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Providing Adaptive User Interfaces in Deviceless Learning Environments

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Abstract: While smart devices such as smartphones and tablets have become indispensable in educational settings, many studies have mentioned related issues such as significant operational costs and low pedagogical effects. Additionally, the problem of inadequate area of students' desk that results in no vacant desk space to place a smart device in addition to learning materials on the desk, that makes it difficult to utilize IT in educational settings, is highly relevant to current times. Consequently, to realize deviceless learning environments, the author of this paper designed "Followable Learning Environment (FLE)". Because the mechanism of FLE is similar to projection-based AR techniques, it can freely control the size and shape of projected user interfaces (UIs). This paper presents methods of detecting the area of blank space onto a student's desk and project UIs that adapt size and shape into the space.

Keywords: Learning Environments, Adaptive UI, Projection-Based AR, One-to-One Computing

1. Introduction

The use of smart devices, such as smartphones and tablets, has become indispensable in educational settings. However, many challenges have arisen to their use, such as operational costs and imprecise pedagogical effects. It is important to ensure proper pedagogical effects and to meet the challenges of using smart devices as a pedagogical tool where they are more of a distraction for the students (Karsenti et al. 2013). When the learning activity does not require a smart device, students must be instructed to turn it off, place it in a bag, and so on, but teachers might hesitate to incorporate devices at all, depending on the instructional model they choose, as the process of restricting their use can impair their convenience (Roblin et al. 2018). Further, a school environment in which students' desks are narrow may lead teachers to hesitate to use smart devices in class, as the students may not have sufficient space for their smart devices where other teaching materials are also necessary to use. This study brings a novel method to bear on these problems to promote utilization IT in educational settings.

2. Methods

2.1.1 The Concept of Deviceless Learning Environment

The author previously proposed a deviceless learning environment called the followable learning environment (FLE) (Mizutani 2019). An FLE detects the arrangement of the students' desks and gestures with the use of sensors located on the ceiling and projects user interfaces (UIs) on each student's desk, using the partial area of a projector placed on the ceiling of the classroom (Figure 1). While the concept of this approach is fundamentally the same of projection-based AR techniques, FLE is distinguished by projecting one UI in the partial area of one projector (Figure 2). Using this area, one projector can project multiple UIs for each student at the same time. Moreover, FLE can detect a desk layout, can adaptively project UIs with adjusted angles or layout sizes (Figure 3). Theoretically, using FLE, several large UIs and personal UIs can be projected at the same time on the area provided by adjoining desks. Hence, FLE can easily realize collaborative environments.

Increasing the number of sensors and projectors, it is possible to provide UIs to the entire classroom. As this approach does not require individual devices, students do not need to be prepared for each student. An application instance of UI, which is projected on the desks, is executed on the FLE system, similar to a thin client system. It is to be expected that this method can reduce management costs relative to the use of smart devices.

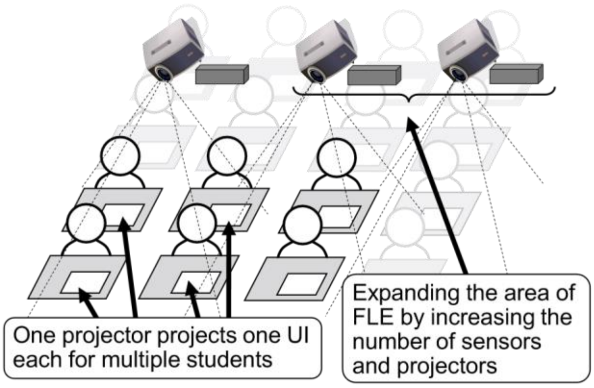


Figure 1. Concept of the followable learning environment.

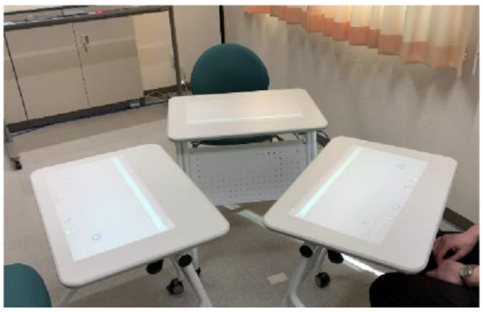


Figure 2. An example of UI projection for three desks separately, using one projector & one sensor.

