Extensions of Exercise and Performance Learning Assistant System for Usability Improvements

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Manuscript submitted May25, 2023; revised June 30, 2023; accepted September 15, 2023.
doi: 10.17706/jsw.18.4.218-277

Abstract: To support exercise or performance learning at home, we have developed an *Exercise and Performance Learning Assistant System (EPLAS)* as a web application system using Node.js. EPLAS provides the model performance video from the instructor to be followed, and the feedback function of rating the user performance using *OpenPose*. Currently, *Yoga* performances are implemented in EPLAS as a popular exercise. However, the current implementation of EPLAS is not sufficient in making the user immersed in practicing the performance. Besides, it is not friendly for a user to control the exercise from a distant place. In this paper, we implement two extensions of EPLAS for improving usability by adopting the mood-elevating background using scenery videos of tourist spots and the remote-control function using *Quick Response (QR) code*. For evaluations, we prepared 10 Yoga videos and 10 tourist videos for the extended EPLAS and asked 20 students in Okayama University, Japan, to use them. We confirmed the effectiveness of the questionnaire results.

Key words: EPLAS, QR code, yoga, python, entertainment

1. Introduction

Physical activity and exercise are important parts of living a healthy lifestyle. It can have immediate and long-term health benefits. Thus, it can improve our *Quality of Life*. Exercises help us to prevent health problems, build strength, increase energy, and reduce stress. Exercises make us refresh our minds and maintain mental and emotional health by engaging in enjoyable activities.

Previously, to support exercises or performance learning such as Yoga at home, we have developed *Exercise and Performance Learning Assistant System (EPLAS)* as a web application system. EPLAS provides the model performance video from the instructor to be followed, and the feedback function of rating the user performance using *OpenPose* [1]. The platform was implemented using Node.js [2] to run *OpenPose* on the server from web browser operations. During exercise, it automatically takes photos of key scenes of the performance to rate them. Then, *OpenPose* extracts the coordinates of the key points of the human body from the photos. By comparing the corresponding coordinates between the user and the instructor, EPLAS rates the user's performance and feedback to the browser.

However, the current implementation of EPLAS is not sufficient to immerse users in practicing the performance. The user should enjoy the comfortable scene and/or the instrumental music for relaxing while practicing the performance. Besides, it is not friendly for the user to control the EPLAS interface on a browser from the place to practice, because it needs to click a button. The user needs to install the remote mouse for the remote control.

In this paper, we improve the usability of EPLAS by adopting a mood-elevating background using scenery videos of tourist spots around the world with instrumental music and the remote-control function using *Quick Response (QR)* code to control the screen automatically. The user can select the preferred video from the given choices and click the start/stop button by showing the *QR code* printed on paper to the camera of the EPLAS platform.

For evaluations, we asked 20 students at Okayama University, Japan, to use the extended EPLAS with the *QR code* and the scenery video, and to answer 10 questions in the questionnaire on usability. Then, we calculated the *System Usability Scale (SUS)* scores from the answer results, which confirmed the effectiveness of the proposal.

The rest of this paper is organized as follows: Section II explores relevant studies in literature. Section III reviews EPLAS in previous studies. Sections IV and V present the implementations of the mood-elevating background and the remote control with *QR code* respectively. Section VI shows evaluations. Finally, Section VII concludes this paper with future works.

2. Related Works

In this section, we explore related works to this paper. Some of them focus on systems for exercise or entertainment, and *QR codes* used in applications.

2.1. Systems for Exercise or Entertainment

In [3], Ichinose et al. created a system that motivated participants to complete a simple task and measured the difference in task performance using three entertainment elements: contest, improvement, and collection. Their student experiment found that all three elements increased work motivation and efficiency when compared to non-entertainment support. They found that contest increased work efficiency the most, and collection increased work motivation the most.

Hossain *et al.* [4] studied a novel aged-people entertainment support system that is context aware. They focused on the design of the system by identifying its needs from the standpoint of the elderly and carers. This system's notable functionality includes describing explicit, implicit, and automatic modes of interactions that the elderly and carers are encouraged to use. They highlighted unique issues relevant to the design of the system, such as context awareness and entertainment recommendations.

