retraction*

# **Retracted: Apparel Design and Development Based on 3D Scanning Technology**

### **Scientific Programming**

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

### **References**

- [1] G. Zhang, "Apparel Design and Development Based on 3D Scanning Technology," *Scientific Programming*, vol. 2021, Article ID 7933206, 7 pages, 2021.

## Research Article

# Apparel Design and Development Based on 3D Scanning Technology

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With the development of computer science, especially the application of 3D scanning technology in garment design, intelligent modeling is realized, which is impossible to achieve in traditional design methods. In this paper, we propose the 3D model construction of human garments based on the motion recovery structure method. The eigenmatrix is obtained from the camera parameters, and the transformation matrix is calculated by matching the image feature points with the help of scale-invariant feature conversion algorithm to realize the 3D reconstruction technology of human garments based on multiview image sequences. The effectiveness of this method is verified through experiments, and it has good robustness and accuracy. Through the form of style modeling, the design thinking and method can be extended to form a more reasonable garment structure and guide the innovation of garment production mode.

## 1. Introduction

As computer vision technology is widely used in various fields such as virtual reality and digital cities, more convenient and efficient acquisition and construction of 3D models of human clothing have become a current research hotspot, which in turn promotes the improvement of computer vision algorithms and applications [1–3]. The use of relevant algorithms to construct 3D models of features from multiview image sequences captured with ordinary digital cameras has the advantages of wide use and convenient application, and they are most widely used in the field of 3D model construction [4–7].

Currently, 3D technology in China has received strong support from the government. China's manufacturing industry must rely closely on deepening reform and innovation to promote its transformation from bits to strong, thus promoting the development of 3D technology in China [5]. This paper discusses the design and development of garments based on 3D scanning technology, taking women's shirts as an example. The purpose is to change the traditional design made through a new creative thinking in the 3D era [6].

With the advancement of virtual reality, computer vision, and computer graphics, interactive apparel design has attracted attention as an innovation in apparel technology and a future trend in apparel design. In interactive apparel design, 3D virtual human models based on 3D scanning technology are used to instantly display the garments in the design phase and are a crucial part of the entire workflow [7, 8].

The new interaction design development process includes 5 objects: human body, virtual mannequin, 3D garment, 2D paper pattern, and physical garment. First, the point cloud data of the human body are captured using a modern 3D scanning system, which is used as the basic input for building the 3D virtual model. Then, according to the initial design sketch, the paper pattern of the garment is drawn on it using the relevant design software [9]. Then, the latest 3D fitting software CLO3D can be used to generate the 2D paper pattern directly into a 3D virtual garment. After the final 3D garment effect is determined, the 3D garment can be unfolded into a 2D garment paper pattern using CATIA (Computer Aided Tri-Dimensional Interface Application) software. Finally, the 2D paper pattern can be put into industrial production for mass production. Throughout

the process, there are 8 interactions and 3 traditional interaction techniques that are used for the virtual mannequin, namely, garment fitting/fabric simulation/texturing, data scanning, and garment unfolding. Production and physical inspection interactions are more traditional practices in the apparel design industry (Figure 1).

In this paper, we propose a 3D model construction of human clothing based on the motion recovery structure method. We obtain the eigenmatrix from the camera parameters, match the image feature points with the help of scale-invariant feature conversion algorithm, calculate the transformation matrix, and realize the 3D reconstruction technology of human clothing based on multiview image sequences [10]. The effectiveness of this method is verified through experiments, and it has good robustness and accuracy. Through the form of style modeling, the design thinking and method can be extended to form a more reasonable garment structure and guide the innovation of garment production mode.

## 2. Related Work

The current research on the algorithm for constructing 3D models of human clothing based on multiview image sequences has been focused by scholars on two aspects: image sources and algorithm improvement. In terms of image sources, the study in [11] used images acquired using digital cameras and associated linkage maps to achieve measurements and 3D reconstruction of human clothing. The work in [12] used handheld cameras to simulate drone shots and useful features around objects to obtain camera calibration parameters for each image using image pairs to complete 3D modeling. A method for building high-resolution digital elevation models using captured images from consumer-grade digital cameras was proposed in [13]. These studies are based on a small amount of image data obtained with a specific instrument and are not adapted to the large amount of image data obtained using different instruments. For this reason, Mao et al. [14] used a large collection of unstructured images downloaded from the Internet to successfully construct a 3D model of the target. High-resolution, multi-channel image sources have a fundamental impact on the application area and accuracy of 3D model construction.