Figure 3. An example of the UI projection for a group of four desks.

2.1.2 A Method of Providing Adaptive UI in the FLE

2.1.3 The Purpose of Adaptive UI

Students' desks in Japan are often relatively small. In a typical Japanese primary school, a desk is approximately 600-mm wide and 400-mm long. Because the desks are small, there is insufficient space for smart devices in addition to teaching materials such as textbooks, notebooks, reference documents, distributed printouts, and stationery. This makes it difficult to utilize smart devices in conventional classes that require the use of such materials. In the future, these materials might be integrated into smart devices. However, from a pedagogical perspective, the use of physical tools such as notebooks could be superior to smart devices in terms of enhancing students' understanding. This study considers a method of providing adaptive UI with a size and shape that are adjusted to fit the free area on a desk, to respond to this this problem and enable a learning environment where IT can be utilized in conventional classes.

2.1.4 A Method for Blank Space Detection

To detect areas of blank space on a student's desk, the method of this study uses a mask-type object detector, which extracts segmented areas of detected objects in an image. Examples of this detector include Mask R-CNN, a convolutional neural network model. This study uses Mask R-CNN to detect the areas of objects on each desk, such as textbooks, notebooks, and stationery. Because the FLE has a detection function to be for the area of each desk, the area of this space is calculated as the difference between the areas of each desk and the area of each object.

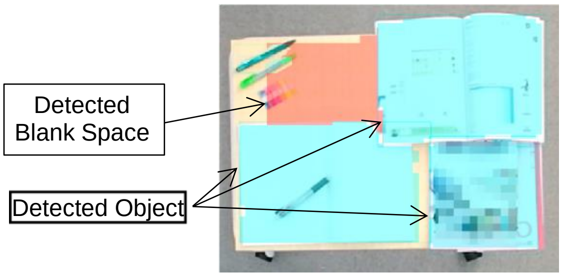
2.1.5 A Method of Projecting Adaptive UI

After the blank space is detected on the desks, adaptive UI is projected, adapting to the size and shape of the blank space area by tree steps as follows: (1) if detected areas are adjacent, they are combined into a single area; (2) a suitable area for UI projection is selected, with its position, square area, and aspect ratio; (3) a UI is projected that is adjusted in size and shape adapted to the selected area. Figure 4 shows an example the result of detecting objects and selected area of blank space on a desk.

3. Developing Prototype System and Consideration

This method was implemented to the prototype system of the FLE. As a model of Mask R-CNN, Inception ResNet V2 1024 × 1024, a pretrained model of TensorFlow Object Detection API, was used. Because the FLE was developed as a.Net Framework application, this model was converted to an ONNX model and implemented on FLE.

Figure 5 shows an example of projected adaptive UI with the prototype system. The adaptive UI of the prototype system is a pseudo UI. In the future, application programs which have adaptive UIs will be implemented such as learning support, CSCL tools and so on. Since the system used a high definition detection model, detecting objects on a desk takes approximately 5 seconds. The precision of object detection is also insufficient. In particular, as the kinds and shapes of the stationary used are various, more sample images are needed to train the model. Resolving these issues is necessary for practical use.



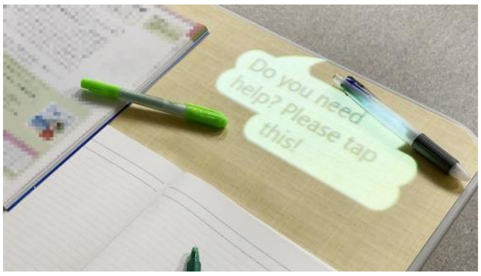


Figure 4. An example detection result on a desk*. *Figure 5.* An example of projected adaptive UI*.

*There is no mosaic of textbooks in the actual images (copyright reason)

4. Conclusions

This paper describes the FLE method and prototype system, developed to provide adaptive UI in a deviceless learning environment. Because UIs are projected in a way that adapts the size and shape to blank space on a desk, the system ameliorates the problem of students' desks being too narrow and enables the increased use of IT in conventional style classes, using teaching materials such as paper-based textbooks, and notebooks.

Acknowledgements

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