Developing block-movement, physical-model based objects for the Reactable

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ABSTRACT

This paper reports on a Short-Term Scientific Mission (STSM) sponsored by the Sonic Interaction Design (SID) European COST Action IC601.

Prototypes of objects for the novel instrument Reactable were developed, with the goal of studying sonification of movements on this platform using physical models. A physical model of frictional interactions between rubbed dry surfaces was used as an audio generation engine, which allowed development in two directions - a set of objects that affords motions similar to sliding, and a single object aiming to sonify contact friction sound. Informal evaluation was obtained from a Reactable expert user, regarding these sets of objects. Experiments with the objects were also performed - related to both audio filtering, and interfacing with other objects for the Reactable.

Keywords

Reactable, physical model, motion sonification, contact friction

1. INTRODUCTION

The Reactable [6, 7, 8], developed by the Music Techology Group at University Pompeu Fabra (UPF) in Barcelona, is a novel electronic instrument, whose user interface is projected on a tabletop surface. Users interact by moving and rotating objects placed on the table. In that sense the Reactable features a rich and specific interaction language, both from a tactile and a visual perspective. The Reactable is intended mostly for control of auditory devices typical in electronic music, such as sequencers, oscillators and LFOs. Each audio effect is represented by a physical object, marked with a unique fiducial pattern.

In this paper, we describe a research project performed during a short term scientific mission (STSM) visit of the first author to University Pompeu Fabra (UPF) in Barcelona, which took place in January 2008. During this visit, auditory feedback using physical models - that aims to add an 'acoustic' behavior to the motions performed during interaction with a Reactable - was investigated.

1.1 Reactable interaction language

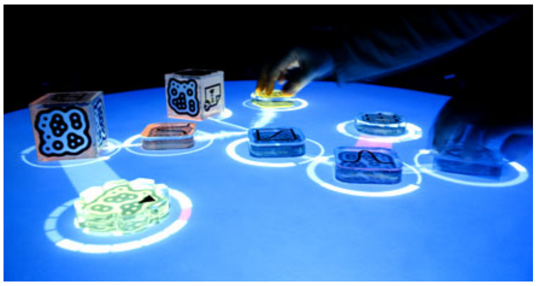

Figure 1: Interacting with a Reactable (from [9])

Typically, a Reactable user interacts and creates sounds by moving and rotating different types of objects on the table. Depending on the object types and their proximity to one another, so-called "links" are established between them, which determine the audio flow. Reactable objects have a physical representation (consisting of the object and the fiducial marker it carries) - and a corresponding visual representation (generated by the Reactable engine), projected on the table top itself, based on the position and orientation of the physical object's marker. There are many types of Reactable objects - some represent sequencers, others represent samplers, envelopes, LFOs and other typical electronic music sound creation devices. In essence, each object can be manipulated through its rotation, through a 'finger' parameter (which is set by pressing the finger on the table in a proximity of an object), and through its position on the table - this represents a main part of the interaction language of the Reactable. Although the "links" between objects are automatically established based on objects' proximity, by briefly touching two objects it is possible to establish a 'hard link' between them - which doesn't break if another object is brought in proximity.

As these motions usually change some parameter of an electronic music instrument device (like filter amount or a sequence number), typically slow but precise motions are required from the player. This is also represented in other modes of electronic music performance, where sound is continuously generated, and the player only changes certain parameters of the individual instrument devices. In that sense, the Reactable does not exhibit 'acoustic' behaviour in a physical sense; however, due to the tactile nature of the way to interact with it, one can easily imagine a related - physical - set of table and objects, made of a rough material. In this 'rough physical' case, gliding of the objects upon the table surface would produce a contact friction sound, which lasts as long as the objects are in motion. To create an analogy with the real world: assuming that objects and table are made of, say, wood - it is easy to conceptualize that to produce significant amount of sound from this system, would require both a significant amount of force, and specific motions, from the player. For the purposes of this paper, we will name such motions 'block movements'.

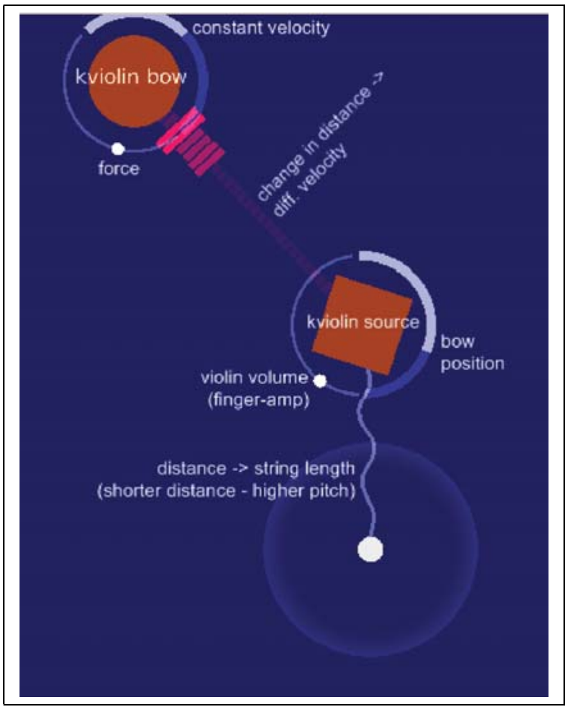

Figure 2: Reactable simulator showing the first proposal for a mapping strategy to connect the Reactable to the friction model.

