VR Hand Hygiene Training System That Visualizes Germs to Be Washed and Removed

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***Abstract*—Although people should wash their hands to prevent infection especially in a place where many people gather, such as in a hospital or a school, it is difficult to teach young children to wash their hands properly. The challenge is to make them understand why they should wash their hands even if they are looking already clean. We propose a novel VR hand washing training system for preschool and lower school grade of children. This system superimposes germ illustrations on their hands through a HMD, and germs get removed when children move their hands in a proper washing motion. Then, they can intuitively learn the reason and the method. We had an experiment to evaluate if our proposed VR system is more effective than a conventional hand hygiene instruction for young children. The result of the experiment will suggest the effectiveness of the proposed system.**

***Keywords*—Virtual Reality,Interactive learning environments**

I. Introduction

In the field of paediatric medical care, there is a risk of contact infection via things such as children's toys. The easiest and most effective precaution of contact infection is hand hygiene. Hand hygiene awareness is necessary not only in the epidemic period such as influenza but also on a daily basis. Currently, hospitals put up a poster and hold a class "How to wash hands" for children. On the other hand, many researches have been conducted to improve the awareness of hand hygiene such as the development of simulation games [1] or the projection mapping to alcohol bottles for disinfection [2]. These studies are not particularly targeted to children. In this paper, we propose a novel VR hand washing training system for preschool and lower school grade of children. First, the system obtains a position and a posture data of both user ' s hands. It superimposes germ illustrations on user's hands through a HMD, and germs get removed when the user moves his hands in a proper washing motion such as rubbing both hands. It is expected that this experience makes children intuitively learn a proper method to wash their hands and its importance. A data glove is used to obtain posture of user's hand as a VR device. In this research, we use Leap motion to obtain posture of a hand because of portability and price. By the way, a hand occluded by the other can not be detected through recognition based on image such as the Leap motion. We assume that the hand stays and continues as the previous process time, even if one hand is not detected. Then the system judges washing motion with typical gestures for each part of the hand advised by a medical doctor. In Chapter 2, we will describe specific gestures and judgment method.

II. VR hand washing training system

The areas where the germ illustration is superimposed as palm, fingertip, back, thumb, interdigit and wrist of both hands are decided according to the WHO Guidelines[3]. The method of "how to wash each area properly" is usually explained as Table I. By the way, our proposed system obtains the hand position and posture through Leap Motion. Hand position is given by position of wrist, and hand posture is given by relative position of a joint and fingertip from hand position, normal vector of a palm plane, and radius of a sphere that fits to a curvature of a hand for grip condition. We decide each gesture for each washing method using these data. The gestures to wash are defined as Fig. 1 to Fig. 6. The current hand position and posture are judged whether they match each gesture by comparing the following values with a threshold value.

TABLE I
HOW TO WASH EACH AREA PROPERLY

palm	rub hand palm to palm
fingertip	rub with clasped fingers of a hand in another palm
interdigit	palm to palm with fingers interlaced
thumb	grasp thumb with another palm and rub
back	rub back of hand with another hand
wrist	rotating rub of a wrist in another palm

palm
- **distance**: distance between palm of both hands is less than threshold
- **orientation of palm**: horizontal element of palm normal is greater than threshold

fingertip
- **distance**: distance between washed finger and another palm is less than threshold
- **orientation of palm**: horizontal element of palm normal is greater than threshold
- **orientation of finger**: horizontal element of orientation of finger is greater than threshold

interdigit
- **distance**: distance between interdigit of both hands is less than threshold

orientation of palm: horizontal and vertical element of palm normal is greater than threshold

thumb

distance: distance between washed thumb and another palm is less than threshold
orientation of palm: depth element of palm normal is greater than threshold
radius: radius of sphere fitting to hand curvature is less than threshold

back

distance: distance between palm of both hands is less than threshold
orientation of palm: vertical element of palm normal is greater than threshold

wrist

distance: distance between washed wrist and another palm is less than threshold
orientation of palm: vertical element of palm normal is greater than threshold
radius: radius of sphere fitting to hand curvature is less than threshold

