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Projet d'Étude et de Recherche

Three-dimensional musical instrument

Supervisor: Aurélie Bugeau
Clients: Myriam Desainte-Catherine, Joseph Larralde, and Florent Berthaut

Mohamed Bourara, Jean Bui-Quang, Omar Ourhi, Jean-Michaël Celerier
Marie Immacula Omiscar and Damien Clergeaud

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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 2

Subject and definitions

2.1 Subject presentation

3D Musical instruments
At the **SCRIME**[1] and **LABRI!**[2], three-dimensional musical instruments have been implemented within the context of research in interactive virtual reality and music computing.

The **Drile** [BDCH+10] is a 3D musical instrument which allows manipulation of the structure of a song using live looping, in an immersive virtual reality scene.

The **Aerial Percussion** is a 3D musical instrument which generates sounds using the position in space of sensors which are put at the end of drumsticks. Virtual 3D shapes like cubes, cylinders, are positionned around the instrument and the musician. According to the position, the orientation, and the speed of the sensors, sounds are generated.

Objectives
We were asked to implement a prototype of a 3D render and display device, for musical performance. It is necessary to take into account the constraints inherent to a musical performance environment, as well as the constraints of the instruments.

Here are some constraints for the performance :

- The musician has to be in front of the audience.
- The musician requires visual cues inherent to the utilisation of the instrument, and the audience must see the instrument to understand the gestures and actions of the musician.

To enact this implementation, a precise explanation of the nature of the 3D musical instruments is required.

Plan for this section
We will first make a short presentation of 3D musical instruments, present and will then define the concepts of immersivity and interactivity.

[1] Studio de Création et de Recherche en Informatique et Musique Électroacoustique
[2] **LABRI!**

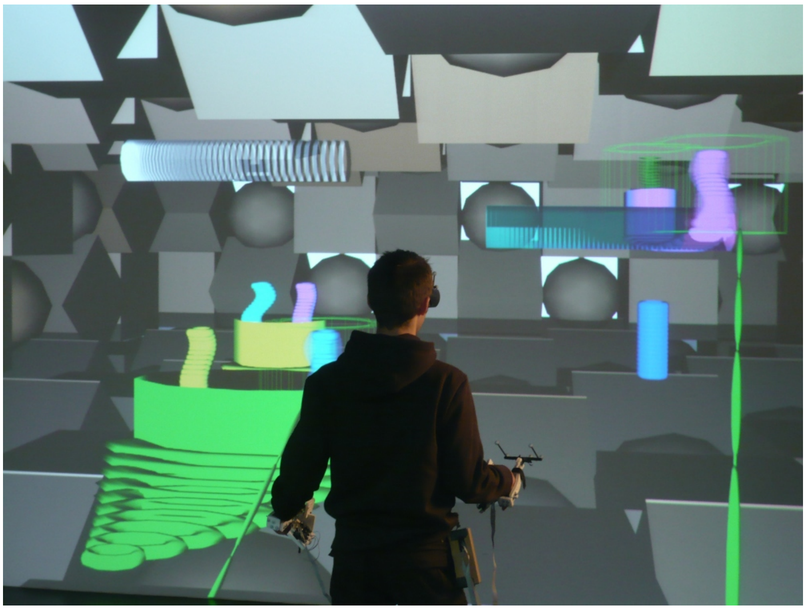

Figure 2.1: Picture of a musician using DRILE

2.2 What is a 3D musical instrument?

//JM TU PEUX CORRIGER CE PARAPGRAPHE SI TU AS LE TEMPS MON BICHON A 3D musical instrument is an instrument which is designed thanks to the progress in virtual reality and computer music. The virtual reality provides display and control methods while computer music provides sound and music synthesis. The goal is to make up with those tools to design an instrument with precision, handling and artistic quality.

Example for the Drile

For instance, the picture 2.1 shows a musician with special glasses, as well as joysticks with force-feedback haptic sensors (Piivert [BHDC10]). The user handles 3D shapes in a 3D environement to influence the music generation. A specific part of this report will be dedicated to a precise study of the **Drile**.