For the same image data, the improvement of the algorithm is a necessary way to improve the accuracy of 3D model construction. Lamb et al. [15] introduced the basic principle and process of Structure from Motion (SfM) technique to show the simplicity and effectiveness of the technique to obtain high-precision 3D terrain data, which are suitable for areas with sparse vegetation.

Roberts et al. [16] addressed the efficient modeling of large, unordered, highly redundant, and irregularly sampled photo sets by SfM. Morris et al. [17] implemented an image-based 3D model reconstruction process using the global SfM method instead of iterative SfM based on the opensource code. Brkic et al. [18] proposed a new incremental motion structure recovery algorithm (SfM-Y) to solve the problems of poor algorithm robustness, low efficiency, and computational redundancy.

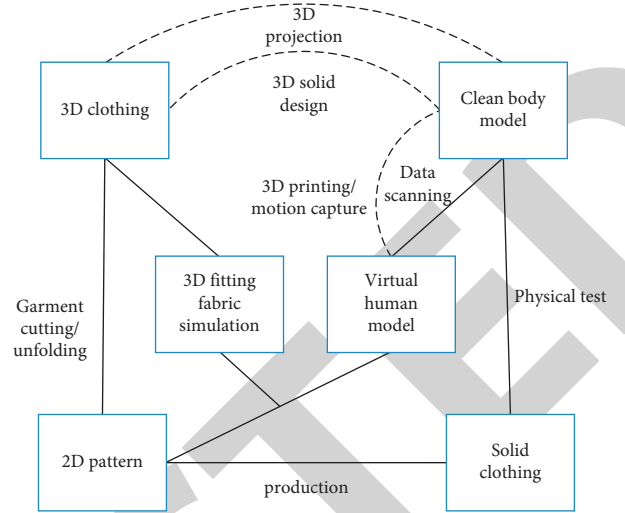


FIGURE 1: Development process of interactive fashion design.

This paper constructs 3D models of human garments based on SfM and uses multiview image sequences and computer vision techniques to extract, match, and reconstruct features of the image sequences in 3D.

## 3. Extraction and Matching of Feature Points

**3.1. Extraction of Feature Points.** The key step of 3D modeling using multiview image sequences is to fuse images taken from different viewpoints into the same coordinate system, so as to display 3D scenes in all directions. The key of image matching is to extract the corresponding points with similar features in the adjacent images, and this paper uses the scale-invariant feature transform (SIFT) [19] algorithm to extract feature points. The algorithm is based on Gaussian fuzzy, and the Gaussian pyramid and Gaussian differential pyramid are established by using different standard deviation values of feature points and down sampling, and then, the corresponding feature points are extracted and the edge points are rejected.

Gaussian blurring is used to extract high-precision feature points on images of different scales, and Gaussian blurring is the basis of the algorithm [20]. Gaussian blurring uses a Gaussian function as a template to convolve the image to make it smooth. In this paper, let the blurring degree, i.e., the standard deviation, be the size of the template  $a \times b$  and the coordinates of the pixel point being processed be  $(x, y)$ . Then, the Gaussian function is shown in the following equation:

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{-((x-a/2)^2 + (y-b/2)^2 / 2\sigma^2)}. \quad (1)$$

In this paper, a  $5 \times 5$  Gaussian template with  $\sigma = 0.6$  is used to blur the image.

This paper invokes the scale space theory to establish a Gaussian differential pyramid. The original image is first processed with different Gaussian blurring to obtain a set of images with different scales, then the image is downsampled, and the downsampled image is processed in the same way to

obtain a set of downsampled images with different scales, and so on, to place the original image group at the bottom and stack the downsampled image groups in turn to build a Gaussian pyramid [21].

The number of groups of the Gaussian pyramid is calculated using the empirical value formula given by Zhang et al. [22], with different parameter sets according to the specific need. The number of groups is calculated as shown in the following equation:

$$0 = \lceil \log_2(\min(M, N)) \rceil - 3. \quad (2)$$

where 0 is the number of groups and  $M, N$  is the image size.

After the Gaussian pyramid is built, the Gaussian differential pyramid is obtained by differencing the adjacent images of each group in turn.

**3.2. Matching of Feature Points.** After the feature points are extracted, each feature point has information such as position, feature vector, and scale; in order to accurately represent the feature points, descriptors are constructed for the feature points and ensure that they are rotationally invariant for matching. In this paper, we use the descriptor construction method recommended by Kellomaeki et al. [23], which takes  $4 \times 4$  windows around the key points, and each subwindow has gradient information in 8 directions, east, south, west, north, southeast, northeast, southwest, and northwest and a total of 128 gradient vectors constitute the descriptors of the feature points, as shown in Figure 2.

