Virtual Cloth Cutting

Yuko MESUDA*, Shigeru INUI**, Yosuke HORIBA***

** Graduate School of Science and Technology, Shinshu University, 3-15-1 Tokida, Ueda City, Nagano 386-8567, Japan*

*** Faculty of Textile Science and Technology Division, Shinshu University, inui@shinshu-u.ac.jp,3-15-1 Tokida, Ueda City, Nagano 386-8567, Japan*

**** Faculty of Textile Science and Technology Division, Shinshu University,3-15-1 Tokida, Ueda City, Nagano 386-8567, Japan*

Abstract: There have been reports of real-time handling of a cloth model from studies already conducted. We proposed that the cloth model be moved according to hand gestures in the real world. However, manipulating textiles have to be added other manipulations. Therefore we suggest the cutting method in textile model. This method can cut the cloth model by hand gesture in the real world. The cloth model is a particle-spring model. Cutting the cloth is performed a two-step procedure. The cut line is calculated by hand trajectory, then the cloth model is cut. The hand trajectory is obtained by Kinect. Nearest particles to the hand positions are calculated and the cut line is obtained by slopes which are calculated from this set of particles. The cutting the cloth model is performed by making and replacing springs and particles. As the results, we have succeeded in producing slits in the cloth model along the cut line. The cloth model can be cut more accurately by function of Kinect.

Key words:virtual cloth cutting, hand gesture, cloth handling, real-time

1. Introduction

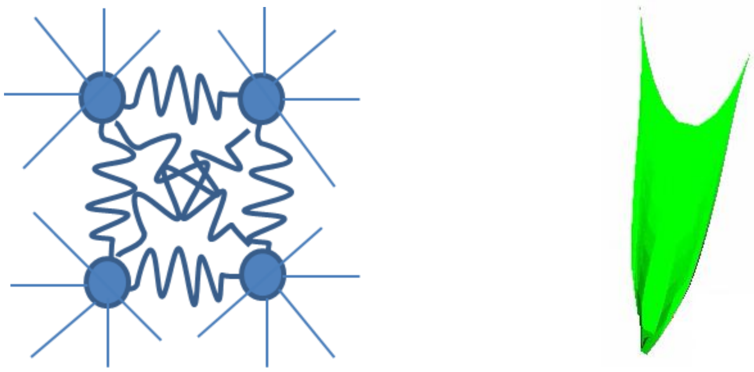
Cloth manipulation in virtual space has some advantages. Cloth and garment have already been simulated, but manipulation of cloth has not been conducted. The cloth manipulation is applied to design of a garment and operation of skin simulation by establishing a technique of virtual cloth handling. Especially real-time cloth handling is more realistic than other methods and becomes possible to watch how the shape of the cloth changes. Therefor, it is important to manipulate the virtual cloth in real-time.

Real-time simulation of cloth handling has been conducted and used [8,5]. In these studies, the mouse is used to manipulate cloth. However, maneuvering feeling by mouse differs from actual cloth manipulation because mouse manipulations are carried out in two dimensions. Handling by gesturing in three dimensions would be more realistic than mouse manipulations.

We proposed a cloth handling method which follows the hand gestures in the real world [4]. This method succeeded in moving a virtual cloth. However the method has to add other manipulations such as cutting cloth, attaching and releasing cloth. We have already succeeded in cutting the cloth model by inputting cut position data [7]. In this study, we suggest cloth cutting method by using hand gesture instead of the cut position data.

2. Cloth handling

We suggested a cloth handling method according to the hand gestures in the real world [4]. Kinect (Microsoft) is used in this method. Kinect is a sensor which can read human's motion. It can obtain three-dimensional coordinates of various parts of the body. A hand coordinate is obtained by Kinect and a cloth model is moved by moving a point of the cloth to the coordinate. The cloth model used in this method is mass-spring model. Figure1 shows the cloth model. This model consists of particles arranged on grid with springs connecting nearest and next-to-nearest particles. Dynamic position of each particles is obtained by calculating total force which is applied to each particles and solving equation of motion with the numerical integration [6]. And, collision detection and collision reaction are also defined. A virtual object model consists of a point cloud. Collision detection [6] involves calculating the distance between each particle in the cloth model and object model. If the shortest distance is smaller than a predefined constant, collision between cloth model and object model is signaled. If collision is detected, a repulsive force is applied to the colliding particle in the cloth model. The repulsive force is calculated by distance between the collided particles.