2.3 Immersion

Definition

Immersion is a psychologic state where the subject stops about taking care of its own physical state. The immersion is quite important in virtual reality. For instance, for the Aerial Percussion, it would come down to the state the performer is when he stops thinking consciously of the disposition of the shapes he interacts with. The musician will then be immersed in the virtual 3D environment which consists in the shapes disposition.

Hence, to immerse an user, multiple parameters are accessible to the 3D instrument designer. They are mostly linked to the senses of the human body. In our project, we will mainly focus on vision, and more precisely on 3D display devices.

Interactivity & reactivity

Interactivity is an important aspect of the immersion capacities of a musical system. The user is more likely to get an immersive feeling in a virtual world, if the world instantly reacts to his actions and gestures [BD95]. This leads us to an important part of the 3D musical instrument : the interface, the controls that the performer requires to operate the instrument.

2.4 Control

In order to understand and define what is the control of a 3D musical instrument, it is necessary to think of the instrument in two different ways :

1. First of all, it is a musical instrument, which implies multiples constraints :
    - It has to be adapted to the human body shape so that the musican can manipulate it.
    - It has to be precise enough for the performer to be able to learn how to play the instrument.
2. But it is also an interactive immersive system, which means that it requires :
    - A lot of interactivity.
    - The usage of senses for a feedback : for instance, immersive visual and haptic feedback (as well as auditive, since it is a musical instrument).

Musical instrument gestures

In order to conceive a 3D musical instrument, it is necessary to understand the movements that the musician does while playing. For instance, the Cadoz gesture segmentation [Cad99] is an attempt to differentiate different families of gestures while playing.

Cadoz defines three kinds of gestures that all come to play when playing music:

- Selection gestures : The musician selects a component of the instrument that he will play on. For instance, for stringed musical instruments, where the same tone can be achieved on different strings, but with a different timber, it is the choice of the string on which the note will be played.
- Modification gestures : It is an action that modifies the physical state of the instrument. For instance, it would be the case of the guitar player who presses its hand on the guitar strings against the wood.

- Excitation gestures : These actions are the ones generating the actual sound of the instrument, by making the air vibe. On a guitar, it would be picking a string, and on a violin, it would be moving the bow against a string. This gesture is the one the artist can put expression inside : for instance, a violonist can press his bow softly or hardly, in order to change the nuance.

Control and immersion

In order to correctly play an instrument, the user requires some kind of manipulation comfort : it must not be painful or too tiring to play. Hence the requirement for immersion : being immersed means that the user does not need to put effort into playing the 3D musical instrument, he becomes part of it. An easy way to improve immersion is to make the environment react to the performer's movements.

This can be achieved by using head tracking, with a **Kinect** for instance, or a **HMD**[1], a **CAVE**[2] or other virtual reality devices and methods like Fishtank VR [RCVD97]. This allows to adapt the scene's projection to the movements of the head of the user : for instance, if he turns his head to the right, the display will adapt by showing him what he would see if it was real.

Haptic feedback buttons also increase the consciousness of the user's actions, which implies an increased precision.

Florent Berthaut thought about most of these problematics while conceiving **Piivert** [BHDC10], the control interface to the **Drile**.

[1] Head-mounted Display
[2] CAVE Automatic Virtual Environment

Chapter 3

Three-dimensional displays

3.1 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.

3.1.1 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 the depth provided by what is now called 3D displays or 3D movies in cinema. Another litteral but limited definition for a 3D display would be a display that really exists in three-dimensions; one could think for instance of programmable matter and claytronics, or at least of a display that would be able to show a scene or an object from any point of view.

Hence, we have to qualify what is 3D and what it is not, in order to build a real definition.

3.1.2 Parameters

In the litterature, the main idea is to relate to the human brain and body capabilities to define 3D vision ([Oko76], [PS12]). 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 the only parameter.

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.

3.1.3 Presentation of common visual cues

Most of the visual cues on 3.1 are explained in-depth in [PS12], however a short explanation is provided in the glossary for many of them.

A complete classification of the current state of the art in 3D displays using these visual cues is present in [MPWL13] on Table 2.

