A Structured Instrument Design Approach: The Video-Organ

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Abstract

The Video-Organ is an instrument for the live performance of audio-visual material. To design an interface we apply a modular approach, in an attempt to split up the complex task of finding physical interfaces and mappings to control sound and video as generated by the computer. Generally, most modules, or *instrumentlets* as they are called, consist of a human interface element mapped to a certain effect. To describe the instrumentlets a design space is used consisting of the parameters degrees of freedom, range and precision. This paper is addressing the notion that traditional approaches to composition are challenged and changed in this situation, where the material is both audio and visual, and where the design and development of an instrument becomes involved in the process of performing and composing.

INTRODUCTION

To develop a new instrument form from the ground up is not an easy task [5]. In the case of traditional instruments the shape and form factors of an instrument have always been dictated by the physical process to be controlled, ie. a vibrating string. The virtue of electronic instruments is at the same time the problem: their total freedom to be shaped in any form. It is only obvious to take human factors as a starting point, which calls for analysis and study of human motion and intent. Especially when attempting to include the latter, human intent which in this case can be called 'composition' or at least 'inspiration', the issue gets notoriously difficult and is usually unknowingly avoided. In this paper we present a modular design approach, which attempts to deal with the complexity by breaking down the problem into smaller bits.

Interaction can be defined as 'mutually influential', that is, both partners in the discourse (whether machine or human) will have changed state, frame of mind, views, after the interaction. Most interactions with computer systems however are merely *reactive*, including so called interactive art works. On the other extreme, computers offer many possibilities to generate a world of their own under only minimal control or influence of the user, and many installation art works and instruments are based on this. In order to make a truly interactive instrument, it seems to be necessary to take a step back and develop the necessary -reactive?- groundwork which will provide a base for building up a more balanced, truly interactive level of discourse between human (whether performer, composer, or audience) and the art work.

Over the last one and a half years the authors have collaborated on the development of the 'video-organ' - a flexible instrument for the live performance of image and sound. The aim is to create a gestural performance interface to enable speed, direction and combinations of image and sound to be controlled live - film-maker Andrei Tarkovsky writes 'time becomes the very foundation of cinema: as sound is in music, colour in painting, character in drama' [17]. The development of a tool for live video performance takes this time based medium to another level, incorporating a dynamic interpretation of space as discussed in the secion on 'elastic narrative' below. Several performances with the video-organ, as described in this paper have helped us to assess the reasons, problems and benefits behind the move towards performance and the live possibilities of video and sound placed in space.

Figure 1: Part of the Video-Organ control surface

BACKGROUND

Using the computer as a tool to play, edit and even synthesise image material is becoming increasingly possible with the current state of processor power, memory sizes and encoding / decoding algorithms. Video editing is now catching up with audio editing and computer music, however the real time or performance setting of video, although increasingly common, lacks a tradition of live performance. An interesting analogy can be made with tape-music: electronic music was for decades a purely non-performance idiom. Technological developments in the eighties helped the re-discovery of live performance for electronic music by pioneers such as Michel Waisvisz with The Hands or the electronic glove of Laetitia Sonami, and a similar transition seems imminent in video art. VJ's in popular (club) culture are pioneering this issue, and other initiatives often come from the field of electronic music, for instance the Image/ine software developed at STEIM (Studio for Electro-Instrumental Music in Amsterdam), rather than from the field of video-art.

There appears to be a close relationship between techno-logical developments and the activity of bringing together music and visual art. At the end of the 19th century when electricity became more widespread 'colour organs' were developed by the inventor A. W. Rimington as well as the well known example of Scriabin's "Prometheus" [15]. In the 1920s to 1940s several instruments were developed by people like Thomas Wilfred, Kurt Schwitters and Oskar Fischinger, who came from a film background - it was also an active period of abstract films by for example Hans Richter and painters influenced by music as can be seen in the works of Wassily Kandinsky or Paul Klee. Currently, the rapid pace of development of digital technologies play a role in the intensified interest in the relationship between the visual and the auditory. Dick Raaijmakers [16] traces a technological and artistic progression over the last century towards a *morphological* view of the previously distinct disciplines of music (electronic sound), image (photography) and architecture (liquid).

