# Vodhrán: collaborative design for evolving a physical model and interface into a proto-instrument

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## ABSTRACT

This paper reports on the process of developing a virtual-acoustic proto-instrument, Vodhrán, based on a physical model of a plate, within a musical performance-driven ecosystemic environment.

Performers explore the plate model via tactile interaction through a Sensel Morph interface, chosen to allow damping and localised striking consistent with playing hand percussion. Through an iteration of prototypes, we have designed a standalone proto-instrument that allows a bodily interaction between the performer and the virtual-acoustic plate in a way that redirects from the perception of the Sensel as a touchpad and reframes it as a percussive surface. Due to the computational effort required to run such a rich physical model and the necessity to provide a natural interaction, the audio processing is implemented on a high powered single board computer embedded within the object itself.

We describe the design challenges and technological solutions we found during the implementation of the Vodhrán.

## Author Keywords

Physical Modelling, Interaction Design, collaborative Design

## CCS Concepts

•**Applied computing** → **Sound and music computing;** *Performing arts;* •**Human-centered computing** → **Interface design prototyping;**

## 1. INTRODUCTION

Learning and developing skilful performance with a musical instrument requires perceptually attuning to, and coupling fine-grained actions to the sound-producing properties of that instrument. This process entails the need for active exploration of the perceivable behaviours of the instrument in response to the types and variations of actions that can be enacted upon it [2, 8]. Moreover, patterns of interaction during the exploratory phase of tool learning may impact upon whether and how a learner skilfully interacts with its properties later [1, 4]. By carefully studying the ways that musicians interact with new instruments, these processes may be better understood. Within [6], we outline ideas for effective framing of such studies into musical interaction.



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As a step in exploring our ideas in [6] and building our understanding of instrument exploration and skills acquisition, following the likes of [3], we have designed a proto-instrument, the *Vodhrán* displayed in Fig. 1. The Vodhrán is utilised to provide musicians with an intuitive and naturalistic interaction with a physical model. We define it as a *proto-instrument* as its evolution will be informed by participatory, user-centred, and cooperative design [7] using professional performers to explore and help create a musical dictionary of Vodhrán techniques that can then be taught to novices. Feedback from both groups will help shape what will become a fully developed musical instrument in education and professional performance contexts.

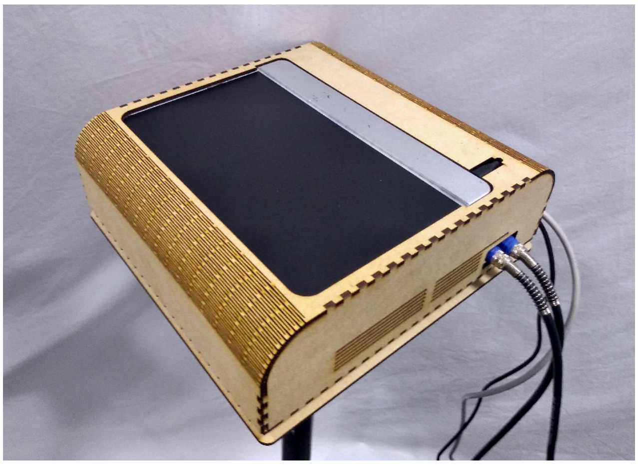

**Figure 1: Vodhrán with Sensel Morph interactive surface.**

## 2. SYSTEM IMPLEMENTATION

### 2.1 Sound engine

Vodhrán's audio engine is a bespoke JUCE[1] based VST plugin, *Glossina*, that runs a re-configured version of a virtual-acoustic string-bridge plate developed in previous work [9, 8]. It facilitates exploring sounds of an inherently mechano-acoustic nature through real-time adjustment of parameters characterising its resonating structures and their connections via two nonlinear springs. In its original form, the audio plugin was sounded through interaction with a silent string controller sensing the force signal from plucking or other forms of string excitation, and routes this as an input force to the virtual-acoustic string. The underlying physical model of Glossina is exactly the same as that presented in [9] except the single force input to the string is replaced with two input forces to the virtual-acoustic plate. This turns

[1]`https://juce.com/`

the system into a plate-based resonator in which the bridge and string effectively function as a 'non-linear soundpost'.