Ikehara *et al*. [5] developed an exercise machine as a set of applications that detects driving devices and physical movements. The machine can get to work among others through activities using a smartphone, sound input, a jumping rope action, and a handgrip action. Because of its highly instinctive and simple operations, it is likely that this machine will appeal to many people from the elderly to children, as well as to people who are afraid of difficult machine operations.

Khedekar *et al*. [6] proposed an original system for image-based authentication, in which the image serves as the authenticated user's identification. This system uses a method to store a special ID or password in an image, which aids in restricting any unauthorized user access to the system. The suggested algorithm will assist in eliminating the weakness of password authentication and avoiding the risk associated with password authentication. The authentication method aids in the storage of product information across a network.

Rishan *et al.* [7] proposed a system that can recognize the poses of the user and visually advise the user. This process must be conducted in real-time. A vision-based technique was used to recognize *Yoga* postures. The program captures user movements with the phone camera, which is subsequently sent to the detecting system with a resolution of 1280 × 720 at 30 frames per second. The system is divided into two parts: a pose estimation module that employs *OpenPose* to identify 25 key points in the human body using the *BODY 25* dataset, and a pose detection module that employs a deep learning model, time-distributed neural networks, long short-term memory, and SoftMax regression to analyze and predict user poses or asana using a sequence of frames.

Liu *et al*. [8] outlined the current issues in *Yoga* tourism. Combining the characteristics of" tourist plus" and *Yoga*, it was proposed that the Yoga tourism market should play a supporting governmental role in establishing professional organizations and developing high-quality *Yoga* tourism projects that meet consumer expectations. They improve the feasibility of future developments of Yoga tourism, promote industry standards, improve the basic environment, establish professional organizations, strengthen publicity, and offer diverse *Yoga* and travel experiences.

Agarwal *et al.* [9] studied various *Yoga* mobile applications using artificial intelligence techniques to provide customers with personalized experiences and positive feedback, as well as to introduce a new concept of AI-based *Yoga* trainer, which reminds, instructs, guides, and motivates a user to do *Yoga*.

2.2. QR Code Use in Application

Ishak *et. al.* [10] proposed a system that employs *QR codes* as plant tags that can be scanned to obtain information about the plants. Visitors only need to use their mobile devices to detect the plant to receive its information on their devices.

Khandal *et al*. [11] proposed a work that extends the encoding and decoding application of *QR codes* to create a new articulated user identification and access control. A new synchronous registration process for workplaces and groups is also proposed. The suggested system retrieves information from the candidate's QR identification number and transfers it to the digital application form, as well as authenticating the allowed QR code images from the database. The system can enhance service quality and may improve the efficiency of any organization.

Tiwari *et al*. [12] introduced the QR code technology. It offers a high data storage capacity, rapid scanning, and readability. Various types of QR codes, such as logo *QR Codes* and encrypted *QR codes*, are available, and users can select the most appropriate one for their purposes. *QR code* is utilized in numerous application fields relating to marketing, security, and academics, and is gaining popularity at an extremely rapid rate. Increasing numbers of individuals are becoming aware of and utilizing this technology daily. With the growth of smartphone users, *QR code* is rapidly achieving high levels of acceptance around the globe, as their popularity continues to increase.

Hermanto *et al.* [13] designed a student presence system using a *QR code* on an Android smartphone. *International Mobile Equipment Identity (IMEI)* is also adopted to verify the phone owner so that the phone cannot be used by other students. The presence process can be completed by reading the *QR code* from the lecturer's smartphone or via the web. The result will be displayed via a projector. The presence system will provide students' attendance recapitulation at every meeting.

3. Review of EPLAS

In this section, we review our previous studies on EPLAS [14, 15].

3.1. Software Architecture

On the client side, HTML, CSS, and JavaScript are used to create the interface pages on a browser. The interface provides the menu for selecting the pose and controlling the system, the instructor video, the user body view captured by the PC camera, and the feedback result of the *rating function*.

On the server side, JavaScript and Python are used to control the user requests, show the selected video, run the rating function with *OpenPose*, and return the result to the user. The database system is not adopted where all the data is managed in the file system.

3.2. Rating Function

The *rating function* is implemented by *Python* on the server side. From the captured body photo, *OpenPose* extracts the *coordinates* on the pixel coordinate system of the 25 *keypoints* of the human body. Then, the distance of the *keypoint* coordinates between the instructor's body and the user's body photo for the same pose is calculated and used to rate the accuracy of the user's performance. Before running the rating function, it is assumed that the coordinates of the instructor's body were extracted using *OpenPose* from the body photo that is extracted from the instructor video and saved in the file.