Psychological cues
Occlusion
Linear perspective
Atmospheric perspective
Shading
Motion parallax
Kinetic depth

Physiological cues
Stereoscopy
Convergence
Accomodation
Retinal image size [MPWL13]
Texture gradient [HR12]

Figure 3.1: Common visual cues

3.1.4 Definition of a 3D display

The definition retained in [PS12] is the following : a 3D display is a display that uses at least one of the physiological cues. We will see that most of the displays use the stereoscopy cue, because it is the one that provides the most convincing 3D experience[KKN+06].

3.2 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.

3.2.1 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 existing at the time:

- 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).

3.3 In-depth presentation of some 3D display methods

This section describes the different technologies used by manufacturers of 3D displays, and also explains some 3D visualization systems in detail. But first we will define what are stereoscopic and auto-stereoscopic displays.
Stereoscopy is the set of techniques used to reproduce a depth perception from two planar images.
Autostereoscopy is a method of image representation, either in three-dimension or stereoscopic, which requires no additional device to render the 3D effect.

3.3.1 Two-view 3D displays

Since a decade, a new generation of screens appeared: 3D screens. The main feature of these screens, which distinguishes them from conventional screens, is their ability to display stereoscopic images : each eye of the observer will receive a different point of view. There are multiple technologies that are able to power such screens; we will explain some. But an exhaustive list is present in [MPWL13].

Wavelength selective displays

To view in 3D, it is necessary to provide our brain two images of the same scene taken from two different points of view. This is the principle of stereoscopy. The distance between the two points of view is used to compute the depth of field to achieve the 3D effect.
Different methods exist so that each eye receives the intended image.

The most famous are the anaglyphic glasses, pictured on figure 3.2. However, the result is of poor quality and unpleasant after some time.

Figure 3.2: Red/cyan color filter 3D glasses[Vie]

In this case, images are filtered by color. The two images are superimposed and the glasses incorporate a color filter. Each eye can only see the image intended for it, so this can be used to create a stereoscopic effect.

This is a passive method.

Time-sequential two-view displays

The idea is that the images are shown one after the other, but it has two requirements :

- The switching between images must be fast : a refresh rate of 48 Hz is theoretically minimal for a 24 fps movie, however research [HDFP11] shown that 58 Hz is a practical minimum.
- Each eye must see only the images directed to it. There are multiple technologies to achieve this, passive and active.

Passive method
This technique uses polarized glasses. The right lens is polarized in one direction while the left lens is polarized in the other direction.

Figure 3.3: Polarized 3D system[Pol]

This is not an expensive method, however the image is often less bright. It is generally used in movie theaters.

Active method
This technique uses active glasses, with LCD shutters that needs to be synchronized with the screen refresh rate : one of the glass goes black while the other allow the light to pass, which allows the eyes to receive only the wanted image at the wanted time.

This method is more expensive, but reviews often said it offers a better experience.

Time-parallel two-view displays

This is the opposite of time-sequential two-view displays. Both eyes receive a stream of images at the same time.

Simple stereoscopy
There are multiple designs available. One would be a variation on the polarized glasses : instead of having the images one after the other, they are put together, for instance by using a dual projector. However, this can lead to crosstalk.

Another design uses multiple LCD displays, one seen in transmission and the other in reflection in a mirror, in order to change the polarization of the reflected screen.

Auto-stereoscopy
This technique is interesting, because no special headgear is required : the correct light information is sent directly by the screen to the eyes.

However, the viewer has to be at a precise position in front of the screen for it to work. Hence, it only works with a single person except in the case of a very large and expensive screen.

Some recent designs can for instance use reflective screens [SSR13].

3.3.2 Horizontal parallax multiview 3D diplays

Multiview or multiscopic displays are displays that can be seen from a finite number of point of view and show a different picture corresponding to this point of view.

There are two main types of technology for multiview parallax displays: either by applying a parallax barrier, or by application of a lenticular panel.

A parallax barrier is a mask of parallel black stripes that reveals the different parts of the underlying image depending on the direction of observation.

