Digital Design 2004

Interactive Colour & Sound Space

7. semester Digital Design report @ Aalborg Universitetet Esbjerg
Report created by Teodora M. Grindeanu & Torsten B. Fix

Abstract

The purpose of this report is to provide the theoretical background for our Interactive Exhibition. It contains a brief description of the difference between interactive and traditional exhibitions. There is an in depth analysis of the colour theories of how Newton and Goethe define the relation between sound and colours, and what the differences are between their theories. Lastly, there will be a detailed description of how this interactive exhibition / installation have been created.

Keywords: Newton, Goethe, Interactive Exhibition, Exhibition, Installation.

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          Teodora M. Grindeanu   Torsten B. Fix

1. Introduction

Art is generally perceived as a passive experience where people observe paintings, sculptures or listen to music, etc.

Today we have limited interactivity when it comes to what we perceive on an exhibition. Our interaction is limited to accepting what is shown or move to another artefact.

We would like to see what happens when people are given a wider range of choices for participating in an interactive exhibition where they could be the artist and would have the chance to make their own plastic choices. The result could be that we would reach people that normally have little or no interest in visiting exhibitions.

2. Problem definition

The general theme for this semester is 'World of Experience'. In that it is a broad theme with many interpretations we decided to create our own little world of experience.

We planned doing this by creating an interactive exhibition where the participant / participants will be surrounded by sounds and colours.

In order to create this exhibition we had to research what an interactive exhibition is, and how to map the colours and sounds.

The exhibition will physically be build as a cube therefore we decided to name it CUBE**.**

3. Historical context

3.1 Exhibitions

In the old days exhibitions were a passive experience. The viewer was only asked to interpret what it was exposed and not to actively participate in what may become an interaction between him and the art.

There are numerous and different kinds of art forms which are organized in some general categories like 'visual arts', (i.e. painting, sculpture, architecture and photography), music, etc.

It is almost impossible to categorize art. In fact many artists make it a habit of breaking the general public's perception of art. Here are some examples of artists who in their time broke people's expectations of what art is.

3.1.1 Non interactive exhibitions

In this section we will present 2 non interactive exhibitions from some artists who tried to question the shape of our sensibility in a very upfront and brutal way.

Anatomi, by Christian Lemmerz 1994

Christian Lemmerz is one of these artists. In 1994 he opened an exhibition at Esbjerg Kunst Museeum called *Anatomi*. The exhibition consisted of several pieces. One of them was a huge painting made of pigs blood smeared all over stainless steel plates. This can be perceived as a bit weird but not groundbreaking strange.

The main piece of the exhibition was three dead pigs which were displayed in huge glass display cases.

Figure 1 - Christian Lemmerz , *Anatomi*

The exhibition created a massive discussion in media and in people's homes. The discussion was whether or not that was art, and what would happen to the pigs while they were on display.

One of the results of the debate was that people who normally didn't visit the art gallery came to see what all the fuss was about.

Goldfish in blender **by Marco Evaristti**

In 2000 Marco Evaristti created an installation at Trapholt in Kolding. As you can see on the picture, part of the installation consisted of 10 kitchen blenders with water and fish in them. The absurd thing about the exhibition was that the blenders were connected to power. This gave the spectators the possibility to turn on the blenders and kill the fish.

This part of the exhibition caused a huge stir in the media, which was quickly to condemn the exhibition. An animal rights movement filed a complaint to the police which fined the owner of Trapholt museum. This led to a two days trail where the rights and feelings of fish where part of the discussion.[1]

Figure 2 - M. Evaristti, *Goldfish in blender*

3.1.2 Interactive exhibitions

Interactive exhibitions and "normal" exhibitions have a lot in common. The main difference is of course the interactive part. There are several degrees to involve the, otherwise passive, spectator. The artist could give him the possibility to interact with something that is already happening. An example of this could be the "fish in the blender" installation described in the previous section of the report. We don't think the artist intended it to be an interactive exhibition. The artist probably wanted to confront the spectator with the real consequences of his or her act as a real possibility. A life-or-death consequence. It's always possible to interact, as some attempts to destroy famous works of art prove. Usually, we do not dare either because is forbidden to 'touch' or because we forbid ourselves or are used to establish a respectful distance. The artist probably wanted to prove that if the spectator wanted to interact with the installation, he could.

Interactive exhibitions usually take up a lot of space and, in most of the cases this is the reason why they usually aren't shown on a permanent basis on smaller art galleries. In Esbjerg there is a semi permanent exhibition called *The 9 Minds* which is on show 10 months a year. They showed instead a non interactive installation from the same artist who made *The 9 Minds*.

The 9 Minds by Erik Andersen

The basic idea behind the seven moods is that sounds you associate with a particular mood will change over time and later become part of another mood. The installation is made of 9 walls, displayed is zigzag. 6 walls were equipped with headphones and the other 3 were equipped with microphones. The idea is that the participant will choose a mood to listen to, or he would make his own sound that will be added to the database. All these sounds will be distorted, transformed and repeated in the different moods. The creator claims that the machine behind will cycle the sound you just recorded every 28 years. In other words the chance of the participant hearing its own voice is not very slim.

"Split second" by Skeel & Skriver

The installation consists of 13 B&O televisions that are connected to a camcorder and some electronics which control the picture on each screen.

The purpose of this exhibition is to take a picture and split it along time. The basic principle resembles the bullet time effect from *The Matrix*. The main difference is that this is done real-time so that one can

Figure 3 - Skeel & Skriver, *Split second*

actually see himself in a split second.

We tried the installation on our visit to the museum, and we can only agree that it is at first confusing when you enter. We tried to **Figure** out how it worked and only after some minutes we understood that the pictures were cycling through the television screens and afterwards starting over

again from the first television. We guess the most confusing with this installation is why they only decided to use 13 screens and not 25 screens like the number of frames in a second of film. When you view the installation you see the screens update from left to right but when the last television has drawn its picture everything pause for a moment before repeating again. We had a discussion if it was repeating the last frame or showing the next. Only by moving fast out of the picture we could see that the installation was not repeating the frame.

3.1.3 Interactive music

Recently we have visited an exhibition at Esbjerg Vestjyskmusikkonservatoriet, called *A Sound Lab for Children*. There was presented a range of sound stuff, all within the concept of *'object sonore'*. The idea behind the exhibition was to provide children, or musical beginners, with an intuitive and tangible way of exploring different sound objects recorded either before or during the process of sound manipulation.

The sound elements presented gave the impression for the participants that they were actually touching the sound, not only activate or trigger it in some way. The settings of the exhibition were composed by three elements: a sound box, sound manipulators and a sound producing carpet. The latter was not actually present, but as we will use it in our own exhibition, we will therefore explain it afterwards. The description of the sound elements is based on the exhibition's brochure.

The sound box

The sound box was made of Plexiglas and designed as a standard laboratory box with a microphone. It was possible to isolate the sound created in the box because of the inner sides of the box that were coated with different materials which made the box more or less resonant. Because of the connection of the microphone to a computer, it was possible to amplify and store the sounds created. There could

Figure 4 - A sound lab for children, sound *box*

be created sound with the different materials stored in the box like stones, leaves, water, etc.

The sound manipulators

There were presented different sound manipulators, all characterized by a small physical interface that vary in shape, material and functionality. The manipulators were connected to a computer and offered their functionality to either already recorded sounds, or to a real time manipulation of the sound to be recorded in the sound box. The software used to handle the real time manipulation of the sound was MaxMsp. We will take a closer look at it later in this report.

There were three sound manipulators, but we will only describe one because the basic functionality is the same. The difference consists in the design of the user interface.

The manipulator we choose to describe consist of a white ball which could be rolled on a black square. The ball could be moved either slow or fast and furthermore, the user could put more or less pressure on the ball while moving it around. The

Figure 5- A sound lab for children, *sound manipulator*

different parameters of the sound algorithm were controlled by the ball's movement, speed and pressure.

The main purpose of this research in the exhibition domain was to see what have been done in and around Esbjerg. Our opinion is that interactive installations are interesting alternative to relate art and technology. This is the reason why we have decided to build our research project upon the process of building an interactive exhibition. This being said we move towards the colours and sounds, which will make the content of our exhibition.

3.2 Colours and sounds

We mentioned previously that we plan to make use of colours. We decided to investigate the theories of 2 different authors in order to understand their approach within this context: Sir Isaac Newton and Johann Wolfgang von Goethe.

The reason why we decided to use these authors is because their different but fundamental point of view on the subject of colours. In the next sections we will cover each of them in more detail.

3.2.1 Sir Isaac Newton (1642 – 1727)

Most people heard about Newton from his famous theory on gravity. He was a Physicist but also developed numerous experiments and observations in Mathematics and Optics. His notes On Colour are most interesting from the point of view of that we want to demonstrate with our project

The following is based on the books: *Goethe contra Newton* and *Farvernes metafysik*.

The starting point in Newton's colour theory was the prism experiment. He took a glass prism and led a light beam strike one of the sides of the prism. The experiment took place in a dark room, so that Newton could observe the refracted light, the spectrum, on the wall.
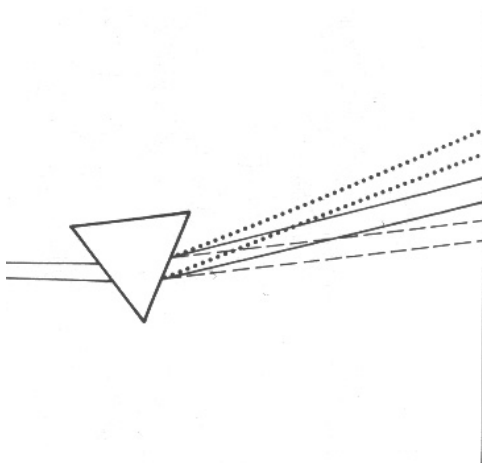Here is a diagram and a picture of a reproduction of that experiment.