(a) (b)

Figure1: Cloth model (a) and the dynamic response of cloth (b)

3. Cutting

Cloth cutting is performed as following steps. The virtual cloth is displayed on computer screen. A position of user's hand is displayed as a dot on virtual space of computer. First, hand is moved along the line where you want to cut the cloth model. In this step, hand trajectory is obtained by Kinect. Next, a cut line in the virtual cloth model is calculated from the trajectory. Last, the cloth model is cut along the cut line. The line to cut is indicated by moving hand, then the cloth model is cut. A cut line is made along a grid line of the cloth model for simplicity. One of the problems to cut elements of the grid is that various shapes of mesh element appear. The other problem is that it is difficult to replace springs according to the shape. In addition, spring constants have to be redefined according to the shape. These problem make it difficult to cut the cloth in real-time. Therefore the cloth model is cut along a grid line. However, the cut line is jagged in this method. This problem is solved by making mesh element smaller.

3.1 Getting a hand coordinate

The hand trajectory is obtained by Kinect. The hand trajectory acquisition is started when distance between the cloth model and the object model is smaller than a threshold. The hand trajectory acquisition is finished when the distance is bigger than the threshold. Then a cut line is calculated by using the hand trajectory. The distance between the hand and the virtual cloth is calculated by the hand coordinate and the nearest particle coordinate of the virtual cloth.

3.2 Getting a cut line

Particle position corresponding to the trajectory in the cloth model is calculated from set of the hand coordinates obtained by Kinect. The corresponding particle is particle closest to the hand coordinate. The hand coordinates are discrete data because they are updated every few tenths of a second. Therefore the set of particles are not always directly connected to each other with a spring. Some particles have to be added because every particle of the set has to be connected directly to make a cut line. A cut line is obtained as follows [7]. The added particle is determined by the consecutive two particles in the set of particles. Consider a cut line between particle $P_i\,(u_i\,,\,v_i)$ and particle $P_j\,(u_j\,,\,v_j)$. Figure2 (a) shows method of making a cut line.

First, particle on coordinate $(u_k\,,\,v_i)$ is obtained. The range of u_k and k is

$$u_i < u_k \leq u_j\,,\ i+1 \leq k \leq i+|\,u_j - u_i\,| \qquad (1)$$

u_{i+1} is x-coordinate of particle next to particle P_i. If the cut starts at the top or the bottom of the cloth model, particle on coordinate $(u_i\,,\,v_i + 1)$ is added only in very first particle. Because, a part of the cut line follows the edge of the cloth model if particles in the weft direction are picked up preferentially (Figure2 (b)). Then the slope a of the line through particles P_i and P_j is calculated as

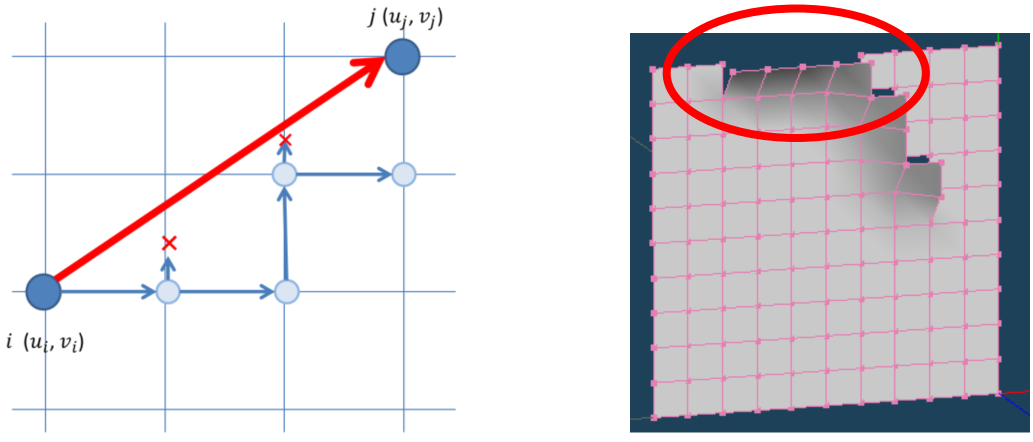
$$a = \frac{v_j - v_i}{u_j - u_i} \qquad (2)$$

v and v_k are calculated from slop a. Formulas of v and v_k are expressed as follows.