The determination of descriptor edge length requires interpolation, which is calculated by bilinear interpolation in this paper. And, the direction needs to be rotated to the main direction of the descriptor before the descriptor calculation to ensure the rotation invariance, as shown in Figure 3.

After the descriptors are obtained, the descriptors between matching image pairs are found and the one with the most similar descriptors is the matching feature point. The previously extracted feature points are used to match, and the feature points that do not have corresponding points are eliminated [24].

## 4. Construction of the 3D Model of Human Clothing Based on Multiview Image Sequences

**4.1. 3D Model Construction of Human Clothing with Dual-View Image Sequences.** Before constructing the 3D model of the dual-view image sequence, the relationship between the target point locations in the camera image plane of two consecutive shots should be determined first [25], that is, to determine the relationship between the key points of the overlapping parts of the two images when taking consecutive shots, as shown in Figure 4.

In Figure 4, the target point is point  $X$ , the image coordinates are  $x_1$  and  $x_2$ , and the distances between point  $X$  and the two image planes are  $z_2$  and  $z_1$ . The internal reference matrix of the camera is  $K$ , and the external reference matrix of the two shots is  $T_1R_1$  and  $T_2R_2$ .

Let  $x'_1 = K^{-1}x_1$  and  $x_2 = K^{-1}x_2$ . The eigenmatrix between the two shots is calculated from equation (6) by matching points (at least 5 pairs) between the two images  $\hat{T}_2R_2$ .

$$x'_2 \hat{T}_2 R_2 x'_1 = 0. \quad (3)$$

Using the eigenmatrix and matching the relationship between the two image planes, the image points are processed using the triangulate method to obtain the world coordinate system of the target points. The point cloud image of the target feature is formed by displaying all the points of the world coordinate system, and the 3D model construction based on the dual-view image sequence is completed [26, 27]. In this paper, the results of constructing 3D models based on dual-view images are shown in Figure 5.

**4.2. 3D Model Construction of Human Clothing with Multi-view Image Sequence.** The 3D model construction based on the dual-view image sequence is the basis for the 3D model construction of the multiview image sequence. However, if only the previous matching method is followed, matching the previous image slice with the next two images in sequence, only the rotation matrix between adjacent images can be obtained and their displacement vectors cannot be obtained, because the displacement vectors calculated by the above function are unit vectors. The result of such a method is that when the difference between the images is large, there will be few matching points to use and the accumulated errors will lead to poor matching results.

In this paper, we use the Perspective-n-Point Projection (PNP) method [28] to derive the shooting position of the image from the real 3D coordinates of the target point and its image point coordinates, so as to know the displacement vector between the images. The PNP problem is shown in Figure 6.

Firstly, the initial point cloud is established; i.e., the first two images are matched using the dual-view image sequence reconstruction method, the external reference matrix is solved, and the coordinates of the matched points are triangulated. After getting part of the world coordinates and image point coordinates, we use the PNP method to calculate the camera pose of each image in turn to get the displacement vector, then obtain the rotation matrix by triangulation reconstruction, and match the images in turn to get the 3D point cloud of the target feature for incremental update. After that, we use software such as Geomagic Warp to thicken [29], encapsulate, and add textures to the generated point cloud data and finally get the results of the 3D model of human clothing based on multiview images.

**4.3. Example Applications.** The experimental data in this section are obtained from the human body photographs taken by the Canon 5D3 camera, and the experimental analysis is performed using the multiview-based image sequence 3D reconstruction method [30, 31]. The image sequence data are shown in Figure 7.

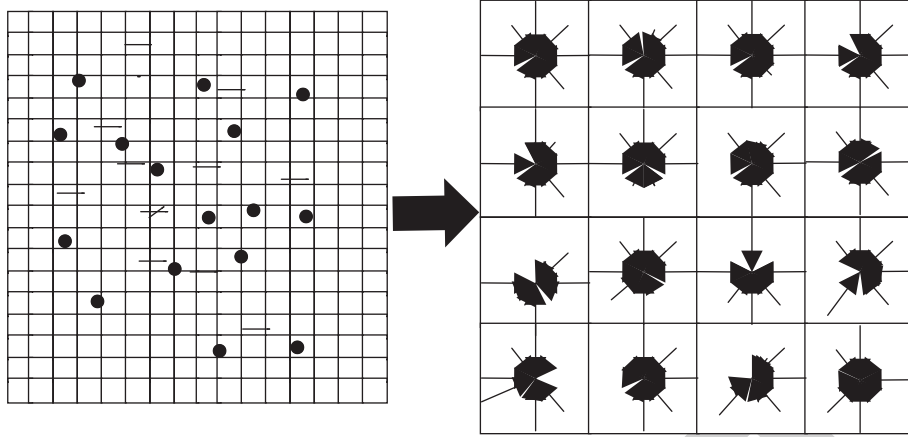


FIGURE 2: Descriptor gradient histogram.

