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PER

Three-dimensional musical instrument

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Contents

List of Figures

Introduction

A three-dimensional musical instrument might sound quite abstract for the bystander. One can think of it as a musical instrument taking place in the virtual reality or augmented reality domain. While an exact definition might be hard to settle because every instrument will be different in core features to others, a general definition might be an instrument which can have either :

- A visual representation in a three-dimensional space
- Interactions in a three-dimensional space

The two points are generally shared, however it is harder to display the instrument in 3D than to interact with it.

The display can have two goals : [BHDC10]

- Giving visual cues to the spectators of the musician's actions.
- Helping the musician to perform.

One of the main focuses of this exposé will be to assess the different display techniques suitables to a 3D instrument, and the other will explain how it can improve existing 3D instruments.

The last part of this report will be about the choices we had to make in order to setup our own 3D musical instrument.

Chapter 1

Relationship between 3D musical instruments and 3D displays

A 3D musical instrument, or an immersive virtual musical instrument, represents sound processes and their parameters as 3D entities of a virtual reality so that they can be perceived not only through auditory feedback but also visually in 3D and possibly through tactile as well as haptic feedback, using 3D interface metaphors consisting of interaction techniques such as navigation, selection and manipulation.

1.1 Immersion

1.2 Control

Chapter 2

Three-dimensional displays

2.1 Definition of a 3D display

While it is commonplace to hear about 3D display in television or smartphone advertisement nowadays, the distinction between 2D and 3D might be more difficult to settle.

2.1.1 The problem

If we take the simple definition : a 3D display is a display that can show 3D images, it is really ambiguous, because of what is supposed to be "3D". For instance, for years, video games have been advertising 3D engines and spectacular 3D graphics, even without what we now call 3D displays.

Hence, we have to qualify what is 3D and what is not.

2.1.2 Parameters

In the litterature ([Oko76], [PS12]), the main idea is to relate to the human brain and body capabilities. For instance, a big part of the "3D" feel is due to the fact of having two eyes that looks in the same direction, but from a slightly different angle, but it is not all.

The visual cues of 3D vision are separated in two families:

- Physiological cues. They will relate to the capabilities of the human body.
- Psychological cues. They will relate to the information inference capabilities of the human brain.

2.1.3 Presentation of common visual cues

Psychological cues
Occlusion
Linear perspective
Atmospheric perspective
Shading

Figure 2.1: Psychological cues

2.2 Classification of the 3D displays

One of the main problem while trying to find a proper display for a given application is to choose a relevant classification for the displays, that allows a choice with criterions relevant to the application.

2.2.1 Criterions

There was a lack of proper nomenclature in the literature for a long time [PS12]. However, some attemps have been made to find relevant criterions that would be general enough to cover the current display techniques, but also the ones that are not yet thought of.

Different classifications

The first classification was in [Oko76], and it was really based upon the different kinds of displays :

- Lens-sheet three dimensional pictures.
- Projection-type three dimensional displays.
- Holography.

However, it did not hold well against the emergence of new techniques, like volumetric displays for instance.

Other classifications would limit themselves to only a subset of 3D displays.

Hence the need for a classification that would not base itself on the different technologies, but on criterions that would be inherent to the idea of display and human vision.

Chosen classification

In [PS12], the main idea is to classify the displays according to two axes :

- The display depth (flat or deep).
- The number of points of view from which the image can be seen (duoscopic, multiscopic, or omniscopic).

2.3 In-depth presentation of some 3D display methods

Pepper's Ghost

Glasses

Head-mounted displays

Hologram

Autostereoscopic screen

Chapter 3

Presentation of 3D musical instruments

3.1 History of the 3D musical instruments

De nombreux instruments de musiques immersifs se concentrent sur la navigation dans un environnements 3D virtuelle. Tout d'abord le projet Phase [RLC+05] explore la génération, la prise en main et le controle de son ou de musique à l'aide d'un capteur haptique et d'une représentation visuelle pouvant guidée l'utilisateur. Un second projet, Plumage [JAC+07], est une interface pour le contrôle interactif de la composition audio spatialisées. Des plumes dispersées dans une scène 3D représente des grains sonores, générent du son lorsque des têtes de lectures les parcours. Les têtes de lectures sont contrôlées directement par l'utilisateur. Néanmoins ces deux projets ne permettent pas de manipuler directement la structure de la synthèse sonore, mais seulement de la manipuler.