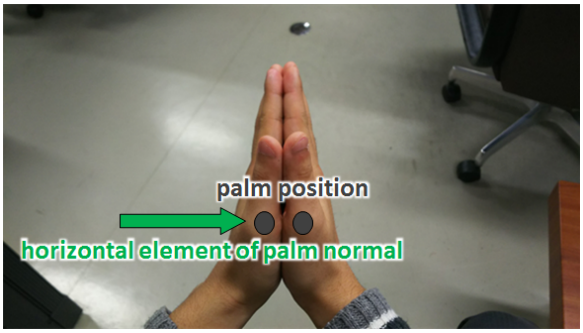

Fig. 1. Gesture of washing a palm

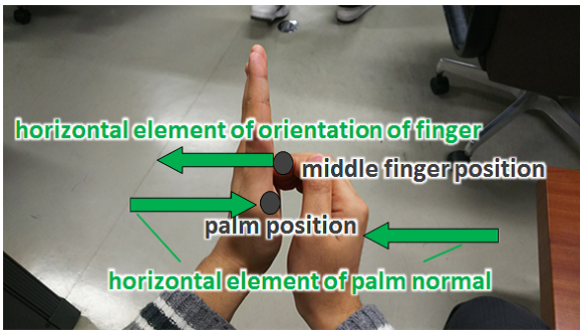

Fig. 2. Gesture of washing a fingertip

The system checks if the input posture matches with each gesture at regular intervals. When an occluded hand is not detected through Leap Motion, it is assumed that the hand stays and continues as the previous process time. The damaged point of corresponding germ is increased if the posture matches with a gesture. The germ gets transparent, then removed in accordance with an increase of the point. Because this system is used by children, it is necessary to show the system interesting. The image of hands captured through an infrared camera of Leap Motion is processed to skin color, and shown on a HMD. The germ CG illustrations are also colored, and shown on a HMD. Illustration of a character supporting the