If the coordinate of a *keypoint* in the user photo is much different from that in the instructor one, this user should care about the related body part to improve performance. For this purpose, the Euclid distance between the user/instructor coordinates for every *keypoint* is calculated. Then, the *average value* and the *standard deviation (SD)* of the Euclid distances for all the *keypoints* are calculated. After that, the linear summation of the average value and the SD is obtained for the *threshold*. If the distance is larger than this threshold, the corresponding *keypoint* is regarded as abnormal to be cared for, which will be marked in the output body photo.

4. Mood-Elevating Background Video

In this section, we present the mood-elevating background of the interface with the tourist place video so that the user can enjoy the atmosphere during exercise at home.

4.1. Selection Page

Fig. 1 shows the selection page to select a video for the background by the user. It displays the world map indicating the tourism places around the world that are covered by the video content in the system. Currently, 10 tourist places in Japan, Taiwan, Indonesia, Australia, Russia, Europe, Africa, South America, North America, and Greenland are covered. When the user selects one country on the map, a short introduction about each country will appear. Then, this page will be directed automatically to the mood-elevating background page.

Fig. 1. Selection page.

4.2. Mood-elevating Background Page

Fig. 2 shows the mood-elevating background page using the selected tourism place video with instrumental music. Using this background and the music, the user will be transferred to a pleasant mood by lowering stress hormones and promoting sensations of happiness. These effects can also have several long-term favorable consequences on the user's body, such as reducing stress and anxiety and improving the sleep pattern.

In this page, the user can adjust the volume and the playback speed of the instrumental music. Then, when the user clicks the EPLAS logo on the top left side, the selection page appears again to select a different interactive video.

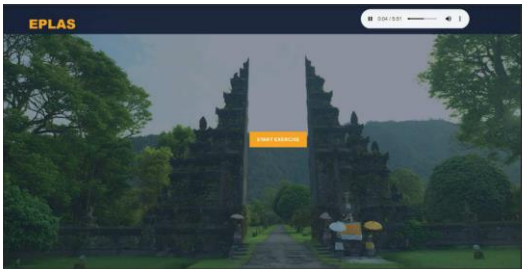

Fig. 2. Mood-elevating background page.

5. Remote Control by QR-Code

In this section, we present the implementation of the remote-control function using *QR code* to start the instructor video at a distant place from the PC.

5.1. Generated QR Code

In this paper, the remote-control function for starting the instructor video by the *QR code* is implemented because the user needs to stay at a place that has the proper distance from the PC such that the PC camera can cover the whole body of the user. Besides, the video will be automatically stopped at the end.

Fig. 3 shows the generated QR code to start the instructor video, instead of clicking the corresponding button. To show it to the PC camera, a smartphone or printed paper can be used.

Fig. 3. QR code to start instructor video.

5.2. QR Code Reading

To read the QR code by the system, the following two JavaScript programs are implemented. Fig. 4 shows the JavaScript program to start the exercise page for the correct *QR code.*

```
function onScanSuccess(qrCodeMessage) {
document.getElementById('result').innerHTML = '
    <span class="result">'+qrCodeMessage+'</
    span>';
if (qrCodeMessage == 'Start Exercise') {
window.location.href = 'exercise.html';
 } else {
```

Fig. 4. JavaScript program for starting exercise.

Fig. 5 shows the JavaScript program to show the error message for the incorrect QR code.

```
document.getElementById('result').innerHTML = '
    <span class="result">'+'Please use the
    right QRCode'+'</span>';
     }
    }
function onScanError(errorMessage) {
}
```

Fig. 5. JavaScript program for the error message.

Fig. 6 shows the interface page when the *QR code* is read. Then, the selected instructor video will be started automatically. Therefore, the user can enjoy the performance at the current position.

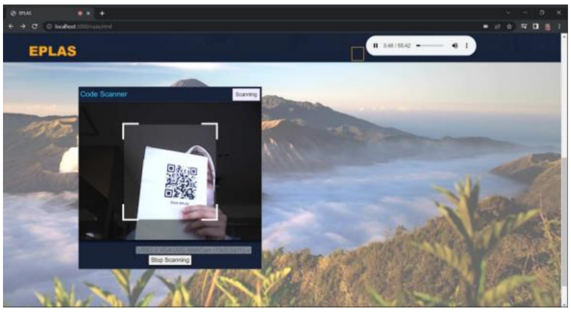

Fig. 6. QR code reading on interface.