The Video-Organ is using sampled image and sound material (one could call this *video concrète*), rather than synthesising such as in the case of colour organs from the Ocular Harpsichord built around 1730 to more current work such as the Dichromacord [8]. Although different from the Video-Organ, these interesting cases investigate the relationship between tonality in sound and the colour spectrum of light, pitch/timbre/envelope versus colour/hue/shape.

With an instrument as described in this paper, it becomes apparent that the previously distinct acts of composition, performance, music, video, conflate into one. Moreover, we assert that the actual building of the elements of the instrument become an important part of the compositorial process. This notion becomes increasingly common in this field [2]

APPROACH

To handle the complex situation of performing and composing with audio-visual material we employ a structured approach based on deconstructing it into separate issues, and then building a new situation from the ground up. The shape of the instrument itself has to emerge from its parts, which we call *instrumentlets*. These instrumentlets, or little instruments, are parts of the human interface that perform only one or a few sensing tasks (but can be highly sensitive with many different Degrees-of-Freedom, DoF's, see below) and a certain shape. We research the mapping between the manipulation of each instrumentlet and sound and/or image,. The composition therefore is built up from the stage of instrument building and the collection of sounds and images. Closest to traditional composition is the making of short clips, consisting of image and sound. Each clip has its own movement characteristics that suggest ways of controlling them with gestures and actions, which are the design parameters that shape an instrumentlet. Sounds, images, and combined clips with sound and image form part of the compositorial palette, as well as the sensors to capture the performers gestures, and the ability to place the material in architectural space. The composition builds up from these elements. It is not technology driven, but rather interface design and mapping become part of the compositional process. The video-organ as an instrument is different from traditional instruments in that it is being developed, designed, built, and composed for all at once allowing rapid iterations towards solutions in the process.

Traditional instruments are an important source of inspiration and heuristics, knowing that the historical development of such instruments including their performing practice, institutionalised teaching, and composing, happened at a very different pace. The technology of our time develops at a high pace, and we can build on the accumulated knowledge and skills over many years. It is therefore reasonable to assume that the instruments of our time (including the aspects mentioned) can develop at a much higher pace, reaching a point where instruments are usable within a few years rather than centuries. However, even if all ergonomic considerations have been satisfied in the design of the instrument, we still have to work and perform with them for many years in order to develop a proficiency to make relevant communications. The simplicity of the approach towards all material of the Video-Organ is a conscious reflection of these ideas and is in constant development.

THE SET UP

The software and hardware, including the human interface, evolved and changed over the course of the performances, based on the Max programming environment on Apple PowerMacs. Most image material is created using a DV camera (Canon MX1), and video-editing and morphing programs.

Hardware

Generally the performances take place using two Apple PowerMac G4's and several projectors connected to the monitor output, the images are Quicktime format clips. It was found that with fast G4's a resolution of 640x480 and full frame rate (25fps) is just about possible to play correctly when using the Sorensen codec. To have the highest possible frame rate is essential because we often slow clips down to access the individual frames - much like a flipbook.

In the earliest performance, a PowerMac G4 with Media100 hardware was used enabling a high image quality. However, it was found that the Media100 proprietary codec (coding/decoding algorithm) was more suited to constantly moving images rather than individual frame access and progressions as needed in our situation. A workaround is to disable the use of fields, so that frames are individual and not relying on information of the next or previous frame.

By contrast, another performance (of the piece called "BAT"), we used an iMac DV and a G3 PowerBook and had to work with a considerably lower image quality.

Software

All sounds and images are played and manipulated from the Max programming environment, according to mappings defined in this environment as well. For sound manipulation we are using MSP, and for images the standard Movie object and sometimes the Movieplus object written by David Rokeby, which has extended features for image manipulation and is easier to use with multiple files.

Interfaces

To enable control over the sound and image material a number of instrument parts, the instrumentlets were developed, ranging from simple push sensors, turnpots and sliders to more complex combinations. The human interface will be described in more detail in the next sections.

