The Eighteenth International Symposium on Artificial Life and Robotics 2013 (AROB 18th '13),
Daejeon Convention Center, Daejeon, Korea, January 30-February 1, 2013

Estimating the clothes characteristics with the image and depth sensors for developing virtual fitting room

Yuka Mastuba[1], Jehan Jung[2], Hiroyuki Funaya[1], Kazushi Ikeda[1], Rammohan Mallipeddi[2], and Minho Lee[2]

[1]Nara Institute of Science and Technology, Japan
[2]Kyungpook National University, Republic of Korea
[1](Tel: 81-743-72-5984, Fax: 81-743-72-5989)
[2](Tel: 82-53-950-6436, Fax: 82-53-950-5505)

[1]{yuka-m,hiroyuki-fn,kazushi}@is.naist.jp
[2]{jjhan,mallipeddi,mholee}@knu.ac.kr

Abstract: Creating physically simulated animations of real clothes is needed for virtual fitting rooms. In this paper, we propose a method for estimating the parameters of real clothes using the motion data obtained from a commercial RGB-depth sensor. Our method determines the parameters using simulated annealing so that the distance between the spatiotemporal trajectories of the real and the computer-simulated shapes of clothes. Here, the shapes of the clothes are expressed by several points identified by a feature-selection algorithm. In our experiments, the method showed a good reconstruction of motions of a skirt.

Keywords: clothes characteristics, optimization, simulated annealing, virtual fitting room

1 INTRODUCTION

A virtual fitting room (VFR) enables customers to see their fashion coordinates in online clothing shops by displaying computer graphics. VFRs have been in need and developed recently because the main reason of customers' hesitancy in buying stuff online is that they could not try on them [1]. One example of VFR is H&M's online dressing room [2] which allows customers to change various clothes on a fashion model and see the coordination. Digital fashion ltd is a similar service but different from the H&M's in that they prepare a special studio where the fashion models in clothes are captured from all directions [3].

Although all those systems have been developed and commercialized, there are still some limitations: 1. they provide only the clothes sold in a shop, 2. displayed models including garments are static although dynamics of the clothes also influences the purchase decision, and 3. an expensive studio is need to register garments with sufficient information. To make a dynamic model of garments and to create animations, their physical parameters should be estimated.

There are several systems that estimate the physical parameters of fabrics. Kawabata Evaluation System is a standard tool for a thorough evaluation of textile fabrics deformability. Although it gives the behaviors of a fabric in tension, shear, bending, compression and friction [4], the system requires a special and expensive device to measure the characteristics of the fabric.

Bhat et al., for example, used video images to estimate the static and dynamic parameters of fabrics [5]. Their system swings a swatch of a fabric using a robot arm, extracts features from video images and estimates the parameters of the fabric using an optimization algorithm. Hasler et al. proposed a similar system using clothes silhouette [6]. Their approaches generatively estimate the true parameters of clothes using swatches and applied them to generate animations. The systems have to prepare the same swatch as the given real cloth in advance that seems not realistic.

The essential difficulty of this problem lies on the estimation of the physical parameters of clothes. The conventional systems estimate them from the movement of swatches for known forces. To avoid this difficulty, we estimate the parameters used in a 3D physical simulator, instead. A 3D physical simulator generates computer graphics according to given physical models. It uses not necessarily a cloth model according to the material mechanics but a simpler one. In that case, we need to estimate only the parameters in the simulator.

Our system estimates the parameters in the simulator by comparing the real trajectory of clothes with the simulated one. This idea makes it possible to employ any cloth model in the simulator. The trajectory of the clothes is measured using a commercial-use depth and image sensor, Kinect^{TM} [7], so that it is affordable at home.