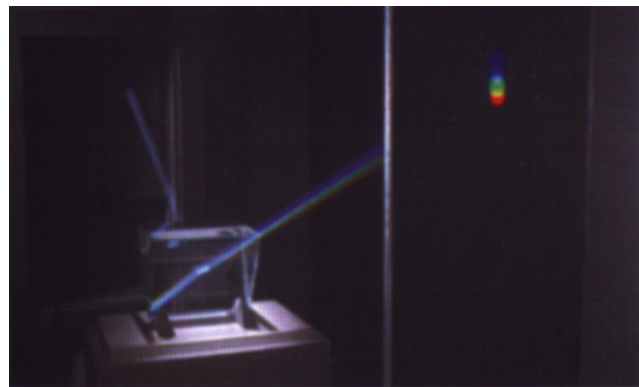**Figure 6 - Prism experiment diagram**

Figure 7 - Prism experiment picture

Based on this experiment and several others along with his mathematical knowledge, he came to the conclusion that all the colours are contained in solar light, and the fact that we can see all the colours is due to peculiar properties such as reflection, refraction, diffraction and so on.

Besides discovering the spectrum, Newton also calculated a function which, after his meaning, could approximately calculate the predisposition of the so cold natural body to absorb or reflect a given colour. Based on this calculus he presented his colour circle.
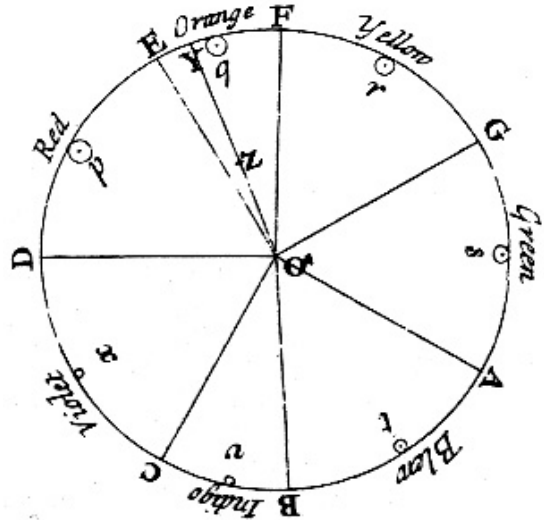

Figure 8 - Newton's colour circle

The figure on the right presents the default settings of the circle, which in this case represents the white colour.

This colour circle also represents a basic approach to mapping of colours to the sounds. As it can be seen, the musical octave starts at the colour red. This theory is based on the frequencies of colours and sounds, in that the colour red, with the longest wavelength is mapped to the D note with the lowest frequency.


3.2.2 Johann Wolfgang von Goethe (1749 – 1832)

This section is based on the books *Goethe contra Newton* and *Lyset, mørket og farverne*

Observer of nature, philosopher and a great poet, Goethe remains in the history of literature as the one who came as close as possible to the Shakespeare's renowned with his masterpiece *Faust*. He was also interested in science; this is why he wrote publications about anatomy, botany and chromatics.

His interest in colours led to a repetition of Newton's experiment. To his surprise, he did not see the spectrum of colours as Newton described in his theory. This was because Goethe did not completely recreate the experiment in the same manner Newton did.

The mistake was that the prism experiment was not effectuated in a dark room. But when he moved the prism towards the edge of the window, he was able to see the colours that Newton saw; this was possible because, in the absence of the direct light ray, the colours were done on the window at the transition of darkness to light. This is also why, where was white colour he could not see any colour of the spectrum.
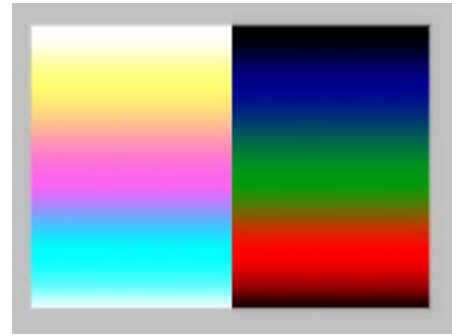
Figure 9 - Spectrum Newton contra Goethe

The left half of the figure 9 shows the colours that Goethe sow in his experiment, and the right half shows the colours
That both Newton and Goethe saw in theirs prism experiments.

Besides seeing more colours in the prism experiment, Goethe discovered another property of the colours. The so cold trübe-effect which demonstrates that yellow colour is the complementary of blue colour.

Based on his darkness – light theory, and the yellow-blue colours, Goethe elaborated his own colour circle, the harmonic colour circle as he self named it.

Figure 10 - The colour circle according to Goethe

The discussion between Goethe and the work Newton did is perfectly summed up by Wittgenstein in the book *Lyset, market og farverne (1998)*:
"Goethe theory about the structure of the colours in the spectrum has not been proved as an unsatisfied theory as not being a theory at all. It is not possible to prove anything from it… There are not even any experiments to prove or disprove the theory." (p. 104)
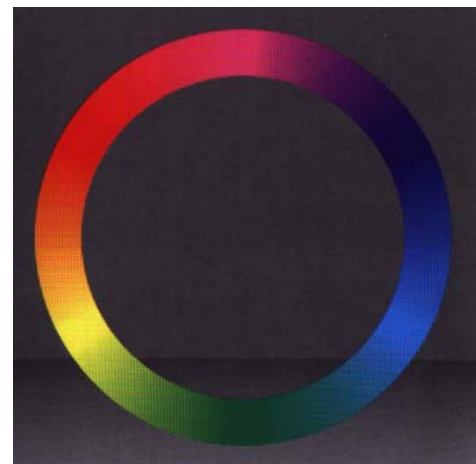
If we look at the 2 colour circles from either Newton or Goethe, there are obvious differences. The first will be the order in which the colours are placed compared to each other. To understand this difference we need to understand their background. Newton's theory about colour is based on mathematics and physics. This is why his colour circle is based on frequencies of both colours and sounds. In this way, his colour circle was created to predict the outcome for a given colour in a given situation.

Goethe's theory on the other hand is more humanistic and based on how humans with their senses perceive the colours as a whole. This is why it is not possible to predict anything with Goethe's circle. Nevertheless, it is also very useful, because, even if we do not realize, we are using Goethe's theory in our every day life.

As mentioned several times in the paper, we are building our interactive exhibition around colours and sounds. We took into consideration the 2 previous theories because theirs different approach to the subject. The Newtonian theory is more measurable because of his mathematical background; this is why this approach will ease our work in mapping the colours to the sounds. Goethe's theory on the other hand has a more artistic approach, and this will ease our choice of which colours to use.

Looking back at what have been said (theories) and done (exhibitions), we have gathered a solid background for the future step in the developing of our exhibitions.

4. Concept of our exhibition

This part of the paper will contain the description of the content of our exhibition. We decided to structure this section as follows: the first part will describe the physical frames for the exhibition and the second part will describe our choice for the content of the exhibition.

4.1 Physical frames

The basic room

The idea for the product of this semester started a bit different than it usually does. Normally we are given fairly strict guidelines when we write these assignments. But given that we just started on a master degree, we guess that the project description has been a bit vague to give us the possibility to create our own specific idea with almost no boundaries.

Our idea started with the technical aspect of the room, not the content. We wanted a room which would completely create an environment which we immerse the participant without given him claustrophobia. We therefore decided to create a room 3 by 3 meters, and 2.5 meters tall. The walls of this room are made of semitransparent fabric, which is supposed to let light from projectors in but not blind the participant.

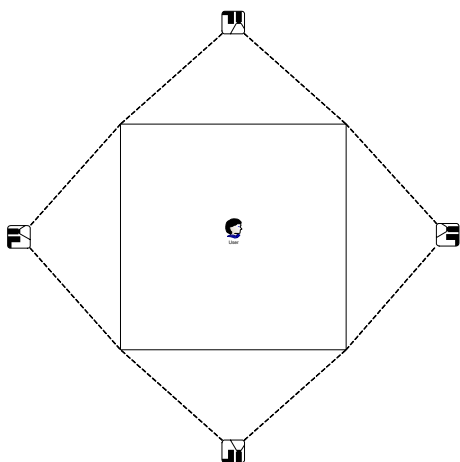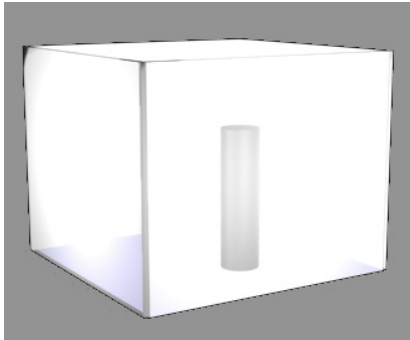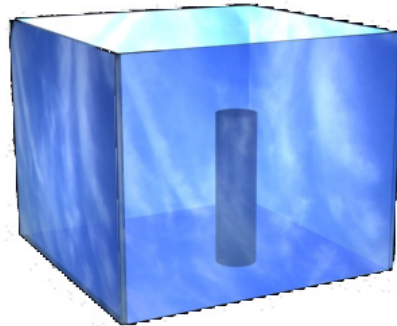Here is a schematic of the room described above:

The participant is inside the room and moves around. The projectors project images onto the entire wall. This means that the participant is surrounded by images and light.

