BoxVox

The Beauty of Sound

New electronic and digital technology enables unprecedented types of instruments, musical expressions and artistic performances. Using computing power as a key ingredient allows us to explore new expressions and interaction possibilities beyond traditional acoustic instruments.

The goal of this project was to explore the creation of a new instrument that is aesthetic in visual, acoustic and interactive expression and also suits to the the tradition of acoustic instruments.

The BoxVox targets amateur and professional musicians with an experimental lust. It should be able to be a centre-stage act as well as a supporting instrument. Its novelty comes not from its role or sound, but instead from its interaction and holistic expression. The BoxVox puts the artist into the role of the creator of a multi-sensory performance. The worshipping, full-body movement gives the performer the feeling of shaping the music with the own body and spellbind the audience through an acoustic and visual experience.

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1. Introduction

We believe that artistic expression trough music is an interesting area for interaction design since it conveys an emotional message by different channels such as sound, visual appearance and choreography. Thanks to the advancements of digital technology, sound generation and interaction do not need to be couple so tightly which gives the possibility to create new forms of performance. Starting off with the Theremin, a new breed of instruments, sound generators and beat-boxes has developed. In the same experimental spirit, the BoxVox was created to be suitable for on-stage use and also band playing by its control, interaction and suitable holistic experience. Instead of using new possibilities just for the sake of it, we wanted to use them meaningfully. This is why we wanted to create an avant-garde instrument for musicians with an experimental lust.

The project was carried out in spring 2006 as a part of a ten weeks project course in interaction design at the IT-University of Gothenburg. The focus of the course was to explore expression and gestalt in relation to interaction design of digital devices.

2. The Creators

• **Gustaf Carlberg** had been studying media engineering at Luleå University of Technology (Sweden) before joining the Human Computer Interaction and Interaction Design programme at the ITU of Gothenburg (Sweden). With experience in web design and sound editing, he was strongly involved in creating the concept of the BoxVox. Thanks to his creative spirit and strong ambition he by now finished his Master's studies and works as an interaction designer.

• **Jon Bernhold Olsen** joined the ranks of the ITU of Gothenburg after his initial studies of computer and multimedia technology at Gjøvik University College (Norway). His professional design skills and strong interest in music were strong driving forces behind the BoxVox and also made him the musicians' representative. After finishing the laborious lacquering of the BoxVox he wrote his Master's thesis recently and now works as an interaction designer.

• **Wolfgang Mähr** first studied software engineering at the Vorarlberg University of Applied Sciences (Austria) when discovering his interest for usability and smooth interaction. that was to be satisfied at the ITU of Gothenburg. Analytical problem solving and ambition were his major contributions to the project resulting in the interior and exterior of the BoxVox. He is currently finishing off his Master's degree and hopes to work on interaction beyond computer screens.

• **Björn Östlund** is an IT student at Chalmers University of Technology (Sweden) and was the main developer of the Java and MIDI software.

• **Robin Söderström** studied computer science at Gothenburg University (Sweden) with interaction design as speciality and recently graduated. He was working on the electronics including sensors, lights and micro-controllers.

3. Description of the BoxVox

Technically speaking, the BoxVox is a shiny, polished, black cube of 40 cm edge length made of wood and standing on rubber stoppers (see Figures 1-4). The corners and edges are rounded, the sensor and light fittings are embedded in two opposing sides and the top. These fittings hold two sets of LED halogen lights and a pair of silver ultrasound sensors. One side we regard as the front, features a standard ungrounded female power connector and a 6.3 millimetre female stereo audio jack for sound output to an amplifier.

Figure 1: The cube.

Figure 2: The fittings.

Figure 3: The plugs.

Figure 4: The surface.

The connoisseur should immediately recognise the BoxVox as a musical instrument. Unlike many other experimental instruments, the BoxVox puts an emphasis on the holistic experience and does not attempt to explore fancy technology just for the sake of it. We wanted it to be mystical but tameable and predictable so that it could be used as an instrument and not as a sound generator. Especially for the use on-stage not only the level of control but the quality of the interaction and choreography have to be suitably intriguing.

3.1 The Sound

The sound is a key characteristic of an instrument and we therefore base all decisions on the sound. The design of the sound was done with the help of characteristics that were elaborated in a process involving artists. After a preliminary sound was decided, the rest of the instrument was developed and finally the sound was fine-tuned to fit the overall look and feel. We would describe the sound as "murky" and like a "dark church organ", which goes well together with the mysticism of the physical cube, the organic pulsing of the light and the worshipping interaction.