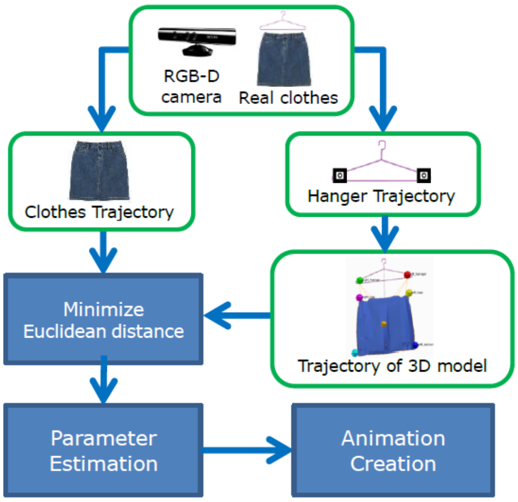

Fig. 1. The procedure of our method

The detail of system is shown in Section 2 and its effectiveness was confirmed by experiments in Section 3 and 4. Section 5 gives our conclusion.

2 METHOD

Our goal is to generate realistic 3D CG animations based on the measurement of real clothes. To accomplish this goal, our proposed method estimates the parameters of clothes in a simulator by minimizing the distance between the measured trajectory of clothes and the simulated one of clothes. The term "trajectory" means time-series data of 3D locations of five feature points of a cloth captured frame by frame in our system. The five feature points are defined as the four corners and the center point of real clothes

One point of our method is that we need not to know the force to clothes a priori. The force is measured through the trajectory of the hanger that produces the movement of the clothes (Fig. 1). Hence we can swing the hanger by human hand. The hanger has two markers so that we can easily measure the trajectory from the depth and image sensor. Note that we have to click the center point of markers for detection in the first frame at this time. After the second frame, our system can track the markers using the AR toolkit [8] and OpenCV [9].

The measurement of clothes should be marker-less since clothes have no common markers. Hereafter, we consider the cases of a skirt and a T-shirt for clothes (Fig. 2). We use the depth image as a silhouette because some kinds of clothes are difficult to extract feature points from the surface. In the case of skirt, after eliminating the background from the depth image, we extract the four corners of the skirt using the Harris corner detector, therein we rotate 45 degrees clockwise so that the corners have the maximum/minimum x-/y-coordinate. In the case of a T-shirt, the leftmost and rightmost points in the original coordinate correspond to the left-top and right-top points, respectively (Fig. 3).

Fig. 2. The experiment condition for measuring. Yellow and green lines present the vertical position of hanger.

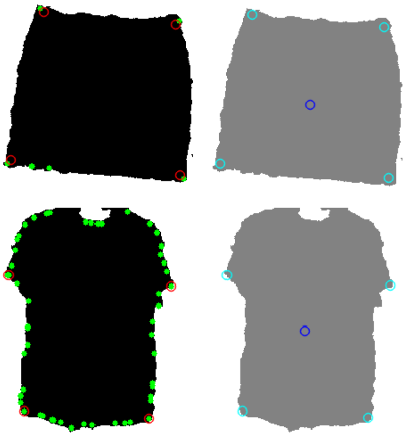

Fig. 3. The result of Harris corner detection and Dijkstra algorithm.

We add the center point as a feature point, which is defined as the max-min distant point from the four corners. Here, the distances are calculated as the lengths of geodesics and minimized using the Dijkstra algorithm [10].

Our system compares the measured trajectories of the feature points with the simulated ones. The simulated trajectories are synthesized using a physical simulator, Blender [11]. Blender has a cloth simulation function that has six parameters (Table 1).

The parameters $\boldsymbol{\theta}$ of the simulator are adapted so that the two sets of trajectories match. Here, the distance of the two sets is defined as the Euclidean distance,

$$D(R,S) \equiv \frac{1}{N}\sum_{n=1}^{N}\frac{1}{M}\sum_{i=1}^{M}\|r_{in}-s_{in}\|_{2}. \qquad (1)$$

Table 1. Parameters in cloth simulation function

parameter	Description
Mass	The mass of the cloth material
Struct	Overall stiffness of the cloth
Bend	Wrinkle coefficient (higher creates more large folds)
Spring	Damping of cloth velocity (higher creates more smooth, less jiggling)
Air	Have normally some thickness which slows falling things down
Velocity	Help with the cloth wobbling problem

Table 2. The definition of parameter values

parameter	value			
	initial	*minimum*	*maximum*	*interval*
Mass	1.0	0.15	10.0	0.5
Struct	30.0	5.0	80.0	15.0
Bend	20.0	0.1	150.0	10.0
Spring	3.0	0.0	25.0	4.0
Air	5.0	1.0	10.0	5.0
Velocity	0.95	0.9	1.0	0.01

where r_{in} and s_{in} denote the position of the ith feature point (a corner or the center point) in the nth frame. Because, the function D is no-convex, our system minimizes it with a simulated annealing method, that is, perturbs the parameters randomly within a range depending on a decreasing temperature. The perturbation is accepted with a probability also depending on the temperature.

