

## Synchronized Recording System Using Multiple Smartphones

Naoki Morita, Md Saidi Muhammad Ashraf Naim  
 School of Information Telecommunication Engineering  
 Tokai University  
 Tokyo, Japan  
 e-mail: {wv062303@tsc, 0cjt2118@cc}.u-tokai.ac.jp

Kenta Morita  
 Faculty of Medical Engineering Dept.  
 Suzuka University of Medical Science  
 Mie, Japan  
 e-mail: morita@suzuka-u.ac.jp

Chiharu Nakanishi, Chiaki Sawada  
 Kunitachi College of Music  
 Tokyo, Japan  
 e-mail: {nakanishi.chiharu, sawada.chiaki}@kunitachi.ac.jp

Kazue Kawai  
 Faculty of Literature  
 Seitoku University  
 Chiba, Japan  
 e-mail: kawai.kazue@wa.seitoku.ac.jp

**Abstract**—The author aims to pass down the tradition of classical music to the next generation by significantly reforming and evolving traditional piano teaching methods. Most of the studies on piano lessons aim to teach beginners how to accurately read scores and play the keys with accurate rhythms and without mistakes. This study aims to enable intermediate students to master musical expression. A system was developed to retrospectively analyze the movements of the upper body, hands, and feet from various angles using synchronized recording with multiple smartphones or tablets. This allows for multi-angle viewing without the need for complex wiring or data transfer from USB cameras or video cameras. By objectively evaluating actual performances, it is anticipated that disparities between the ideal and reality will be identified, and new challenges will be discovered.

**Keywords**- Piano Lesson; support; Recording system; visualization.

### I. INTRODUCTION

This paper is part of research conducted at Japanese music universities to pass down the tradition of classical piano to the next generation. Most of the previous studies on piano lessons [1] - [15] have been aimed at helping beginners learn how to read scores accurately and play keys with accurate rhythms and without mistakes. The Idea, Connection, and Extension (ICE) model [16] is a framework describing phases of learning. In the piano ICE model, these preceding studies were in the Idea stage.

This study focuses on the Connection stage in which musical expression is acquired. In order to acquire musical expression, it is necessary to understand the overall picture of the song and play it using the whole body, not just the fingertips. Recording one's own play-through on video and reviewing it is important. However, traditional video playback platforms did not allow for quickly cueing up specific phrases or scenes.

This study aims to develop a “Piano Lesson Total Visualization System” that allows the user to instantly check the movements of the performer’s body (upper body, hands, feet) in conjunction with the score [17] - [19]. In this study, we report on the development of a system that can utilize smartphones and tablet devices to record performances from multiple angles and allow playback from annotated points through cueing up.

The remainder of this paper is organized as follows. In Section II, this paper discusses the results of a survey on reviewing piano lesson videos, and Section III explains the concept of the proposed system that visualizes the entire piano lesson. Section IV discusses the multi-angle recording system developed in this study, and Section V provides conclusions and discusses future work.

### II. QUESTIONNAIRE SURVEY RESULT

We conducted a survey regarding reviewing piano lesson videos [17]. The following responses were obtained:

- (1) Most of the students record their piano lessons. However, almost none of them reviewed all previously recorded lesson videos due to a lack of time and motivation to watch the videos from the beginning until the end.
- (2) Students feel dissatisfied when watching the videos, e.g., “I can’t see how I touch the keyboard,” “I can’t see my own face or hear my tone.”
- (3) Students were dissatisfied with video viewing, e.g., “It takes too much time to find my desired video from the video archive,” “It is difficult to pinpoint the part that I am interested in,” “It is difficult to go back in time to watch.”
- (4) Students and instructors have complaints about the device itself and application when handling the device, e.g., “Connecting is difficult,” “I don’t know how to use the app.”

### III. THE SYSTEM CONCEPT

We have the following concepts for the visualization system of piano lessons:

- (1) A system that can synchronize recording using multiple smartphones or tablets. This function will be discussed in Section IV.
- (2) The system can instantly play a specific part of the video, playing the video from the measure clicked by the user. The association between the score and the video is made by comparing the scale recognized from the score and the pitch recognized from the video. These functions are currently successful with some melody scores and arpeggio staves [19].
- (3) Videos recorded in the system are added to the calendar index by score name and recording time. Past and current performances can be instantly searched.

### IV. THE DEVELOPED SYSTEM

The developed system realizes multi-angle recording and linkage of recorded performance videos and calendars.

#### A. System Architecture

This developed system consists of a server and a client. The server side is implemented using the Laravel framework, and the client side is implemented using Vue.js. The server coordinates with database and file management, as well as previously developed [19] score analysis and video analysis modules. The client provides a calendar, score upload, video recording, and video viewing to the user.

