Designing Professional Instruments for Computer Music Performance

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Introduction on Computer Music Performance

What *IS* computer music performance?

live performance of computer music by a human performer

(this excludes human compositions played by a computer)

Introduction

Professional Computer Music Instruments

I am investigating the ideal of a *professional* instrument:
an instrument which…

…could become a respectable entity within the music world.
…could develop a following of musicians who identify as *players* of the instrument.

…could be functionally competitive alongside typical traditional instruments.

Introduction

Outline

- **DESIRABLE CHARACTERISTICS**
  - What are the primary characteristics a professional instrument should possess?
- **DESIGN PRINCIPLES**
  - What are the important factors to consider when designing professional instruments?
- **INSTRUMENT ANALYSIS**
  - How do real world instruments hold up against these criteria?

Characteristics of Professional Instruments

Overview

The literature suggests three primary desirable characteristics:

- **VIRTUOSITY**
- **EXPRESSIVITY**
- **FLEXIBILITY**

Characteristics of Professional Instruments

Virtuosity

VIRTUOSO: *an individual who possesses outstanding technical ability at singing or playing a musical instrument*

(Wikipedia)

A *virtuosic* instrument is an instrument which can support virtuosic players.

Characteristics of Professional Instruments

Virtuosity

An instrument which possesses

(a) a high ceiling for technical play (depth)
and **(b) broad technical potential (complexity)**

will tend to promote virtuosity.

Characteristics of Professional Instruments

Virtuosity

- NOTE -

Difficulty does *NOT* imply depth.

(Obfuscation ≠ virtuosity)

Depth is derived from *relevant difficulty:*

difficulty which is productively employed in musical output

Characteristics of Professional Instruments

Expressivity

(musical)
EXPRESSION: *that element of musical performance which is something more than mere notes*
(Brittanica)

An *expressive* instrument is an instrument which can facilitate this type of expression.

Characteristics of Professional Instruments

Expressivity

Typical modes of musical expression include…

- Dynamics – variation of softness/loudness
- Articulation – variation in ‘connectedness’ of notes
- Vibrato – rapid and subtle change in pitch
- Tremolo – rapid and subtle change in volume

Characteristics of Professional Instruments

Expressivity

An instrument which possesses

(a) varied methods of altering sound texture
and **(b) fine control over these methods**

will tend to promote expressivity.

Characteristics of Professional Instruments

Expressivity

Expressivity is a challenge for computer music instruments.

Creating interfaces which allow for nuanced input is challenging task.

Traditional instruments tend to have very *multi-dimensional* inputs…

…electronic interfaces tend to be very *one-dimensional*.

Characteristics of Professional Instruments

Flexibility

FLEXIBILITY: *a ready capability to adapt to new, different, or changing requirements*

(Merriam-Webster)

A *flexible* instrument is an instrument which can be adapted on-the-fly with minimal effort.

Characteristics of Professional Instruments

Flexibility

Computer music instruments have the potential to be *uniquely flexible.*

Software allows for radical and rapid changes in an instrument's behavior during a performance…for example:

- **The type of sound can be changed.**
- **The instrument can be 'retuned.'**
- **The method of input can be altered.**

Characteristics of Professional Instruments

Flexibility

Accessing this flexibility becomes a question of interface:

A feature which cannot be easily used during play does not contribute meaningful flexibility.

Characteristics of Professional Instruments

Summary

So, let's recap – we are searching for instruments which are:

- **VIRTUOSIC** (technically deep and complex)
- **EXPRESSIVE** (allowing for nuanced control of sound)
- **FLEXIBILE** (adaptable mid-performance)

Design Principle Overviews

Next, we'll discuss two important principles for the design of computer music instruments:

- **MAPPING**
- **BODY/GESTURE**

Design Principle
Mappings

(natural)
MAPPING: *taking advantage of physical analogies and cultural standards*

(Design of Everyday Things)

Mapping is the correspondence between action and reaction in an interactive object.

Design Principle
Mappings

Good mapping in the context of a computer music instrument means interactions correspond to changes in sound:

- **Displacement of a hand may be mapped to pitch.**
- **Velocity of struck key may be mapped to volume.**
- **The location of a key press may be mapped to timbre.**

Design Principle Mappings

Natural mapping requires not only that actions are mapped to reactions, but that they are mapped in a reasonable manner.

Faster key presses should equate to a louder sound, not a softer one.

