18th World IMACS / MODSIM Congress, Cairns, Australia 13-17 July 2009
http://mssanz.org.au/modsim09

A Training System for the Japanese Art of Flower Arrangement

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Abstract: Computer Graphics (CG) and Virtual Reality (VR) technologies have rapidly improved in recent years. It enabled us to develop some useful systems such as air hockey, catch ball, tennis and horseback riding for sports field, surgical simulations and support systems for medical field, calligraphy and flower arrangement for educational field. The good training systems have force feedback for users to feel so that they can learn the skills effectively. These days, there are so many systems that use CG and VR technologies; however, there are little training systems for the Japanese art of flower arrangement. One system is a robot that can make an arranged flower according to the training data, and others are learning systems, with which people can train for flower arrangement. These systems, however, are two dimensional and do not have force feedback. Although they can learn the beauty of flower arrangement, they cannot learn the feeling when they insert flowers into pinholders.

Therefore, we have developed a training system for the Japanese art of flower arrangement, which is a three dimensional system so that people can see the arranged flowers from any viewpoint. Users can also feel the tactile sense when they insert flowers into pinholders and also when flowers, which users are having, contact with other flowers. In order to make the tactile sense of flower arrangement, this system has a haptic device that can generate force feedback. By measuring the hardness of flowers with a durometer and applying the measurement results to the system, we can generate real force feedback.

In order to perform fast collision detection between a flower and a pinholder or among flowers, the flower model is hierarchically constructed with some parts such as petal, stem and leaf. Each part also has one of three attributes that are “Active”, “Inactive” and “Passive” so that fast and effective collision detection can be performed. For the real force feedback, the hardnesss of some flower stems is measured with a durometer, and the flowers are sorted into three types: soft grass, hard grass and branch. An approximated equation, which calculates the force according to the flower type, is introduced based on the result of the mesurement. The measured datum, however, is a force that is generated when the stem of a flower contacts with one pin of a pinholder. Then the number of pins that contact with the stem should be calculated according to the radius of the stem, and the true force should be calculated by multiplying the measured force with the number of pins.

Finally, the training system is consructed with a personal computer (PC) and a haptic device (see Fig. 1 (a)). By using the stick of the haptic device, users can grab a flower and insert it into a pinholder. They can feel the force feedback during inserting it into the pinholder and when the flower contacts with another one. Unless the flower is deeply enough inserted into the pinholder, the flower falls down so that the falling down simulation is necessary. The simulation image appears on the display of the PC (see Fig. 1 (b)). They can not only change the viewpoint but also make zooming in and out of the image at any time. As the result of some questionnaires to users, they can feel the force feedback and can train for the skill of flower arrangement by themselves without any real flowers.

Figure 1. The training sytem and image.

Keywords: *virtual reality, computer graphics, training systems, flower arrangement*

1. INTRODUCTION

Nowadays, there are many useful systems that are using CG and VR technologies. In sports fields, air hockey (e.g. Oshima et al., 1998), catch ball (e.g. Wu et al., 2000), tennis (e.g. Yoshii et al., 2001), and horseback riding (e.g. Shinomiya et al., 2001 and Aoki et al., 2002) are there. In medical fields, abdominal surgical simulation (e.g. Suzuki et al., 1998), support system for preoperative planning (e.g. Nakao et al., 2003), surgical simulator for opthalmolosistes (e.g. Mukai et al., 2002), local anesthetic surgical simulator (e.g. Sakai and Mochimaru, 2004), and bleeding simulation (e.g. Mukai et al., 2002) are there. These systems are used not only in sports and medical fields, but also in educational filed such as calligraphy and flower arrangement. One example is virtual caligraphy system (Henmi and Yoshikawa, 1998), with which students can learn each stroke of a teacher with the feeling of the pressure between the virtual brush and the virtual paper. Another example is a writing learning system (Inami et al., 2004 and Muranaka et al., 2006), which enables us to learn Japanese character repeatedly by using a liquid cystal pen tablet. There are also other systems called remote calligrapher navigation system (Fukuda et al., 2006) and humanoid robot arm (Hoshino, 2008). With the remote calligrapher navigation system, students can learn calligraphy based on strokes of a teacher who are in a remote location. On the other hand, humanoid robot arm can generate calligraphy motion, which is controlled for slow and fast movements according to the stoke that depends on each character.