#### B. Recording

This section explains multi-angle recording using an example of three angles: the upper body, hands, and feet. Four smartphones are used. One is used as the controller machine for starting/stopping and for recording with the microphone. The remaining three smartphones are used as video cameras.

After logging in on the controller smartphone, the system displays a QR code when selecting the score that the user uploaded in advance. The QR code contains the URL of the recording web address and user authentication information. When the user scans the QR code with another smartphone and clicks to allow camera access, the camera activates and will be in the recording standby state. Figure 1 shows the placement during the recording of a performance and each camera angle.

Recording is synchronized with the start/stop signal from the controller device, and automatically uploaded to the server upon completion. This allows for multi-angle recording without the cumbersome wiring of USB cameras or data transfer from video cameras. This system has been tested for operation using Chrome browsers on PCs, iOS, and Android. The audio is saved in mp3 format on iOS, recording is possible in mp4 format for up to approximately 12 minutes (110MB), and on Android, in WebM format for up to approximately 27 minutes (45MB).

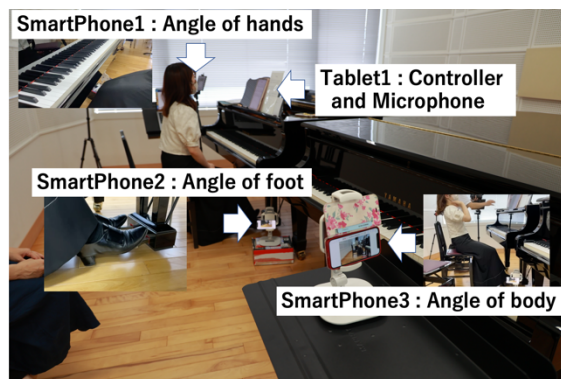


Figure 1. Example of camera angle.

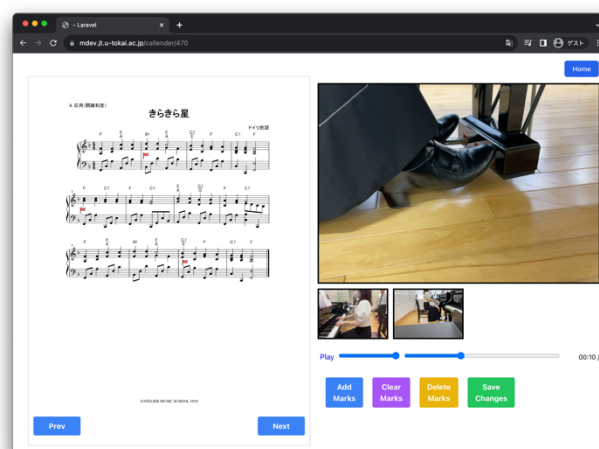


Figure 2. Example of score and video viewing page.

#### C. Review

When the user clicks on an index (score name and practice time) on the calendar, the score and the video are displayed. Figure 2 is the viewing page. One angle of the video is displayed prominently, while the remaining angles are displayed as thumbnails. Selecting a thumbnail switches between the enlarged display and thumbnail display. If the previously developed Score Analysis Module [19] and Video Analysis Module [19] allow the linkage of scores and videos, playback can be started from the corresponding scene by clicking on a measure in the score. If a module cannot be parsed correctly, the user can watch the video once and add an annotation to the timestamp they want to review, making it easier to review from the second time onwards. In the example in Figure 2, annotations are added at the 2nd, 5th, and 11th measures during the initial listening session.

#### D. Trial

Before using this system in an actual class, we conducted a demonstration and interviewed an instructor.

- USB cameras are difficult to set angles because the screen is not visible. On the other hand, smartphone cameras are easy.

- It is convenient because no data transfer is required.
- The sound quality is not very good.

#### E. Discussion

The purpose of this research is to develop a user interface that enables recording and playback from multiple angles using readily available PCs and smartphones, simplifying the review process through annotation functionality, all without the need for special equipment for the “Score Click Playback System.” The current system can only record up to 12 minutes, so it cannot record an entire 60 minutes lecture. However, it is possible to record a single performance. In addition, being able to review immediately without data transfer is considered useful for reviewing performances. External microphone support may be needed to improve sound quality issues.

#### V. CONCLUSION

This study aimed to record performances from multiple angles so that performers themselves can check how they use their bodies. Traditional single-camera shooting had problems, such as difficulty checking the use of hands and feet when shooting the whole. In this study, a multi-angle recording system was built that can shoot in cooperation with multiple smartphones. Future work will be to make the sound quality clearer. And then, examine the effectiveness of the system in actual lessons.

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