PRESS RELEASE

岡山大学
OKAYAMA UNIVERSITY

令和　３年　５　月２７日

ウィルスの拡散防止する行動獲得のための VR 教育コンテンツの開発

◆発表のポイント

・バーチャル・リアリティ（VR）技術によって生み出された仮想空間内で医療行為を通したウィルスの拡散・伝播状況を疑似体験することで、現実世界における医療従事者の感染対策行動を促す教育コンテンツを開発しました。
・現状では、病室の環境清拭用コンテンツを通してウィルスの付着や除去の状況が確認できます。
・今後、様々なシチュエーションを想定し教育コンテンツを充実することで、院内感染対策への貢献が期待されます。

岡山大学学術研究院医歯薬学域 萩谷英大 准教授、ヘルスシステム統合科学学域 五福明夫 教授、工学部創造工学センター 柴田光宣 技術専門職員、廣田聡 技術職員の研究グループは、医療従事者の感染対策意識を向上させるためのツールとして、バーチャルリアリティ（VR : Virtual Reality）を適用した教育コンテンツを開発しました。本コンテンツでは、市販の VR システムを用い、通常目に見えないウィルスを仮想空間内の医療環境において視覚化しました。この仮想空間内で実際の医療現場で行われる診療・看護を行い、医療行為を通したウィルスの拡散・伝播状況を疑似体験することで、現実世界における手指衛生等の適切な感染対策の実施を促すことを目的としています。これまでに、病室の環境清拭用コンテンツを開発しましたが、順次、薬・文書の病室内配送、点滴バッグ交換、点滴ライン確保、手術創部観察・ガーゼ交換、尿量測定、おむつ交換などの様々なシチュエーションを想定したコンテンツを開発し、医療従事者向けの教育プログラムの開発へと発展させる予定です。

◆研究者からのひとこと

新型コロナウイルス感染症のパンデミックは、医療従事者全般における基本的な感染対策の重要性を浮き彫りにしました。VR 技術を用いて医療環境における微生物の伝播状況を疑似体験することで、現実世界での行動改善につながることを期待しています！

萩谷　准教授

五福　教授

この教育コンテンツを試用した時、手指衛生に気をつけた行動を採らないと、こんなにあちこちにウィルスが付着するのかと愕然としました。まだまだ研究開発すべき点は多いですが、この教育コンテンツにより、急ぎの場合でもウィルスができるだけ拡散しない行動を医療従事者が無意識に採れて院内感染を防ぐことに役立てば嬉しいです。