Another application is flower arrangement. In this field, there is a robot that can make flower arrangement (Yoshioka and Kiyohiro, 1995 and 197). This robot can trim some extra branches according to flower arrangement rule by inputting the image from a camera. Another one is an artistic design system (Suzuki and Ikeda, 2000), which is a retrieval system of industrial products from a sketched image drawn by a designer, and is applied to the color and structure design of vases for flower arrangement. There is also “Origami” modelling method for flower arrangement (Kaino et al., 2000), which shows how to generate CG images of some complex digitate leaves for flower arrangement. There is only one educational support system (Hagiwara and Saruwatari, 2008), with which people can learn flower arrangement; however, the system is two dimensional and they cannot feel the force feedback. Therefore, this paper describes a flower arrangement system (Takara et al., 2008), with which users can feel the tactile sence when they insert flowers into pinholders and when the flower, which they are having in hand, contacts with another one.

2. FLOWER MODELLING

In order to perform fast collision detection, flower models have to be hierarchically constructed with some parts: petal, stem and leaf. Fig. 2 shows two examples of flower model, where each part has ID number. Fig. 3 shows the hierarchical structure of the model. At first, collision detection is performed with flower model that includes all parts. If the flower model collides with other ones, the more detail collision detection is performed to check which part collides with another one.

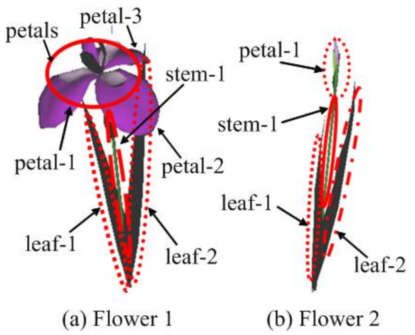


Figure 2. Flower model.

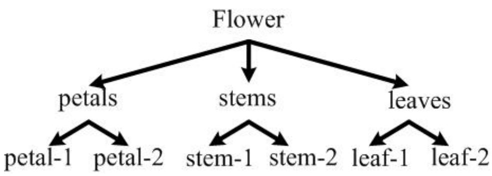


Figure 3. Hierarchical structure.

In this system, SmartCollision is used for the collision detection. It has been developed by 3D Corp., and is based on Gilbert-Johnson-Keerthi (GJK) distance algorithm (Gilbert et al., 1988), which is a method of determining the minimum distance between two objects by using Minkowski sum (Hernandez-Barrera, 1997). Although GJK algorithm can be applied only to convex objects, SmartCollision divides the objects into convex ones so that it can detect collisions between two objects including concave ones. It also attaches one of three attributes to each object to perform fast collision detection, which attributes are “Active”, “Inactive” and “Passive”. Table 1 shows the relationship for two objects that have one of three attributes. An object that has the attribute of “Active” checks collision detections for other objects that have the attributes of “Active” or “Passsive”. Other objects that have the attributes of “Inactive” or “Passive”, however, do

Table 1. Attribute and operation

	Active	**Inactive**	**Passive**
Active	**Check**	**NoCheck**	**Check**
Inactive	**NoCheck**	**NoCheck**	**NoCheck**
Passive	**NoCheck**	**NoCheck**	**NoCheck**

not check collision detections actively for any objects. The difference between "Inactive" and "Passive" is that an object that has the attribute of "Passive" is checked by objects that have the attribute of "Active", while another object having "Inactive" attribute is not checked even by objects having "Active". Objects having "Inactive" attribute are indifferent to the collision detection. However, these attributes are not fixed to objects but they can be changed according to the status of the simulation.

3. HAPTIC DISPLAY

3.1. Force Measurement

In order to make force feedback during inserting flowers into a pinholder, the force should be measured with a durometer. Fig. 4 shows the durometer made by T.R.Turoni Corp. In Fig. 4, a needle, which diameter is 1 mm, is attached for the measurement since the diameter of the needles on pinholders is 1 mm and it does not depend on the type of pinholders. On the other hand, the length of the needles depends on the type of pinholders; however, the maximum is 20 mm. Then, some stems of flowers are cut off at the length of 20 mm, and the hardness of the stems is measured with 2 mm interval between 2 mm and 20 mm. Fig. 5 illustrates the process of the measurement.

