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Yiyang Li
Old Dominion University

Yuzhong Shen
Old Dominion University

Charles I. Sukenik
Old Dominion University

SIMULATING FUNCTION GENERATORS AND OSCILLOSCOPES IN A VIRTUAL LABORATORY ENVIRONMENT

Li, Yiyang[1], Shen, Yuzhong[2], and Sukenik, Charles I.[3]

[12]Department of Electrical and Computer Engineering
[3]Department of Physics
Old Dominion University
yli013@odu.edu

ABSTRACT
This paper discusses the development of a virtual laboratory for simulating electronic instruments commonly used in science and engineering courses, such as function generators and digital storage oscilloscopes. Mathematical equations are used to represent continuous signals and ensure signal integrity, while C# delegates are adopted to enable communication between simulated devices. The approach allows for loose coupling between software components and high cohesion of individual components, and can be applied to other virtual laboratory developments. The virtual laboratory provides a means for students to gain hands-on experience with electronic instruments and improve their understanding of theoretical concepts.

Keywords: virtual environment, education, simulation

INTRODUCTION

Online education has made learning accessible regardless of geographic location, but laboratory experiences are still a challenge. Modeling and simulation provide potential solutions to mimic electronic instruments in a virtual environment, allowing students to conduct experiments and analyze results safely and conveniently. The virtual lab includes modeling and simulation of electronic instruments such as function generators and digital storage oscilloscopes, providing both in-person and online students with hands-on experience. This approach addresses challenges such as limited lab schedules and potential hazards. Modeling and simulation also has the potential to improve the educational experience by allowing students to explore extreme conditions and test hypotheses in a controlled environment.

MATERIALS AND METHODS

Autodesk Maya was utilized to generate the 3D model of the electronic devices. Figure 1 shows the 3D models.

(a) (b)

Figure 1. 3D models of (a) Oscilloscope, (b) Function generator.

Through observation of the digital storage oscilloscope and function generator, key features necessary for virtual lab were identified. The key features for users to use the virtual oscilloscope include adjusting the vertical and horizontal systems, selecting autoset button, and observing the waveform on the display. The key features of virtual function generator include adjusting the frequency dial and button, and switching between waveform. The sampling rates of the autoset function at different signal frequencies of the oscilloscope were also recorded.

The oscilloscope simulation was divided into two parts: signal sampling and waveform display. The sampling component stores sampled data into an array for the display component to display. The display component uses Unity's graphics capabilities to render the waveform in real-time and project the waveform to the virtual screen. The implemented features also include adjustable horizontal and vertical scaling.

To represent signals and keep the signal integrity on the virtual function generator, we use math equations to describe the shape and behavior of the signal instead of generating voltage value directly. For example, the equation for a sine wave is $y = Asin(2\pi ft + \varphi)$, where y is the output signal, A is the amplitude of the signal, f is the frequency of the signal, t is time, and φ is phase shift.

In order to maintain loose coupling and optimal resource usage in the virtual lab, we used C# delegates to implement the interaction mechanism between devices. When the user adjusts the frequency on the function generator, the oscilloscope is notified to re-acquire and redisplays the signal by triggering a frequency changed event. This ensures that the oscilloscope only acquires new samples when necessary, rather than constantly acquiring new samples regardless of user input. Likewise, when the user adjusts the vertical or horizontal systems on the oscilloscope, the oscilloscope triggers an event to acquire new sets of sample points. This event then calls the appropriate method on the function generator, ensuring that the function generator only generates signals when needed.

RESULTS AND DISCUSSION

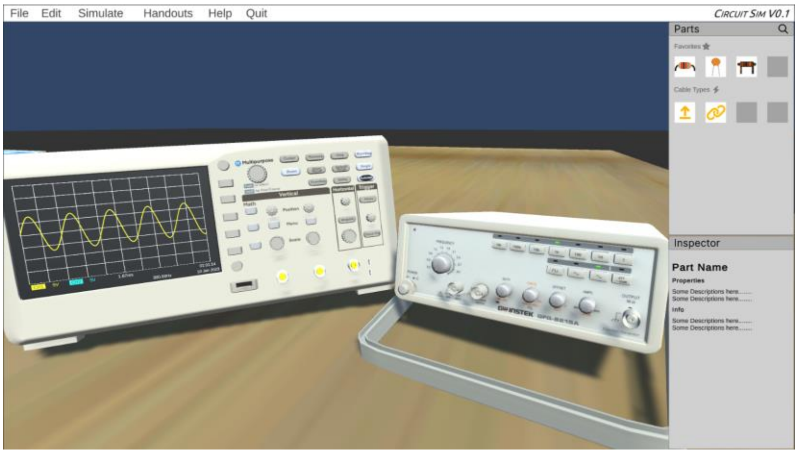

Figure 2. The user interface of the virtual lab.

The proposed approach has been implemented in Unity game engine, Figure 2 shows the user interface and interaction between the virtual function generator and oscilloscope.

CONCLUSION

This paper presented the current work on developing computer models of electronic instruments and devices for virtual lab. Specifically, it described the modeling and simulation of virtual oscilloscope and function generator. This paper also presented the interaction mechanism between there virtual instruments.