Sound Design

Finding a good and interesting sound for a new instrument is a challenge. There are no limits to creativity and the possible characters of a sound can be unlimited. To help narrowing down the degrees of freedom we decided to set up contradicting attribute pairs to describe the intended sound as a foundation for the sound design. These 44 pairs ranged from basic sound attributes (heavy - light, cold - warm, ...) over more metaphorical pairs (Kiruna - Ibiza, wood - metal, ...) to far-off attribute pairs (brass-knuckles - baseball-bat, Paris Hilton - Dalai Lama, ...). As group we picked one attribute in each pair and balanced the vote with the input from music related experts (musicians, audiophiles, instrument and sound sales personnel). Based on these ratings we compiled following description of the sound:

1. predictable, organic
2. warm, harmonious, powerful with beat
3. thick, melancholic, dynamic, intellectual, continuous, complex, raw, rhythmic, spread

Some pairs had no clear preference such as the pairs of hard versus soft and rhythmic versus irregular. We used these pairs to define the third dimension, which can be changed dynamically while playing. Then, we created different sounds and tweaked them until we found them representing the terms named above

Finally we settled with the software synth using two oscillators, one for a strong, low sine wave for a base octave and one oscillator two octaves higher creating a saw waveform. The sound range is two octaves and the mixing is slightly in favour of the bass while the higher portion still provides a clearer edge without breaking the balance. Chords can be played as well as the top sensor can be used to control a roaring effect. It also registers higher tempo playing and modifies the sound accordingly into a more distorted and dispersed sound with a pronounced metallic edge.

Acoustic Expression

The BoxVox can also be seen as a comment on the discussion about what is a musical instrument, and what is not. Using a software synthesiser and MIDI on the inside, one can argue that the BoxVox is no instrument but merely an input device. However, was the it not only built to resemble classic musical instruments like pianos and guitars but also, but also would not any sound suit to its overall expression. With the BoxVox we emphasise that there is more to an instrument than only its sound. Not the question whether the sound can be modified by acoustically (i.e. sordinos, etc.) or electronically (i.e. amplifiers, effect pedals, etc.) distinguishes musical instruments from simple input devices and sound generators, but the holistic expression and its support of the performer conveying emotions.

Temporal Aspects of the Sound

One advantage of the software synth is that it gives more flexibility such as changes over time depending on different variables. Software based instruments can easily use program logic to manipulate the sound outcome. For us, changes depending on playing style gave interesting expectations and again finding the balance of using the possibilities without being contra-productive was the challenge. An excess usage of complex program logic could create an instrument that has a will of its own and cannot be mastered anymore. Supporting the performer creating sentiments but giving a challenge of an instrument with attitude requires more subtle changes.

3.2 Visual Expression

The look of a an instrument is crucial, it conveys interaction cues, affordances and supports the overall expression. The shape was created by brain- and body-stormings, prototyped in clay, polystyrene and wood and evaluated in relation to the sound and its descriptive terms. The goal was to create an interesting interaction and a shape supporting this. Unfortunately we also got limited by our production capabilities, which made more complex shapes not doable. We decided that the cube would not only be a shape we can produce, but it also well represents the mystique metaphor since it is a special, harmonious and super-natural shape. This feeling was even more supported by the pulsing lights and the choreography of bowing and worshipping. Its size and shape should also be comfortable to play and the symmetry allows the musician to use in any direction wanted.

Colouring and Surface

Initially we planned to use thermochromatic colour adding mysticism by slightly changing the texture on of the BoxVox in the course of interaction. Since we could not achieve the wanted glossy lacquering quality with the thermochromatic colour, we had to use classic spray cans. The final result are 18 layers of colour and lacquer creating a glossy black surface that resembles the piano but still make the wood recognisable underneath.

Illumination

The BoxVox uses LED lamps for visual effects, atmosphere and feedback (see Figure 2). The interaction fields are marked by lights and on the bottom there is a pulsing glow. The lights next to the sensors spread a visual atmosphere and provide visual feedback for the position of the hand. The closer the hand gets to the BoxVox, the stronger the light, while with the head control this behaviour is reversed. The lights go off when the performer leaves the interaction field and no music is played, giving valuable feedback. The bottom lights are positioned to be not visible for the normal observer. They provide a pulsing brightness contrasting to the blackness of the cube, giving the cube an organic touch.

3.3 Tactile Expression, Material and Surface

The material and tactile expression is important for the artist. Traditionally, most instruments are made of hard materials like wood, metal and plastic. We wanted to stay in this tradition and give a solid but organic feeling, which wood is perfectly suitable for. It feels more solid and natural than plastic and flake board and can be handled well. The extensive lacquering emphasises the solidness and seriousness of the instruments while not denying the material. This should bridge the gap between traditional acoustic instruments and digital instruments.

