Development of a new method for manipulation of dental images using a motion sensor in dentistry

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Aims and objectives

Currently, dental radiography and/or pantomography has been used for examination and treatment of periodontal disease in dental radiology. These images were taken by using medical imaging equipment for diagnosis and/or treatment. In the past, diagnosis and/or treatment were based on film images.

Today, dentists can perform image manipulation and display of reference images by using of image display system. During dental treatment, dentists needs image processing operation such as paging, enlarging change brightness to assess dental conditions.

In order to analyze the images for any abnormal findings, dentists sometimes require previous dental x-ray images. Since dentists always wore gloves to be kept clean, he or she could not operate the image processing on console by hands.

Therefore, we developed a newl image operation system using a motion sensor. We investigated the time required by the conventional method using the mouse and by the finger operating method with a motion sensor including removing and fitting time of gloves.
Methods and materials

We used the Leap motion sensor (Leap motion, Inc., San Francisco) [1] as shown in Fig. 1 which is a gesture recognition technology to read the movement of dentist. This sensor consisted of three infrared laser emitter for gesture recognition. Fig.2 shows photograph of the Leap motion sensor which was taken by camcorder to observe the infrared laser ray. This image makes us understand that this device emit the infrared rays from center and both sides.

For development of proper software, the Leap motion sensor was plugged into the USB port of a MB-W800S-SH (Mouse Computer Co.,Ltd.Tokyo Japan) and was loaded with a Leap motion software development kit (SDK)[2]. We used the "Leap motion for Windows SDK", v.0.8.1.6221 for Windows (Leap motion, Inc.), and "Visual Studio 2012" (Microsoft, Redmond, WA, USA), which enabled us to create applications that support gesture by using the Leap motion for Windows sensor for dental application. The basic requirement for software development was the addition of a postscript for command programs such as swipe, drag, drop, and click by use of various detected data from the Leap motion sensor.

As an application for dental image display, an AZEWin viewer (AZE, Ltd., Tokyo, Japan) was used as a medical image viewer. The data detectable by the Leap motion included a large amount of information such as the coordinates of the palm and fingers, the direction and speed of their movement, and the rotation angle for motion and gesture. These data were analyzed and sent to the application, and many different commands were developed.

The accuracy of the Leap motion sensor is quite high compared with other motion sensing device such as Kinect[3] because of a high frame rate of 290 per second[4]. Therefore, this device can obtain the data quickly in three dimension. We investigated the detection range with high accuracy of this motion sensor. Furthermore, we investigated the time required by the conventional method using the mouse and by the finger operating method with this motion sensor.

In this study, we use one clinical cases with two pantomographic image and four dental images, and then the total of six images. We conducted an observer study by use of these images.

And we used nitrile inspection examination glove (Kimberly-Clark) as commonly used in clinical situation (Fig.3). The usefulness of the image operation system with a motion sensor was evaluated by fourteen students on a simulated viewing of a clinical case in the following manner. Although dentists would operate this motion sensor in operating rooms, we carried out an observer study with fourteen students, because we expected that, if students were able to use the motion sensor properly, dentists would also be able to do so.
In this experiment, observer removed the gloves when use the mouse for image viewer, because reproducing the clinical site. The instruction based on scenario for the operation of the observer for dental image display were given to student orally. The scheme of definite experiment were shown in Fig.4 and Fig.5.

In this observer study, after finger operating practice of a total of 30 minutes and glove fitting practice, observers were asked to manipulate each of five images in the order from zooming, display a predetermined location by roaming and then adjustment of brightness and contrast. When the observer may complete all of the display operations on one image, the observer can move to the next image and repeat the same operation on six images in the same manner. In order to monitor and maintain proper levels of adjusting the image at all steps by an observer, an experienced physicist as a judge determined to confirm that each of displayed images would be at a proper level. Observer can move to operate at the next step, only when the physicist indicated verbally the displayed image to be acceptable.

For proper display of simulated viewing for the sequence of clinical dental images including paging, enlarging change brightness processing, we investigated the comparison of the average time required by the conventional method using the mouse including twice removing and fitting time of gloves and the finger operating method with motion sensor. The observer study was conducted twice.
Images for this section:

**Fig. 1:** Photograph of the Leap motion sensor. The size and weight of this sensor are 13 mm height, 76 mm width, 30 mm depth, and 45 grams.

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Fig. 2: Photograph of the Leap motion sensor with three infrared LED laser emitters.

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Fig. 3: Used gloves (Kimberly-Clark)

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Fig. 4: Scenario for the observer operating test by the finger operating method

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**Fig. 5:** Scenario for the observer operating test using the mouse

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Results

As a result of measuring, detection range with high accuracy of the motion by the Leap motion was about 70mm-300mm from top of sensor (Fig.6). For initialization of the system, the right or left hand of the dentist needs to be recognized by placement of the palm of the hand over the sensor. For paging to the next image, he/she may swiping of their finger from left to right. For zooming, adjustment of brightness and/or contrast, and roaming the image, we designed this software to operate images by grasping the image. Fig. 7 show the movie of these operation. The average time required by all observers for each case is shown in Fig. 8.

As a result of measuring operation time, after practice of a total of 30 minutes, the average operation time by the convention mouse method was 109.8±1.9 second. And, the average time of the finger operating method is 94.7±9.1 second. We found out that the motion sensor method was significantly shorter (p<0.01: Paired Two Sample t-Test) than the conventional method using the mouse. We recognized the difference time between mouse and finger operating method were twice change gloves time. If dentists need to adjust images by themselves, they need to change gloves each time. For dentist's examination and/or treatment, it is very inconvenient for dentists, and may impose an additional work load such as throughput and/or cost. For this reason, nurses and/or dental hygienists may operate the display system instead of dentists, but there may be a loss of time due to communication error between dentists and nurses and/or dental hygienist. However, most people are not familiar with the operation of the image by their finger movement. Thus, observers need to practice to become familiar with "operation by finger movement". The second operating time for the finger movement became shorter than that in the first attempt.
Image for this section:

**Fig. 6:** Detection range with high accuracy of the motion by the Leap motion sensor

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**Fig. 7:** Manipulation movie for paging, zooming, roaming and change brightness of clinical dental images

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Fig. 8: Comparison of the average time required by the conventional method with use of the mouse and the finger operating method with motion sensor (average time ±standard deviation) for proper display of simulated viewing of a sequence of clinical pantomographic and dental images. The average time required by the conventional method with use of the mouse is including twice removing and fitting time of gloves

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Conclusion

With the image operation system using a Leap motion sensor for dental examination, various image processing can be performed quickly with our finger movements, which is a new operation technology for dental examination.
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