In most cases two Sonology MicroLabs were used to read the signals from the sensors, in a customised version of the general purpose interface box with 32 analog inputs, switch matrix for 16 switches and one ultrasound distance measuring channel. All values are sent to the computer in MIDI note numbers and control change values of maximal 7 bits. Dedicated MIDI controllers are used too, such as a 2-octave keyboard and a touch/fader box, and several (modified) USB input devices such as keyboards and a drawing tablet.

There is no other visual interface than the images produced during a performance. Only during development we use the visual interface objects in Max.

THE PHYSICAL INTERFACE DESIGN SPACE

To structure the development and description of the many elements and parameters in the Video-Organ instrument as a multidimensional physical human interface, which is the control surface that actually primarily matters to the user, a design space is used consisting of the parameters described in this section. This Physical Interface Design Space was first developed to create a taxonomy of physical human interfaces [3], and has been further developed over the last years [5].

The problem with making a categorisation of input devices, as shown in the existing taxonomies [1, 9, 12], is the issue of 'comparing apples and oranges' without having a notion of the class of 'fruit'. This is because the developments in input device technology for computers are still going on and happening at a high pace (though not effectively enough - we are still stuck with the mouse in most applications!). In order to describe the interfaces the solution proposed here is to split up the device and describe it in its components - for example the mouse is a combination of sensing of the lateral movements of the arm (through a ball and rotational sensors), one or more switches, and often a rotary dial. All these elements have their own parameters. Another important issue is the notion of feedback - the feel of an instrument or device. The device can be free floating (gesture trackers), grounded (joystick on the table), or contain active haptic feedback (tactile and force feedback generated by the computer). Any action one performs in the real world is guided by this feedback, and therefore one cannot appropriately describe an interface without taking this into account. The Physical Design Space is based on

- description of both input and output, the interface as a two way device
- breaking up the functions of the device into separate sensors / actuators
- describing each of these elements along the dimensions of the design space
- the design space consists of Degrees of Freedom, Range, and Precision

The Physical Interface Design Space describes the *physical* layer of the interaction between human and computer, on top of which the higher layers can be described which convey *meaning* and *intent* (semiotic, syntactic, semantic) and the *mapping* between content and action. The notion of the importance of including this in the instrument design space has been the topic of several papers in this field [11,13,18].

The Design Space is described elsewhere in further detail [7]. The issue of mapping is addressed in the Instrumentlets section and on another level in the section about Elastic Narrative.

Degrees of Freedom

The movement of each object in the three-dimensional space can be described along the three axis (X, Y and Z, or horizontal, vertical and back and forth) and its rotations (around the same axis, called pitch, yaw and roll respectively). An input device can be described in elements each with their DoF's, for instance a mouse has two lateral degrees of freedom generally defined as X and Y (left - right and forward - backward respectively). Pressure sensors are generally defined as being sensitive in the Z direction. This is a somewhat arbitrary convention, a different definition of the orientation of the orthogonal set could be decided upon - this is also true for the rotational DoF's. The descriptions here are based on the normal use of the sensor, though in most cases the user can choose to move along another axis.

Range

The range of a physical sensor is measured in distance (in millimetres, lateral movements) or number of degrees covered (rotational movement), from zero; this is the case of isomorphic or pressure measurement. Acceleration can be measured in G (the unit of gravity).

Precision

The precision of the range of a sensor is also dependent on the electrical interface (eg. A/D converter resolution or switch matrix) and can therefore range from two (a simple switch on/off event) to 7 bits range in the MIDI protocol (rather poor range of 128 steps) to the more desirable precision for most analog readings of at least 10 bits.

The speed of the reading of the signal is mainly dependent on machine factors such as A/D converter sample rate and the lower level information processing in the computer's operating system or specific MIDI drivers.

Haptic feedback

This parameter of the design space describes the 'feel' of a controller, and is defined as either *passive* (the mechanical or inherent feedback from a physical object) or *active* - this refers to a palpable feedback generated by the computer system through actuators. The feedback can be described in the same parameters as the input, ie. resolution, displacement range, degrees of freedom, etc, resulting in a description of the force (or torque in the case of rotational degrees of freedom) patterns or characteristics. This is beyond the scope of the present article, but is described in further detail elsewhere [4,7].