3.4 Performance Expression

The interaction with the instrument is one of the core aspects of the BoxVox and was created in carious brain- and body-storming sessions together with the shape (see Figure 5-7). The goal was to create a meaningful metaphorical interaction that also works for creating music. Having only two dimensions of sound (volume and pitch) would decrease the versatility of the instrument which is why we decided to add an extra dimension that had to be controlled. The hands and head movements seemed natural and controllable to us, which is why we decided for the resulting interaction metaphor of “praising a mystical object”. The BoxVox plays along these lines of supernatural objects are not to be touched, nor to be looked at. The surface invites touching, but does not have any results except of greasy fingerprints. The head needs to bow to control the vibrato, but the light discourages direct looking into the fittings.

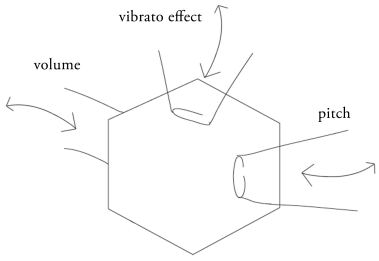

Figure 5: Interaction fields.

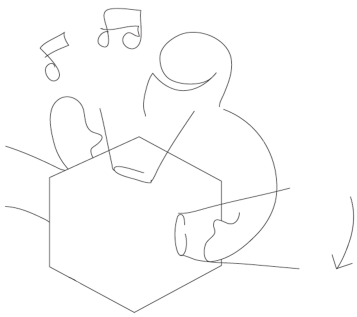

Figure 6: Playing chords.

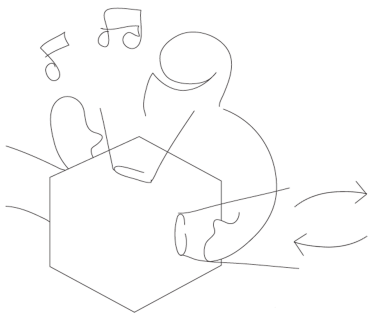

Figure 7: Aggressive playing.

All three interaction fields steer one sound property each. Moving the hand closer in the 30cm volume field raises the volume, removing it mutes the BoxVox. The pitch can be controlled by the other hand in the 30cm interaction field with the high pitch close to the instrument. Removing the hand straight out of the field will freeze the pitch to free the hand. Moving the hand across this field will produce a chord with its spread being controlled by the speed of movement. The head controls a vibrato effect that increases the closer an object is moved to the BoxVox

4. Performer and Audience Impressions

An instrument must find the balance between being difficult and simple to play. Too simple will give no challenge while too difficult frustrates the student. We believe that the BoxVox does a good job in enabling the performer to create a great experience. Not limiting the performer on specific movements but allowing all body movements is an important factor for this.

The BoxVox project was displayed to the public for a week in the *Stadsmuseet* in Gothenburg (Sweden) as part of the course curriculum. During that time, members of the group frequented the exhibition and collected user feedback through various methods. While the common observation was that the visitors first needed some time to discover what to do with this black cube (since only holding the hand in front of one sensor will not result in any reaction), they then quickly started exploring the instrument mostly focussing on the manual interaction. Often people commented on the value of the light feedback when starting to play. During the whole exhibition we could also observe three prominent interaction styles:

- *Aggressive noise interaction*. These visitors were obviously appealed by the BoxVox ability to create brutal noise. With maximum volume, frenetic head movements fuelling the vibrato and jerky pitch adjustments these visitors gave a performance with an expression suitable for an industrial synth band.

- *Melancholic chord interaction*. These users searched for harmonics by taking gentle chords. The vibrato was not used to the same extent as in the previously described interaction style and when used, it was with the hand. These performances gave a concentrated impression with large and controlled gestures.

- *Interaction in pairs*. Several visitors decided to try out the BoxVox in pairs, one person controlling the volume and the other the pitch. We don't know whether the reason for interaction style were due to democratic tendencies in the crowded exhibition or because of the BoxVox' characteristics. Still, the performances in pairs, with one person on each side, seemed to be effective but not as serious as the two other interaction styles we identified.

The BoxVox was also presented to one experienced musician, who has experience in playing the Theremin and had been involved in several experimental music projects. He gave valuable feedback on the BoxVox saying that he liked its looks, shape and controls. He only would have preferred larger fields of interaction since the two octaves on 30 cm required him to be very precise. The touch of the BoxVox was different to anything else he ever tried before and would need some training but would be interesting and give new possibilities.

5. Technical Description

All construction was designed to avoid excess use of energy and space. In fact, one critical task was to build the whole instrument hiding the computer inside. The musician should not need feel to have a computer but simply have an instrument that works. Having some start-up time therefore was already regarded as problematic but unavoidable. Similarly disappointing were the different sensors initially tested. While we first aimed for multi-dimensional sensors based on capacitance measurement and Doppler radar due to their flexibility, problems with information processing forced us to abandon them for one-dimensional sensors.