Figure 11 – Projectors setup

We have made a simple 3D model of the room, so that the reader can have an idea of how the exhibition will look like.

Rendering with white light   Rendering with sky texture   Rendering with background texture
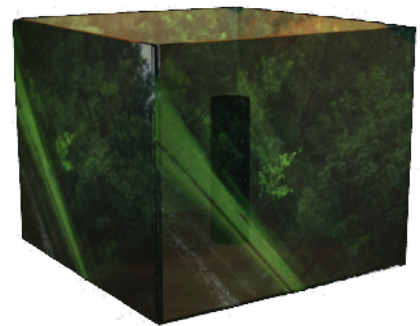
Figure 12 – 3D models of the CUBE

Building the room

The room is constructed using timber, nails, fabric and some Velcro.

First a frame is constructed.

Figure 13 - Pavilion

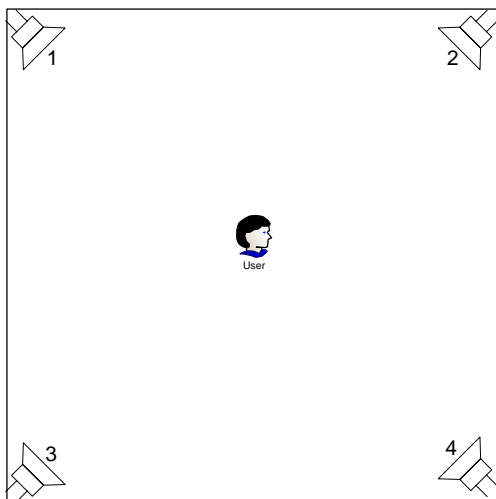Then it's covered with semitransparent fabric.

Figure 14 - White fabric

A door is made with Velcro so participants can come in and out of the room, but the room still gives the illusion of being seamless.

Sound setup

Speakers will be placed in each corner. This will give the possibility to create sound which appears to come from anywhere in the room.

Figure 15 - Quad Sound Setup

In stereo you can create the illusion of a person walking from one speaker to the other. This is technically done by increasing or decreasing the sound volume in each speaker.

In quad surround you can use the same concept. Here is an example: let's say we want to create the illusion of a man walking from the upper left corner (1) to the lower right corner (4).

When the man starts to walk only speaker 1 plays the sound. When the man gets out of the corner the other speakers starts to play almost silently. On the way to the middle of the room
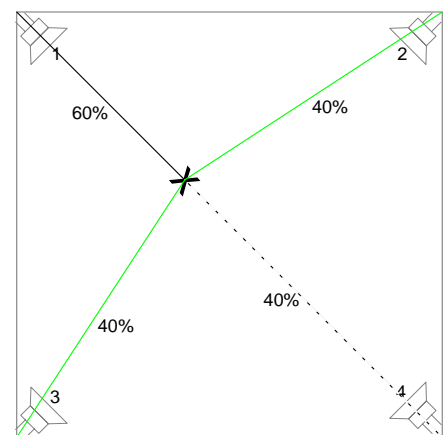
Figure 16 - Volume at a given point

volume of speaker 1 decreases to 50% volume speakers 2,3 and 4 increases to 50%. On the left we made an illustration of the volume of the different speakers in a given situation.

This way of creating surround is of course primitive but gives a fairly realistic surround representation. If we wanted to create an even more realistic environment we would have to add reverb, distortion, echo, etc. This would require quite a lot more calculation to define all the variables.

4.2 Sensors

We have had some discussions about what kind of sensors we would use for our exhibition. We talked about using Soundbeams, microphones or developing our own type of sensor. The input data will be very different depending on what kind of sensors we decide using. We will therefore list some of the positive and negative possibilities with some of the sensors we have discussed.

Before we get started with the description of the sensors possibilities, we would like to describe what the ideal sensor for the project would be. The ideal sensor would be a sensor that could only be influenced by the participant not the system we create.
There are many sensor that for fill this requirement. Motion sensors for example, these sensors have two states. Either they are on or off. This would not be enough for us. We want to se where the participant is in the room. We therefore narrowed the possibilities to a couple.

Microphones
These could be placed in each corner of the installation and record the movement of the participant. Depending on what he dose inside the room, the microphones would register the sounds that would be made. From these data we could extract a rough placement of the person in the room, or just make the system react to the amplitude of the sounds.

There is one immediate problem with microphones. It is our intention to play a combination of music and sound inside the room. These will be interactive and react to the movement of the participant. A problem could arise when the microphones react to the sound the speakers make; this

would create a feedback loop where the loudspeakers play sounds that trigger the microphone which again sends new sound to the loudspeakers and so on. A solution to this problem could be to program pauses into the input of the microphone, but we think this would make the experience more unpredictable.

Video Cameras

One possibility could also be to use video cameras. Cameras have the ability to capture visual information. This would sound like a good idea for our installation. We could analyse what is happening in the room and get it to react to that. In this case there are again problems with this method of getting input to the system. First of all, video create a lot of information that has to be interpreted. This could easily increase the response time from the system, so that it's not a real-time system anymore. Secondly there are problems like the feedback loop that most likely would happen when we create the visual part of the system. These problems would have to be solved for us to use the camera as an input sensor.

The Soundbeam

There is a brief description of the Soundbeam on their website:

http://www.thesensorycompany.co.uk/

The invisible expanding keyboard in space

Soundbeam has been used most extensively and thoroughly evaluated with children across the Severe Learning Difficulties spectrum, including profound and Multiple Learning Disabilities and MDVI. The benefits to children and adults with a range of genetic and acquired/behavioural syndromes including Autism and ADHD have also been documented. Soundbeam is identified as a key resource by the Qualifications and Curriculum Authority in assisting children with learning disabilities to attain learning targets as prescribed by the National Curriculum for Music. Additional Beams are available for the more adventurous.

The Sensory Company is proud to offer this fantastic product to you.

We have access to this product but we had doubts that it would be able to fur fill our requirements. From what we could **Figure** out the Soundbeam works in a circular motion. This means that it would only register whether the participant is in the middle or how far from the middle he or she is. Here is an illustration of what we mean.
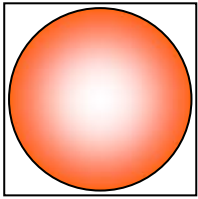
Figure 17 - Expected working area of a soundbeam

The square is the room seen from above. The circle represents the area where the Soundbeam registers movement. This information is only registering information on how far from the middle the participant is. We can only extrapolate the

movement and the speed of it not where the participant is in the room.

There is another problem with the Soundbeam. The beam from the sensor is cone-shaped this, in our case, means that we would register different information depending on the height of the participant.

The Sound Carpet / TabTiles

We found this product almost by chance when we participated at the exhibition at Esbjerg Vestjyskmusikkonservatoriet, called *A Sound Lab for Children*. The sound carpet has the qualities we are looking for. We got in touch with one of the developers of the sound carpet from Aarhus University Audio-Design and Research Lab., and here is a translation of the response we got.

The sound carpet

Our blanket is 1 by 2 meters and divided into 9 areas which are equally sized. These areas aren't pressure sensitive, but homemade and created from a bugler alarm system. It registers if someone moves over one of the areas. Unfortunately it only has 9 outputs. These outputs are 9 MIDI notes. The controllers for the

Figure 18 - Sound Carpet

sensors are homemade too, and its task is to send out the midi notes. The midi notes can be used to what ever we want, because of the possibilities that PD software offers.

TapTiles

The sound tiles are base on the ICubeX-system. ICubeX is also a controller but it interprets a change in voltage and converts it to midi information. This solution is more versatile than our old controller.

The ICube is connected to 9 TapTiles which are pressure sensitive sensors. They register the weight from 4.5 to 100 kilo.

The ICube then sends the raw midi data out. Then you need a small standalone program which is included to the ICube. This program is used to configure a hardware sampler or use a piece of software like Max/Msp or PD.

We decided to use the sound carpet. We find this product the easiest for us to use. There are of course some limits to its functionality, but we have to limit our product. Have we had more time / money, we would probably have gone for the TapTiles. They would have given us the possibility to fill the entire room with sensors instead of just the 1 by 2 meters.

4.3 Software

In this section of the paper we would discuss the software choices for implementing our concept as well as the choice we made. For realising the audio and visual (graphical) part of the project we need some software that can take the signals from the sensors we use and transmit them to the computer were they will be converted to data we can work with.

After a little bit of research we came down with two possibilities the PD (Pure Data) and the MaxMsp software. The question was just which one to choose, because both are offering almost the same capability. The only impediment is that the MaxMsp software is not freeware like PD, and therefore licence required. But we could use a 30 days full trial version, period in which we could be done with our project.

4.3.1 Pure Data

Originally developed by Miller Pukette, PD is a real-time graphical programming environment for audio, video and graphical processing, and is part of the family of patcher programming languages. PD allows data to be treated in a more unrestricted way and opens it up to applications outside of audio and MIDI (Musical Instrument Digital Interface), such as graphics and video.

As mentioned before, PD is freeware and can be downloaded either as an operating system specific package, as source package or from CVS. PD is relatively simple and portable and platform independent, this is why users using Windows, Linux, MacOS or even PocketPC can easily gain access to the potential that PD offers. There are two great features in PD. Firstly, the GEM package for PD makes possible for simultaneous computer animations and audio. Secondly, an experimentally facility is provided for defining and accessing data structures.