The same effect can be obtained with the lenticular sheets, which are linear networks of narrow cylindrical lenses. Both techniques are used to show a unique view of each position in the viewing area. Thus, a viewer feels the motion parallax and binocular stereo without the use of special glasses.

Lenticular Displays

The application of a lenticular panel to deflect the rays from the pixels of the screen in order to reproduce a stereoscopic display giving the images an impression of depth.

A lenticular panel is composed of a regular grid of small spherical lenses. Each lens covers an area of several pixels of the flat screen and will divert the direction of the light emitted by the pixels covered.

As we can see on figure 3.4, each eye only sees the right or left pixels. An observer looking at a lenticular 3D screen does not see the same screen pixel between his left eye and his right eye, although both eyes see the same lenses.

With horizontal lenses, projecting changing images, the perceived image depends on the angle between the eye and the lenses.

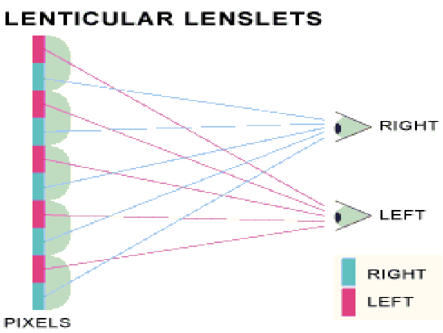

Figure 3.4: A lens array[gla]

Parallax Barrier Displays

Instead of lenses, multiple small masks are put in front of the pixels. The images are divided into columns of a width of one pixel. Each mask is precisely placed so that the observer, himself set at the correct distance from the screen, views the image that corresponds to each eye.

Thanks to the cache, an image is sent to the right eye and another in the left eye, as in figure 3.7; the brain recreates the 3D picture by stereopsis.

In comparison with the lens array, we can see each spherical lens replaced by an opaque surface and a small hole in its center. Therefore, as in the case of the lens array, an observer looking at a small hole in the 3D screen does not see the same screen pixel between his left eye and his right eye: this is because the parallax barrier is not contiguous to the flat screen, but there is a distance of a few millimeters between the two panels.

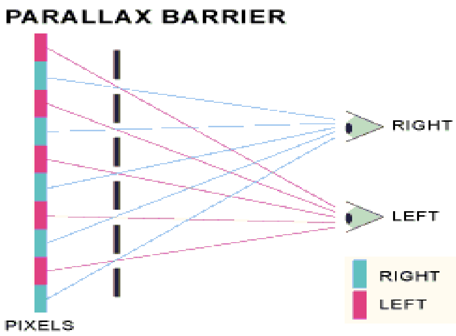

Figure 3.5: A parallax barrier[gla]

This technique provides a 3D vision without wearing glasses.
However, there are some disadvantages :

- It must be placed precisely over the screen, if the observer is not in a precise position, he will see superimposed images which will make thie miage look garbled.
- Hence, movement is not compatible with this system, but it is very difficult for human beings to stay still for the length of a movie, for instance.
- It does not allow visualization of stereoscopic image for multiple viewers at the same time.
- Brightness is generally lower due to most of the light being occluded by the maks. However, a recent amelioration on this technique greatly improves brightness[LZWW14].

Multi-Projector Displays

This method consists in positioning several projectors in a circle. They all display the image under a different angle. The images are projected onto a special screen. For instance, a double lenticular lens example (a spherical lens) works well, but the easiest way is to project these images on a cylindrical fog, as in figure 3.6.

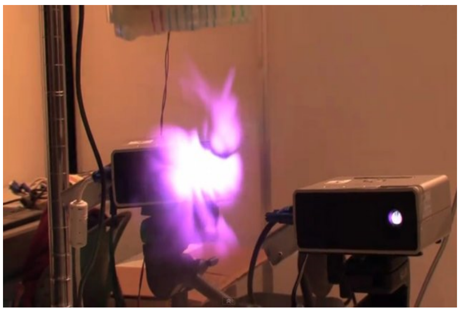

Figure 3.6: 3D multiviewpoint display[3Dm]

In this example, is possible to turn around the rabbit in 3 dimensions and view it from every angle.
This technique has some advantages :

- There is no limit of size for the projection, which makes it good for live performance.