Design Principle
Body and Gestures

(natural)
Gesture:

a movement usually of the body or limbs that expresses or emphasizes an idea, sentiment, or attitude

(Merriam-Webster)

The body-instrument connection, sometimes referred to as gesture, is the incorporation of the player's physical actions into the sound produced.

Design Principle

Body and Gestures

Traditional instruments make this connection necessary – the physical action is literally what produces the sound…

…by contrast, electronic interfaces make this connection hard – the causal chain between body and sound is tenuous and incidental.

Design Principle
Body and Gestures

We can emulate the body-instrument connection, and provide strong gesture by…

…building interfaces which are as tangible as possible.
…allowing the movement or positioning of the performer's body to influence the sound.

…adding more depth to physical interactions.

Design Principle Summarys

We now have an established set of characteristics and design principles we can apply to a computer music instrument.

Desirable Characteristics	Design Principles
Virtuosity	Mapping
Expressivity	Body/Gesture
Flexibility	

Analysis of Existing Instruments

Overview

The characteristics and principles we've established should serve as useful criteria for analysis of real instruments.

Let's turn to this analysis now, to see how the criteria interact in practice.

Analysis of Existing Instruments

Overview

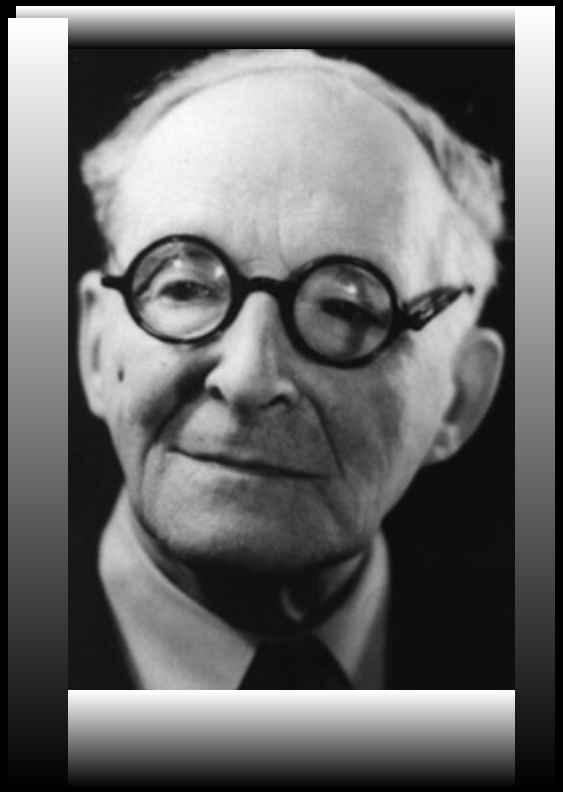
I will briefly discuss and analyze two electronic instruments:

- The Theremin
- The Eigenharp

Analysis of Existing Instruments

The Theremin

The Theremin was created in 1920 by Léon Theremin, and was the result of research in proximity sensing technology.



Analysis of Existing Instruments

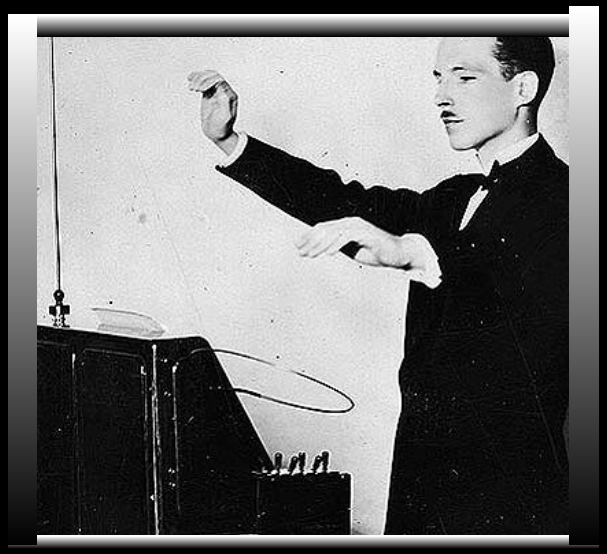
The Theremin

The Theremin operates by measuring the distance from two antennae to each of the performer's hands.

Analysis of Existing Instruments

The Theremin

One hand controls the instrument's pitch:



…the other controls the instrument's volume.