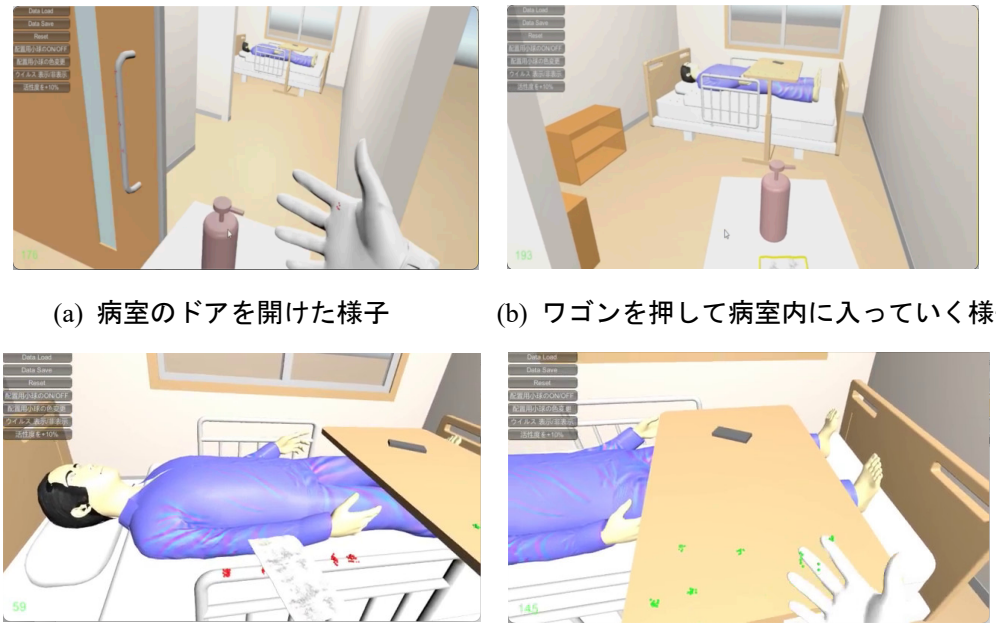
■発表内容

＜現状＞

新型コロナウィルス感染症をはじめとした様々な感染症の蔓延を防止するためには、集団免疫の確立（ワクチン接種）、物理的な感染経路の遮断（隔離診察）、個人防護具（マスク・ガウン・アイガードなど）の充実とともに、医療従事者一人一人の日常的な感染防止行動が重要です。感染防止行動としては手指衛生が最も重要で、WHO（世界保健機関）は 2009 年に”5 Moments for Hand Hygiene”（手指衛生のための 5 つの場面）を提唱し、医療従事者における手指衛生行動の改善を啓発してきました。しかし、微生物は目に見えないことから、どのような医療行為・環境で感染リスクが高いのか、実感し難いという課題がありました。

＜研究成果の内容＞

岡山大学学術研究院医歯薬学域 萩谷英大 准教授、ヘルスシステム統合科学学域 五福明夫 教授、工学部創造工学センター 柴田光宣 専門技術職員、廣田聡 技術職員の研究グループは、バーチャルリアリティ（VR：Virtual Reality）を適用した教育コンテンツを開発しました。この教育コンテンツでは、市販の VR システムを用いて、目に見えないウィルスを仮想空間内の医療環境において視覚化しました。この仮想空間内で実際の医療現場で行われる診療・看護を行い、医療行為を通したウィルスの拡散・伝播状況を疑似体験することで、現実世界における手指衛生等の適切な感染防止行動につながるよう支援します。これまでに、図に示す病室の環境清拭用コンテンツを開発しましたが、順次、薬・文書の病室内配送、点滴バッグ交換、点滴ライン確保、手術創部観察・ガーゼ交換、尿量測定、おむつ交換などの様々なシチュエーションを想定したコンテンツを開発し、医療従事者向けの教育プログラムの開発へと発展させる予定です。現状ではコントローラで病室ドアの開閉、カートの移動、病室内の物体把持などの操作を行う必要があり、操作性に課題がありますが、今後はデータグローブを用いて自然な操作感で疑似体験できるように開発を進める予定です。



(a) 病室のドアを開けた様子　(b) ワゴンを押して病室内に入っていく様子

(c) ベッド廻りを清拭している様子　(d) テーブルに触れ人差し指にウィルスが付着した様子

図　環境清拭のタスク用の VR 教育コンテンツの画面例（ウィルスは色のついた点群で表示）

＜社会的な意義＞

本技術・教育コンテンツは、新型コロナウィルス対策に留まらず、インフルエンザ・ノロウイルス・薬剤耐性菌など様々な感染対策に応用することが可能です。院内感染を最小限にし、患者・医療従事者の安全確保につながります。また、言語を要さない教育プログラムであり、グローバルな展開も期待されます。

■研究資金

本研究は、公益財団法人 西川医療振興財団（2020 年度医学研究活動費助成事業助成金）の支援を受けて実施しました。

■補足・用語説明

・バーチャル・リアリティ（VR：Virtual Reality）

コンピュータによって描画した仮想世界をゴーグル型のディスプレイによって表示することにより、あたかも現実世界と同等の感覚を持たせる技術。類似の技術に、現実にある対象物にコンピュータ表示を付加した拡張現実感（AR：Augmented Reality）や、現実と仮想を等価に融合した複合現実感（MR：Mixed Reality）などがある。

＜お問い合わせ＞
岡山大学 学術研究院 ヘルスシステム統合科学学域
教授　五福　明夫
（電話番号）　０８６−２５１−８０２２
（FAX）　０８６−２５１−８０２４
（メール）　gofuku-a@okayama-u.ac.jp