However, it has important requirements :

- Multiple projectors are needed.
- Headlights must be precisely aligned.

Pepper's Ghost:

Pepper's ghost est une technique d'illusion d'optique utilisée dans le théâtre et dans certains tours de magie.
L'invention de cette illusion par un certain Henry Dircks remonte à 1862, il a crée un effet d'optique qui semblait faire apparaître et disparaître des fantômes sur scène.
La même année, John Henry Pepper, s'implique à son tour dans l'illusion après avoir vu le show de Henry Dircks. Pepper s'était rendu compte, qu'avec quelques modifications techniques, l'illusion pourrait être plus rentable pour les propriétaires de salles.
Le nom de cette méthode est tiré du nom de John Henry Pepper, qui a popularisé cet effet.
Par exemple dans le théâtre, cet illusion se produit en utilisant des plaques de verre et des effets d'éclairage. L'acteur qui incarne le fantôme ou l'apparition est placé dans une pièce sombre invisible du public (scène cachée). Le public peut alors voir le reflet de l'acteur. En raison de l'angle de la vitre, la réflexion semble apparaître en trois dimensions.

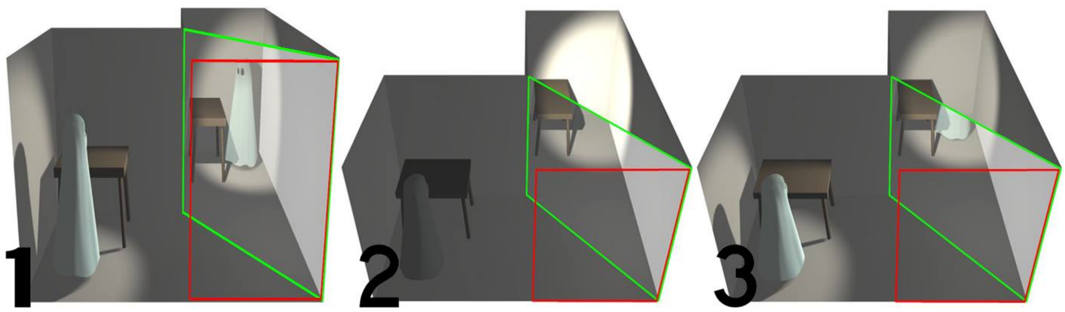

Figure 3.7: Pepper's ghost [Pep]

1- A viewer looking through the red rectangle sees a ghost floating next to the table. The illusion is created by a large piece of glass situated at an angle between viewer and scene (green outline). The glass reflects a room hidden from the viewer (left), sometimes called a "Blue Room," that is built as mirror-image of the scene.[Pep]
2- If the mirror-image room (left) is darkened, it does not reflect well in the glass. The empty room (top) is brightly lit, making it very visible to the viewer.[Pep]
3- When the lights in the mirror-image room are raised (with the empty room being dimmed slightly to compensate), the ghost appears out of nowhere.[Pep]

Aujourd'hui, la scène cachée est remplacée par un vidéo-projecteur, ce qui permet de faire apparaître des personnages ou encore des créatures imaginaires. Souvent, lorsqu'il est question d'hologrammes au théâtre, c'est du Pepper's Ghost dont il s'agit. Il semblerait que le numérique donne une nouvelle vie au Pepper's ghost.

Glasses

Head-mounted displays

Hologram

Autostereoscopic screen

Chapter 4

Presentation of 3D musical instruments

4.1 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, génèrent 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.

