

# AR Dental Surgical Simulator Using Haptic Feedback

Katsuhiko Onishi<sup>1</sup>, Kiminori Mizushino<sup>2</sup>, Hiroki Ikemoto<sup>1</sup>, and Hiroshi Noborio<sup>1</sup>

<sup>1</sup> Osaka Electro-Communication University  
1130-70 Kiyotaki, Shijonawate, Osaka 575-0063, Japan  
{onishi,t10007,nobori}@oecu.jp

<sup>2</sup> Embedded Wings Co. Ltd.  
5-2-3 Ina, Minoh, Osaka 562-0015, Japan  
k\_mizushino@ewings.biz

**Abstract.** We describe about our dental surgical simulator which enable users to simulate dental surgical operation. Our simulator which enables the user to learn dental surgical methods through actual hand and body postures. The proposed system uses a display showing a virtual tooth model and real teeth and gums that are positioned close to the hands of the user, which allows the user to directly manipulate objects with haptic feedback. As a preliminary evaluation, in display system, we measured the deviation between real object image and virtual object image at user's view positions. And we confirmed the capability and the limitation of our system.

**Keywords:** Dental surgical simulator, augmented reality, direct manipulation.

## 1 Introduction

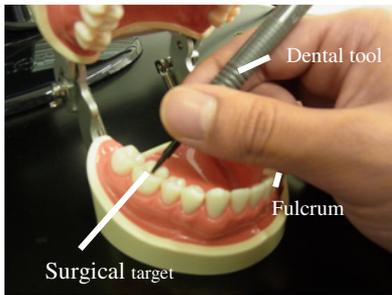
In dental surgery, most surgical training methods use plastic teeth or live patients. Although these methods are good for improving surgical skills, for example, the use of surgical tools and surgical procedures, task repetition is difficult because of the need for new plastic teeth or live patients for each task. Therefore, several types of dental surgical simulator have been proposed [1], [2], [3]. These simulators allow users to learn dental surgical methods using a unique interface. Most of dental surgical simulator use the haptic feedback interface for simulating dental surgical operation. However, most of these simulators use a typical computing display system, and so the user cannot experience the actual hand positions or body posture required during dental surgery.

In this paper, we describe about our preliminary work of a dental surgical training system for learning about real hand position and the body posture. To realize the practice of user's hand position and the body posture, our system set a display close to user's hand position and allows the user to operate surgical tasks directly. And it shows combined image with virtual teeth model as a surgical target and a real tooth model as other parts of the patient dental model. In order to adapt to any head position of the user, the system measured the head position of the user and the position of the real teeth model.

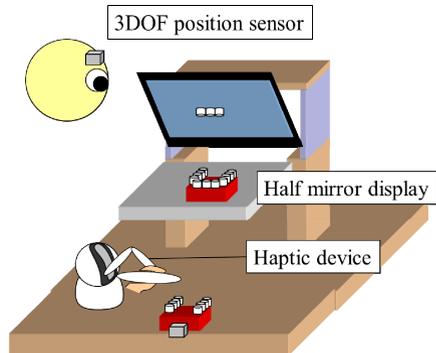
## 2 Our Dental Surgical Simulator

In dental surgery, the surgical environment is usually such that a patient is lying in front of a dentist while the dentist operates. In such a situation, the positions of the dentist hands and the body posture of the dentist are different from those in traditional dental surgical simulation. For example, Figure 1 shows a typical hand position in dental surgical operation. It is needed strict movement to manipulate a dental tool for operating surgical tasks. The dentist put their hand on the patient teeth or gum as the fulcrum.

In order to realize manipulations with respect to user hand positions and body posture, the proposed system incorporates a half mirror placed horizontally between the head position and the position of the hands, as shown in Figure 2. The system then presents a combined image of the virtual teeth and the teeth model on the half mirror display. Furthermore, in order to adapt the head motion of the user for probing and confirming the surgical target, the system measures the head motion of the user and the teeth model. The virtual teeth are shown on an LCD display that can be adequately viewed by the user. The system uses a real teeth model around the surgical target teeth and the user is able to steady their hands against the model while performing surgical tasks, allowing the user to perform the surgical simulation tasks precisely.



**Fig. 2.** An example of surgical hand position



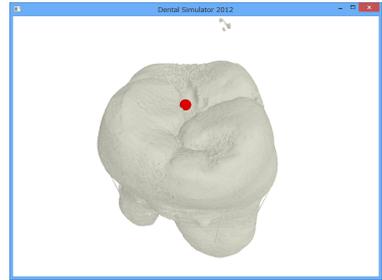
**Fig. 1.** Our dental surgical system

## 3 Prototype System

The prototype display is shown in Figure 3. The proposed system is implemented on a Windows PC, and the system measures the user's head position and real teeth and gum model position using 3DOF magnetic sensors. It shows the users a teeth model and virtual teeth reflected onto the display from the half mirror. Figures 4 shows virtual teeth model which our system uses. This model is created as a surface model by each parts and the system check the collision detection in real time between surgical



**Fig. 3.** Our prototype display



**Fig. 4.** Virtual teeth model

tools and the teeth model. And it is deformed the shape by user's surgical operation. Figures 5 is a usage image of our system. The system measures a viewing position of the user and shows the appropriate view based on that position. Then, the system allows the user to display the virtual and real teeth models simultaneously from any viewing position.

As a preliminary evaluation about the display system, we have measured the deviation between real objects and virtual objects in the user's view image. We use a cube model as the target model for measuring the deviation precisely. And it is measured from 8 view positions on a horizontal line. The deviation is about from 0.06cm to 1.00cm in these view positions.



**Fig. 5.** An example of our display system

## 4 Conclusion

We proposed a dental surgical simulator system for a dental surgical simulator. The proposed system enables the user to view a combined image of virtual teeth and a teeth model. The user can see the combined image from any point of view by tracking his or her head position and the model position. We constructed a prototype system and confirmed the capability and the limitation of this system.

In future work, we will evaluate the haptic feedback module in this system. And we will improve the accuracy of the user's view image.

## References

1. Rhienmora, P., Gajananan, K., Haddawy, P., Suebnukarn, S., Dailey, M., Supataratarn, E., Shrestha, P.: Haptic augmented reality dental trainer with automatic performance assessment. In: The 15th International Conference on Intelligent User Interfaces (IUI 2010), pp. 425–426 (2010)
2. Kim, L., Park An, S.: Efficient virtual teeth modeling for dental training system. *International Journal of CAD/CAM* 8(1), 41–44 (2008)
3. Yau, H., Tsou, L., Tsai, M.: Octree-based virtual dental training system with a haptic device. *Computer-Aided Design & Applications* 3, 415–424 (2006)