Japan. Committed to SDGs　岡山大学 OKAYAMA UNIVERSITY　SUSTAINABLE DEVELOPMENT GOALS

岡山大学は持続可能な開発目標（SDGs）を支援しています。

A VR-Based Training System to Make Healthcare Personnel Recognize the Importance of Infection Prevention

Mitsunobu Shibata[1)], So Hirota[1)], Mahiro Izumi[2)], Hideharu Hagiya[3)], Akio Gofuku[4)]

1) Center for Engineering Innovation, Faculty of Engineering, Okayama University, 3-1-1, Tsushima-Naka, Kita-Ku, Okayama, 700-8530, Japan
2) Department of Mechanical and Systems Engineering, Faculty of Engineering, Okayama University, 3-1-1, Tsushima-Naka, Kita-Ku, Okayama, 700-8530, Japan
3) Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, Okayama University, 2-5-1, Shikata-Cho, Kita-Ku, Okayama, 700-8558, Japan
4) Graduate School of Interdisciplinary Science and Engineering in Health Systems, Okayama University, 3-1-1, Tsushima-Naka, Kita-Ku, Okayama, 700-8530, Japan (gofuku-a@okayama-u.ac.jp)

***Abstract*—In this age of COVID-19 pandemic, every medical staff needs to acquire appropriate skills for infection prevention to avoid the spreading of contagious diseases. Hand hygiene is an essential part of such basic countermeasures for infection control; however, a behavior of medical staff is necessarily not desirable against the invisible etiologies. This study develops a training system applying virtual reality (VR) to make them recognize the importance of infection prevention. The training system uses a commercial HMD (Head Mounted Display) type VR device to artificially visualize the existence of invisible microorganisms as colored-small dots on their hands and the surroundings in patients' rooms. The system has a function to simulate the extinguishment or inactivation of the microorganisms by a simple model. Some training tasks to clean up a patient room and so on have been developed. Preferable feedbacks were obtained from three medical staffs who underwent a trial application of an implemented task. Future works should include implementations of various training tasks such as changing infusion bags, daily rounds of patients, *etc*. It is also necessary to evaluate the applicability and educational effectiveness of the VR training system in developing the basic infection prevention skill.**

Keywords—training, virtual reality, medical staff, infection prevention, infectious diseases, hand hygiene

I. INTRODUCTION

The infectious viruses like COVID-19 are invisible without an electric microscope and a virus can be alive for several tens of hours on the surface of an object. The COVID-19 exhibits most strong infectious capability just before the onset. Many nosocomial infection cases happen by the characteristic features of COVID-19 although medical staffs make a great effort to sterilize their hands and hospital rooms. In order to prevent the spread of infection, medical staffs are necessary to acquire suitable skills of infection prevention for invisible viruses.

Virtual reality (VR) is a technology to provide senses to users as if they behave in real space. A virtual space is usually created by computer graphics and a user sees the objects in a virtual space by wearing an HMD (Head Mounted Display). Current most virtual reality systems provide visual and audio senses. Studies to give senses of tactile, taste, and smell are also extensively carried out [1, 2].

VR has been applied to the training of pilots and drivers with combining simulators of aircrafts and automobiles [3-5]. Because VR is a strong tool to visualize physical phenomena, applications to the operations of industrial plants have been investigated [6]. The technology is also applied to construction engineering training and planning of decommissioning operations. [7, 8]

Several commercial VR devices appeared in 2016. From the year, VR systems become popular for safety training of workers, virtual sightseeing, education of medical staffs, etc. In this study, the first version of a VR training system has been developed to make medical staff recognize the importance of virus infection prevention and obtain suitable behavior patterns to prevent the spread of virus infection through the virtual experiences of a variety of daily medical activities.