## 2.2 Choice of interface

Because we are using a physical model of a plate, we chose the Sensel Morph[2] for capturing interaction as it aligns with a plate as a flat multi-touch interactive surface. Willemsen et al. [10] have similarly used a Sensel for controlling physical models as it offers high resolution tracking of contact position, force and area. Combined with an AKG 411 contact microphone providing excitation into the plate model, it effectively enables the exploration of the timbre space and instrumental techniques afforded by the virtual-acoustic plate in an ecological context. Sensel contact information is used to localise excitations and derive damping parameters.

### 2.2.1 Keeping the Sensel low-latency

In order to ensure minimal latency and jitter while reading and forwarding data from the Sensel, we created a second dedicated JUCE based VST plugin, *Stomoxys* using the Sensel API. This bespoke implementation allows us to guarantee a consistent data stream from the Sensel hardware at its default target sample rate of 125Hz.

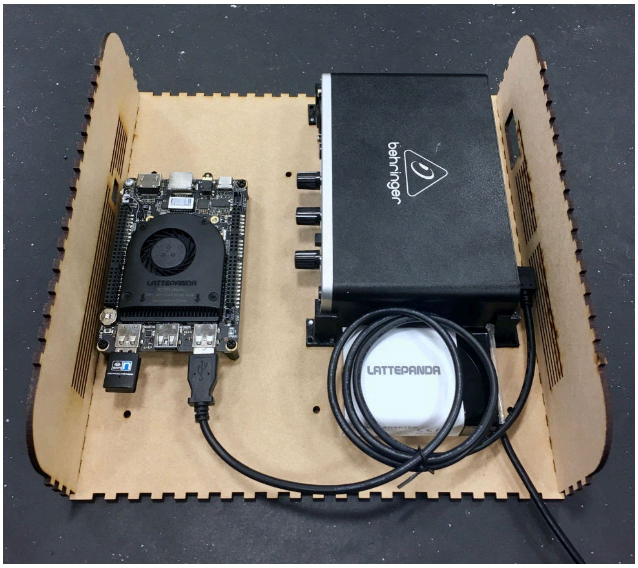


**Figure 2: LattePanda and audio interface**

In order to guarantee that data reaches the plugin running the plate model with minimal latency, data is forwarded over an audio channel using data-as-audio technique, described in depth in [5, p.177-179]. As a host DAW guarantees an audio block will pass through the entire effects chain every update, passing data-as-audio guarantees that all Sensel data will arrive at the target plugin within one audio block[3]. While data-as-audio does require modifying the receiving plugin, for high volume data it is much faster than OSC (~100-200ms latency[4]) and offers much better bit depth and more flexibility than MIDI.

## 2.3 Creating the physical proto-instrument

A Sensel on the table connected to a computer presents itself as a trackpad not a musical instrument. It was therefore necessary to distance the Sensel from its default context, and physically reframe it as a proto-instrument that encourages interactions more akin to percussion.

In order to consolidate as much of the system into a single physical object, we run the system on a LattePanda Alpha 864[5] Single Board Computer Fig. 2. Glossina's implementation relies on Intel® AVX2[6] technology. The LattePanda Alpha includes an Intel Core m3-8100Y processor which is compatible with AVX2 instruction set, in a form factor that is only 115mm x 78mm x 14 mm allowing it to be embedded into the instrument itself. It is compatible with Windows, Linux, and OSX and is able to run Vodhrán's sound engine.

# 3. CONCLUSIONS

The Vodhrán is designed to allow research into skill acquisition and development of repertoire. Initial player feedback indicates that the wide-ranging intuitive sonic response of the plate-model controlled through the encased Sensel provides a rich natural environment for experimentation.

# 4. ACKNOWLEDGEMENTS

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[2] `https://sensel.com/`

[3] Low-latency low-jitter sample code demonstrating use of the Sensel and data-as-audio at `https://github.com/transientstatic/Stomoxys/`

[4] Tested using Reaper's inbuilt OSC server.

[5] `https://www.dfrobot.com/product-1729.html`

[6] `https://software.intel.com/en-us/articles/intel-mkl-support-for-intel-avx2`