PHYSMISM: RE-INTRODUCING PHYSICAL MODELLING FOR ELECTRONIC MUSICAL EXPLORATION

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ABSTRACT

In this paper we describe the design and implementation of the PHYSMISM: an interface for exploring the possibilities for improving the creative use of physical modelling sound synthesis.

Four different physical modelling techniques are implemented, to explore the implications of using and combining different techniques.

In order to evaluate the creative use of physical models, a test was performed using 11 experienced musicians as test subjects. Results show that the capability of combining the physical models and the use of a physical interface engaged the musicians in creative exploration of physical models.

1. INTRODUCTION

To synthesize sounds using physical models means to understand the physics of sound production mechanisms and simulate these using numerical algorithms. Physical modeling techniques provide the possibility to add new perspectives to the constant search for novel interesting sounds present in the world of electronic music.

Different physical modeling techniques have been researched for decades [5, 8, 2], but they have not been completely accepted in the performance and production of electronic music compared to many other synthesis techniques.

Only a few and not completely successful attempts have been implemented in commercial synthesizers. It appears that physical modeling techniques have been mostly used in the academic milieu.

In this paper, we are interested in investigating the reasons for the lack of use of physical models in electronic music production and performance. It seems necessary to re-introduce physical models by rethinking their role in the electronic music scene and the ways in which they can fill it.

After talking to different musician experts in electronic music, we realized that physical models have not been utilized to their full potential. This might be due to the lack of musically interesting implementations of the technique.

Most of the physical models we have encountered focus mainly on the interactive aspects of physical modelling or the ability to simulate an existing acoustic instrument as accurately as possible. If one were to only focus on the sonic qualities of a sound itself without being concerned with accurate simulation of physical mechanisms, would it be possible to further explore the musical potentials of physical models?

Many physical models have been created, emulating acoustic instruments and physical phenomena found in nature. A lot of characteristics of the natural instruments have now been captured and a diversity of physical models has been developed. Most of the physical models produce sound like an original acoustic instrument with the possibility to change the physical parameters and characteristics of the instruments. Would using these models to keep the characteristics of the existing instruments, but then merging them with something completely different, help to enhance the creative exploration of physical modelling?

In the early 60s the so-called modular synthesizers were...
introduced. These synthesizers gave the users the possibility to have full control of the sounds they produced and to combine the different parts of the synthesis techniques themselves instead of simply using a preset from the factory. Together with the synthesizers followed a variety of manuals concerning how to combine different oscillators, envelopes, filters and so forth, to reproduce existing sonorities such as bells or bird sounds. Several musicians used such synthesizers to simply reproduce sounds existing in nature, while others tried to create their own experimental sonorities. Some users followed the manuals, while others tried to experiment with the modules as part of a creative process. The output produced consisted of artificial electronic sounds far from the every day sounds or existing instruments.

The initial idea behind this research is that the same creative process could be achieved when exploring physical modelling sound synthesis.

In order to achieve this goal, the possibilities as well as the benefits and drawbacks of physical modelling synthesis have been explored and analyzed.

Parts of the work review in the analysis is presented in the following section.

1.1. Creative use of physical modelling

Most commonly used in compositions is the use of physical models to extend possibilities offered by traditional instruments. One of the pioneers of the use of physical models in compositions is David Jaffe. In his piece Silicon Valley Breakdown, premiered in Venice during the International Computer Music Conference 1982, a physical model of a plucked string implemented using the Karplus-Strong algorithm [6] is extended to reach unreal dimensions, such as the length of the Golden Gate bridge. Another pioneer in the use of physical models in creative applications is Chris Chafe. In [3], he reviewed the work of himself and other composers regarding this topic.

Paul Lansky also used physical models in his creations. In [3] it is described how he has enjoyed using the physical model of a flute by Perry Cook, using a 20 feet long tube with a diameter of 3 feet as the resonator in some of his pieces.

Other composers are using replica extended models to achieve abnormal excitation. An example is the piece Pipe Dream by Gary Scavone, written in 2003. In this piece, Scavone uses a physical model of a saxophone, over-blowing the excitation.