2. METHODOLOGY

The work of developing objects that would demonstrate block motions on a Reactable, was made much easier by the efforts of the Reactable team, who provided a working and fully compatible standalone Reactable simulator for Windows, with an audio engine based in PureData (Pd) [10]. The simulator renders the visual representation of the Reactable objects on screen, and allows these representations to be manipulated through the GUI - as on a real Reactable. Patches developed on the simulator can then be ported and tested on a real Reactable. As it was relatively easy to build upon existing objects for inheritance of the user interaction, most of the work consisted of audio programming in Pd.

Since one of the defining high-level characteristics of block motion sound seems to be the relationship between sound volume and velocity of the objects on the table, it was decided that the main parameter obtained from the objects (besides the standard parameters), would be the velocity of the objects, which could then be mapped to a sound parameter. In principle, a contact friction sound is perceptually noisy, and thus it could be generated through variuos sources [1].

A Pure Data real-time implementation of a physical model of frictional interaction between dry surfaces was available, which has already been described in [12, 13, 11]. It was decided that this friction model could be used as a sound generator for contact friction - especially in those ranges where high forces and low velocities would be involved. Due to the limited duration of the STSM visit, only a design and implementation of a prototype object was initally planned, to be followed by an expert user evaluation.

2.1 Mapping between the Reactable and the friction model

Figure 2 shows the first proposal for the mapping strategy between the Reactable and the friction model, called 'kviolin' in this simulation. The screenshot was extracted from the Reactable simulator. In the first proposal, four parameters of the friction model (velocity and position of the excitation, amplitude and frequency of the resonator) were selected and controlled by objects of the Reactable. The object called "source" controls the amplitude of the sound using a finger, and the excitation position using the rotation of the object; while the distance of the object from the table center, is mapped to fundamental frequency of the friction model. Excitation velocity and force are kept constant. Upon adding the exciter object, it is possible to additionally control the exciter force and velocity. The exciter force is controlled through a finger parameter, whereas rotation of the object maps to a constant velocity.

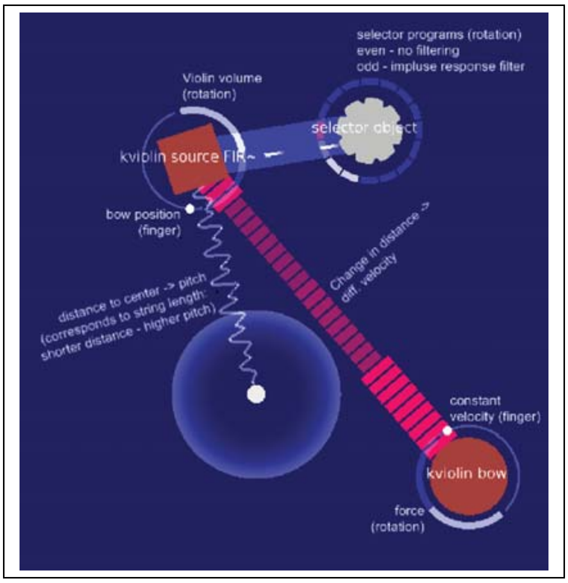

Figure 3: Reactable simulator showing the second proposal for a mapping strategy to connect the Reactable to the friction model.

This first proposal contradicted with common mapping strategies used in the Reactable, where frequency is related to rotation of an object. Moreover, the relatively slow camera used for tracking, created some differences in response between the simulator and the tangible interface. Therefore a second mapping strategy was investigated, as shown in Figure 3. In this second strategy, the parameters mapped in the exciter object were switched, the constant velocity was mapped to a finger parameter and force was mapped to rotation. The second prototype was further improved, to produce the strategy shown in Figure 4.

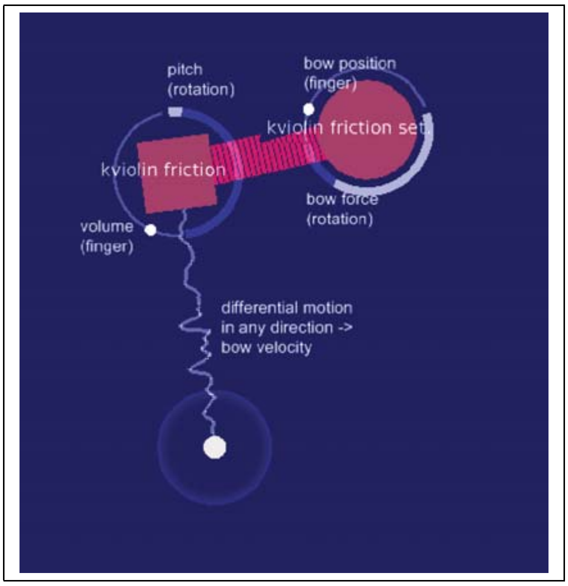

Figure 4: Reactable simulator showing the third proposal for a mapping strategy to connect the Reactable to the friction model.