Figure 4. Durometer.

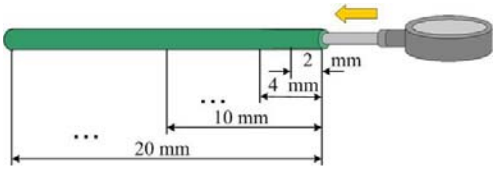


Figure 5. Measurement process.

In the art of Japanese flower arrangement; there are three types of flowers: soft grass, hard grass and branch. Soft and hard grass types of flowers are easy to be inserted into the needles of the pinholder; however, it is difficult to insert the branch type of flower into the needle. Therefore, the bottom of the stem is broken so that it is easy to be inserted and also water can easily go up to the whole of the flower. This technique is called "Mizuage" method. In the measurement, the bottom of the stem is broken with a hammer for its method. Fig. 6 shows the results of the measurement. There are three types of curves that correspond to three types of flowers and these curves are approximated as follows.

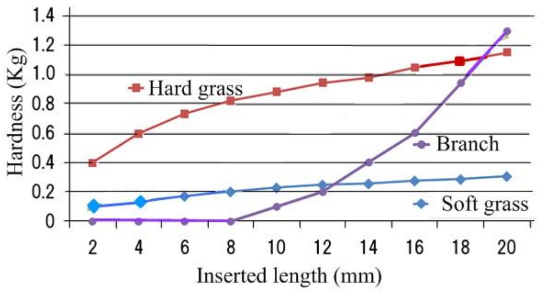


Figure 6. Results of the measurement.

- $H = 0.087\ln(L) + 0.088$ for soft grass ...(1)
- $H = 0.318\ln(L) + 0.381$ for hard gras….(2)
- $H = 0.029L^2 + 0.024L + 0.006$ for branch...(3)

Where, H is the hardness and L is the inserted length of the stem. The force, which is conveyed to users, can be calculated with the above equations.

Table 2. Number of needles for insertion.

Radius	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
Max.	1.0	1.0	2.0	4.0	4.0	5.0	6.0	8.0
Min.	0.0	1.0	1.0	1.0	2.0	4.0	4.0	4.0
Ave.	1.0	1.0	1.5	2.5	3.0	4.5	5.0	6.0

3.2. Force Generation

The forece measured in the above experiment is the value for one needle; however, the number of needles that are inserted into flowers is different according to the radius of the stem. Therefore, it should be researched how many needles of the pinholder can be inserted to the stem according to the radius. There are many kinds of pinholders; however, the radius of the needle is 1 mm and the interval of needles is 2 mm, which are the same for all pinholders. On the other hand, the stem radius of flowers that are used at the art of Japanese flower arrangement is usually less than 10 mm. The stem, which radius is less than 2 mm, might not be inserted into the pinholders which interval is 2 mm. Then, Fig. 7 illustrates how many needles can be inserted to the stem under these conditions. The upper figure shows the maximum number of the needles that can be inserted into the stem, while the lower one shows the minimum number. Table 2 shows the maximum, minimum and average number of the needles for each radius of the stem. In the simulation, the average number is used with one exception that at least 1 needle is needed to be inserted to the stem having 2 mm radius.