Other examples of creative and alternative use of physical models in compositions include hybrids of physical models, where composers combine different resonators or excitations. As an example, S-Trance-S by Matthew Bartner is a piece where a saxophone acts as a controller for a physical model of a string [1].

As another example, Voice of the Dragon by Juraj Kojs is a composition where physical singing tubes interact with virtual ones, simulated using physical models [7].

2. PHYSMISM

The PHYSMISM, shown in Figure 1, is an interface designed to investigate how physical models can be controlled and used creatively. Based on the review presented in the previous section, a set of goals for what the sound synthesizer should be able to implement, was proposed.

It can be difficult to present an electronic musician with everything physical modelling has to offer because of the complexity of the technique. A balance between simplifying the control of the models while still leaving room for creative exploration must be achieved. We are interested in making the controls simple enough to comprehend while still giving the user the feeling of endless possibilities. Furthermore we want to explore the implications of interacting physically with the models.

The goal of the sound synthesis engine is to implement many different physical models. They must be able to simulate real instruments, with the possibility to vary their parameters in order to make them extend limitations of the real world. Furthermore, we want to allow the possibility to use the same excitation device to control different models.

Finally, we are interested in combining different physical models in an intuitive way.

2.1. Implementation of physical models

In the PHYSMISM, each model chosen represents a difference in sound, technique, complexity, resonator, and exciter. This is mainly in order to show the diversity of physical models. For the current prototype the following physical models were chosen:

- A turbulence model, which implements a one dimensional waveguide [8] with a non-linear excitation [8].
- A stochastic model, which implements the PhISM model [4] having a randomized stochastic excitation.
- A friction model, based on one dimensional waveguides with a complex non-linear excitation, described in [7].

The models were written in C and compiled as Max/MSP externals in order to control and combine them inside the Max/MSP environment.

2.2. Mapping strategies

The users had the possibility to control four parameters related to the resonator. By limiting each model to having only four parameter controls the user is provided with a fast overview of each model thereby achieving control.

\[ \text{http://moogmusic.com/history.php} \]

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Table 1. A physical excitation device is created to suit the excitation of each of the physical models.

<table>
<thead>
<tr>
<th>Model</th>
<th>Excitation</th>
<th>Excitation device</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbulence</td>
<td>Blowing</td>
<td>Flute</td>
</tr>
<tr>
<td>Stochastic</td>
<td>Grinding</td>
<td>Crank</td>
</tr>
<tr>
<td>Friction</td>
<td>Rubbing</td>
<td>2D-slider</td>
</tr>
<tr>
<td>Impact</td>
<td>Hitting</td>
<td>Drum pads</td>
</tr>
</tbody>
</table>

The user was then able to combine each model with each other. This was done by taking the output sound from one model and using it as an input for another model, thereby creating the possibility of obtaining different hybrid models. In this way the second model is not excited by the energy from the user, but by the sound from the first model. This feature demanded some extra work concerning the implementation of the actual models. All the models needed a sound input. This sound input needed to have a significant impact on the sound produced, in order to avoid the effect of just adding the two models together.

3. HARDWARE INTERFACE

The PHYSMISM was implemented as a novel hardware synthesizer where the goal was to take advantage of what the physical models had to offer. This was achieved by creating a physical excitation device for each of the four physical models (See Table 1 and Figures 1 and 2).

Furthermore the PHYSMISM was equipped with two parameter control stations. The user was then able to assign whichever model he wanted to a control station and control the parameters of that model using the four dials (See Figure 2).

Finally, in order to let the user combine the models a patching system very similar to the old analogue modular synthesizers was implemented. The user was capable of patching two models together, one being the output, and one being the input model, using a patching cord to connect the models (See Figure 2).

4. THE PHYSMISM IN ACTION

A test of the PHYSMISM was conducted using 11 professional musicians. The test was conducted as a session where the subjects were free to explore the sonic capabilities of the PHYSMISM for approximately 30 minutes. After this the subjects were asked to fill in a questionnaire. During the whole test period, observations and additional comments from the test persons were annotated.