II. VR ENVIRONMENT

The VR system used in this study is VIVE Pro Eye (HTC corp.). The system is composed of a HMD, two controllers, two sensing devices, and a control PC. The HMD has an eye tracking function that makes a user more realistic VR experience by detecting eye fixation points than that of the previous version (VIVE Pro). A controller has several buttons to initiate actions such as grasping an object, etc. by pushing the buttons. A data glove system (Noitom International Inc., Hi5 VR GLOBE) can be used in replace of a controller. The sensing devices are diagonally placed in the edge of a real working space and measure the location of the controllers or data gloves in the real space. By the measurement, the handling behavior of an object by the controller or data glove of a user is reflected in the virtual space.

A VR application software develop environment, Unity, is used to develop VR training tasks. In the Unity, the motion and appearance of an object are easily changed by editing the parameters of the object.

Figure 1 shows an example of the scene to perform a VR task. A doctor wearing the white coat performs the

task in the VR space shown by the HMD using the black controllers.

Fig.1 Example scene of performing a task.

III. Tasks

A. *Tasks for training medical staffs*

The purpose of this study is to lead a medical staff to prompt suitable behavior changes and to acquire desirable behaviors to prevent the spread of infectious viruses. For this purpose, a variety of VR training tasks based on the daily tasks of medical staffs are necessary to be developed to make a medical staff know the problems of his/her behaviors by performing the tasks. The tentative list of the tasks to be developed is shown in Table 1.

Table 1 List of tasks

Task name	Task content
Hospital room sterilization	Sterilize a room and objects in the room. a) One day after the discharge of a patient b) Just after the discharge of a patient c) When a patient is sleeping on the bed
Delivery of medicine and water	Deliver medicine and water to a room. a) Without tidying the room b) With tidying the room
Document explanation	Explain the contents of documents to patient and ask him/her to sign them
Checking the urethral balloon	Check the urethral balloon and record the urine volume a) Without disposing the urine b) With disposing the urine
Intravenous exchange	Change the intravenous bag
Gauze exchange	Change the gauze of a patient
Round	Measure the body temperature and blood pressure of a patient

The tasks of “Hospital room sterilization”, “Delivery of medicine and water”, “Document explanation”, and “Checking the urethral balloon: a) Without disposing the urine” have been implemented. The authors will implement the other tasks in order. In the next section, the VR display in each implemented task will be explained.

IV. Implemented VR Tasks

A. *Display of virus in VR space*

A group of viruses is displayed as a dot in VR space as shown in Fig. 2. Each group is displayed in a different color depending on the object where it originally adheres to. The figure shows that some groups of viruses adhere to the knob of a door as red dots. When a hand touches the door’s knob with viruses, some of viruses adhere to the parts of hand as shown in Fig. 3. After the adhering viruses to a hand, some of the viruses adhere to the object where the hand touches. In the current study, a simple model of adhering constant rate of viruses to the hand/object by the touching motion.

There are two modes of virus display in performing a task. The one is virus visible mode that virus groups are displayed as colored dots in the VR space. The other is virus invisible mode that viruses are not displayed. In addition, the viruses can be displayed after performing a task in the virus invisible mode by changing the mode from the control PC.

Fig. 2 Example of display of groups of viruses as dots.

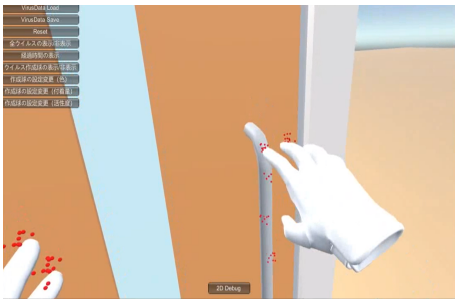


Fig. 3 Example of adhering viruses to hand.

Fig. 4 Example of adhering viruses to the object where a hand with viruses touches.

B. Hospital room sterilization task

The task is to sterilize the objects in a hospital room and the door and wall of the room by cloths for sterilization. In the current version, the floor and ceiling are excluded from the targets of sterilization. A medical staff is asked to enter a hospital room and sterilize the room.