$$v = a(u_k - u_i) - \sum_{n=i+1}^{k-1} v_n \qquad (u_i < u_k \leq u_j) \qquad (3)$$

$$v_k = \begin{cases} [v] & if\ v \geq 1 \\ 0 & if\ |v| < 1 \\ -[|v|] & if\ v \leq -1 \end{cases} \qquad (4)$$

If $v_k \neq 0$, particles are located between coordinate (u_i, $v_i + \sum_{n=i+1}^{k-1} v_n$) and (u_i, $v_i + \sum_{n=i+1}^{k} v_n$). After the particles are obtained, u_k is added one. The cut line is the line passing through the particles obtained by the repetition of the process.



(a) (b)

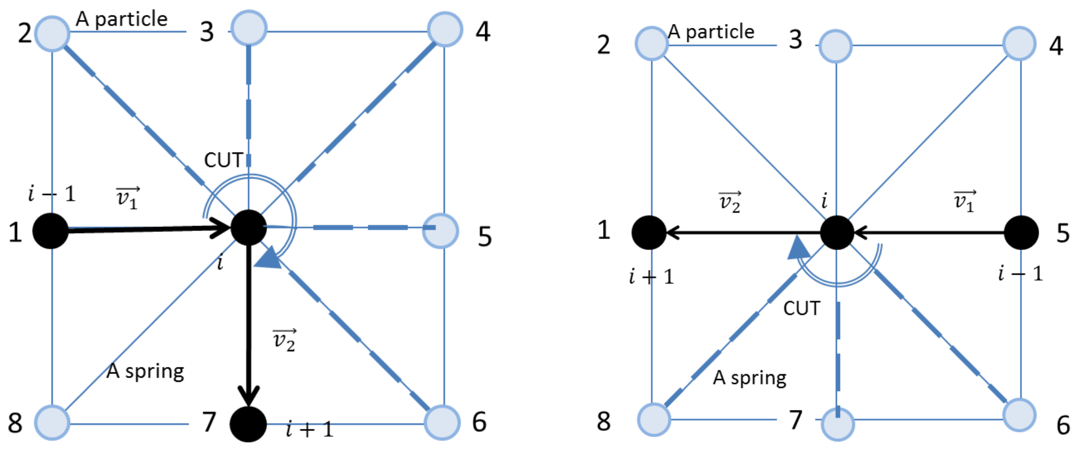
Figure2: Getting cut line method (a) and the case of failures in which starting position is top or bottom (b).

3.3 Cutting

The cloth model is cut by making new particles on the cut line and reconnecting springs to new particles. And, a new spring connection is established for the new particles [7]. The springs that need reconnection are determined by how the three particles involved are arranged. Present particle i , previous particle i-1 and next particle i+1 are used in this cut method. The particles i -1, i and i+ 1 are used for the judgement. Vector v_1 and v_2 are calculated from these three particles. v_1 is made by particle i and particle i-1, and v_2 is made by particle i and particle i+1. Springs on the left side of these vectors are reconnected. Figure3 shows reconnected springs. In figure3 (a), springs at positions 8, 1-3 are reconnected. In figure3 (b), springs at positions 6-8 are reconnected.

The way to reconnect springs is as follows.A new particle is made at the same position as the original particle to which springs are reconnected. Springs are disconnected from original particle and reconnected to new particle. The new particle is connected to the particle made in the last step with a new spring.

For very first particle, the springs cannot be determined because there is no particle ahead to the very first particle. Therefore, reconnected springs are calculated by the first and the second particle. The spring on the left side of the first particle and the spring on the left side of the vector which is made by the first and the second particles are reconnected.