4.2 The DRILE

4.2.1 Livelooping

L'instrument Drile qui constitue une partie importante de notre étude, est basé sur la technique live-looping hiérarchique, il est donc bon de parler de cette technique.
Tout d'abord le live-looping classique est une technique qui consiste à enregistrer des échantillons audio ou de contrôle, et de lire cet enregistrement en boucle, en temps réel . L'idée de base de cette technique est de prendre (capturer) et de mettre en boucle, une partie d'une performance ou d'une chanson en temps réel puis de pouvoir jouer d'autres morceaux par dessus.
Le live-looping hiérarchique est plus adapté pour obtenir de bonnes structures musicales, il permet d'améliorer le live-looping classique en ajoutant une structure arborescente à ce dernier. Un arbre est composé de nœuds, de feuilles et d'enfants. Dans cette structure arborescente que propose le live-looping hiérarchique, les feuilles contiennent tout ce qui est audio et les nœuds des événements de contrôle. Pour les deux techniques, les effets qu'on peut ajouter à une composition musicale sont pratiquement identiques sauf que, pour les nœuds il y a en plus les effets de contrôle.
Il existe un ensemble d'opérations qui permet de manipuler ces arbres. La possibilité de fusionner ces différentes opérations, facilite la construction de structures musicales variées et complexes, contrairement à la technique live-looping classique.

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4.2.2 Piivert, a new controller

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4.2.3 Drile world

Objects

In order to use the hierarchical live looping technique, the Drile implements several objects. This world tries to take the best part of the graphical interface.

Worms
The first object is what we call a *worm* (figure). It is the representation of the nodes of the live-looping trees. They look like their associated analysed audio spectrum in order to ease the identification of each sound during a manipulation.

Those worms have graphical parameters such as color hue, size, transparency and so on. They are mapped to different audio effects parameters in such a way that modifying a worm's appearance would modify its audio effects. The current mapping are based on the result of a user study : size/volume, color hue/pitch, transparency/distortion, .. Moreover, the mapping is relative to each audio sample, so that each worms starts with the same appearance. To improve interaction a graphical parameter also gives the current value of the effect. The rotation of a worm on the y-axis provides information about the reading position of the associated audio.

Tunnels
Worms audio parameters and their associated graphical parameters can be modified by grab-

bing and sliding them through *tunnels*4.1. Each tunnel is used for one specific parameter modification.

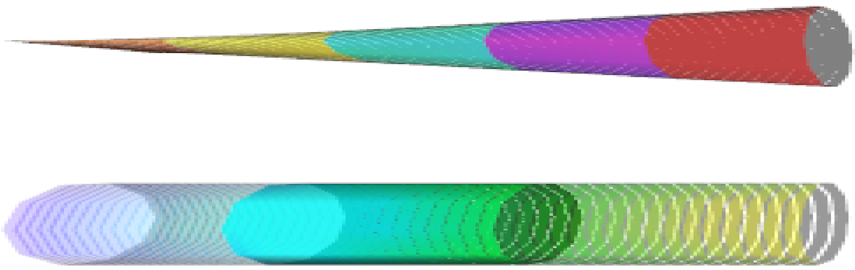

Figure 4.1: Tunnels

Hierarchy manipulation

As the size of worms is used to control node volume, manipulating worms through depth-axis would create perception problems. To settle that we use an *interaction plane* which is at a fixed distance and allows manipulation of Drile objects. Depth-manipulations are maintained for less accurate uses.

Live-looping trees are represented by connected worms organized by depth4.2. The closest level to the users is on the interaction plane. To access the different levels, the user can pull and push the tree using the Piivert.

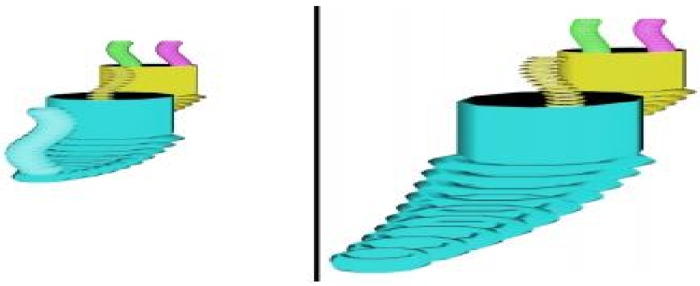

Figure 4.2: Tree nodes containing colored worms. Appendages represent tree edges

Also, the user can take advantage of the 3D world by grabbing one worm directly with the ray-casting and then manipulating it. This can be facilitated with the head-tracking technique which simulate the fact of moving aside in front of a real scene and then it becomes easier to access objects in the back of the scene. Common tree operations (merging, duplication, ..) are mapped to Piivert gestures that look natural to improve immersion. For example merging gesture is colliding two worms.