If an incorrect *QR code* is read, the message *Please use the correct QR Code* will appear on the page. Fig. 7 shows this message.

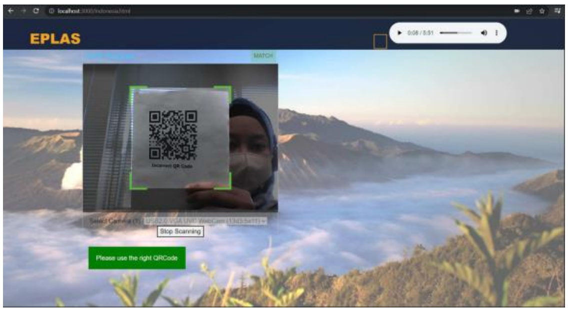

Fig.7. Message for incorrect QR code.

5.3. Exercise Page

Fig. 8 illustrates the exercise page. When the correct QR code is posted to the camera and is recognized by the system, this page will appear with the selected mood-elevating background video.

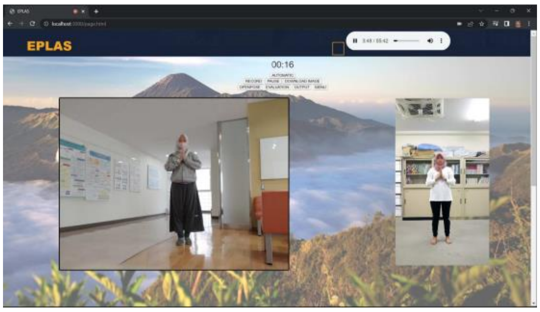

Fig. 8. Exercise page.

In this page, the *left field* displays the user's body from the PC camera by running the *JavaScript* library on a browser. For use in the rating function, the body view will be captured automatically at the timing that is specified at each video content as the *key pose*.

The *right field* displays the instructor's model performance video. The user is expected to practice the exercise or performance by following it.

The *top field* displays the buttons to control the system, such as the video pause/stop button, the rating button, and the output button.

5.4. Operation Procedure

Now, we discuss the whole procedure of using EPLAS with the implemented functions in this paper.

1. Place the PC at the appropriate distance from the user.
2. Run *Node.js* and the EPLAS program on the PC.
3. Access the menu page of EPLAS by a browser and select the performance to be performed.
4. Select the tourism place video for the mood-elevating background.
5. Stand at the proper location so that the camera can capture the whole body of the user.
6. Present the *QR code* to start the instructor video at the current location.
7. Perform the performance by following the instructor's video, while the system automatically takes photos of the user's body for *key poses*.
8. Run the rating function including *OpenPose* where the rating result will automatically appear on the page.
9. Go back to the menu page if necessary.

Fig. 9 shows the flowchart of this procedure.

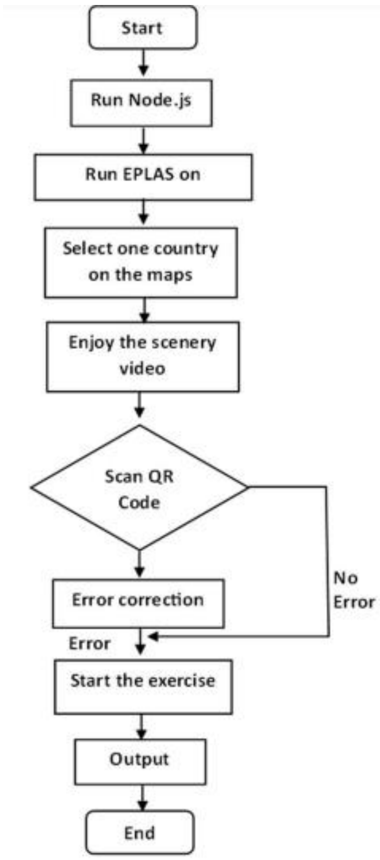

Fig. 9. Operation procedure flowchart.

6. Evaluations

In this section, we evaluate the EPLAS platform with the extended functions through applications of 20 students at Okayama University, Japan.