VIDEO-ORGAN INSTRUMENTLETS

In Table 1 a concise overview of the Instrumentlets developed and used is given, described in the parameters of the Physical Instrument Design Space.

In the next sections some instrumentlets that illustrate the design approach as outlined in this paper are described.

Table 1. An overview of the Instrumentlets

name	DoF's/amount	Range	Precision [bits]	connection	material
Squeezamin	pitch, roll, Z	90°, 26mm	7	MIDI	A
Knobbiesbox	yaw/3	270°	7	MIDI	A
Knobbiesbox+	yaw/5, Y	270°, 26mm	7	MIDI	A
Knobbiebox	yaw/1, Y/2	270°, 1mm	7, 1	MIDI	V
Estrella	Z	0	7	MIDI	A/V
Presmorphs	Z	0	7	MIDI	V
Turnamin	pitch, Z	360° (mod 2π), 26mm	7	MIDI	A/V
Tabletring	X, Y	130mm, 90mm	9	USB	A
Faderbox	Y/10	60mm	7	MIDI	V
Keyboard	Z/60	8mm	1	USB	V
Keyboard	Z/18	3mm	1	USB	V
Keyboard	Z/24, pitch/2, yaw/8	12mm, 180°, 270°	7	MIDI	V
Accelring	X	± 2G	7	MIDI	V
Sliders	Y	50mm	7	MIDI	V
Pankeys	Z/6	1mm	1	MIDI	A
Stompin' Pedal	pitch, roll, Z	60°, 22mm	7	MIDI	A/V
Gesticulator	X	1000mm	7	MIDI	A/V
Drum 'n Bass Stick	ptich, roll, Z/22	150°, 1mm	5, 1	USB	A

The Squeezamin

To honour the oldest and still most widely known and used electronic controller, the Theremin, we sometimes contaminate this name with a word that describes the properties of the instrumentlet. (Most names of the instrumentlets are informal and appear a bit silly in an academic paper.)

The Squeezamin allows for manipulating material in the computer by squeezing sponge like material with sensors embedded. It consists of two rigid plates of about 5cm x 5cm, a 3cm thick piece of foam in between, and four sensors placed so that movement down is sensed (lateral movement along one axis) as well as inclination of the top plate (rotations around two other axis). These three DOF's are usually mapped to volume and panning of four sound tracks, and with switches different sound sets can be selected.

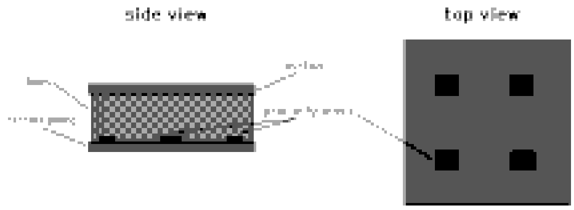

Figure 2. The Squeezamin

Knobbiesboxes

Using an assembly of several potmeters, the Knobbiesboxes are applied to control several closely related parameters in a more precise way.

Figure 3. The Knobbieboxes

There is one bigger knob which controls looping speed in a sound sample between loop points set with two smaller knobs, and in a later version two more potmeters evolved which control filter parameters and a slide pot which controls volume. The smallest one, the Knobbiebox, contains just one pot, the movement of which is mapped to playback speed of a clip. Several clips can be selected with two buttons on the side of the box.

The Turnamin

The Turnamin (or Turn 'm In) is inspired by the use of turntables by DJ's, spinning a little wheel influences the playback speed of a sound sample ('scratching') and video clip. It is based on a small motor which acts as a dynamo, and generates a movement speed dependent voltage which is fed into the Microlab. A few diodes limit and channel the voltage (which reverses polarity depending on the direction of turning) into two separate channels. It was found that the range of the readout was a lot smaller than the real vinyl thing (limiting factors are A/D conversion and the MIDI protocol) so a small slide pot had to 'grow on' to control a multiplication factor. Usually the sound consists of some loud and clear drumbeats, which work well when played very slowly and are more rhythmic when played fast.

Figure 4. The Turnamin

Sliders

For playing very short clips (about 5 seconds or 125 frames) we often use simple slide potentiometers, that travel smoothly and play the clip just like the flick of movement of the performer.

