PORTABLE MODELING OF VIRTUAL PHYSICS FOR AUDIO AND HAPTIC INTERACTION DESIGN

Edgar Berdahl, Zachary Berkowitz

Center for Computation and Technology, LSU, Baton Rouge, LA

ABSTRACT

Synth-A-Modeler is a language for specifying and parameterizing virtual models of vibrating structures. These models can be compiled into a wide variety of target formats for real-time digital signal processing.

To enable users to interact with the virtual models in real time, an open-source haptic device called the FireFader is provided. In demonstrations, users employ a FireFader to pluck a virtual vibrating string, from which they receive audio and haptic feedback.

Digital signal processing is employed to calculate the audio and haptic signals. The audio signal is sampled at a fast rate such as 44.1kHz, and the haptic signal is downsampled at a lower sampling rate as limited by the USB bus. The entire toolchain is open-source and straightforwardly extensible.

1. INTRODUCTION

1.1. Haptics

A "haptic" device is a human-computer interface that not only senses position, but also actuates along the same axis (see Figure 1 for an example). Through feedback control of a haptic device, it is possible to render various programmable touch sensations to the user.

Since different haptic devices have different mechanical properties, researchers use different haptic devices in different projects. Accordingly, researchers have often found themselves reimplementing the same elementary haptic models over and over again for different devices and in various programming languages.

1.2. Haptics and Audio

The Synth-A-Modeler project addresses this problem by creating a library of **portable** elementary virtual physics models, which can be compiled into a wide variety of target formats [1]. Each model can be used to render audio and haptics in real time.

Accordingly, users can learn about the field of audio and haptic interaction design by iteratively (1) becoming familiar with the library of models and (2) prototyping new models of their own.

Fig. 1. The FireFader is an open-source hardware device based on the Arduino platform and is used for providing force feedback.

1.3. Toolchain Based on Faust

A growing library of physical models (currently numbering about one hundred) will be provided in an upcoming release of the Synth-A-Modeler compiler [1]:
`http://computermusic.us/hybridmodels/`
New models can be created through different arrangements of virtual objects (see Table 1).

Figure 2 illustrates many of the possible paths enabled by the Synth-A-Modeler compiler working in concert with the Faust compiler [2]. This setup will be described in more detail in the demonstration at ICASSP.

2. CONCLUSIONS

Although formal user tests have not been conducted, users have informally reported that they perceive the audio and haptic stimuli as being perceptually fused, corresponding to a unified and immersive virtual reality simulation.

3. REFERENCES

[1] Edgar Berdahl and Julius O. Smith III, "An introduction to the Synth-A-Modeler compiler: Modular and open-source sound synthesis using physical models," in *Proc. Linux Audio Conference*, Stanford, CA, USA, April 2012.

[2] Yann Orlarey, Dominique Fober, and Stephane Letz, *New Computational Paradigms for Computer Music*, chapter FAUST: An Efficient Functional Approach to DSP Programming, Edition Delatour, Sampzon, France, 2009.

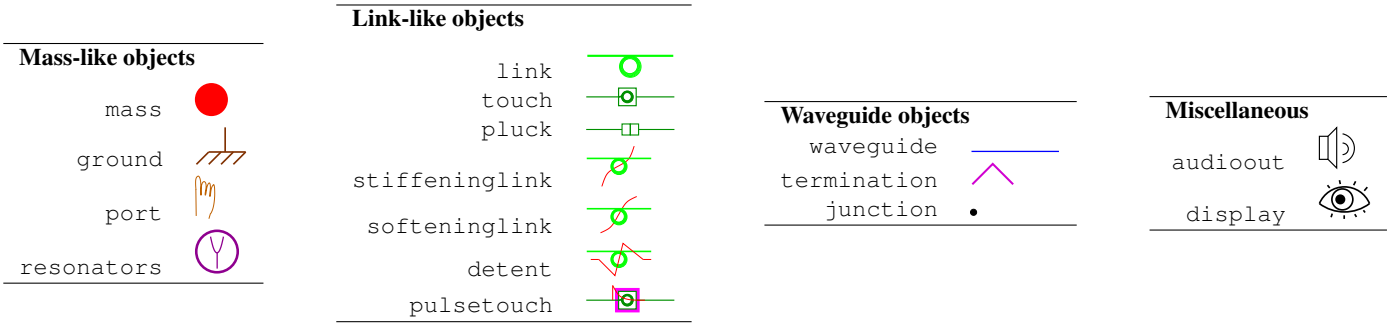

Table 1. Virtual physics objects currently available in Synth-A-Modeler (to be described during the demonstration).