Because viruses may survive for some days depending on the room environment and the type of object that viruses adhere to, there are three kinds of the task to simulate the differences of virus active level as already shown in Table 1. Figure 5 shows an example scene of the task when a patient is sleeping on the bed. The difference of virus active level is simulated by changing the decreasing rate of viruses that are still active after a swiping motion using cloth for sterilization. By considering the active rate depending on the elapsed time after discharging a patient, a medical staff will behave more carefully in the sterilization of a hospital room when a patient is treated in the room.

Fig. 5 Example scene of hospital room sterilization task.

C. Other implemented tasks

The authors have implemented the tasks "delivery of medicine and water" and "document explanation". We have also implemented the task "checking the urethral balloon" without disposing the urine.

In the task of "delivery of medicine and water" with tidying the room, a medical staff is required not to spread the viruses by carefully handle the objects in the room. We expect that a medical staff will acquire a behavior to sterilize his/her hand after each handling of objects in the room.

In the task of "document explanation", a patient is supposed to sign the document after the explanation of its content by a medical staff although the behavior of the patient has not been implemented yet. The medical staff will have a good virtual experience that viruses may adhere to his/her hands when the pen used to sign is returned to him/her and he/she may spread the viruses to somewhere in his/her hospital.

V. Preliminary Evaluation Experiment

A. Purpose

The authors conducted a preliminary evaluation experiment if VR experiences change awareness and behavior of medical staffs. The purposes of the experiment are 1) to evaluate if a medical staff can easily use the VR system with controllers to do the tasks implemented, 2) to evaluate if a medical staff has a sense of reality in doing the tasks, 3) to collect the opinions of the medical staffs what effects will be expected by the VR training system, and 4) to collect the opinions of them for future improvements of the system.

B. Participants and tasks

The participants of the experiment are two doctors (a male doctor and a female doctor) and a female nurse working in Okayama University Hospital. They have no experience to use this kind of VR system.

The tasks of the experiments are two modes of "hospital room sterilization" task. The one (Task A) is to sterilize a room one day after discharging a patient from the room. The other (Task B) is to sterilize a room just after discharging a patient. The difference between the tasks is the active rate of viruses by a swiping with sterilizing cloth as explained in Section IV B.

C. Questionnaire

A questionnaire is prepared to evaluate the applicability of the VR training system to acquire the abilities to avoid the spread of viruses. The questions and answer formats are shown in Table 2.

Table 1 Questions and answer formats of questionnaire

Question		Answer format
Category	Question statement	
VR system	What level do you feel reality?	1 (No) to 5 (High level)
	Is the system easy to use?	1 (Hard) to 5 (Easy)
	What improvements do you think are necessary?	Free description
Counter measures of virus spreading	What do you take care for not spreading viruses in daily medical treatment works?	Free description
Finding by performing tasks	What is necessary to take care for the work in a room?	Free description
	What is necessary to take care for a task to sterilize a room?	Free description
	What is necessary to take care at leaving a room?	Free description
	What are the differences between Task A and Task B	Free description
Idea for education	What idea of applying the system for education do you have?	Free description

D. Experimental procedure

First, a participant is explained how to use the VR training system. Then, the participant conducts a trial task for a couple of minutes to be accustomed with using controllers. The trial task is to open the sliding door of a hospital room, enter the room, walk in the room, and to grasp and release some objects placed in the room. In the trial task, viruses are displayed as dots in VR space.

Then, a participant is asked to do

1. Task A with visible mode of viruses and
2. Task B with invisible mode of viruses.

After performing Task B, the participant observes the virus condition of the sterilized room in the virus visible mode.

After performing tasks, the participant is asked to answer the questionnaire.

E. Results

A participant felt a difficulty to use the buttons of controllers to keep the grasping of an object just after starting to use the VR system. However, all participants successfully used the VR system after some minutes to start the trial task.

Participants gave high points to the system. The average evaluation points of the VR system are 5 and 4.3 for reality and usability, respectively. As to the improvements of the system, there are some proposals: 1) some feel is necessary when a hand touches an object, and 2) wider VR space is necessary to perform the task. The proposal 2 is desirable to be considered in the future version of tasks. However, it may be hard to realize by the area of a room and the limitation of the range to sense the controller place in VIVE Pro Eye. The bed in a single room of a hospital is usually placed around 5 meters apart from the door of the room because a toilet and a washbasin are placed between the door and the room space placing a bed.

