Using virtual reality (VR) simulation to help developing a smart meeting space with AI Product to support moderator

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Abstract. Smart building has a pivotal role in promoting the industrialization of buildings. Meeting room is a common type of public space. Developing a smart meeting space can play an important role in addressing the issue of research on smart building. In this paper, we develop a smart meeting space with AI product to support moderator. We create 3D model of the meeting room and import it into VR headset to having an experiment. 20 participants are engaged to answer questionnaire and have interview. The results of this study show that most of the participants think the meeting space we develop is smart than usual one. We also found that participants expect functions of smart meeting room in AI assistance, energy saving, smart display solution, remote meeting. And participants expect devices of smart meeting room in AI assistance product, sensors, and devices for remote meeting.

1. Introduction
Smart building has a pivotal role in promoting the industrialization of buildings. It can be divided into two parts, smart residential building and smart public building. There are many studies about smart residential building, but very few studies on smart public building. Meeting room is a common type of public space, developing a smart meeting space can play an important role in addressing the issue of research on smart building. Meeting room is a public place to communicate information and generate ideas. People also can reach agreements in meeting room. However, in current meeting process, someone needs to take minutes or arrange meeting room devices. Usually, moderator can not have an accurate overview of the meeting so that they can not making a rational decision.

Several attempts have been made to help achieving smart meeting in an ambient environment, remote meeting, meeting analysis and so on. Freitas, Carlos Filipe, et al developed a context aware middleware for supporting idea generation meetings in smart decision rooms (Freitas et al., 2011). Sfikas et al using IoT approach to implement and manage a smart room (Sfikas, Akasiadis, and Spyrou, 2016). Venkataraman, Vinay, et al empowered remote user to interact with the capabilities of an agent-based smart conference room. It supports remote participants while also enabling them to control most aspects of the smart conference room (Venkataraman, 2016). Serdaroglu and Baydere proposed an edge computing solution for real time meeting room attendance control system. Attendance decision obtained from the tracking system can be used by a meeting room planner to decide if the planned meetings have started, ongoing or completed (Serdaroglu and Baydere, 2019). In order to provide a clearer picture of the papers reviewed and the functions and demand in smart meeting space discussed in each one of them, Figure 1 has been created.
| Attendee Analysis | Touch Table | Ambient Intelligence | AI Assistance | Meeting Room Significance | Detection of Meeting Room Occupancy | Energy Saving | Meeting Analytics | Device and Equipment Management | Access Control | Remote Meeting Room Booking | Auto-id in Hygiene System | Smart Sanitation System | Meeting Room Assignment | Smart Display Solution | Hearing Impaired Friendly | Remote Meeting | Attendees Recognition |
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**Figure 1.** Smart meeting space literature approaches: 2010-2019
Most of the previous studies focus on the product aspects, few of them see this topic form the view of architecture. The specific objective of this study is to develop a smart meeting space to support moderator that can keep track of meeting situation and make rational decisions and organize the meeting more efficiently. Smart meeting space in this research is defined as a meeting space that have automatic device and environment management in an ambient intelligent environment to support moderator. We created a 3D model in SketchUp and using Unity to make VR application to evaluate this smart meeting space.

2. Method
In order to develop a smart meeting space to support moderator, the AI product information and building material information should be collected, and the model of the smart meeting space should be created and evaluated. This section describes AI product and building material information collecting, model creating, and conducting a survey to evaluate the smart meeting space.

2.1. Product and building material information collecting
Some text. From the perspective of product information collecting, we mainly considered four aspects, namely, remote meeting system, access control system, meeting management system, meeting environment control system. The function and product picture can be found in Appendix C.

To achieve remote meeting, we chose the following products: Surface Hub 2S, Steelcase Roam, APC Charge Mobile Battery, Logitech Tap, Rally camera, Rally speaker, Rally mic, Rally display hub, and RALLY remote meeting system. To achieve access control, we chose the following products: 8-inch temperature measuring face recognition machine, and KOB 280kg Electronic magnetic lock. To achieve meeting management, we chose Microsoft Black Tower AI assistant (prototype). To achieve meeting environment control, we chose the following products: Electric control dimming glass, Electric roller blinds, Temperature and humidity sensor, Light sensor, Human body infrared sensor, Smart curtain control panel, Smart infrared sensor, Smart thermostat, and RGBW color changing light bulb.

From the perspective of building material information collecting, we mainly considered 3 aspects, namely, metal stud of wall and ceiling, insulation materials, board of wall and ceiling. The Type and material picture can be found in Appendix D.

After obtained the product and building material information, we can be combined those products and meet the function and demand of smart meeting (Figure 2). Based on these functions, we create three scenes to support moderator in smart meeting space. The first scene is moderator can keep track of meeting situation and make rational decisions. The combination of human body infrared sensor and AI camera can help capturing, recognizing, and visualizing human semantic interactions in a smart meeting (Bhattacharya, Eshed, and Radke, 2017). For instance, with the interaction recognition result, it is possible to make index about "the persons who proposed a lot of ideas", "the persons who were critical", "the topics that were common interest", "the topics that were not agreed by all the members", etc (Yu et al., 2017). Therefore, moderator can keep track of meeting situation by watching the analysis result in Logitech Tap and making rational decisions. The second scene is a real-time meeting record and a summary can be displayed on the screen. Hearing-impaired persons can see the conversations of others through the screen to understand what other people are talking about. Also, those who are late can keep up with the meeting based on the meeting overview show on the screen. The third scene is device and equipment manage automatically and it is beneficial to reduce energy consumption. For example, in summer, when the sensor detects the meeting room is vacant, the electronic blind will automatically roll down to save energy form HVAC. When the sensor and access control terminal detects the meeting room is occupied, the electronic blind will automatically roll up and the thermostat will be turned on. Moreover, when speakers display slides on the screen or they are going to have a remote meeting, the electronic blind will roll down to prevent attendee from discomfort glare.
2.2. Model creating