(a) (b)

Figure3: replacing springs

4. Results

The cloth size is 10*10. The hand trajectory is simple line or curve rather than circle and complex line. The cloth model and hand position are displayed on a computer screen while moving the hand (Figure4). The user indicates the position for cutting the virtual cloth by moving the hand as he/she watches this screen. The color of the mark of the hand is changed from blue to green when cutting is started. Figure5-8 shows results of the cut of the cloth model. Figure (a) shows the position of the hand, corresponding position of the cloth and cutting line. (b) shows the results of the cutting cloth. To make it more understandable, the fringe of the cutting line is pulled up. Figure5 shows the successful experience of the cut cloth model. Other figures show the case of failures.

As the results, we have succeeded in obtaining the cut line according to the hand trajectory. And this algorithm can cut cloth model along the cut line. The cloth model can be cut in both of the straight and curve cut line. In any cut starting point, the algorithm can cut the cloth model. However, the cloth model can not be cut along the hand trajectory in some cases because the accurate cut line can not obtain. In Figure5, the cloth model is not cut at the end point as it is possible to male a slit by this algorithm. In Figure6 and 7, a part of the cloth model is not cut because the cut line follows the edge of the cloth model. On the other hand, in Figure8, the colth model can not cut when the hand trajectory is very complex.

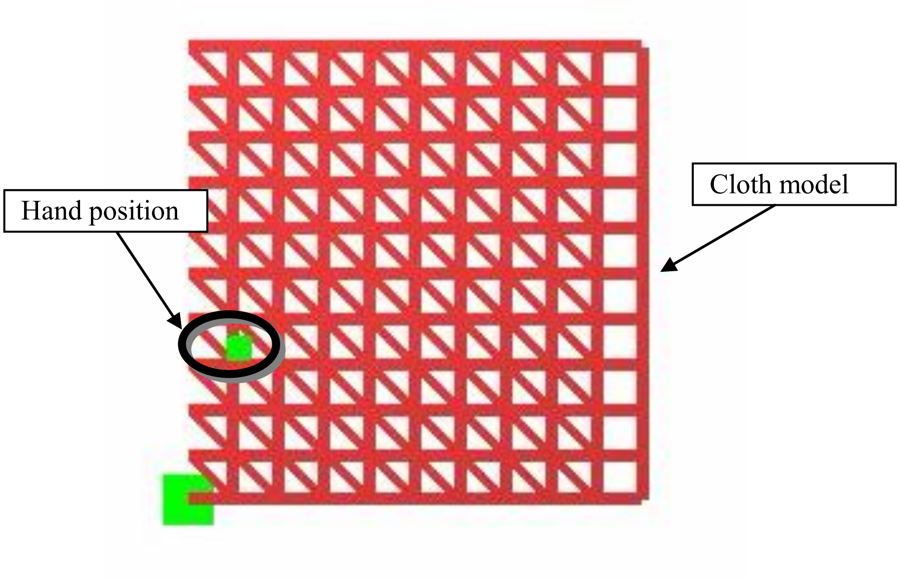
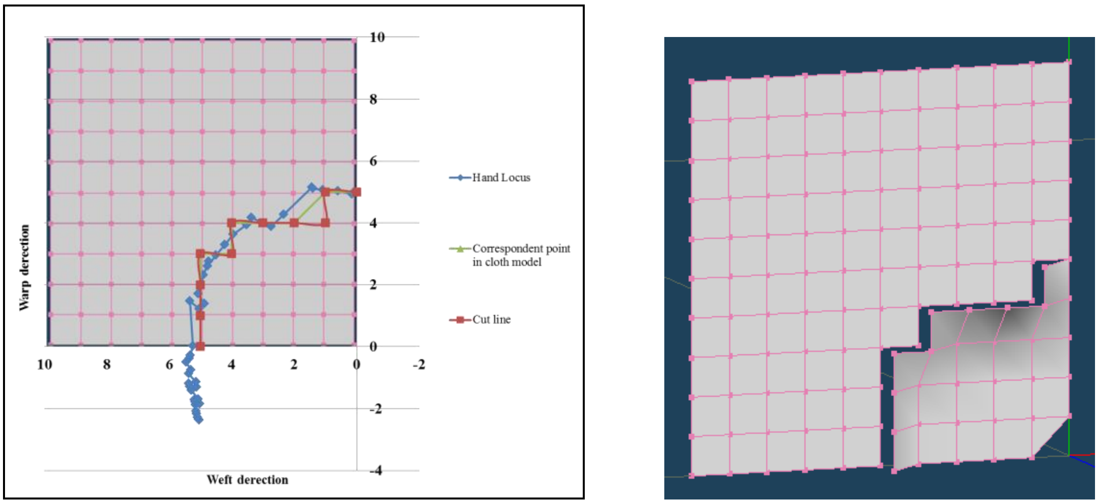
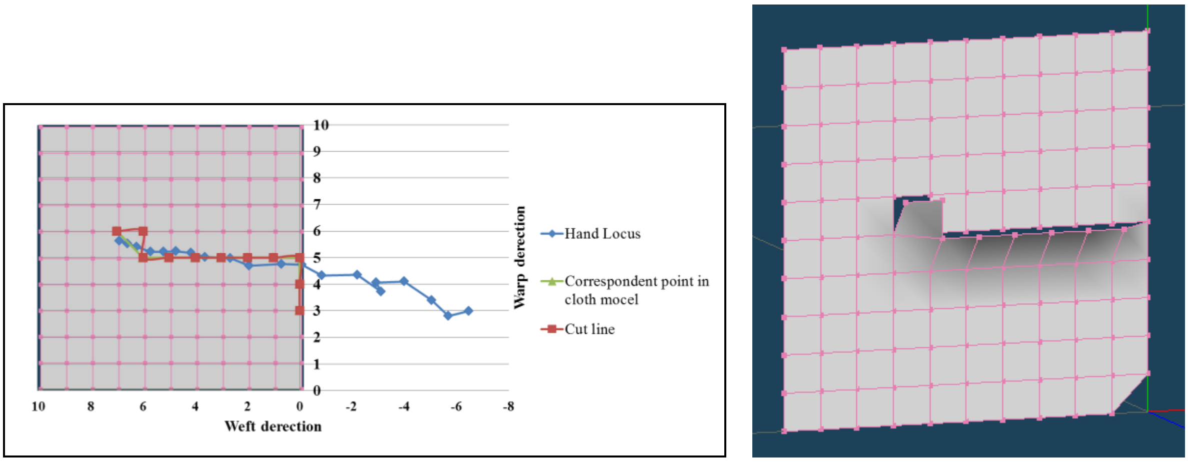