PD is based on the object-oriented concept which makes easier the defining and use of the feature that the already contained objects are making available.

4.3.2 MaxMsp

Like the PD, Max was originally developed by Miller Pukkete, back in 1986, as a project for producing interactive music at the Institut de Recherche et de Coördination Acoustique/Musique (IRCAM) in Paris. Later on, in 1991, Max became a commercial product from Opcode Systems, with future development by Pukette and others, and from 2000 it was published by Cycling'74.

Like PD, Max is a graphical music programming environment, based on the object oriented programming concept. Max was extended with MSP, so that it includes audio data and with Jitter so that it includes image/ matrix data. In this way, it is possible, like with PD, for simultaneous computer graphics and audio.

Although an old piece of software, only recently MaxMsp became available for windows platform. Otherwise, the MacOs platform also supports the program.

Except that PD is younger than MaxMsp, they can both do the same thing, with respect to the computer graphics and audio. This is because both relay on the old standard MIDI protocol.

MIDI

We have mentioned before the Musical Instrument Digital Interface (MIDI). The description is based on theirs homepage at midi.com. MIDI is a communications protocol incorporated both in PD

and MaxMsp. It is the protocol that allows the electronic devices (synthesizers, computers, light show controllers, etc) to interact and work in synchronization with other MIDI compatible devices. For instance, we can play or trigger sounds from other electronic devices remotely by using one keyboard.

To best understand how MIDI works, we can think at the way that two computers are linked together via modem. In the same way the computers share information via modem, the electronic signals are shared via MIDI protocol. The protocol only sends the information about the signal (note) and not the note itself.

4.3.3 Our choice of software

Having seen what the two pieces of software can do for us, it is time to make our choice. We have tried both programs to see how they work. MaxMsp comes with a fancy user interface, which makes very easily for even beginners to discover the program's functionality. But it is a heavy program, in that it uses a lot of memory, and therefore a burden, sometime, for the computer's processor, not to mention the limitation for only windows and MacOs platform.

On the other hand, the PD, even with a poor user interface, is also easy to use and to fine around in, and not that heavy to have running on the computer. This and the fact that it is freeware, including GEM, make the choice easy for us.

4.4 Software patches

In this section we will describe the basic patches in PD & Gem. Like we wrote before, we haven't created the room along with the report, because of time limitations, and we are only able to describe the basics, which in this case means that we will describe some patches for PD & Gem that we believe is relevant for the project and will be partially used in the final patch.

4.4.1 Reading and interpretation of data from sensors

We mentioned before that our input was midi. The Sound carpet delivers midi information. Midi is a native input for PD. This means that there are specific functions and objects for management of midi data.
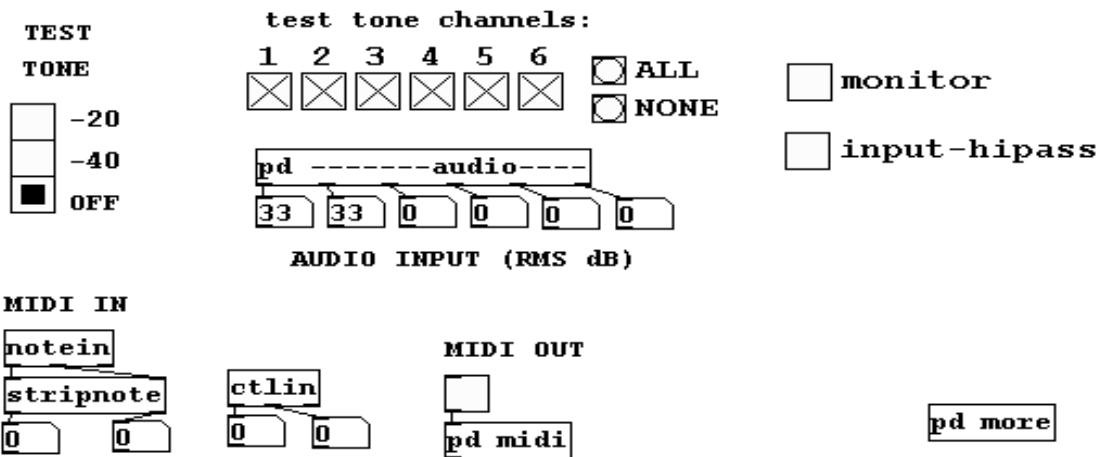
Here is a screenshot of the test patch in PD

Figure 19 - Sound & input tester in PD

4.4.2 Creating visual graphics

There are several additions to the standard PD. One of the add-ons is Gem. Gem is used to create visual graphics in OpenGL. Gem has many possibilities for creating graphics; if we want to we can even create small games in it.

This is the description of GEM from their help page:

GEM is the Graphics Environment for Multimedia. It was originally written by Mark Danks to generate real-time computer graphics, especially for audio-visual compositions. Because GEM is a visual programming environment, users do not need any experience in traditional computer languages.

GEM is a collection of externals which allow the user to create OpenGL graphics within PD, a program for real-time audio processing by Miller Puckette (of Max fame).

There are many different shapes and objects, including polygonal graphics, lighting, texture mapping, image processing, and camera motion. All of this is possible in real-time without any

previous programming experience. Because GEM is an add-on library for PD, users can combine audio and graphics, controlling one medium from another.

In this section we will describe some of the basic patches included in Gem.
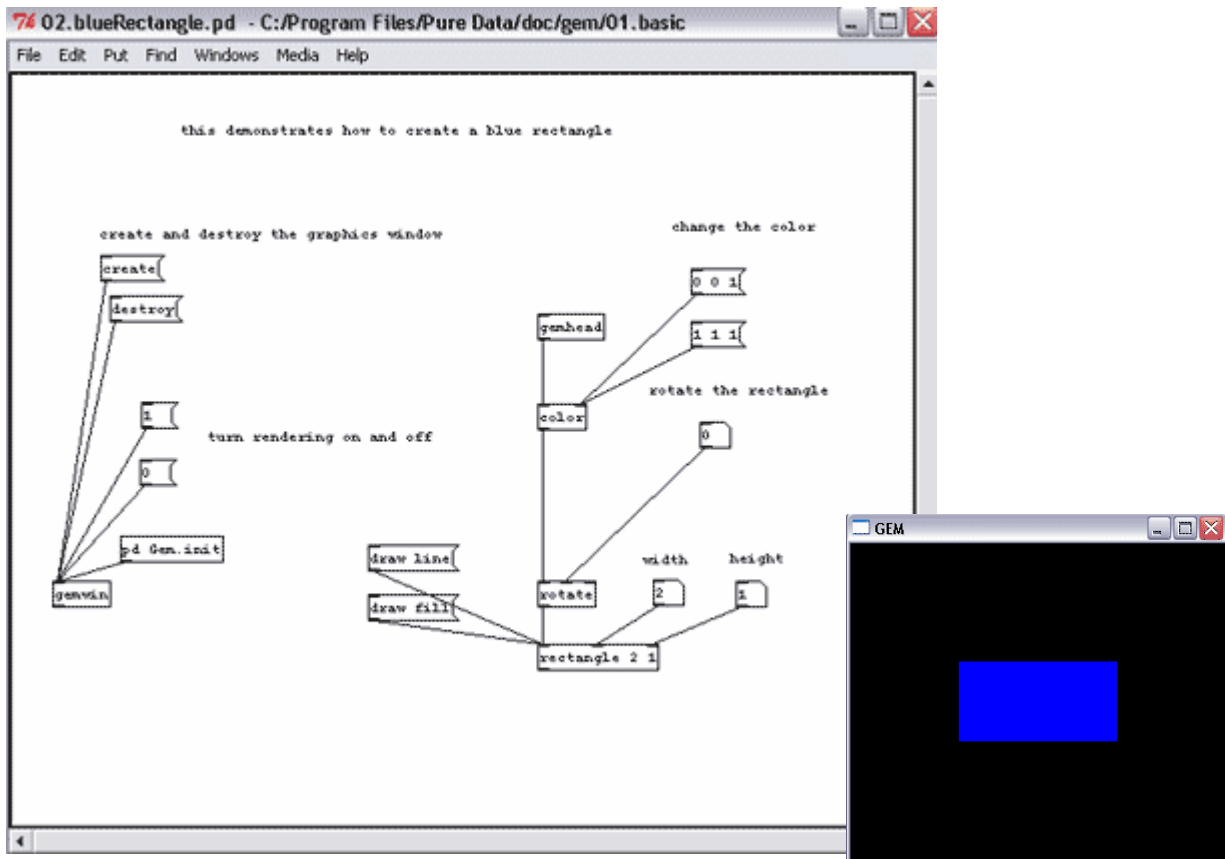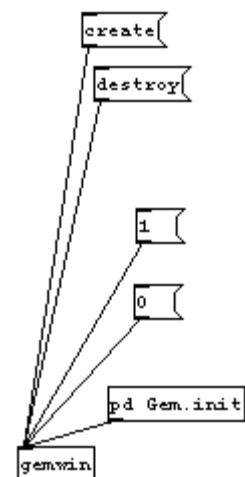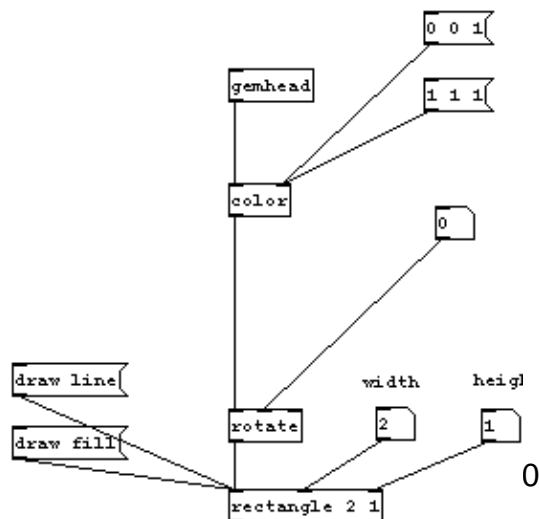
Creating a blue box

Figure 20 - GEM example

Explanation of the symbols and how the patch works

The main object is [gemwin]. This object has several inputs, which means that it can be manipulated by several functions.