There are several answers to suggest the applicability of the VR system for the questions in the category of finding by performing tasks. As to necessary cares in medical treatments, there are answers such that "viruses may adhere to the knob of a door and walls" and "it is necessary to sterilize my hands before touching a patient". As to necessary cares for sterilization, a participant answers that it is necessary to carefully sterilize the places that a patient touches frequently. As to necessary cares at leaving room, there are answers such that "my hands may also be contaminated" and "washing or sterilizing hands are necessary just after leaving a room". As to the difference between Task A and Task B, participants seemed to understand the difference of active level of viruses or total amount of viruses that adhere to an object. The answers obtained suggest the applicability of the VR system to make medical staffs take care of their behaviors in daily medical works to prevent virus infection and spreading viruses in their hospital.

There is an answer for the idea of applying to education such that "students and medical interns will have awareness of hand hygiene through training experiences before the trainings in hospitals".

VI. Conclusions

This study develops a training system applying VR to make medical staffs recognize the importance of infection prevention. The training system uses a commercial HMD type VR device to artificially visualize the existence of invisible microorganisms as colored-small dots on their hands and the surroundings in patients' rooms. The system has a function to simulate the extinguishment or inactivation of the microorganisms by a simple model.

Training tasks were designed and some of them have been implemented. Preferable feedbacks were obtained from three medical staffs who underwent a trial application through the preliminary evaluation of the system using a questionnaire.

Future works should include implementations of the training tasks not implemented. It is also necessary to evaluate the applicability and educational effectiveness of the VR training system in developing the basic infection prevention skill through a long-term observation of the behaviors of medical staffs after training experiences.

References

[1] R. S. Dahiya, G. Metta, M. Valle, G. Sandini, Tactile Sensing – From Humans to Humanoids, *IEEE Transactions on Robotics*, Vol. 26, No. 1, (200). DOI: 10.1109/TRO.2009.2033627

[2] E. Kerruish, Arranging sensations: smell and taste in augmented and virtual reality, The Senses and Society Vol. 14, No. 1, pp. 31-45 (2019). DOI:10.1080/17458927.2018.1556952

[3] S. G. Fussell, D. Truong, Preliminary Results of a Study Investigating Aviation Student's Intentions to use Virtual Reality for Flight Training, International Journal of Aviation, Aeronautics, and Aerospace, Vol. 7, Issue 3, (2020). DOI: https://doi.org/10.15394/ijaaa.2020.1504

[4] D. L. Fisher, N. E. Laurie, R. Glaser, K. Connerney, A. Pollatsek, S. A. Duffy, The use of an advanced driving simulator to evaluate the effects of training and experience on drivers' behavior in risky traffic scenarios. Human Factors, 44, pp. 287-302 (2002).

[5] R. Agrawal, M. Knodler, D. L. Fisher, S. Samuel, Advanced Virtual Reality Based Training to Improve Young Drivers' Latent Hazard Anticipation Ability, Proc. the Human Factors and Ergonomics Society Annual Meeting, (2017). DOI: https://doi.org/10.1177/1541931213601994

[6] R. Mizoguchi, A. Gofuku, Y. Matsuura, Y. Sakashita, M. Tokunaga, Human Media Interface System for the Next Generation Plant Operation, CD-ROM Proc. 1999 IEEE International Conference on Systems, Man, and Cybernetics, Vol. 2, fa081-pdf, (1999).

[7] P. Wang, P. Wu, J. Wang, H. L. Chi, X. Wang, A Critical Review of the Use of Virtual Reality in Construction Engineering Education and Training, International Journal of Environmental Research and Public Health, Vol. 15, No. 6, (2018). doi: 10.3390/ijerph15061204

[8] H. Ishii, Z. Man, W. Yan, H. Shimoda, M. Izumi, Development of an Augmented Reality Based Simulation System for Cooperative Plant Dismantling Work, E-Journal of Advanced Maintenance, Vol. 7, No. 2, 145-153 (2015).