Gesticulator

To allow for gestural control of a long clip with its sound the ultrasound distance measuring channel of the MicroLab is used. To overcome the limited range (128 steps on 1 meter) a simple algorithm is implemented that determines when the *speed* of the movement gets past a set threshold, as an 'escape velocity' that makes the clip jump to another range. This way there are two modes of interaction, small range with high precision and long range, within the clip.

Tabletring

The Tabletring is an example of the use of an existing computer input device with some modifications. It is based on the hardware of the Wacom Graphire drawing tablet, with a sensing surface of 9 x 13 centimetres tracking the movement of a stylus. We use the coil from the stylus which is the actual object that the sensing surface tracks (and communicates its information through), which is placed in a ring on the finger (as shown in Figure 5) of the player while the rest of the electronics were placed in a bracelet. Using Richard Dudas 'wacom' object the movement of the finger is read in 9 bit values in Max. These values were used to control the parameters of a resonating filter.

Figure 5. The Tabletring

PERFORMANCES

A number of compositions have been developed with the video-organ, all in varying circumstances reflected in the use of different material, making a total of eleven performances usually by both authors. The first performances, with the Meta-Orchestra [4], represent the video-organ in its very early development stage and the role was as a member of a larger group of improvisers of music and dance. The subsequent performances have been "solos", one amongst a series of solos with Metapolis Media House, and a final one as a member of another Meta-Orchestra in Barcelona. In the list below the performances are described in further detail, including a description of the material used, in order to give an idea of the flexibility of the instrument and an impression of its practical performance development.

The Meta-Orchestra, Video-Organ as member of large multidisciplinary group. Material: images of meta-orchestra rehearsals as context, various other images. August 2000, Tweed Mill Dartington, England

The Meta-Orchestra second public performance, Video-Organ as group member. Material: images of meta-orchestra Tweed Mill performance, rehearsals, fire. February 2001, Felix Meritis/De IJsbreker, Amsterdam

BAT, Solo Video-Organ. Using four large screens with mirroring and spatialised sound the piece explored subliminal experiences of movement, taking as a starting point the mysterious qualities of a bat navigating by ultrasound at dusk. Composed and performed at Festival Musica a Metronom, Barcelona, June 2001.

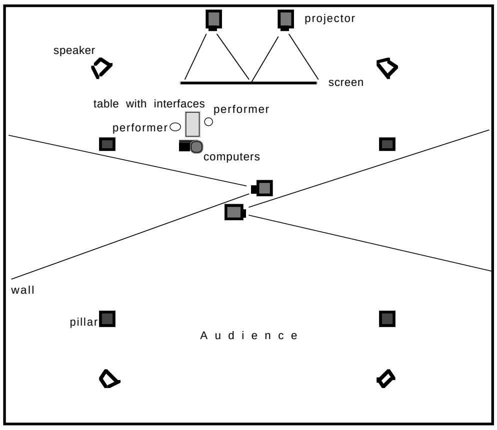

Figure 6. Performance lay-out of the piece "BAT"

Digital Day@Media House, Solo Video-Organ performance in architectural project, as part of 60 minute show characterising a day in the life of a media house, including cooks, kids, net artists and a dancer in a full scale model where the audience walked through the 'house'. The composition used video, models and sounds from the project - from designs to construction - and put them together in the "work room" of the house, a large plastic inflatable bubble which the audience peered in from the outside. Whole performance directed by architect Enric Ruiz Geli, contribution commissioned by Metapolis Architects. Four performances, in Mercat de les Flors theatre, Barcelona, September - October 2001

Light Painting for Still Music, composition for Video-Organ and 6 instrumentalists, with visual score. Piece that explored differences of movement and time in music and painting, for concert series called "Painting Music" in 5th Cicle Internacional d'Influencies Musicals Barcelona. Commission from Ensemble Barcelona Nova Musica, Christiaan de Jong and 'Alternativa' Barcelona Film Festival in CCCB (Centre Cultural Cuidad de Barcelona) November 2001

Metronom Meta-Orchestra, Video-Organ as member of multidiscplinary group. Material: two specific images only, sounds - no context images, January 2002, Festival Musica a Metronom, Barcelona