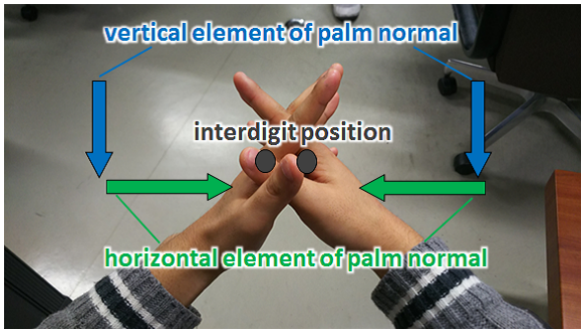

Fig. 3. Gesture of washing a interdigit

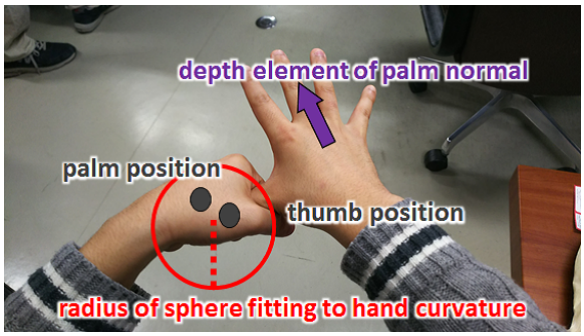

Fig. 4. Gesture of washing a thumb

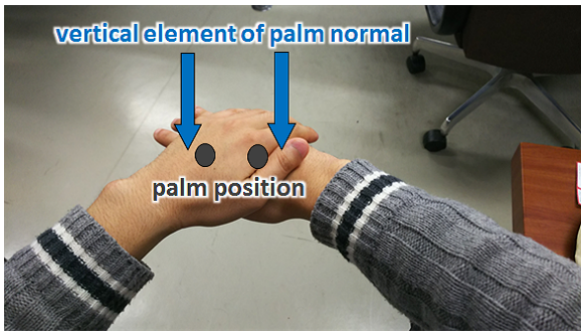

Fig. 5. Gesture of washing a back

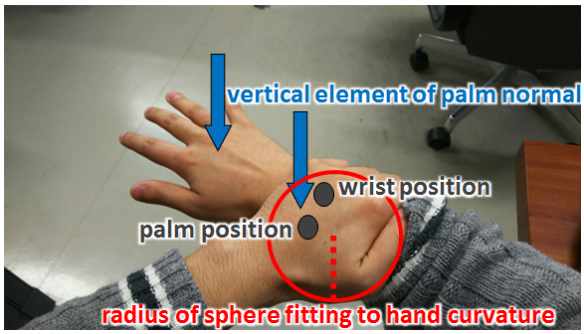

Fig. 6. Gesture of washing a wrist

Fig. 7. Hands and germs displayed on a screen

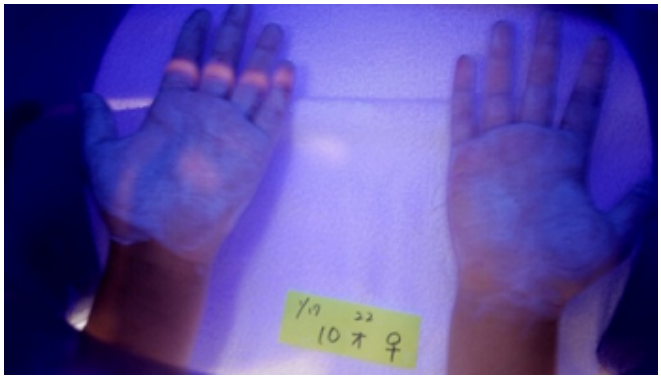

Fig. 9. Handwash check with black light, good example

hand washing is drawn in the background. In addition, an effect sound is made when germ is damaged and removed. The gauges showing time limit and damage points are displayed like video games. Three result screens are prepared, and one of them is displayed according to the total damage point at the end of washing. System execution screen through the HMD is shown in Fig.7. You can wash your hands while looking germs, and recognize the disappearance visually.

III. Experiment and Result

We had an experiment to evaluate whether our proposed VR system is more effective than a conventional hand hygiene instruction for young children. We used monocular vision HMD to use with mobile phone in consideration of the risk of visual function. Leap Motion was attached on the front of the HMD. The mobile phone screen is synchronized to PC screen with USB cable. The HMD is fixed on the stand as shown in Fig. 8, because it was too heavy to wear for young children. The subjects were 12 children who were admitted at the Aichi Children's Health and Medical Center. First, a nurse and a childcare-giver taught 5 children how to wash their hands using a illustration and oral instruction, then checked the areas of their hand using fluorescent paint and black light. If the hand is rubbing tightly, the fluorescent paint spreads in the hand, then it becomes white (Fig. 9). If the hand is not rubbing, the fluorescent paint does not spread, so the back of

Fig. 8. Experiment scene

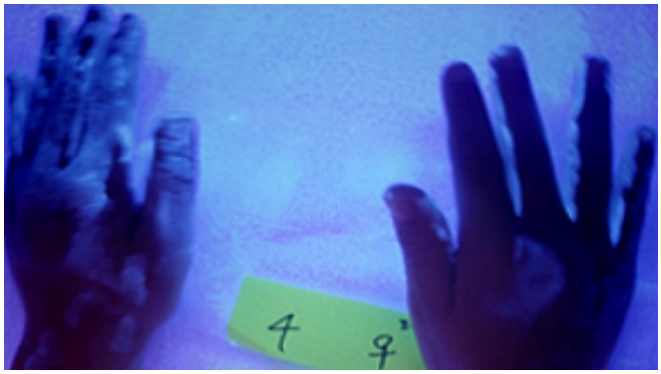

Fig. 10. Handwash check with black light, bad example

the right hand is not white (Fig. 10). The other 7 children learned how to wash their hands using proposed system, it means, tried to remove germs by rubbing their hands, then they were also checked as a same way. We gave 2 points if child could wash interdigit, thumb and wrist respectively, thanks to preventionist's advice that it is usually difficult to wash those areas. The other three areas were given 1 point. This test was in 9 points. The average points of Table II and III suggest that our proposed system was better than conventional oral explanation, especially on the difficult areas. We published a press release, and held a demonstration event. Five outpatients used this system (Fig. 11), then they and their parents gave positive opinions.

TABLE II
Result for Conventional Instruction

age/sex	7/F	11/M	6/M	3/F	5/M	ave.
palm	1	1	1	1	1	1
fingertip	1	1	1	1	1	1
back	1	1	1	1	0	0.8
interdigit	2	2	2	0	2	1.6
thumb	2	2	2	0	2	1.6
wrist	0	0	0	0	2	0.4
total	7	7	5	3	8	6

TABLE III
RESULT FOR PROPOSED VR SYSTEM

age/sex	11/F	6/F	10/F	6/M	6/F	7/M	11/M	ave.
palm	1	1	1	1	1	1	1	1
fingertip	1	1	1	1	1	0	1	0.86
back	0	1	1	1	0	0	1	0.57
interdigit	2	2	2	2	2	2	2	2
thumb	2	2	0	2	2	0	2	1.43
wrist	0	0	0	2	2	2	0	0.86
total	6	7	5	9	8	5	7	6.7

Fig. 11. Demonstration scene

IV. CONCLUSION

In this research, we proposed VR hand washing training system for preschool and lower grade of school children in order to improve the hygienic environment in pediatric medical care. In the future, we would like to put our system to practical use at an outpatient section, a preschool, and a school for small children. We also would like to analyse data of use of this, then improve hand recognition and its correction, judgement method to wash, and a way to show for children.

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