Pre-construction evaluation of smart meeting space is necessary, so we started to create 3D model in SketchUp. For the purpose of making this smart meeting space suitable for both traditional meetings and remote meetings, we designed two layouts to address this problem. Figure 3 (a) shows the layout that suitable to have a remote meeting. The U-shaped table can let the camera capture every participant face. Figure 3 (b) shows the layout that suitable to have a traditional meeting. All the devices of two layouts are the same, but the position to put the table is different, which can be changed flexibly to fit the meeting style.

We put the main camera and speakers under four pieces of Surface Hub 2S and put the Logitech Tap in front of the moderator. Then we let two participants use one mic so that the voice of each one can be heard clearly and loud enough. If people need to discuss something privately, they can simply press the button on the mic to mute it. In order to analyze every participant's video and voice, the Microsoft Black Tower AI assistant should be put in the middle of the table. Most sensors are

Figure 2. Using AI product to meet smart meeting space demand and functions
integrated and installed on the ceiling. Temperature measuring face recognition machine is put in the hallway to have access control. Figure 4 (a) shows the structure of a metal stud wall and ceiling and plasterboard with a sensor embedded. Figure 4 (b) shows the detail of the sensor container. We designed this sensor container to integrate different kinds of sensors and put them into plasterboard with a prefabricated hole that filled with glass wool around. This structure can reduce the heat exchange and reduce energy consumption.

Because the pre-construction evaluation will be conduct in VR, so we need to import the SketchUp model into Unity to build a VR application. In the beginning, we set up the Unity environment with Virtual Reality Supported setting and switch to the Android platform to make it suitable for VR application development. Then we import the SketchUp model into the Unity project and drag it to the scene. To develop mobility and simple interaction with the model, we import VR Beginner: The Escape Room as a tool kit. To move in the smart meeting space, teleporters were added and configured to move to a new location. To make some object interactable, adding Rigidbody, Mesh Collider, and XR Grab Interactable component to make the interactable object can be reached and picked up by press and hold the grip button on the controller. After all the function is added, we can build and run the VR application in Oculus Quest, which is a VR headset (Figure 5).

Finally, we design a questionnaire and make a survey to evaluate the smart meeting space. The full-text of the questionnaire is shown in Appendix E. Out of a large group of Kanazawa University students, 20 students ages, 20-35, from different division volunteered to participate in the experiment. We approached each participant individually. We asked them using a VR headset to experience the smart meeting space and fill out the questionnaire. We collected the questionnaire to be examined and analysed them. Then we interviewed 10 out of 20 students about which part of this smart meeting space can be improved and how to improve it.
3. Result and Discussion
The first set of questions aimed to compare the difference between the current meeting room and this smart meeting room in satisfaction aspect. The analysis of the result is shown in Figure 6. The average rating is 6.11 for the current meeting room and 8.47 for this smart meeting room. This result shows that the smart meeting room we developed did better than the usual ones.

The second set of questions aimed to evaluate this smart meeting space in different aspects. Figure 7 (a) and Figure 7 (b) show that participants are more satisfied with the functions and devices of this smart meeting space, and suggest the layout of this smart meeting space needs to be improved. Figure 7 (c) shows that most of the participants think this meeting space can be called “smart meeting room”. As shown in Figure 7 (d), participants are more interest in scene 1, which is “moderator can keep track of meeting situation and make rational decisions”.

The third set of questions aimed to investigate the expected functions and demand for smart meeting space. As shown in Figure 8 (a), 10 out of 20 participants think the current meeting room has remote meeting function, with the help of computer, projector, projector screen. 7 out of 20 participants think the current meeting room has access control function by using IC card. As shown in Figure 8 (b), 12 out of 20 participants think this smart meeting space have remote meeting function, smart display solution, energy saving, and AI assistance. 9 out of 20 participants think this smart
meeting space have attendee function, remote meeting room booking function. In Figure 9, we can see that most participants think AI product and sensor are crucial for a smart meeting space.

After the survey, we modified the 3D model in the layout and environment based on the feedback of the questionnaire and interview. As shown in Figure 10, we made the aisle side bigger and modified the configure of the light on the ceiling to improve the environment.

Figure 7. (a) Result of “Which aspect of this meeting room participants most impressed by?”; (b) Result of “Which aspect of this meeting room is not good enough?”; (c) Result of “Do you think this meeting room can be called smart meeting room?”; (d) Result of “Which of the following scenes participants think is most helpful?”

Figure 8. (a) Structure of metal stud wall and ceiling and plasterboard with sensor embedded; (b) Sensor container
4. Conclusion
This research using AI product to develop a smart meeting space to support moderator organizing the meeting. We create 3D model and import it into VR headset to having an experiment. After taking a survey about this smart meeting space in VR, we found that participants expect functions of smart meeting room in AI assistance, energy saving, smart display solution, remote meeting. And participants expect devices of smart meeting room in AI assistance product, sensors, and devices for remote meeting.

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