Figure4: The operation screen.



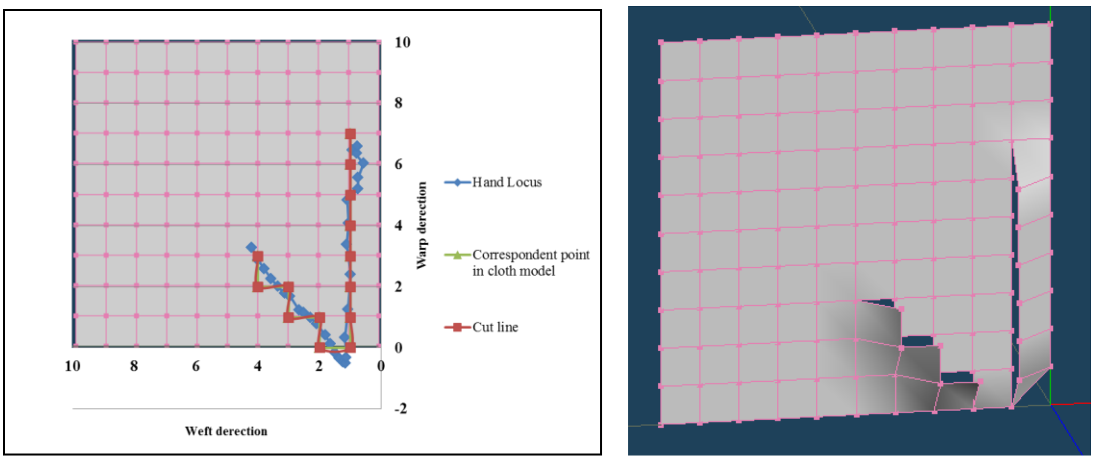
(a) (b)

Figure5: The successful experience of the cut cloth model.