The implementation of the SkipProof (a DJ scratching application and virtual turntable developed by Hansen and others at KTH [5]) engine as a set of DJ scratching objects for the Reactable [2] was also furthered. As interfacing between the friction physical model and the SkipProof engine was attempted as a part of a previous STSM visit [3], it was attempted again - this time as an experiment in the context of Reactable objects.

The original intent to develop a single block-motion object, changed soon after deciding to take upon the friction model as a sound engine base - as also in frictional interactions which happen in the real world, we can observe situations where several objects interact, but only one of them is the primary sound source.

Hence, the goal was extended with development of a prototype of a set of objects for the Reactable, where one would represent the interaction control, and the other would represent the source. As an analogy to bowed string instruments, we can consider these objects as a 'bow' interacting with a 'string'.

3. RESULTS

The main results of the study visit are the production of prototypes of two sets of Reactable objects, and their preliminary (and informal) evaluation by an expert Reactable user.

As a first set of experiments, we tried to emulate the sound of a bow exciting a violin string. The second set is a single object intended to simulate the sound of surface friction of moving objects in contact.

Additionally, video recordings were taken from some of the development tests; these, along with a development log, were posted online [4].

Figure 5: Friction objects for Reactable

4. DISCUSSION

4.1 Reactable as a development platform

As mentioned previously, as the Reactable (both real and simulator) has an interface to Pd, the easiest way to create additional audio capabilities for it, is by creating plugins for Pd. From a perspective of a new Reactable object developer, possibly the only glitch in the engine could be the current impossibility to set the so-called 'finger' parameters of Reactable objects directly from Pd (as it is possible with the 'rotation' parameter of the objects, for instance). Otherwise, it is relatively easy to develop the auditory behaviour of new objects using a Reactable simulator locally.

In our experiments we used a vision tracking system working at 60 fps. This created some problems with motion blur during fast motions. For future experiments, the motion blurring and low (in audio terms) 60 fps framerate must be taken into account - especially for objects that are to be moved in a faster, linear manner across the table. This proved to be a major difficulty in implementing a motion-based object, as for faster linear motions the system failed to detect the object, and the corresponding control signal used in audio was interrupted. Some measures were attemped to overcome this, which were not succesful - which finally resulted in the not-so-extatic evaluation of these Reactable object prototypes.

Here, the framerate issue had to be taken into account for both the exciter object, and the single friction object, whose average velocity of motion across the table was used to derive a bow velocity signal. For these objects, accumulation of signal values, undersampling and linear smoothing was attempted to overcome the sudden change of values (during video tracking blurring). This, however, didn't prove to be efficient; averaging and low pass filtering in audio signal domain, would possibly be a much better approach to overcome these problems. On the other hand, one can try and avoid linear motions when designing interaction, and replace them with rotatory ones - as was suggested by the expert user. Although, it is important to note that the Reactable team currently works on overcoming these problems with the vision input, and at some point in the future, such problems could become minor.

4.2 Problems with the friction model

The first experiment was performed in order to try to tune the friction model to simulate the most common musical instrument driven by friction, i.e., a bow interacting with a string. The same can be extended to applying independent control signals to change the friction model parameters. For instance, in the case of the controller/source set of objects, the friction model can be understood as a crude bowed string model - and the corresponding parameters involved (such as force or velocity), could be understood as a "bow force" or "bow velocity". Initially, one can apply independent signal sources for "bow force" and "bow velocity", but this will not necesarilly produce a physically realistic (or pleasant) sound - as the change of these variables in reality may be coupled (for instance, change of bow force may be coupled to change of bow velocity - as pointed out by both research [12], and expert user evaluation). So, regarding the issue of finding auditorily pleasant parameter values of the friction model, understood as a bowed string (i.e. a violin bow) model - it may be a better approach to acquire recordings of control signals from a real-life source (like a violin) first, which are certain to drive the physical model in a predictable range of attractive sonic output; and then use these as a base for further development of both a friction sound source object, and for an independent controller object for a Reactable. This approach could be extended to any kind of interface that might be applied to a friction physical model - and with the usage of a proper physical model, one could ultimately extend the set of friction Reactable objects, to become a proper set of physical violin controller objects. For example, results described in [13] show that a precise augmented bow interface is an ideal controller for a bowed string physical model.

5. EXPERT USER EVALUATION

The comments collected during the informal expert user interview can be summarized as follows. Usage of a friction model in the Reactable could be interesting, but, before that, some improvements to the sound quality and control of the friction model are needed. The concept of dual objects is found interesting, beyond the notion of a controller - it has been suggested that an exciter object is made, that could similarly change parameters of any Reactable object. The concept of a single, movement-driven, friction object has not been found particularly interesting, and it does not necessarily require a physical model as an underlying sound engine.

So, in spite of some technical problems experienced during prototyping, , there are indications that objects that provide sonification of block movement in the context of the Reactable system, could potentially be a usable musical expression tool (provided the technical problems are overcome).

6. ACKNOWLEDGMENTS

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