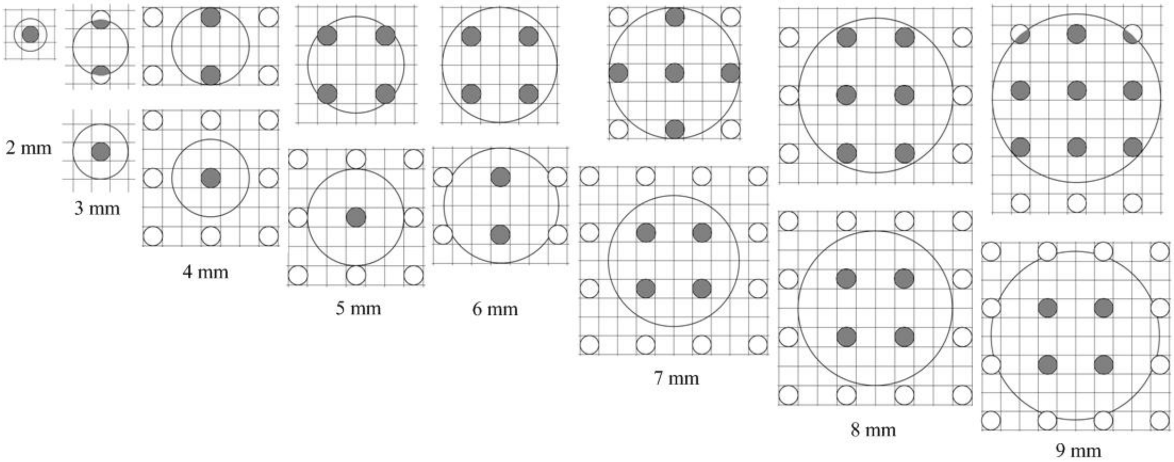


Figure 6. Number of needles for insertion.

The above is the result of the case for flowers to be inserted into pinholders. This force is the strongest in the simulation and can be masured with a durometer; however, there is another force feedback. That is the force which occurs when the flower held by a user contacts with another one or a floor on which a pinholder is set. This force cannot be mesasured so that Hooke’s law is applied to calculate the force. When the flower held by a user is inserted into a pinholer and also contacts with another flower, the force is calculated by combining the two vector force: the force from the pinholder and the one from another flower or the floor.

4. FALLING DOWN SIMULATION

The flower should fall down on the floor if the insertion length is not enough to resist the gravity. Suppose that L is the flower length, M is the mass and the density ρ is uniform. The moment of inertia I should be calculated as follows.

- $I = \int_0^L \rho r^2 dr = \int_0^L \frac{M}{L} r^2 dr = \frac{ML^2}{3}$ …………(4)

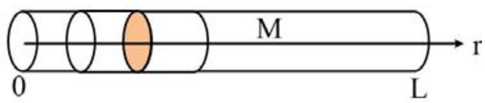


Figure 7. Calculation for the moment of inertia.

Where, r is the length parameter along the axis. Fig. 8 illustrates the rotation of the flower in the case that the insertion length is not enough. In the figure, C is the center of the gravity and the rotation force is $Mg\sin\phi$ at the center of the gravity. Then, the rotation angle θ can be calculated by using the next equations.

- $N = \frac{MgL\sin\phi}{2}$ …………………………......….(5)
- $N = I\alpha$ ……………………………………...……(6)
- $\omega = \alpha t$ …………………………………....……(7)
- $\theta = \omega t$ …………………………………...….…….(8)

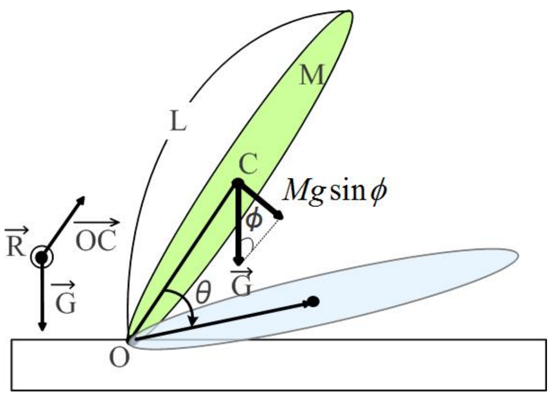


Figure 8. Falling down of a flower.

Where, N is the moment, α is the angular acceralation, ω is the angular velosity, t is time. The rotation axis $\vec{R}$ can be calculated as the vector product of $\vec{G}$ and $\overrightarrow{OC}$ ($\vec{R} = \vec{G} \times \overrightarrow{OC}$).

5. RESULTS

We have developed the training system with two kinds of PCs. The one system is shown in Fig. 9 (a) and some examples of the flower model created with CG modelling software (LightWave made by NewTek Inc.) are shown in Fig. 9 (b). The device the user is holding by his/her right hand is a haptic device, which can convey the force to users. The specifications of the two PCs are sohwn in Table 3. We have used different kinds of PCs to examine the performance. The result of the performace (frame rate) for each PC is shown in Fig. 10. The performance was measured by changing the number of flowers, which is constructed with 1,062 polygons, while the pinholder is constructed with 12,288 polygons and has 500 needles which length is 18 mm. Fig. 10 says that real-time response is possible for 45 flowers even if PC1 is used. On the other hand, 12 flowers are used for the examination of “Ohara”, which is one of the most famous Japanese flower arrangement schools. Therefore, the system has enough performance for the training.