The create and destroy messages makes possible to create an

instance of the object when we need it, and then destroy it after we are done with what we had to do.

The gemwin object is actually the graphical window. The 1 and 0 messages stay for the Boolean values of the rendering being on or off. When the graphical window is initialised, the [pd Gem.init] search for the communication with the [gemhead] object that contains all the information about the content of the gemwin window.

The content of this example is a rectangle which has a predefined width, height, color and a rotate attribute. All these properties can be changed by the user, by marking the correspondent attribute with the mouse and write a new value. In our case, when the graphical window is created, the filled rectangle has a width of 2 and a height of 1 e.g. [rectangle 2 1].

We can choose between a white or blue rectangle, depending on which colour attribute we click on, [0 0 1] and [1 1 1].

The colour selector works in RGB mode, this is why they are presented like [xxx]. The blue colour in RGB is 0 0 255. In Gem this would be [0 0 1]. White is [1 1 1] because white colour is created by adding all colours together.

The rotate attribute is set to the X axis rotation. As we can see, the rotate property has three input possibilities, the dashes on the top of the box. The middle one is set to the number zero, which means that the rectangle is not rotated. If we want to rotate it we just have to hold the middle mouse button and move it up or down (positive or negative values for the rotation degree). The very right dash gives the possibility to change the rotation axis, because it takes as input a list [X Y Z]. Changing the values for the axis between 0 and 1, we set the Boolean values for the rotate X, Y, and Z to false or true. It is not only possible to change the rotation axis but also to translate the filled object, in our case the square.

In addition to these attributes there are the draw line and draw fill. These allow us to switch between rendering just the outline of the rectangle or the filled rectangle.

Now, this was only a very simple example, but PD with Gem can do much more complicated stuff.

4.4.3 Creating music

At this point in the developing of the project we have to mention that the musical part will be done in collaboration with Claus Gahrn from the music conservatory.

Here is an example of how a drum machine can be created in PD:

The machine is from this webpage: http://rogerroger.panicnow.net/PD_patches.htm#CMDG

The front panel window contains all of the controls you need to enable the automatic features and play manually.

Your mouse clicks are quantized with the arpeggiator buttons, and you
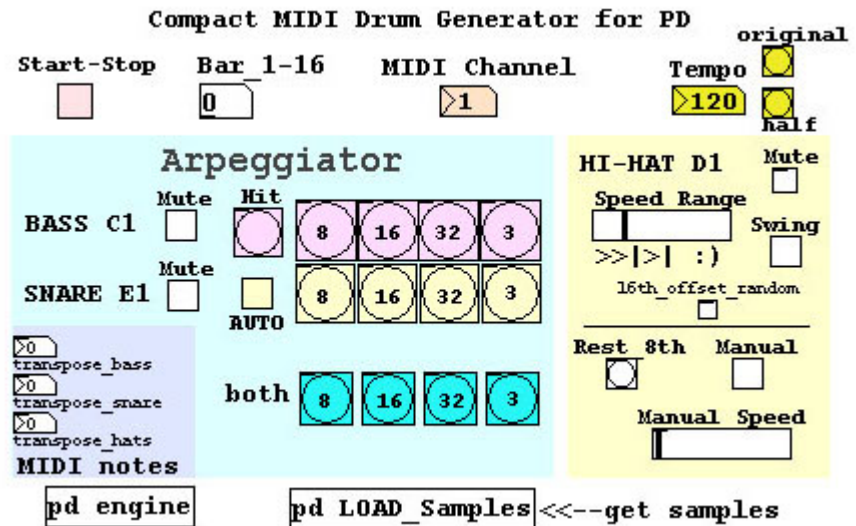
Figure 21 - Drum machine

can get several different syncopations from the timing of one click.

Clicking on the LOAD_samples abstraction will allow you to use audio samples with CMDG.

Each sound has a mute, and auto-snare is optional.
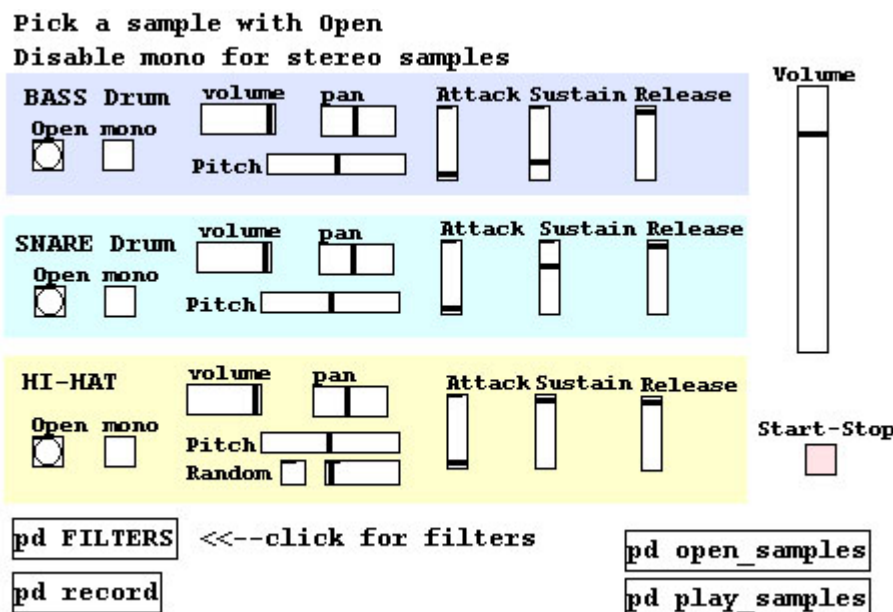
The LOAD_samples window lets you choose your one-shot samples for bass, snare and closed hi-hat sounds. Each sample has basic volume, pan, pitch and envelope controls. Envelope sustain

Figure 22 - Drum machine - Load sample window

is time based, not volume based.

If you open a stereo sample, you must click the mono toggle box off to hear both channels. A mono sample not set as mono will only appear in the left channel.

You can click on the FILTERS abstraction to enable vcf~ filtering and the record abstraction to record audio direct to disk.[2]

 This shows just one of the many possibilities that PD offers.

4.5 Installation Patch

The following section describes the installation patch we used in the realization in our exhibition.

Figure 20 is the main window of the patch. As it can be seen, it consists of 7 objects, plus some control elements that are used to manipulate the main window.
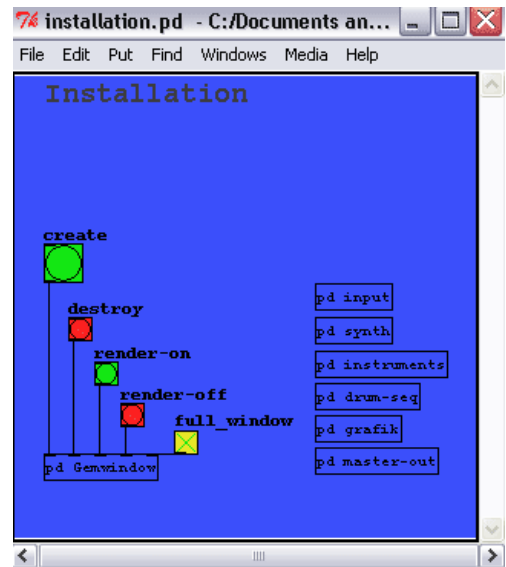
Figure 23 - Main window

Figure 21 represents the Gemwindow
This is instantiated when the create manipulator is pressed.

The inlet receives the manipulators messages from the main window.