The details of the setting are as below.

The perturbation range v_i of ith parameter θ_i was set to

$$v_i = \theta_{\mathbf{s}i} \tan\left\{\pi\left(p_1 - \frac{1}{2}\right)\right\} \cdot \mu T_t{}^{\sigma}, \qquad (2)$$

where $\theta_{\mathbf{s}i}$ is the standard value of the perturbation range of θ_i, p_1 represents a random number between 0 and 1, and μ and σ are gain factors. The temperature T_t at the tth iterations is set to

$$T_t = \frac{T_{t-1}}{(1+\beta t)^{\alpha}}, \qquad (3)$$

where T_0 is the initial value and α, β are gain factors.

The probability that the perturbations are accepted depends on the change of the distance,

$$change = \mathrm{D}(\mathrm{R}, \mathrm{S}(\boldsymbol{\theta}_t)) - D(\mathrm{R}, \mathrm{S}(\boldsymbol{\theta}_t + \boldsymbol{v})) \qquad (4)$$

where $\boldsymbol{\theta}_t$ is the parameter vector at the tth iteration, and v is the perturbation range vector. Then, the parameter vector is updated according to

$$A = \min(1, exp\{(change \cdot \gamma)/T_t\})$$
$$\begin{cases} \boldsymbol{\theta}_{t+1} = \boldsymbol{\theta}_t + v & if\ p_2 \le A \\ \boldsymbol{\theta}_{t+1} = \boldsymbol{\theta}_t & otherwise \end{cases} \qquad (5)$$

where p_2 is also a random number between 0 and 1, and γ is a factor.

3 EXPERIMENT

The effectiveness of our method was confirmed by experiments. In the first experiment, we evaluated the accuracy of the estimation of the center point. In the second experiment, we evaluated the estimation error of our method. The six parameters $\boldsymbol{\theta}$ for a cloth simulation function in the 3D physical simulator, Blender, are Mass, Structural, Bending, Spring, Air and Velocity (Table 1). Their initial, minimum, maximum and interval values were set as shown in Table 2 according to the preset parameters in Blender and our preliminary experiments.

The parameters for the simulated annealing, the starting temperature, the maximum loop count and the temperature decrement parameters (α, β) were set to 1000, 350, and (0.003, 1.0), respectively. Other parameters in (2) ware set to $\mu = 0.1$ and $\sigma = 0.6$. These values were chosen so that the annealing algorithm can search all parameter space within the maximum iteration count.

4 RESULTS

The result of the first experiment showed that the estimated center point had errors of 1.9 cm (4.30 % of the clothes width) on average from the measured center point using an additional marker for the ground truth. This value is accurate enough compared to the estimation error of the corners shown in the second experiment below.

In the second experiment, a short-and-hard skirt was used (Fig. 5). The annealing method reduced both the maximum and mean Euclidean distances in the swung direction (Fig. 6).

The animation in 3D simulator was also considered reasonable and proper by looks. We made another animation of human walking motion in which a human model wore on the optimized clothes (Fig. 7).

5 CONCLUSION

This paper proposed a method for generating realistic 3D CG animations using a depth image sensor and a 3D physical simulator. We successfully captured the motion of clothes as trajectories and optimized the physical parameters by comparing the real and simulated motions. Our method will work as a part of VFR system by combining to other techniques such as a body measurement system [12].

At this time, however, our system cannot treat occlusion that occurs due to bends. We need to change feature points to cope with this problem to make our system applicable to various clothes.