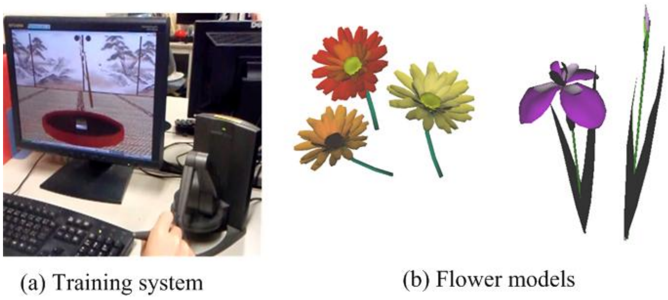


Figure 9. Training system and flower models.

Table 3. Specifications of PCs.

	PC1	PC2
OS.	WindowsXP	WindowsVista
CPU.	Pentium IV 2.6GHz (2 CPUs)	Core 2 Quad 2.5GHz
Memory	1 GB	4 GB
Graphics Board	GeForceFX5200 128MB	GeForce 9800GT 1GB
Haptic Device	PHANToM DeskTop	PHANToM Omni
Environment	Visual C++ 2005	
Library	OpenGL, SamrtCollision, Open Haptics	

Fig. 11 shows some snap shots of the training. Fig. 11 (a) is the initial state, where only a vase and a pinholder are drawn in the screen. A tiny ball is a cursor, which indicates the tip of the user’s finger. Fig. 11 (b) shows the state, where a first branch type of flower is inserted into the pinholder. After that, the user tried to insert the second flower into the pinholder; however, the length of the insersion was not enough so that the flower was falling down on the vase (See Fig. 11 (c)). Fig. 11 (d) is the final state, where the second insersion was successful and the user could confirm the training result by rotating the screen. When the screen is rotated, the system coordinate for the haptic device is also rotated to be coincident with the rotation of the screen.

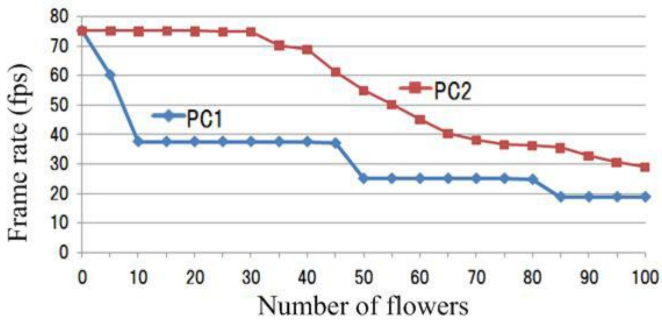


Figure 10. Frame rate for each PC.

For falling down simulation, the threshold of insertion length should be investigated. The length of the needles of pinholers is 18 mm, and much force is not needed for the insertion of branch type of flower until the insersion length reaches 10 mm since the bottom of the stem is broken for “Mizuage” method (See Fig. 6). Then, the threshold of the insertion should be 10 mm for branch type of flower. On the other hand, some force is needed for grass type of flower even if the insertion length is not so long. In the case of soft grass, the force occurred at 4 mm insertion is almost the same as the one for branch type of flower. Then the threshold for soft grass should be 4 mm, while much fource is needed for hard grass even if the insertion length is not so long. At the same time, some insertion length is needed for not falling down. Then, the threshold for hard grass type of flower should be 2 mm.