Analysis of Existing Instruments

The Theremin

A violin virtuosa from a young age, Clara Rockmore transitioned to the Theremin after bone problems left her unable to play violin.

Rockmore became a universally established Theremin virtuosa… so what makes the Theremin a virtuosic instrument?

Analysis of Existing Instruments

The Theremin

Virtuosity

Playing even a single note on the Theremin is an extremely technical event…playing a run of notes is exponentially more challenging.

Each successive note is conceptually located at an unmarked position in the air…and each must be hit with precision.

The technique involved in playing the Theremin is enormous, creating great potential for virtuosity

Analysis of Existing Instruments

The Theremin

Expressivity

On the Theremin, pitch and volume are totally free, on a continuous level.

This allows for great expressive freedom – altering the shape of the sound is natural and powerful.

Analysis of Existing Instruments

The Theremin

Flexibility

Although pitch and volume are totally free, the Theremin constrains the player's actions to these two inputs.

With the exception of additional foot pedals, there is no license for on-the-fly adaptation in the Theremin's interface, so flexibility is limited.

Analysis of Existing Instruments

The Theremin

Mapping

The Theremin's action-reaction connections are strong and straightforward: the distance of one hand maps to pitch, and the distance of the other maps to volume…

…mapping is not necessarily natural, though; does moving the pitch hand closer raise or lower the pitch?

Analysis of Existing Instruments

The Theremin

Body/Gesture

Evaluating the body-instrument connection of the Theremin is interesting.

On the one hand, there is no tangible interaction between the Theremin and its performer…

…on the other hand, the player's body really does *become* the instrument.

In the long run, gesture is a strong part of the Theremin's design.

Analysis of Existing Instruments

The Eigenharp

The Eigenharp was released in 2009 by UK company Eigenlabs.

Its creators tout it as “the most revolutionary new musical instrument of the last 60 years,” and “the most expressive electronic instrument ever made.”

Analysis of Existing Instruments

The Eigenharp

The interface is a huge array of inputs:

- 120 keys, which detect how far they are depressed, as well as their tilt on two axes
- A wind controller for breath control
- Two touch strips along both sides of the instrument
- 12 large keys at the bottom for percussion

Analysis of Existing Instruments

The Eigenharp

It’s difficult to succinctly explain how one plays the Eigenharp, since there are many ways to do so…

We will analyze the instrument with respect to its typical configurations, as in the video.

Analysis of Existing Instruments

The Eigenharp

Virtuosity

Technique abounds with the Eigenharp – the depth and complexity of the instrument guarantee a high skill ceiling.

The instrument is still fairly young, but it seems likely virtuosos could develop in time.

Analysis of Existing Instruments

The Eigenharp

Expressivity

Expression is a key focus of the Eigenharp's design. The instrument's wide range of inputs and high level of precision allows for extensive control over the sound, and each input is built to be very precise and accurate.

Managing all of the different modes of interaction may prove difficult, but the potential for expressivity is great.

Analysis of Existing Instruments

The Eigenharp

Flexibility

The greatest strength of the Eigenharp is its flexibility.

As we've seen the challenge of flexibility, as we've been using the term, is in providing an interface which allows the performer to adapt without significantly interrupting the performance.

Analysis of Existing Instruments

The Eigenharp

Flexibility

The Eigenharp addresses this difficulty with a system which utilizes the instrument's primary keys, called Belcanto.

After entering a special mode with a button press, a short sequence of keys are pressed, issuing a command to the Eigenharp.

This allows the performer to quickly and unobtrusively issue commands while playing.

Analysis of Existing Instruments

The Eigenharp

Mapping

Mapping is difficult to assess on the Eigenharp, because the inputs are used for many different things.

At default, however, most mappings are fairly natural and direct:

- Successive notes are laid out linearly down the instrument, much like a guitar.
- Each axis of each key is mapped to one effect (pitch bend, modulation)
- The wind controller is often mapped to note volume

Analysis of Existing Instruments

The Eigenharp

Body/Gesture

The body-instrument connection is strong when playing the Eigenharp.

Each interaction with a key is very involved, since effectively the angle and force of the key press factor heavily into the resulting sound.

The interface is very tangible, and encourages many forms of physical interaction.

Conclusions

We've now evaluated two real-world examples against our criteria for professional computer music instruments.

These analyses should provide an idea of how the desirable characteristics and design principles come into play in instrument design.

Questions?

Thank You!