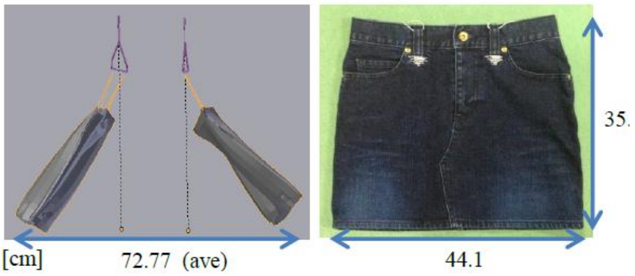

Fig. 5. The detail of clothes used for experiment

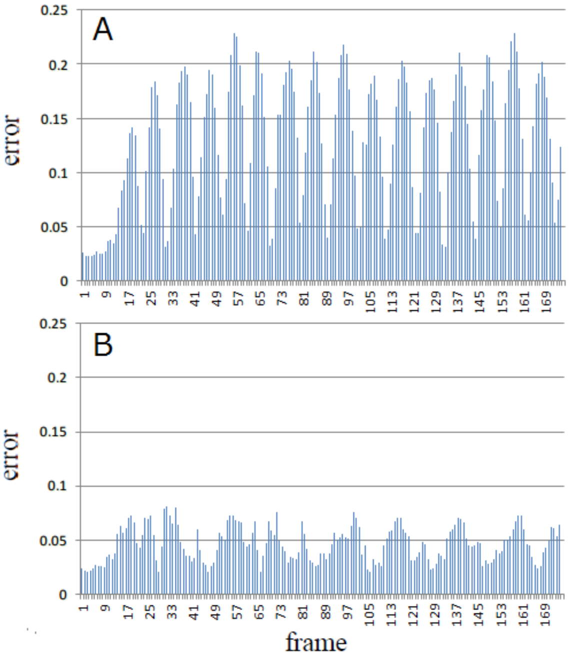

Fig. 6. Errors before (A) and after (B) the optimization experiment. The maximum errors in all frames are 0.2290 (A) and 0.0807 (B), the average errors are 0.1276 (A) and 0.0467 (B), respectively.

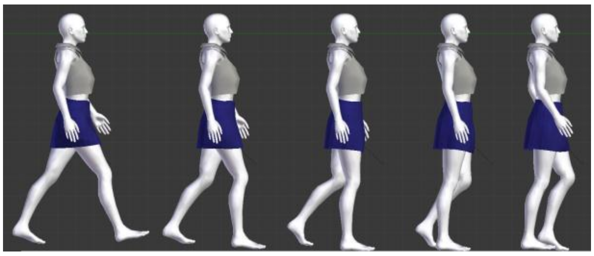

Fig. 7. The animation of human walking motion

REFERENCES

[1] Brian Beck, Key Strategic Issues in Online Apparel Retailing, yourfit.com, 2000, Version 1.0

[2] H&M: http://www.hm.com/

[3] digital fashion ltd: http://www.digitalfashion.jp/

[4] Kawabata S (1980), The standardization and analysis of hand evaluation. Textile Machinery Society of Japan

[5] Bhat K, Twigg C, Hodgins J, Khosla P, Poppvic Z, Seitz S (2003), Estimating cloth simulation parameters from video. In Proceedings of the 2003 ACM SIGGRAPH/Eurographics symposium on Computer Animation (SCA 2003), pp.37-51

[6] Hasler N, Asbach M, Rosenhahn B, Ohm J.-R, Seidel H.-P (2006), Physically based tracking of cloth. In Proceedings of VMV 2006, Aachen, Germany, pp.49-56

[7] Microsoft Kinect^{TM}: http://www.microsoft.com/en-us/kinectforwindows/

[8] ARToolkit: http://www.hitl.washington.edu/artoolkit/

[9] OpenCV: http://opencv.org/

[10] Plagemann C, Ganapathi V, Koller D, Thrun S (2010), Real-time identification and localization of body parts from depth images. In Proceedings of ICRA, Alaska, USA

[11] Blender: http://blender.org/

[12] Weiss A, Hirshberg D, Black M.-J (2011), Home 3D body scans from noisy image and range data. IEEE International Conference on Computer Vision, Barcelona, pp.1951-1958