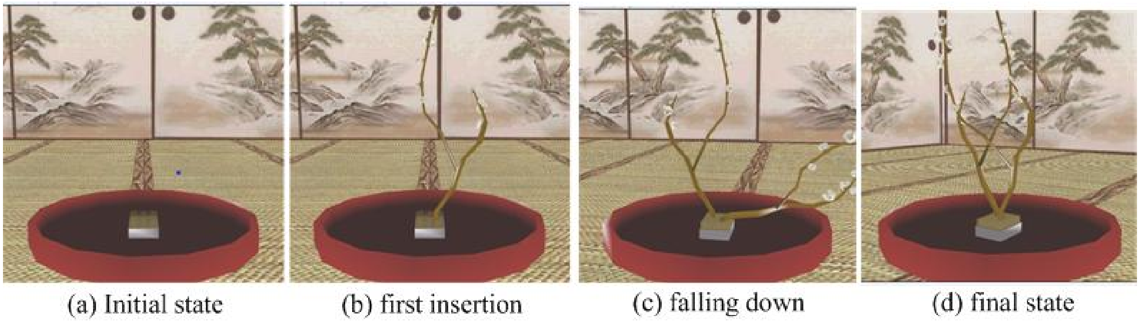


Figure 11. Some snap shots of the training.

6. EVALUATIONS

The training system was evaluated by 12 users. The questionnaires are the following.

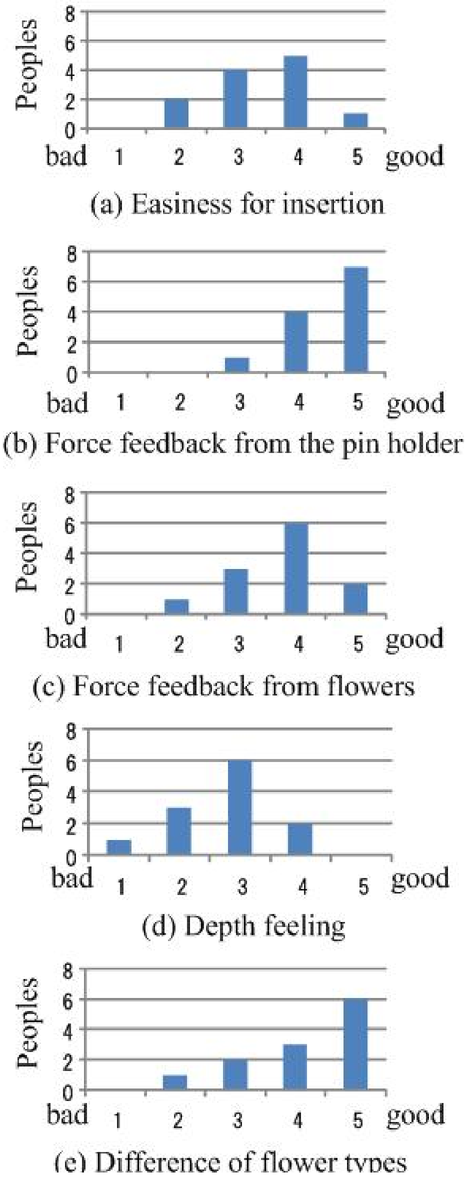
(a) Easiness for insertion: Is it easy to inert flowers into the pinholder? Is there any difficulty for the insertion?

(b) Force feedback from the pinholder: Can you feel the force feedback when you insert flowers into the pinholder?

(c) Force feedback from flowers: Can you feel the force feedback when the flower you are having contacts with another one?

(d) Depth feeling: Can you grasp the depth feeling when you insert flowers into the pinholder? Is there any difficulty to understand the three dimensional distance?

(e) Difference of flower types: Can you feel the difference among three types of flowers: soft grass, hard grass and branch?



The evaluation has 5 grades from 1 (bad) to 5 (good). Fig. 12 shows the evaluation results. For the force feedback, the evaluation was good, and users can understand the difference among three types of flowers. They can insert the flower into the pinholder without any difficulty. However, the evaluation was not so good for depth feeling because the system has only two dimensional display device and does not have 3D stereo view.

7. DISCUSSION AND CONCLUSIONS

We have developed a training system for the Japanese art of flower arrangement. The system has a haptic device, which can generate force feedback when users insert flowers into the pinholder. For the training, there are three kinds of flowers: soft grass, hard grass and branch. The hardness of stems was measured with a durometer, and the force conveyed to users was generated with the approximated curves based on the measurement result. The response time was good enough for the training, and the evaluation result was fairly good.

In the current system, there are not so many flowers for a variety of training so that we have to create variety of flower models. The current flower models are very simple for real-time response; however, the more complex models would be needed in the future training. 3D stereo view is also necessary to grasp the three dimensional distance. The feedback of the evaluation would also be necessary for users to improve their skills.

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