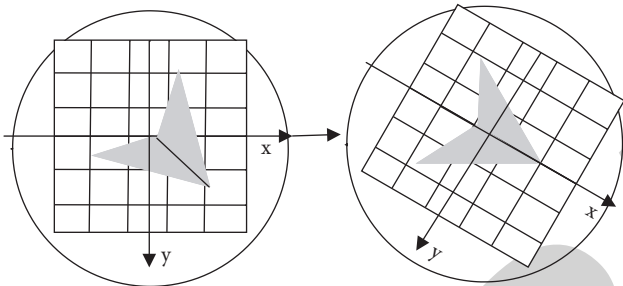


FIGURE 3: Schematic diagram of rotation direction.

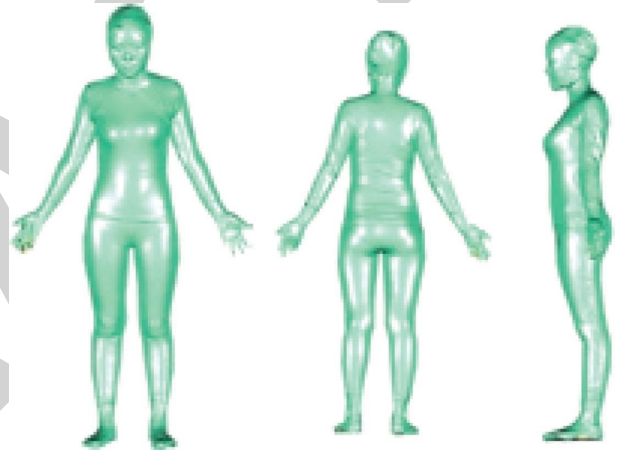


FIGURE 5: Construction results of 3D models of dual-view image sequences.

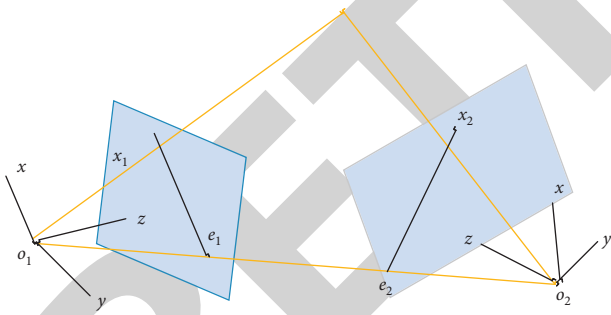


FIGURE 4: Results of constructing 3D models of dual-view image sequences.

On the basis of the 3D virtual human model, the upper body surface of the human model is intercepted and combined with both automatic extraction and manual definition to obtain human feature information from the PHBC human model [32, 33], to realize the extraction of key points and lines of the human body, and to release the key parts of the human body, such as chest circumference, waist circumference, and hip circumference, to ensure the fit of the garment. Finally, we adjust the B-sample curve for the virtual design of the basic shirt and generate the basic shirt model (Figure 8).

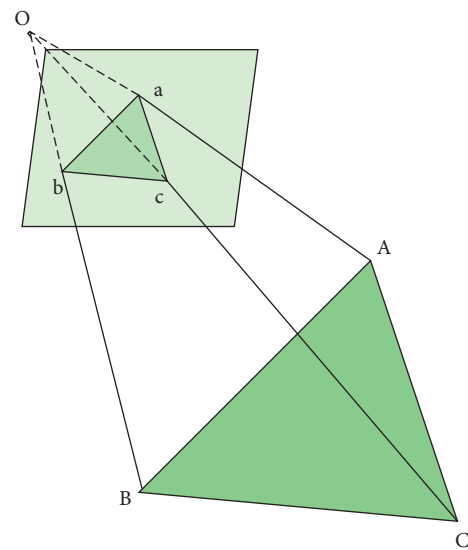


FIGURE 6: Diagram of the PNP problem.