In general the subjects had very low expectations to the capabilities of physical modelling and were therefore quite impressed with the PHYSMISM. We noticed that subjects got easily adjusted to the physical interface, and appreciated especially the natural interactions it provided.

A problem observed with the turbulence and impact model was the high predictability of the sound produced, which contributed to make it uninteresting after a very short amount of time. On the other hand, models which created rather rich, unpredictable and complex sonorities like the friction model were appreciated by most of the test subjects.

Concerning the combination of the physical models, it was interesting to notice that many subjects expressed the fact that the predictable models became much more interesting when combined with other models. As an example, using the rich sonorities of the friction model as input device for the drum resonator, opened up several interesting novel sonic possibilities. Even the impact model and turbulence model, which were the two lowest rated models, became interesting when combined.

Based on the reviews made by the test subjects there is no doubt that where the PHYSMISM succeeds, is in its physicality and capability to combine the models. One could perhaps argue that combining the models simply produces more complex models. This is somewhat true. However, by presenting the users with the models separately and letting them do the combining/exploring gives them a better idea of what each parameter does while also giving them the creative freedom required.

Although some of the observations made by the test subjects were rather expected, it is nonetheless interesting for us to observe that they are shared by several musicians, regardless of their level of expertise with sound synthesis and physical models.

Table 2 provides an overview of the positive and negative elements of the PHYSMISM gathered from the test.

The PHYSMISM was presented at the Sonic Arts Research Centre (SARC), Queen’s University of Belfast as part of the meeting “Physical Models in Action”, December 2006. The application and interface were presented as part of a demo and poster session and later used to give a small concert at the Sonic lab. The feedback from the demo session was very positive. Especially it was noted that the PHYSMISM presented a fine combination of high accessibility of the physical models while still presenting creative explorative potential.
<table>
<thead>
<tr>
<th>Positive</th>
<th>Negative</th>
<th>Application</th>
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</thead>
<tbody>
<tr>
<td>Many parameters</td>
<td>Friction</td>
<td></td>
</tr>
<tr>
<td>Few parameters</td>
<td>Drum</td>
<td></td>
</tr>
<tr>
<td>Predictability</td>
<td>Friction</td>
<td></td>
</tr>
<tr>
<td>Unpredictability</td>
<td>Drum</td>
<td></td>
</tr>
<tr>
<td>Sonic Range</td>
<td>Friction</td>
<td></td>
</tr>
<tr>
<td>Sonic Range</td>
<td>Drum</td>
<td></td>
</tr>
<tr>
<td>Sonic Range</td>
<td>Flute</td>
<td></td>
</tr>
<tr>
<td>Low frequencies</td>
<td>Drum</td>
<td></td>
</tr>
<tr>
<td>Combined models</td>
<td>All models</td>
<td></td>
</tr>
<tr>
<td>Bi-manual control</td>
<td>Physical interface</td>
<td></td>
</tr>
<tr>
<td>Natural interaction</td>
<td>Physical interface</td>
<td></td>
</tr>
<tr>
<td>Clear interaction</td>
<td>Crank</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Summary of the positive and negative features of the different physical models as expressed by the test subjects.

5. CONCLUSION

The starting point of our research was the exploration of the possibilities for improving the creative use of physical modelling sound synthesis.

Based on a review of physical modelling a set of possible factors for improving the creative use of physical modelling was proposed and an application and interface, the PHYSMISM, was designed and implemented.

The PHYSMISM was created using four different physical models each implemented with its own excitation device. The models were each controlled using four parameter controls. Finally, in order to combine the models a patching system was implemented.

A test was performed with 11 different musicians, in order to evaluate the creative use of physical modelling. The test showed that especially the models with significant possibilities of variation of sonorities were desirable. Some of the models had an element of unpredictability and this seemed to enhance the creative use of the models and the application.

The effect of combining the physical models was also evaluated and it showed that some of the more simple and unpopular models, became much more interesting for the users when they were combined with other models.

It seems possible to use physical modelling much more in modern music production if the creative exploration of the models is enhanced. This sound synthesis technique has a lot of potential for creative use, and the musicians seemed much more positive towards the technique after having tried the PHYSMISM.

6. REFERENCES