6.1. Setup

For evaluations, we prepared 10 videos of popular tourist places, and 10 videos of Yoga poses for EPLAS and asked 20 students at Okayama University, Japan, to use them. Before they used it, we introduced how to use EPLAS with *QR code* and the tourism place video. Then, we requested them to choose one video for the mood-elevating background and to perform Yoga exercises by following the instructor's video.

After they finished them, we asked them 10 questions in Table I on EPLAS. For each question, a student is requested to answer with five grades (1: strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree).

Table 1. Questions In the questionnaire for evaluations

No	Questions
1	*QR code* is useful to start the exercise on EPLAS.
2	*QR code* is not easy to use.
3	Using *QR code* on EPLAS interface is user-friendly.
4	The webcam camera cannot detect the *QR code* easily.
5	The error messages displayed are helpful.
6	The instructor's videos are not clear.
7	The background videos are interesting.
8	I found the unnecessary video in EPLAS.
9	I think that the instrumental music is relaxing.
10	I felt not confident using EPLAS

6.2. System Usability Scale

To evaluate the questionnaire result on the EPLAS usability, the System Usability Scale (SUS) score [16] is calculated by the following procedure, where the minimum final score is 0 and the maximum is 100:

1. Calculate the individual score contribution for questions 1, 3, 5, 7, and 9 by subtracting the answer by 1.
2. Calculate the individual score contribution for questions 2, 4, 6, 8, and 10 by subtracting the answer from 5.
3. Calculate the raw SUS score by adding all the individual score contributions for the 10 questions.
4. Calculate the final SUS score by multiplying the raw score by 2.5.

6.3. Results

Table II shows the questionnaire results of 20 students. The average SUS final score among them is 84.88, where the lowest is 77.5 and the highest is 90. It means that all the students positively evaluate EPLAS with the new features. Thus, the effectiveness of the proposal is confirmed.

Table 2. Questionnaire results

User	Answer to question										SUS Raw Score	SUS Final Score
	1	2	3	4	5	6	7	8	9	10		
1	5	2	4	2	4	2	5	2	5	1	34	85
2	4	1	4	2	4	2	4	2	5	2	32	80
3	4	2	5	1	4	1	4	2	5	2	34	85
4	5	1	5	3	5	2	5	2	5	1	36	90
5	5	2	5	2	5	1	5	2	4	2	35	87.5
6	4	2	4	2	4	2	4	2	4	1	31	77.5
7	5	2	5	1	4	2	5	2	4	2	34	85
8	4	1	5	2	4	2	5	1	5	2	35	87.5
9	4	2	4	2	4	1	4	2	5	1	33	82.5
10	5	1	4	2	5	2	5	1	5	2	36	90
11	4	2	5	1	3	2	5	2	5	1	34	85
12	5	2	4	1	4	2	4	2	5	1	34	85
13	4	1	4	2	5	1	5	2	4	2	34	85
14	4	1	5	1	4	2	5	1	5	2	36	90
15	4	2	5	2	4	2	5	2	4	3	31	77.5
16	4	1	5	2	3	1	5	2	4	2	33	82.5

17	5	2	4	1	5	2	5	1	4	3	34	85
18	4	2	4	1	5	2	4	1	4	2	33	82.5
19	5	2	4	1	5	2	5	2	5	1	36	90
20	4	1	4	1	4	1	4	1	4	2	34	85
Average											33.95	84.875

7. Conclusion

This paper presented the implementation of two extensions of the *Exercise and Performance Learning Assistant System (EPLAS)* for improving usability. It adopted the mood-elevating background using scenery videos of tourist spots and the remote-control function using *Quick Response (QR) code*. For evaluations, 10 Yoga videos and 10 tourist videos were prepared and assigned to 20 students at Okayama University, Japan to use. The SUS scores from their questionnaire results confirmed the effectiveness of the proposal. In future works, we will continue improving EPLAS, collect more exercise/performance videos, extend the rating function to dynamic motions, and evaluate EPLAS with various users.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

I. T. Anggraini, conducted the research, wrote the manuscript, and analyzed the data; Wan-Chia Huang, and Cheng-Liang Shih conducted the research; Nobuo Funabiki, Chih-Peng Fan supervised the findings of this work; all authors had approved the final version.

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