Une autre gamme d'instrument 3D se concentre sur une unique synthèse sonore. Dans ce cas nous pouvons trouver par exemple le *Virtual Xylophone, le Virutal Membrane ou encore la Virtual Air Guitar [MPLKT05]. Un autre exemple d'interaction 3D avec une synthèse sonore unique est celle de Mike Wozniewski [WSC06]. Son application permet a un utilisateur de naviguer dans une scène 3D comportant à certain point précis des générations de son. L'utilisateur entend les sons en fonction de sa position et de son orientation dans la scène 3D.*
La percussion aérienne est un intstrument 3D que nous pourrions mettre dans cette classe d'instrument.

Le DRILE propose une nouvelle utilisation de la 3D. Le DRILE utilise l'interaction 3D pour pouvoir manipuler plus aisément la structure même d'une musique.
Le DRILE et la percussion aérienne ont été conçu pour la performance musicale.

3.2 The DRILE

3.2.1 livelooping

3.3 Aerial Percussion

Chapter 4

Realisation

4.1 Required work

Apart from the research work, the application of our research to two musical instruments (the DRILE and the Aerial Percussion) is required.

The goal of our work is to enact a live show with these two instruments, that allows for both the performer and the spectators to see the musical instrument in three dimensions.

4.1.1 Finding a display

The first task is to find a suitable display method that would allow :

- *The performer to interact with the instrument*
- *The spectators to see the performer as if he was part of the 3D scene*
- *If possible, a stereoscopic feel.*

4.1.2 Implementing suitable renderings

There is already some existing work for the rendering engine of the DRILE, however there is nothing for the aerial percussion.

We have to make renders from two different viewpoints : one for the performer, antoher for the spectators.

4.1.3 Customisation

If we have time left, we are to add some customisations to the aerial percussion rendering, in order to make it look like a real show, with special effects, flares, particles, textures...

4.2 Implementation

We will describe here the multiple choices that have been made during this project, and the reason behind these choices, as well as the result of our implementation.

4.2.1 Chosen display techniques

There are multiple factors to take into account :

1. *The availability of the technology.*

2. *The potential price of the required materials.*
3. *The time to setup the display.*
4. *The scaling for a medium-sized audience.*
5. *The compatibility with the double requirement : a view for the performer, and another for the spectators.*

   We are now going to study these requirements point by point.

Availability

This is the main problem : many of the display devices presented in chap:3ddisp have only been the subject of research and not of a real implementation sold by a company (e.g. holograms). Also, the development state of some technologies might not be sufficient for what we are striving for (e.g. autostereoscopic displays which are only present in very small screens like smartphones).

Price

Some technologies might be irrelevant only because of the amount of money needed to get a working implementation. For instance, an active 84" 3D HDTV generally costs more than ten thousand dollars, which is unsuitable to this project.

Setup time

Some methods might require a very long time to setup. While we don't have a required maximum time to setup the show, we should try to keep it as low as possible. For instance, the Pepper's Ghost technique is quite long to setup, because there is a lot of massive hardware, videoprojectors, screens, to setup.

Scaling

Since this is for a show, we need a system that will allow everybody in the room to enjoy the performance. The estimate is at about 40 persons : we need a display that provides big enough viewing angles and is big enough for everybody to be able to enjoy it. A square display with a side of two meters would be ideal to enable complete immersion.

Double-view requirement

This is one of the hardest requirements, because it can easily double the quantity of required hardware. For instance, if we were to use 3D TVs, we would need one TV for the viewers and one for the performer.

4.2.2 DRILE Implementation

Technologies used

Pictures

4.2.3 Aerial Percussion implementation

Technologies used

Displaying the data

Truc sur les angles

Pictures

Conclusion

- *L'article [HDFP11]*
- *L'article [PS12]*
- *L'article [MPWL13]*
- *L'article [KHY+12]*
- *L'article [Cad99]*
- *L'article [BHDC10]*
- *Le livre [Oko76]*
- *L'article [RLC+05]*
- *L'article [JAC+07]*
- *L'article [MPLKT05]*
- *L'article [WSC06]*

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