The Virtual Bodhran – The Vodhran

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Abstract
This paper introduces a subtle interface, which evolved from the design of an alternative gestural controller in the development of a performance interface. The conceptual idea used is based on that of the traditional *Bodhran* instrument, an Irish frame drum. The design process was user-centered and involved professional *Bodhran* players and through prototyping and user-testing the resulting *Vodhran* emerged.

Keywords
Virtual instrument, sound modeling, gesture, user-centered design

INTRODUCTION
In order to have a successful interface it is widely known that it is preferred to employ a metaphor that the end user of the artefact is familiar with. Our overall goal though is not a perfect imitation of the *Bodhran* sound, but to produce a practically functioning expressive sound object, inspired by the *Bodhran* and in particular its playing techniques.

Description of how the *Bodhran* is played
Sound is produced in response to the beater (stick) impacting on the skin (membrane), executed by the right hand. The beater is held loosely in the hand and is controlled primarily by wrist action (rotation). Contact with the *Bodhran* is made with alternative ends of the beater in rapid succession. The sound is modulated/dampened by the use of pressure placed on the inside of the *Bodhran* by the left hand. A variety of different techniques are employed by musicians in the production of a damping factor, ranging from a discrete application of pressure at a point, to a complex manoeuvre involving continuous control achieved by movement of the beater in counter direction to the right hand to achieve a dynamic/colourful range in pitch and timbre (see Figure 1).

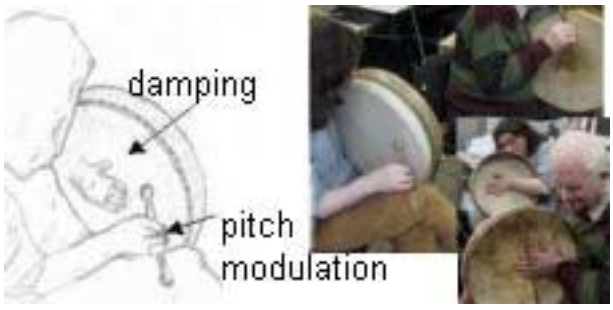

Figure 1 Traditional *Bodhran*

DEVELOPMENT OF THE *VODHRAN*
The development of the system requires a mapping between performers gesture and a sound object model of a *Bodhran*. The sound model for the *Vodhran* was developed as a mathematical model of a skin, which is excited by the beater. The model is implemented in PureData (Pd)[1] for Linux. It is a real-time sound model and it works in conjunction with Polhemus Fastrak motion tracking sensors. The development and implementation of the virtual instrument is leveraged from an existing instrument. [1]

Sound Development
The sound generation mechanism for the *Vodhran* is based on the modal description of the drum and a robust numerical solution of a non-linear stick-membrane interaction model. This approach aims at an integrated "sound object", including different forms of a player's interaction, rather than perfectly realistic reproduction of isolated signals. The technique of modal synthesis [2] forms a well-suited basis for our efforts for several reasons [3]. For example the implementation requires convincing results even under preferably low computational cost; dynamic interactions beating/damping must be provided and synthesis parameters should be comfortably estimable under physical and perceptual specifications as e.g. tuning or intensity of damping.

Motion tracking/Sensor software
The Polhemus Fastrak tracking device[2] was utilised to capture performer gestures. The sound engine for the *Vodhran* is implemented as a module for real time sound processing software "PD". The software imported into the Pd model as an external object is implemented in C, and consists of two layers. The first layer is a driver layer, which interfaces directly with the Fastrak device, and extracts the primary information about the position of the receivers. This information is then sent to the second layer, which extracts the key features from the data, such as the current position of the end of the beater rela-

[1] Pure Data http://www.pure-data.org/

[2] This device tracks the position of up to four receivers in 3d space, relative to a fixed transmitter device. Each sensor provides six degrees of freedom (X,Y,Z position, and Azimuth, Elevation and Roll)

tive to the transmitter, or the velocity of the strike. Pd then reads the information from the Fastrak device as often as is needed to manipulate the model[3]. This is perfectly acceptable even for this sensitive practical realization of a percussion instrument; latencies of sound cards/drivers and gesture control systems are much more problematic. The Fastrak system itself works at a rate of 120 Hz, which is divided among the receivers, in this case giving a rate of 60Hz per receiver. This means that each receiver's position is updated every 16ms, which may well be too slow for this application, and a new or modified system may have to be developed. The driver and interface software have been optimised to allow the system to run at the same rate as the hardware, thus tying the latency to the hardware's refresh rate.

WORKSHOP

Formal analysis, user-centered development

In order to establish the requirements for the system, in terms of usability, methods of interaction and sound quality, a daylong workshop was held. Three expert *Bodhran* players, each with their own different styles and techniques participated. The players had varying amounts of experience in the use of technology in performance. The players were asked to perform different traditional rhythms with the sensor attached to the beater and the results were recorded along with video data in order to further analyse the gestural patterns involved in *Bodhran* playing. The results of the analysis of this data will be used to determine any common movements, gestures, or techniques that are used by the players, so that the control parameters of the model may be extended in order to allow more interaction for the players.

The musicians' initial impression of the *Vodhran* was positive. Players were asked to comment on the degree of deliberate musical control in terms of control selection and sensitivity. Aspects such as its playability, responsiveness, usability, control and intensity of interaction were also discussed.

The players were impressed with the *Vodhran* in terms of its degree of realism and the quality of sound. Regarding interaction, players were initially perturbed by the absence of haptic feedback, but they quickly became accustomed to the novel interface. The players instinctively used their left hand as a frame of reference, which aided their location of the virtual membrane in space. The musicians also used their body as a frame of reference, with some comments on the value of keeping their eyes shut while playing the *Vodhran*. This internal visualisation technique is similar to techniques used by athletes for limb awareness, when refining their movements. Musicians are noted for bodily-kinaesthetic intelligence.

EXTENSIONS TO THE *VODHRAN* MODEL

Another point that was raised by this workshop was that of a frame of reference for the instrument. Currently, the system uses a fixed reference point, which does not move with the player. To meet this requirement, the system must allow the players to move naturally, as they would while playing the real instrument. This would allow players to use their full range of movement. To enable this, the frame of reference for the system needs to move with the player. If they turn or lean as they play, which most players seem to do, the system continues to function, in its new frame of reference.

An extension to the model is the amount of movement allowed by the skin. The performer can now adjust the virtual instrument to control the elasticity of the material of the *Vodhran* "skin" and its transparency and resolution.

The current mode of interaction with a physical instrument is retained, but it was found there is a need to modify model activation parameters as the embodiment of the interface is hard to pinpoint.

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[3] F. Avanzini, M. Rath, and D. Rocchesso, "Physically-based audio rendering of contact," in (ICME-O2), Lausanne, Aug. 2002, Available at http://www.soundobject.org.

[3] At present control messages (as incoming user "commands") are handled with the temporal precision of an "audio buffer" length; practical values for the PD internal buffer size are e.g. 32 or 64 samples, providing a temporal accuracy of approximately 0.75ms or 1.5ms.