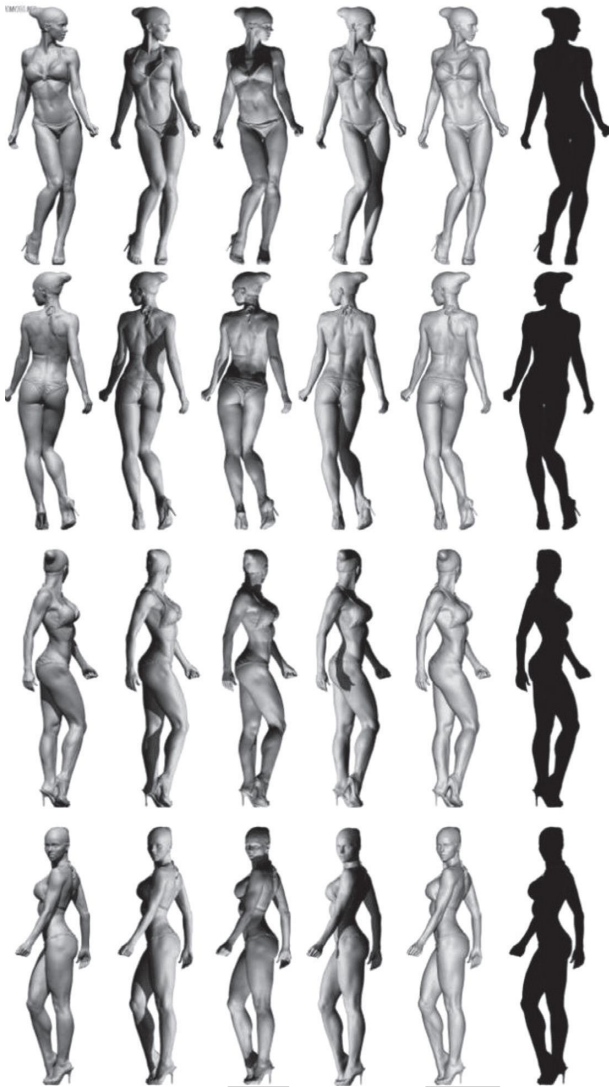


FIGURE 7: Human multiview image sequence.

Due to the irregularity of the human body, a fitted shirt must have certain split lines and the location and shape of the split lines are determined by the design style. First, we imported the base shirt surface into CATIA software [34], selected the free style design platform, and drew the split lines on the base shirt surface. After drawing, we switch to the wireframe and surface design platform, select the unfolded surface from the unfolded shape, select the surface to be unfolded, and set the reference point and unfold direction.

In addition, in order to have the surfaces distributed on the same plane, the same plane should be selected in the unfolding interface, and in this experiment, the ZX plane is selected for both the front and back pieces and the unfolding direction is the Z-axis direction [35]. After unfolding, it is necessary to adjust the position uniformly to form a complete paper sample. After these processes, the unfolded paper pattern of the front and rear surfaces of the net body is obtained (Figure 9).



FIGURE 8: Basic shirt style.



FIGURE 9: Paper sample unfolding.

Figure 10 shows one of the results of edge extraction using the cable operator. From the extraction results, it can be seen that the cable operator has a good effect on the simple image and the clothing edges are successfully extracted, but there are still some background spurious points in the image, so it can be seen that the edge extraction using only the cable operator cannot achieve the expected effect [36].

Figure 10 shows the results of the connected-domain clutter removal, which, when compared, shows that the results are more satisfactory, with the background clutter outside the target being largely removed. Figure 10 shows the new binary image sequence obtained by the pre-processing operation. The size of the images used in the experiments is 589\*800 pixels. In one set of experiments, the processing time of 10 images is 64.417 s and the average time per image is only 6.44 s, which are a good image processing result. By comparing the processing results before and after the process, the processing process can remove the background clutter better for the input 3D reconstructed sequence images and has a better processing effect.



FIGURE 10: Example of processing results of clothing sequence images used in the experiment.

## 5. Conclusions

In this paper, the 3D model of human clothing is constructed based on multiview image sequences. The eigenmatrix is obtained from the camera parameters, the scale-invariant feature transformation algorithm is used to match the image feature points, the transformation matrix is calculated, and the problems arising in the modeling process are analyzed and solved to realize the 3D reconstruction technology of human clothing based on multiview image sequences. Due to the existing technical conditions, how to weaken the perspective error and realize the fine model construction needs further in-depth research.

## Data Availability

The datasets used in this paper are available from the corresponding author upon request.

## Conflicts of Interest

The author declares no conflicts of interest regarding this work.

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