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Development of AR Teaching Material by Tablet for Beginning Students of Sound Wave Propagation and Detection

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Abstract. As the dynamic process of the transmission and reception of sound waves is a phenomenon that cannot be seen by the eye, it is a process that can be difficult for beginning learners to comprehend. In this research, we utilized a tablet, which today is becoming a pervasive device in learning environments, for the purpose of creating a teaching aid that would render sound waves visible to beginning learners by way of Augmented Reality.

1. Introduction

In Japan, the study of sound waves takes place in the first year of middle school. However, as the transmission of sound waves through the air cannot be seen, it is a phenomenon that can be difficult for learners to comprehend. For this reason, it has been reported that there are many learners who are unable to correctly differentiate the transmission and resonance of sound waves [1], and there are many learners who have general misunderstandings about the subject [2]. Oscilloscope measurements have been suggested as a method for visualizing sound waves, which are easily generated on tools such as modern PCs [3]. However, in the learners survey we conducted, we found that there were many learners who were unable to correctly grasp oscilloscope waveforms. Taking into consideration the current state of affairs, we arrived at the following conclusion: in order to help learners correctly understand the nature of sound waves, it was necessary to both visualize the density fluctuations in the transmission medium that occur when sound waves are transmitted, as well as to allow learners to watch the dynamic process of graphing oscilloscope waveforms based on the reception of those sound waves. Techniques for visualizing the transmission of sound waves using Augmented Reality (AR) have been developed in previous research. We believed it was possible to tie this visualization together with the sound wave reception process, making it easier for learners to understand oscilloscope waveforms.

This was our justification for developing AR teaching aids aimed at students studying sound waves for the first time.

2. Teaching Aid Development

For our AR teaching aid, we utilized a tablet, which today is becoming increasingly prevalent in learning environments as part of the broader trend towards incorporating Information and Communication Technology (ICT) [4]. We created two AR markers, with one side showing the transmission of sound waves, and the other side their reception (Fig. 1(a)).

If the marker on the transmission side is recognized by the tablet's camera, it provides an AR display of the transmission of sound waves centered over the marker. High air density is shown in red, and low air density in blue. Sine waves are generated by the tablet to match the AR display, and students are able to change the amplitude and frequency of the sine waves as parameters.

Furthermore, in order to make the sound wave transmission process easy to understand, the passing of time in the AR space was set to 1/1000 of actual time. We also set the space scale to 1/40.

When the reception AR marker is recognized by the tablet camera, air density time variations are displayed in AR over the location of the marker. In order to connect this to the learner's ability to read oscilloscope waves, we allowed them to switch between three different modes, as shown in Fig. 1(b-d). In Fig. 1(b), the point showing the amplitude over the marker location moves up and down. In Fig. 1(c), the point moves on a graph with the horizontal axis representing time. In Fig. 1(d), only the trajectory of the point is displayed, drawing the oscilloscope waveform. We believe that the ability to change between these three modes of reception helps learners to understand how to read oscilloscope waveforms.

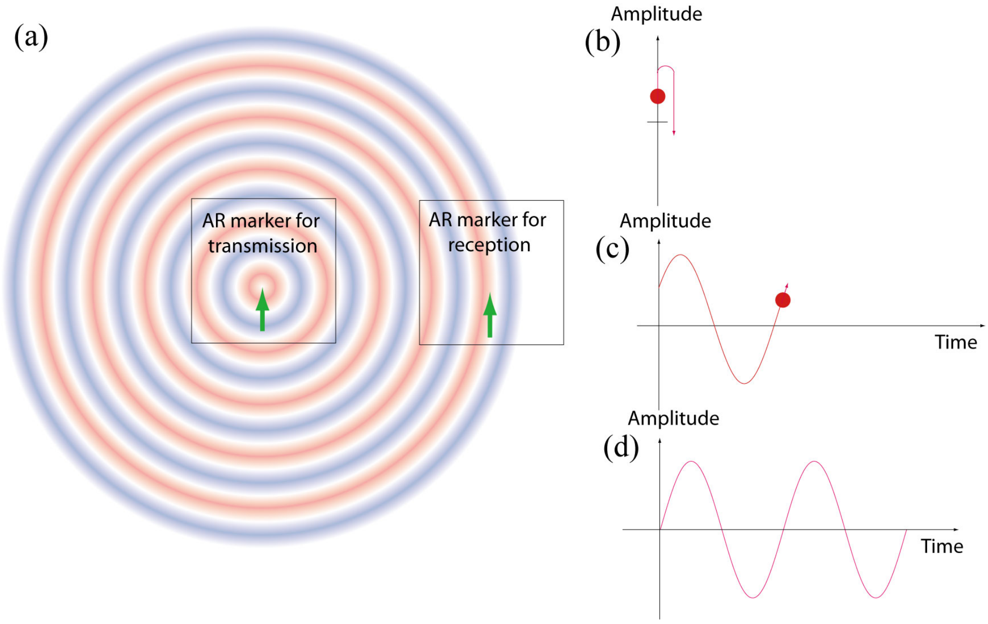

Fig. 1 The transmission and the reception of sound waves (a). Three modes of reception (b-d)

The teaching aid we developed can be seen in use in Fig. 2. As the two markers are independent, it is possible to vary the distance between them in order to also learn about the Doppler effect.

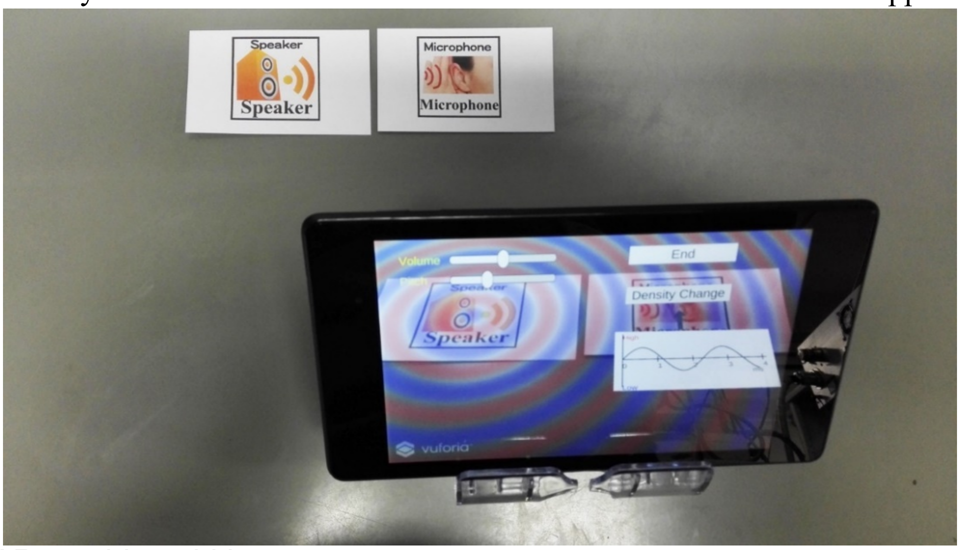

Fig. 2. The AR teaching aid in use

3. Conclusion

In this study, we developed an AR teaching aid to be used by students learning about sound waves for the first time. At the transmission side marker, the changes in air density over time and space that result from sound wave transmission are displayed in AR. At the reception side marker, the time variation of the sound wave reception process is displayed in AR at three different levels. Going forward, we wish to conduct classroom testing of our teaching aid to see how effective it is in assisting students who are learning about sound waves for the first time.

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