Scenes

During a performance, the user might want to use pre-built musical patterns, those ones are stored into *scenes*4.3. He might also want to translate playing nodes from one to another scene in the aim of doing a nice musical transition. The 3D environnement creates a good visual feedback of the scene content which can help the user to choose the right scene.

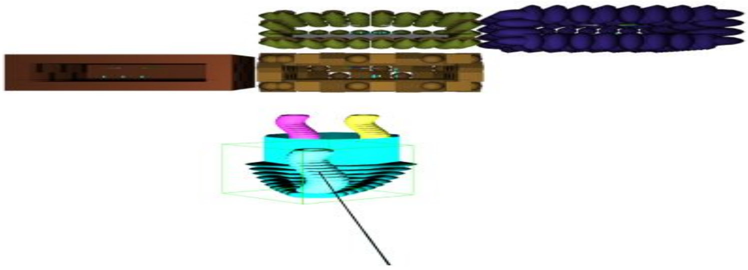

Figure 4.3: Scene selection for a worm translation

Collaboration

The Drile environnement is a multiple users interface as long as each user have one controller. The large display is also an advantage.

Evaluation of the instrument

The author used a dimension space representation **??** to evaluate his instrument according to [BFMW05]. We can see that the Drile environnement "grants" two important sides in this representation : first the Feedback Modalities axe especially with the 3D environnement and the Piivert controller, finally the Inter-Actors axe thanks to its multiple user interface and its large display.

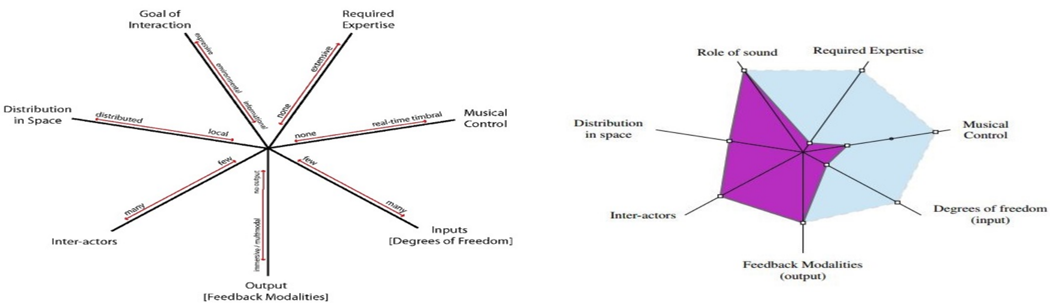

Figure 4.4: On the left the dimension space representation, on the right the Drile representation (in purple for beginner interface, in blue for complete control)

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4.3 Aerial Percussion

Chapter 5

Implementation

5.1 Objectives

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.

5.1.1 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.

5.1.2 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.

5.1.3 Customization

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

5.2 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.

5.2.1 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 3 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.

5.2.2 DRILE Implementation

Technologies used

Pictures

5.2.3 Aerial Percussion implementation

Technologies used

Displaying the data

Truc sur les angles

Pictures

Chapter 6

Conclusion

Penser à mettre perspectives

Glossary

accomodation the change of focus of the eyes in order to perceive clearly what is looked at. 9

atmospheric perspective the impression of depth given by the refraction of the air. For instance, we can say that mountains are far because they appear more blue than close mountains. 9

convergence when the eyes rotate to aim on the point in space a person focuses on. 9

display a visual output device for the presentation of images [PS12]. 10

kinetic depth the visual cues we have of an object in motion. 9

linear perspective the way our visual perception of objects are affected by their position and dimension. 9

live looping A REMPLIR. 5

motion parallax when two objects, one further from another, seem to translate at a different speed if the observer is moving. 9

occlusion when an object is hidden by another. 9

shading the gradient in color and shades that would appear due to the shape of objects and color, intensity, and direction of light. 9

stereoscopy the result of the human eyes receiving two different images. 9

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