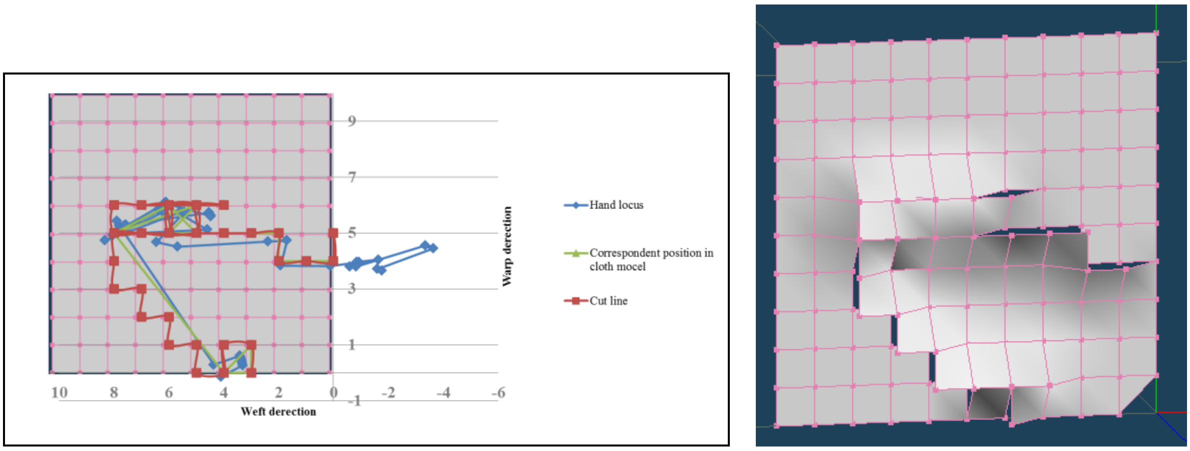
(a) (b)

Figure6: The case of failures No.1. A part of the cut line is along the edge of the cloth.



(a) (b)

Figure7: The case of failures No.2. A part of the cut line is along the edge of the cloth.



(a) (b)

Figure8: The case of failures No.3. The hand trajectory is very complex.

5. Discussion

There are some problems in this algorithm. One of the problems is that it is possible only to make a slit by this algorithm. A new condition has to be added to this algorithm to cut off the cloth model.

The cut line cannot often obtain because the hand trajectory is very complex. This is because noise was mixed when trajectory of the hand is obtained by Kinect. This problem is solved by smoothing the hand trajectory with function of Kinect or calculating moving average of the hand coordinates. On the other hand, at the start and end of cutting, the coordinate of the hand is often fluctuated because the user moves the hand in order to change the distance between the hand and the cloth model. This causes the problems shown in Figure 6 - 8. This problem is solved by using voice-recognition system of Kinect. The fluctuation of the coordinate of the hand can be reduced by starting or ending the cutting by voice signal. If moving range of the hand is too large, a part of the hand trajectory is drawn in out of the cloth model and the cut line is made along the edge of the cloth. The user doesn't understand enough the position relation between the hand and the cloth model. Because, the user can watch the hand position and the cloth model from only one direction while moving the hand. Therefore the system has to show the hand position to the user by changing color of the hand mark when the hand is outside of the cloth model.

6. Conclusions

We proposed the method of cloth handling used the hand motion in the real world. However, draping requires more than just cloth handling. In this paper, we suggest the method which the cloth model is cut by the hand gestures in the real world.

This cutting method is performed by using the hand coordinate obtained by Kinect. The cutting method consists of two steps. First, the cut line is obtained. Next, the cloth model is cut. The nearest particle is calculated from the obtained coordinates of hand. Then the cut line is calculated by this set of particles. The nearest particle is calculated from the obtained coordinates of hand. Then the cut line is calculated by this set of particles. The cut of the cloth is performed by making new particles and reconnecting springs to the new particles.

As the results of the cut, we have succeeded in producing slits in the cloth model along the cut line. However, the cloth model can not often be cut by jiggling hand. This cause is that the user move to start or finish cutting the cloth model. This problem is solved by using voice-recognition system of Kinect.

7. Acknowledgements

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