We have a special manipulator that gives the possibility to run the installation in either full screen or standard, windowed mode. We choose the full screen mode, because we have to project the installation on the walls of the exhibition.
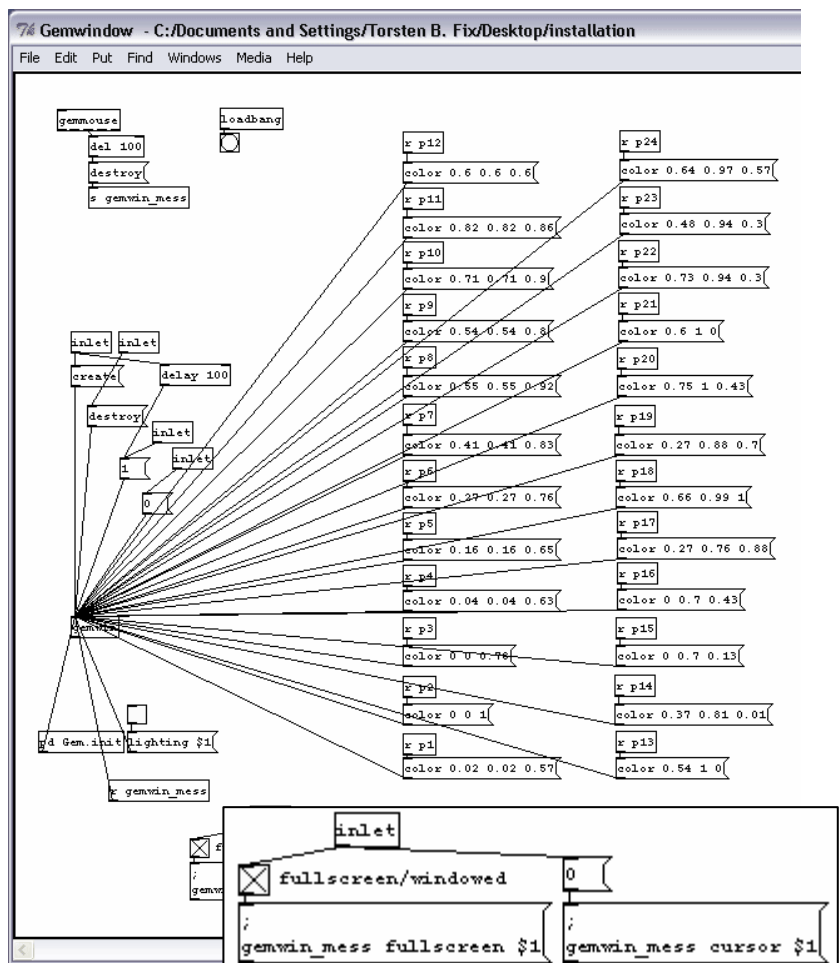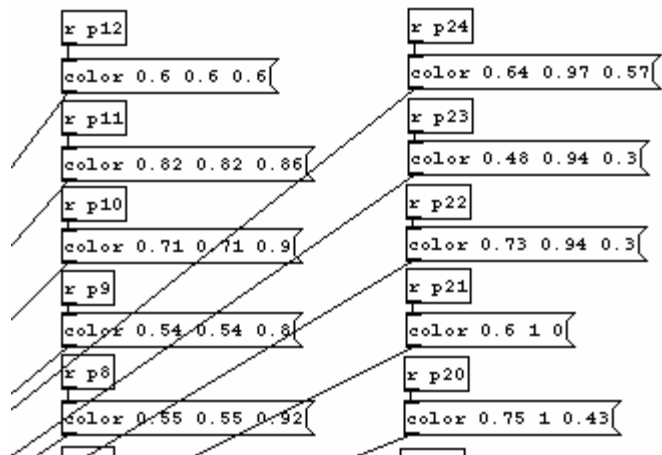

Figure 24 - Gemwindow

From the [gemwindow] we have the possibility to change the background colour. This is done by sending a colour message to the [gemwin] object. The colour message contains the RGB values for the colour we want to use. The changing of the colour is controlled by a receiver object which takes the signal from the sensors and transfers it to the colour message.

```
r p12
color 0.6 0.6 0.6
r p11
color 0.82 0.82 0.86
r p10
color 0.71 0.71 0.9
r p9
color 0.54 0.54 0.8
r p8
color 0.55 0.55 0.92
```

```
r p24
color 0.64 0.97 0.57
r p23
color 0.48 0.94 0.3
r p22
color 0.73 0.94 0.3
r p21
color 0.6 1 0
r p20
color 0.75 1 0.43
```

As you can see in the next picture, 6 of the sensors have 4 different functions attached. This gives the possibility to have 4 different background colours and 4 different sounds to manipulate with from each of the 6 sensors. On the above picture the [r p12] is the receiving of the signal from sensor number 6 with the function p12.

```
t 6
random 3
select 0 1 2 3
50    52   54   56
+ pitch
p6   p8   p10  p12
```
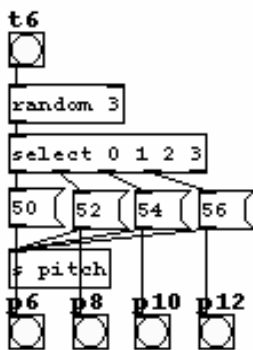
Figure 25 - Sensor input 6

The input patch

```
input - C:/Documents and Settings/Torsten B. Fix/Desktop/installa...
File  Edit  Put  Find  Windows  Media  Help

notein
stripnote
select 1 2 3 4 5 6 7 8 9
```
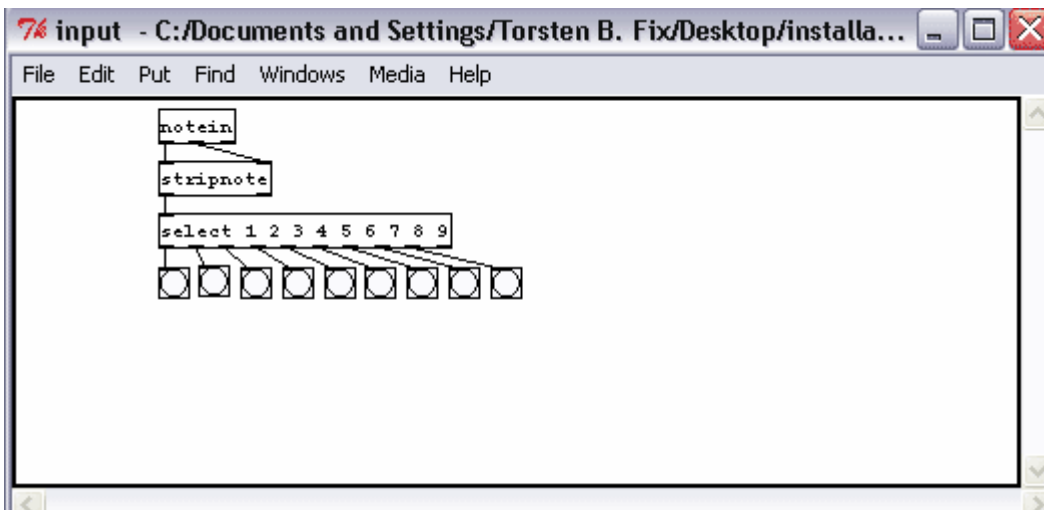
Figure 26 - The input patch

Here it is shown how the sensors are connected to the installation patch. The [notein] object receives midi input from the IcubeX box which again receives and transforms the analogue input from the sensors. After that the [notein] object sends this information to the [stripnote] object which selects the notes we want and removes everything else. The [select] object sorts the notes received and sends out a [bang] message with information on which note is triggered.

The synth patch
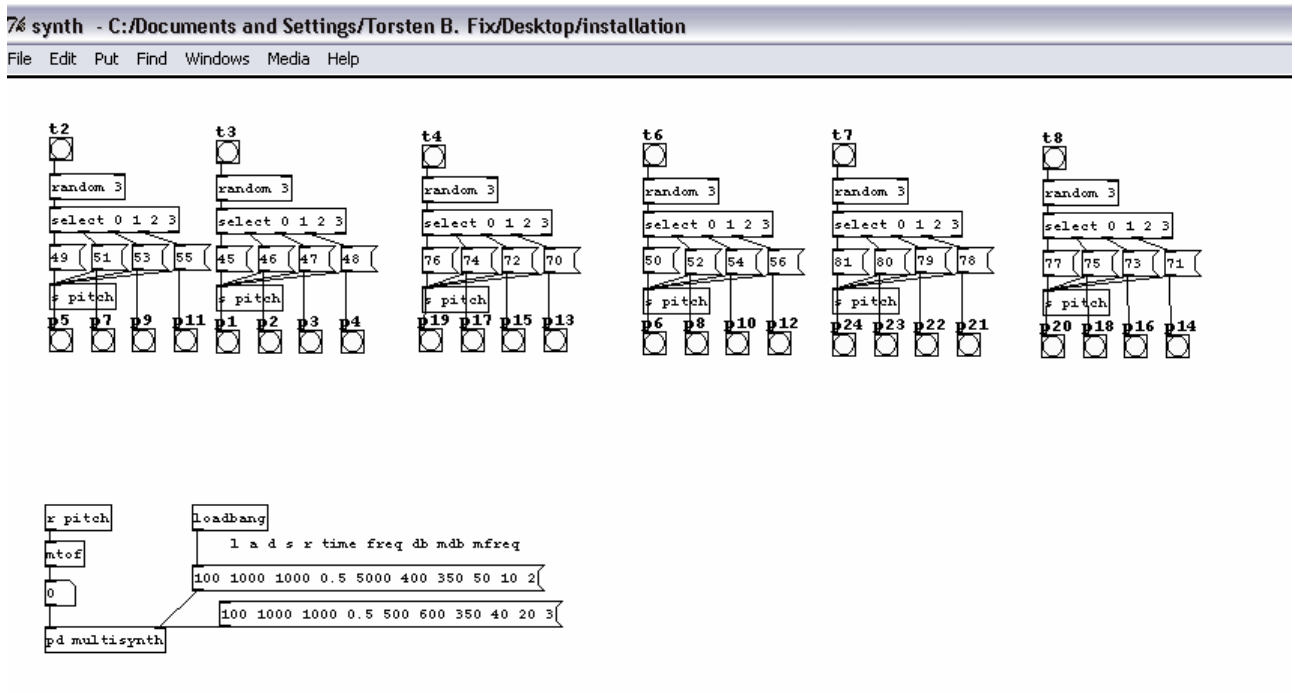
Figure 27 - The synth patch

This patch receives the bang message from the input patch. If the bang is either a t2, t3, t4, t6, t7,or t8 it then makes a random sorting for 1 of the 4 functions to be used. In this case the functions are related to the sounds and this is why every of the [pxx] have their own frequency that can be changed in order to achieve a different sound content of the installation.