5.1 Construction

The construction of the BoxVox can be seen in Figures 8 to 11. Its main difficulty was to create an aesthetic shape and surface while still fitting all components into the system and making these accessible. The resulting wooden cube fulfils this task well. The bottom board is on rubber stoppers

and has a hole in the middle to enable airflow cooling the computer. The top part (top and side walls) can quickly be detached since they are held by magnet locks. The front side houses the two connectors for power and sound.

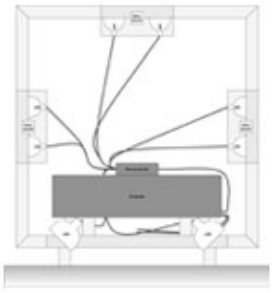

Figure 8: The inside.

Figure 9: The outside.

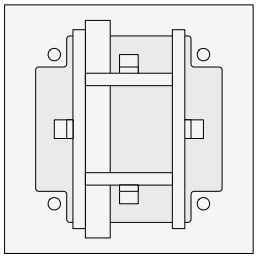

Figure 10: The underside.

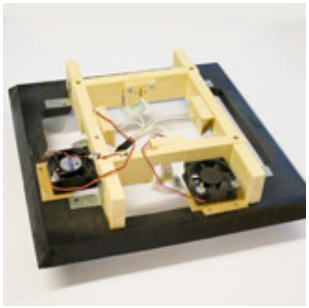

Figure 11: Bottom frame.

On the inside, the microcomputer is fastened on the wooden frame just like the lower lights and two fans for air-flow on the inside. There are also an electricity hub with two adapters, the micro-computer, the MIDI/USB transformer and the other sensors and micro-controllers inside. The sensors and the lights are fixed to the side walls.

5.2 Electronics

The three ultrasonic sensors provide range data that is scaled and packed by a BasicX-24 (BX-24) processor into MIDI data and sent to an mini computer integrated in the BoxVox. The effect (top) sensor is a Devantech FSR05 and the two others are Devantech FSR04. They are polled around 20 times per second, which is enough to provide realtime feedback to the user, but a less than we had intended. Four sets of lights are dimmed according to range measurements of the corresponding ultrasound sensor. The dimming is done by Pulse Width Modulation (PWM)turning the lights on and off rapidly. As the BX-24 only contains two PWM hardware pins, an extra slave BX-24 controls the remaining two lights. The master BX-24 also packages the sensor data into MIDI messages and sends them to the VIA Mini-ITX based computer. This computer runs a mediator software for MIDI processing and forwarding the MIDI data to a software synth creating the sound. This computer is a low-heat system with a VIA C3 processor clocked at 933 MHz and with 512 MB of RAM. It runs a full featured software synthesiser (Propellerhead's Reason 2.0) and the Java based MIDI processing application. The sound is put on the female sound output and can then either be fed into headphones, an amplifier or effect pedals and finally into a loudspeaker.

6. Conclusion

Wanderley (2001) wrote “Instrumentalists simultaneously execute various types of gestures during performance. Some of them are necessary for the production of sound, others may not be clearly related to sound production, but are nevertheless present in most highly-skilled instrumentalists’ performances.” Our goal with the BoxVox was to encourage an interesting interaction while not locking the performer into a specific way of using the instrument. The musician is free to explore own movements, gestures and postures to perform the own, cool choreography. Since the BoxVox is, just like the Theremin, a no-touch instrument, it shares the difficulty of control. The performer needs to have good spatial abilities to master it, but in case of the BoxVox the lights also help on this task. This supports progression through practice but still gives a challenge of learning. This challenge is enhanced by the chords and adaptive sound thanks to computational power. Such features differ the BoxVox from the Theremin but also traditional musical instruments.

Our goal was to build a new instrument that fits into the tradition of musical instruments but still gives more possibilities with light, sound and interaction. We created an instrument that is aesthetic in all three dimensions and that creates a suitable holistic expression by the combination of those. The BoxVox aims for supporting creativity in terms of the creation of harmonies, disharmonies, choreography and precise pauses. Here, the BoxVox truly distinguishes itself from many newer experimental music instruments. However, in the end, the inner workings of an instrument are less important than its sound, image, feeling, expressiveness, control and appearance that create the total experience. The combination of these factors works well for the BoxVox which is why we remain satisfied with this prototype of a novel instrument in the heritage of both, the Theremin but also the piano.

Wanderley, M. (2001): *Gestural Control of Music*. International Workshop Human Supervision and Control in Engineering and Music, Kassel, Germany. Available at (last checked 2006-05-20): http://recherche.ircam.fr/equipes/analyse-synthese/wanderle/Gestes/Externe/kassel.pdf