MediaEval, Solo Video-Organ composition for spatialised sound and multiple screen video. The piece presents an elastic narrative that takes the audience on a journey through landscapes of mountains, light, cities. It begins with an image of a giant hand in the act of notating and the journey is punctuated throughout with abstract notations. There is a dialogue between examining the close-up human artefact of a score present with musical instrumental sounds, and the landscape images with environmental sounds. Performed at Festival Musica a Metronom Barcelona, and at Alicante University Museum Experimental Music Festival, January 2002

MOVEMENT, SPACE AND ELASTIC NARRATIVE

The self-imposed limitations of the video-organ as an instrument enabled or forced us to focus on clarity and simplicity in compositional ideas. By the later performances, video effects are absent. The palette is a combination of the original material - image, sound, image + sound clips - and the manipulation possibilities of the instrumentlets. We have confined this now to variable clip speed, variable direction, access to individual frames, and most importantly a general play function that when played against provides feelings of inertia. The palette is limited to one image at a time, although rapid changes and cuts between images are used. This model is roughly the same for the sound manipulation providing a general compatibility and consistency between the use of image and sound. The only significant difference in treatment of image and sound material is that the sound can be built up in a number of layers simultaneously. In order to achieve sufficient depth in the image we use multiple projections from different sources to compose and play with tensions of similarity and difference between the screens. The simplicity of the set up enables us to focus on one key issue - movement. Any placing together of image and sound raises questions of audio-visual languages - how do the image and sound effect each other, what is their common ground if any, and how can these ideas be developed successfully in performance? A significant common ground between sound and moving image and their basic inherent parameters of time and space, come together in the idea of "movement" [10,16] - this is our main parameter. From the beginning to the end of the composition and design process the concept of movement holds the video-organ development together. Movement is developed from the original material in the following steps:

- movement of the camera/microphone or capturing movement within the raw image
- pre-editing (before live editing) whether in morphs or simple dissolve effects, and selection of clips
- mapping of certain movements to gestures in the instrumentlets, for example, a circular movement is mapped to a circular turning gesture
- placing in space by movement between screens and speakers, for example, by panning the sounds in relation to the four points of the Squeezamin or moving the image between two screens

The issue of narrativity is unavoidable as, however abstract the images and sounds are, when placed together in a sequence they will be naturally understood by the audience as in some way a "narrative". Through our experiences of playing and composing with the video-organ in different circumstances an approach towards structure and narrative has naturally evolved, whereby the general direction and sequence of events is notated before performance, leaving a flexibility in precise timings and allowing a certain degree of improvisation into the performances. This flexibility in live performance is one of the main virtues of the video-organ, encouraging an interaction with audience, atmosphere, the two players. The narrative or journey that the audience is taken through can be described as 'elastic' narrative, giving a sense that the time, movement and position in space can be stretched, spring back and be malleably alive. To achieve and use this elasticity is the performers task as much as it is central to the compositional issues of gathering material and mapping to the control surface.

CONCLUSION AND FUTURE PLANS

Throughout this paper we have mentioned that developing a new instrument is not an easy task, and introduced a structured and modular approach. By focusing on the *content* of the compositorial material rather then the interface, we felt it was possible to perform with the instrument even from its most rudimentary state. After several successful performances we can conclude that this approach is valid, also feeding back the experiences of performing with the instrumentlets into the design process.

Figure 7. Clay models

It has become clear by now which elements may be combined into shapes tending towards a more concrete new instrument form, though many pieces of the puzzle are still missing. Experiments with finding forms that reflect anthropomorphic shapes, as shown in Figure 7, have been conducted. Development of new instrumentlets is still going on, also ones that are outside of the performance model. Many demos have been given with the Video-Organ as a development principle at the new Metronom Electronic Arts Studio, also for groups of school children. This was a valuable source of feedback, and we are currently working on a stand alone instrumentlet (a subset based on the list in table 1) for this purpose, with specially made content. Another spin-off project uses a modified existing gestural game controller to play sounds in an installation in Barcelona.

The modular approach to instrument design enables an evolutionary development, yet is flexible enough to allow more radical changes and improvements. The Physical Interface Design Space is useful for structuring the developments and suggests parameters of new instrumentlets.

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