We have only mentioned 6 of the 9 sensors in the previous section. This is because the last 3 sensors represents the drum sounds of the installation and are mapped in a special manor.
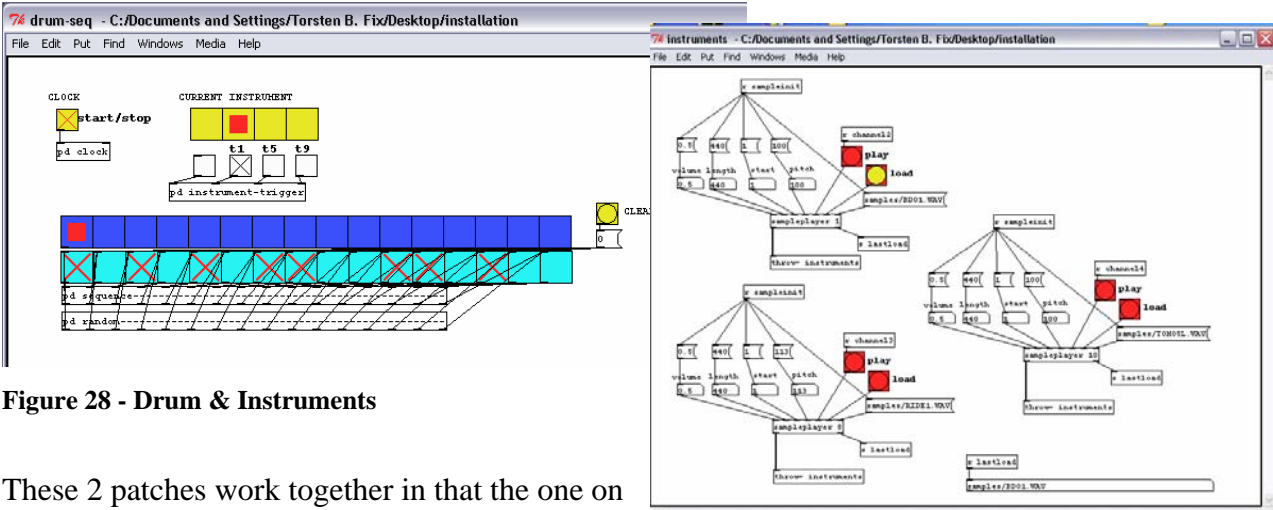
Figure 28 - Drum & Instruments

These 2 patches work together in that the one on the right reads small sound samples and changes the pitch, start length and volume.

The patch on the left represents a drum machine that takes a specific sound sample for the corresponding sensor, and plays it in a sequence.

The graphic patch
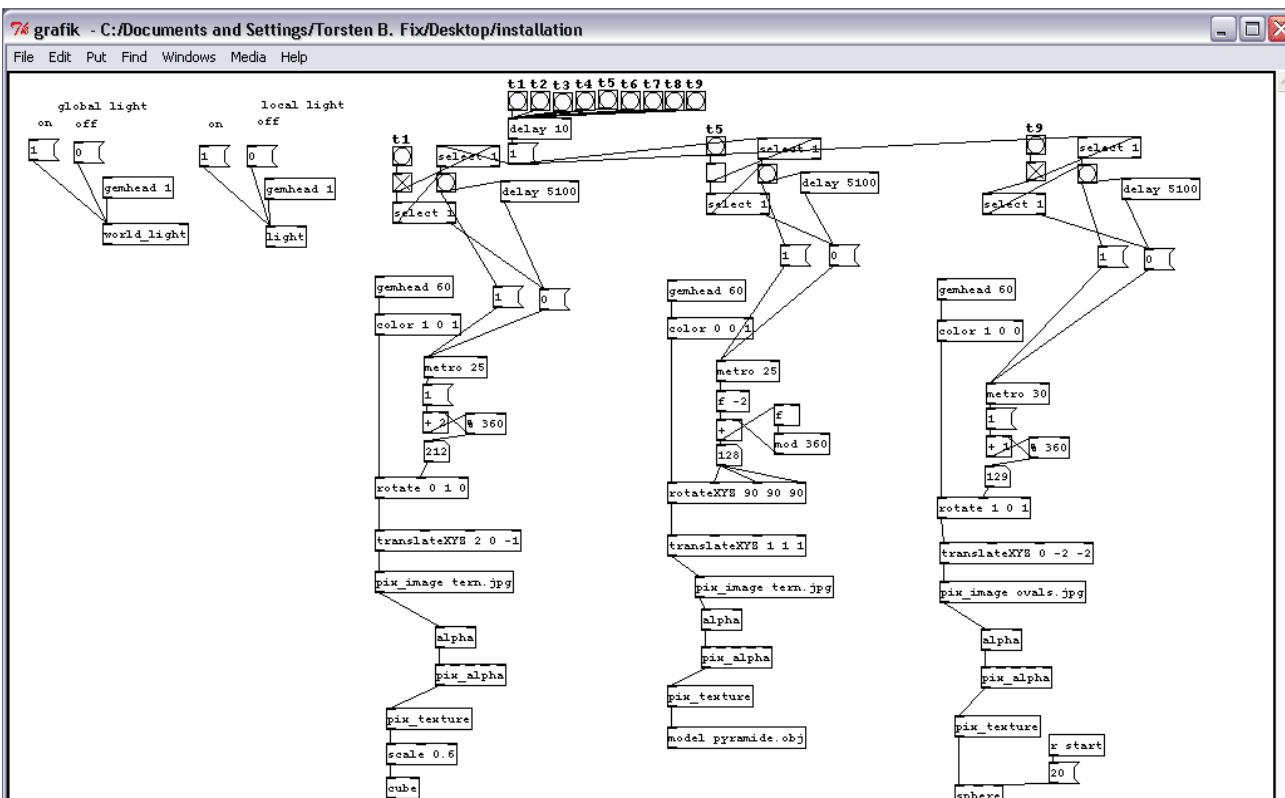
Figure 29 - The graphic patch

We have mentioned that the drum sensors are mapped in a special manor. Besides having complex drum sounds, they also are the only that interact with the graphical objects in the installation patch. The above picture shows the 3 objects: Cube, Sphere and the Pyramid. Every one of the graphical objects has a defined texture, colour and a start position on the screen.

The Cube object has a [rotate 0 1 0] function attached which mean that the cube can be rotate along the Y axis.

The master-out patch

This patch receives the different audio information, sets a delay and sends it to the [dac~] object which is connected with the audio hardware.
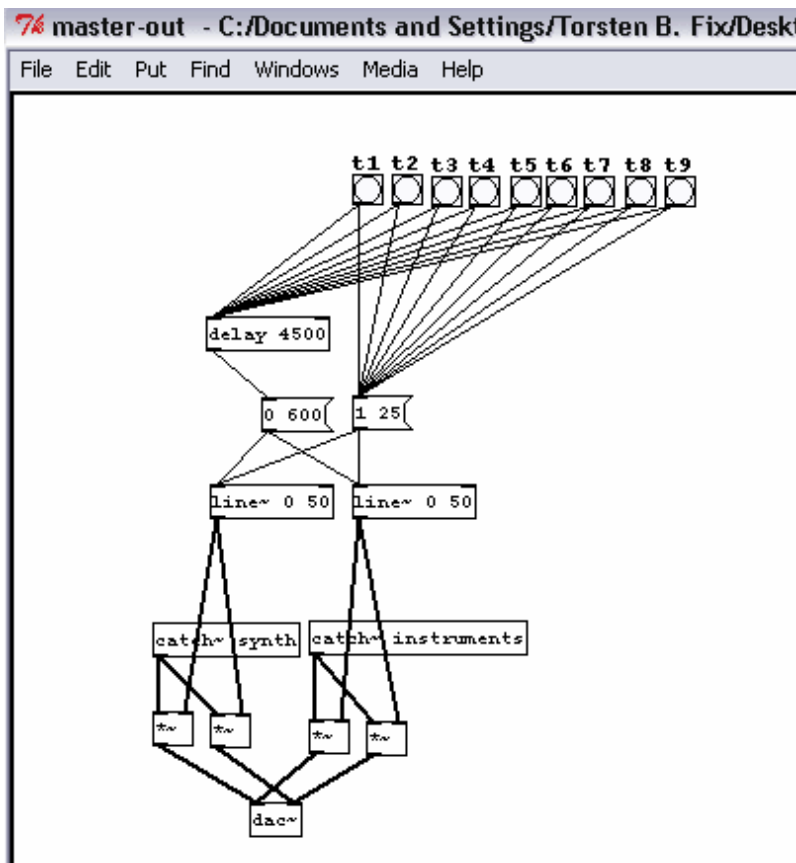
Figure 30 - Master out

4.6 Content of the exhibition

The starting point is the basic installation patch, described on the previous pages. This is because we have developed several others besides the basic patch. The installation has been exposed at the music conservatory in the occasion of a music day. We decided to change the installation patch based on the feedback we got from first time we exhibited the installation. We saw the music day as opportunity to experiment with different mappings mostly because the wide age range of the visitors.

4.6.1 Basic installation patch

The first patch was made in a hurry, because of the time pressure we were confronting. The choice for colours was the mixture of winter and spring colours. The patch was made in winter time, so the choice was quite easy.