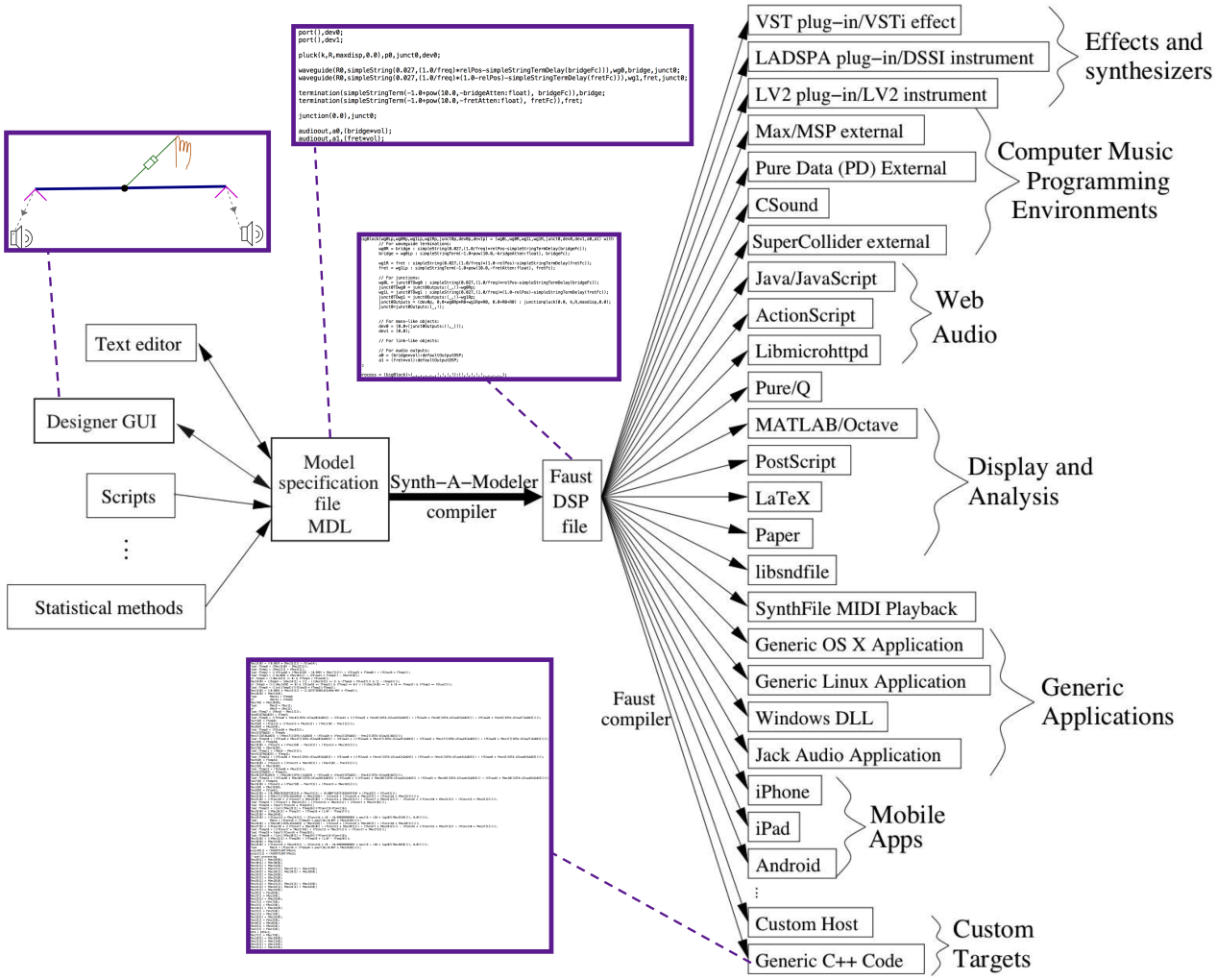

Fig. 2. Using the project toolchain as shown here, a physics model can be compiled into a wide variety of targets. The purple boxes show the particular path undergone when (a) specifying a model of a virtual vibrating string using the Designer GUI, (b) saving the model into an (MDL) model specification file, (c) compiling the model into a (DSP) Faust file, and (d) finally compiling the model into generic C++ code. The signal processing code produced at these successive stages can be viewed by zooming into the present PDF file.