The sensors are divided up into several categories: Drums, winter colours, spring colours, high and low sound.
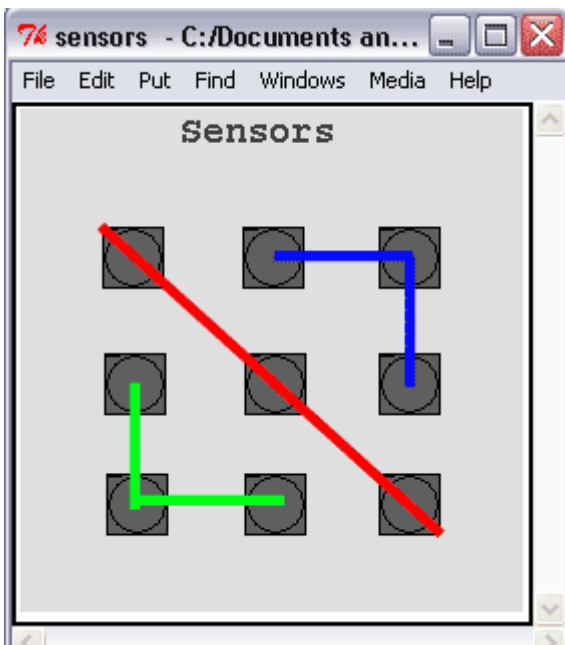
Figure 31 – Virtual setup of sensors

The red diagonal line is represents the sensors that are mapped to drum sounds. Above the red line are the winter colours and the corresponding sounds. Below the red line are the spring colours with the corresponding sounds.

In the setup the corners below and above the red line are the most colour and sound intensive. If we go to the left or right from the corner, we can se a shading of the colour and sound scheme.

In this way the drum sensors can be seen as a middle of a mirror in which the spring time is mirrored to the wintertime.

4.6.2 Extended installation patch

Recently we had the opportunity to present our exhibition at the conservatory. This gave us the opportunity to conduct a small but unscientific experiment on the visitors. We did this by observing and talking to some of the visitors. We decided to extend the basic patch so that it only used two colours. Based on the theories Goethe had about how humans perceive colours we decided to use the colours blue and red. These are contrasting colours and would invoke a better response from the viewers. Here is an illustration of how we have mapped the colours to the sensors.

No	%	R	G	B	R	G	B		Sensor no.
1	0,392157	0	0	255	0,000	0,000	1,000		3
2	0,392157	0	0	242	0,000	0,000	0,949		
3	0,392157	0	0	225	0,000	0,000	0,882		
4	0,392157	0	0	203	0,000	0,000	0,796		
5	0,392157	0	0	179	0,000	0,000	0,702		2
6	0,392157	0	0	154	0,000	0,000	0,604		
7	0,392157	0	0	128	0,000	0,000	0,502		
8	0,392157	0	0	101	0,000	0,000	0,396		
9	0,392157	0	0	75	0,000	0,000	0,294		6
10	0,392157	0	0	52	0,000	0,000	0,204		
11	0,392157	0	0	30	0,000	0,000	0,118		
12	0,392157	0	0	0	0,000	0,000	0,000		

No	%	R	G	B	R	G	B	Sensor no.
1	0,392157	255	0	0	1,000	0,000	0,000	7
2	0,392157	242	0	0	0,949	0,000	0,000	
3	0,392157	225	0	0	0,882	0,000	0,000	
4	0,392157	203	0	0	0,796	0,000	0,000	
5	0,392157	179	0	0	0,702	0,000	0,000	4
6	0,392157	154	0	0	0,604	0,000	0,000	
7	0,392157	128	0	0	0,502	0,000	0,000	
8	0,392157	101	0	0	0,396	0,000	0,000	
9	0,392157	75	0	0	0,294	0,000	0,000	8
10	0,392157	52	0	0	0,204	0,000	0,000	
11	0,392157	30	0	0	0,118	0,000	0,000	
12	0,392157	0	0	0	0,000	0,000	0,000	

The response to this mapping was positive. But we observed that the younger participants were more interested into the sound part of the exhibition, also due to the fact that the colours, being so close to each other and the fact that the fabric of the walls absorbed some of it, was not very intense on the exhibition's walls. Another thing we observed was that the audience was very busy making songs out of the sound part of the exhibition. Of course this was kind of anticipated because we were actually at the conservatory and the participant's backgrounds were related to music.

Based on these observations we decided to make another patch. In this patch we again made changes to the colours, because the sound part was actually okay. This time we mapped 6 different colours on each sensor. Each of these colours could shade from very intense to dark. The mappings are showed in the following table:

No	%	R	G	B	R	G	B	Sensor no.
1	0,392157	0	255	255	0,000	1,000	1,000	3
2	0,392157	0	200	200	0,000	0,784	0,784	
3	0,392157	0	187	187	0,000	0,733	0,733	
4	0,392157	0	0	0	0,000	0,000	0,000	
5	0,392157	0	0	255	0,000	0,000	1,000	2
6	0,392157	0	0	200	0,000	0,000	0,784	
7	0,392157	0	0	157	0,000	0,000	0,616	
8	0,392157	0	0	0	0,000	0,000	0,000	
9	0,392157	255	0	255	1,000	0,000	1,000	6
10	0,392157	200	0	200	0,784	0,000	0,784	
11	0,392157	164	0	164	0,643	0,000	0,643	
12	0,392157	0	0	0	0,000	0,000	0,000	

No	%	R	G	B	R	G	B	Sensor no.
1	0,392157	255	0	0	1,000	0,000	0,000	
2	0,392157	185	0	0	0,725	0,000	0,000	7
3	0,392157	138	0	0	0,541	0,000	0,000	
4	0,392157	0	0	0	0,000	0,000	0,000	
5	0,392157	255	255	0	1,000	1,000	0,000	
6	0,392157	225	225	0	0,882	0,882	0,000	4
7	0,392157	198	198	0	0,776	0,776	0,000	
8	0,392157	0	0	0	0,000	0,000	0,000	
9	0,392157	0	255	0	0,000	1,000	0,000	
10	0,392157	0	225	0	0,000	0,882	0,000	8
11	0,392157	0	185	0	0,000	0,725	0,000	
12	0,392157	0	0	0	0,000	0,000	0,000	

The first we observe with the new patch was that especially the young audience was more interested in trying the exhibition over and over again. The age range was around 10-16 years of age. We notice that the visiting of the exhibition suddenly turn into a contest and a dance floor.

We have to stress again that this was not a scientific experiment that we conducted. If we wanted to do it in a scientific way, we would have selected different target groups and make specific questionnaires to support our research. One thing we notice at the conservatory was that it was not necessarily to focus our attention on a specific target group. Almost everybody gave a positive response to our exhibition. An explanation to this can be the fact that the content of the exhibition is basic in its form and not containing age specific preferences in music and colours. We see our exhibition as being a piece of abstract art. This is why some people like it and some don't.

5. Conclusion

The purpose of this report was to document a solid background for our interactive exhibition: CUBE. The best way to get started and get some insight into the area of exhibitions was to visit local places where there were exhibits related to our project.

The content of the CUBE is a mixture of colours and sounds. In order to use these properly we took a closer look to the theories of Sir Isaac Newton and Johann Wolfgang von Goethe. The fact that we used Goethe's approach is no surprise because of his humanistic concept of perceiving colours.

The process of building an interactive exhibition has given us hands-on experience in the creation part, the learning process in cooperation with all kinds of people. This all led to the broadening of our horizon in the area of interactive exhibitions.

6. References:

6.1 Figures

Figure 1 - Anatomi
Christian Lemmerz (1995) *Christian Lemmerz.* Forlaget Søren Fogtdal, ISBN: 87-7807-244-1

Figure 2 - Goldfish in blender
AP Photo/Nordfoto, Palle Hedemann

Figure 3 - Skeel & Skriver, Split second
Figure 4 - A sound lab for children, sound box
Figure 5 - A sound lab for children, sound manipulator
Figure 6 - Prism Experiment diagram
Dennis L. Sepper (1988) *Goethe contra Newton* (pp. 11). Cambridge University Press, ISBN: 0-521-34254-6

Figure 7 - Prism experiment picture
Henrik Boëtius., Marie L.Lauridsen & Marie L. Lefèvre (1998). *Lyset, mørke og farverne* (pp. 23). Multivers, ISBN: 87-7917-000-5

Figure 8 - Newton's colour circle
Dennis L. Sepper (1988) *Goethe contra Newton* (pp. 12). Cambridge University Press, ISBN: 0-521-34254-6

Figure 9 - Spectrum Newton contra Goethe
Reconstruction of
Henrik Boëtius., Marie L.Lauridsen & Marie L. Lefèvre (1998). *Lyset, mørke og farverne* (pp. 24). Multivers, ISBN: 87-7917-000-5

Figure 10 - The colour circle according to Goethe
Henrik Boëtius., Marie L.Lauridsen & Marie L. Lefèvre (1998). *Lyset, mørke og farverne* (pp. 21). Multivers, ISBN: 87-7917-000-5

Figure 11 - Projectors setup
Figure 12 - 3D models of the CUBE
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Figure 20 - GEM example

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rogerroger.panicnow.net PD PATCHES http://rogerroger.panicnow.net/PD_patches.htm#CMDG
(included on the cd named: rogerroger.panicnow.net.pdf)

Figure 23 - Main window
Figure 24 – Gemwindow
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Figure 30 - Master out
From the Installation patch (included on the cd under the folder Installation0)

Figure 31 – Virtual setup of sensors
From the Cube patch (included on the cd under the folder Installation-cube)

6.2 Books

Dennis L. Sepper (1988) *Goethe contra Newton* (pp. 1-21). Cambridge University Press, ISBN: 0-521-34254-6

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