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THC: AUTONOMY IN MUSIC INTERACTION

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The Happy Cube [THC] is an interactive musical object. It reacts to human actions taking advantage of cube geometry as a model for music creation. The cube produces a different set of electronic sounds (square waves) depending on the side it is leant on. When turning the cube around, some variations and transformation of the original set will occur. Users can explore the cube sonorities changing the object position against the light source. The happy cube is not dependent of any external system, it has a self-regulated behavior related to a state of autonomy that leads the laboratory, sketching and design processes.

1. Introduction

In this paper I describe the design process of a sound device prototype called *The Happy Cube* [THC], as a partial result of an ongoing laboratory survey that explores in the realm of collaborative music activity. Within the subject of research, Networked Music [NM] [Weinberg, 2005], [Barbosa, 2008], [Arango, 2010] there is a paramount concern for social interaction in music performance, since a communication network shared by different musical agents is established. This interaction settings enables synchronization of temporalities and connections between autonomous individuals. THC is intended to act as an autonomous musical agent. It means, in the one hand, a stable roll within the musical context, in the other, a territory of negotiation with physical interaction. The cube works as an independent entity, introducing data from human actions and others agents through a virtual net of musical relations.

In the long term, this project tends to develop a collaborative environment between different musical agents. On the course of laboratory activity some fundamental concepts of NM are being incorporated as design variables: control, autonomy, interdependence, ubiquity, interaction. Future development of these ideas will be implemented in a work-in-progress laboratory that leads THC prototypes construction design.

2. Autonomy

Sonic control with every day objects and musical instrument is traced by relations of dependence. Without stimulation, these objects have an undefined condition within the musical context. To participate as agents they have to be physically excited by the player. In this way, an autonomous musical agent could be dependent on human interaction, but an entity that gets a defined relation within the musical environment.

Although, interaction with other agents is taken in consideration as an important variable to music activity. Here are interdependece relations rising. According to Gil Weinberg, in music performance interdependence and autonomy are opposites [Weinberg, 2005:37]. The power of such a communication context influences and modifies agents individual musical behavior. Cybernetic theoretician Paul Pangaro remarks that "...the division between action and reflection is what makes a system autonomous" [Pangaro, 2010]. In accordance with that idea, autonomy includes taking some distance to observe from the outside the individual behavior within the context.

In Sonology, autonomy is also related to the breakdown of dependence relations with a centralized system. In this sense, the interaction model proposed by MIDI controllers represents an extreme case of dependence. The submission to the system in order to provide an output, and chord connections to the computer make that MIDI controllers are being used just as specialized control devices, and its interaction procedures are subject to other machine operation. Far from being autonomous, MIDI controllers are in a double dependence condition: from another system and from human interaction.

An autonomous musical agent had to be a self-regulated entity that includes a balance between inputs and outputs, as well as, has its own musical interaction procedure. The object depends on itself, but reacts to human actions and creates links with other agents. Although some of these reflections go beyond the scope of this project, the concept of autonomy leaded The Happy Cube laboratory process.

3. Interaction

In order to provide autonomy to the object I took in consideration a cube specific interaction logic. The object qualities had to suggest the interaction procedure and the vocabulary of movements. At the same time, the object had to be operationally self-regulated to consolidate a defined roll within the musical environment.

Initially, 3D figures were analyzed (cube, sphere, cylinder, cube). Depending on the observer position they can adopt different 2D forms. A sphere will always be seen as a circle, although it is in movement or in different places. Cones and cylinders can be seen as a circle according to the observer perspective, as well as if they are turning around its axe. The cube, the chosen figure, offered a diverse and finite collection of states. In the six possible positions that a cube can be placed, there was relatively simple sensor measure conditions. In this way, the project started asking about the particular musical criteria that the cube geometry could have.

In order to freely move and translate the object some size, lightness and strength restrictions were taken in advice. A 20 cm3 were constructed. For the first prototype, the chosen material was a hard foam board sheet, see "Fig. 1". For the second one I used acrylic, see "Fig. 1". Sensors and actuator were carefully placed inside the cube, as well as the arduino and the 9v battery.

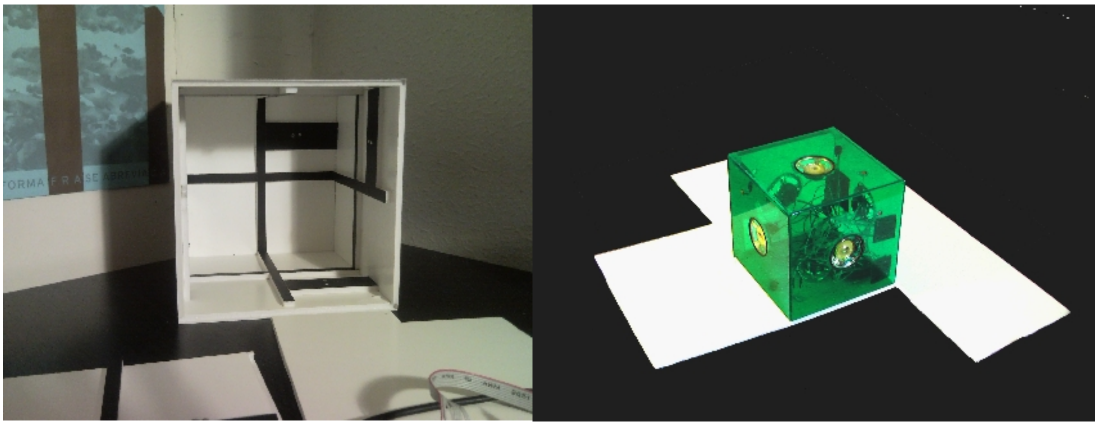


Figure 1. The first foam-board prototype (left) and the acrylic one (right).

4. Tools and Code

The object was developed with the arduino micro-controller, some sensors and actuators. Two prototypes were constructed with different materials. The code looks for interaction links with physical actions, as long as for autonomy conditions and a self-regulated behavior.

4.1 Output

Before choosing the output, some tests were made with some low-level sound output devices as twitters, piezoelectric devices and buzzers. All of them were controlled from the arduino with the *Tone* library. Each one of these components had strengths and limitations to the project. Due to the object scale (20 cm3) an intimate sound level was intended. Six piezoelectric devices were used in the first prototype and tiny twitters were used in the second one.

The main challenge was to build meaningful sound structures with the limited arduino musical resources. The technical restrictions found in the arduino *Tone* library became the deterministic base for the music material. The *Tone* library works with square waves whose frequency and duration parameters can be changed on the course. Even though, it only allows playing one note at time, in other words, it is monophonic. This limitation was balanced with the possibility to use six different sound outputs placed in each side of the cube, see “Fig. 2”.

Two tiny 5volt buzzers were also used. This devices can be operated by the arduino digital and PWM (Pulse Code Modulation) pins. Taking advantage of its considerable higher level a percussive material was composed with the buzzers. In order to provide articulation to the rhythmic patterns a mute damper was adapted to one of the them.

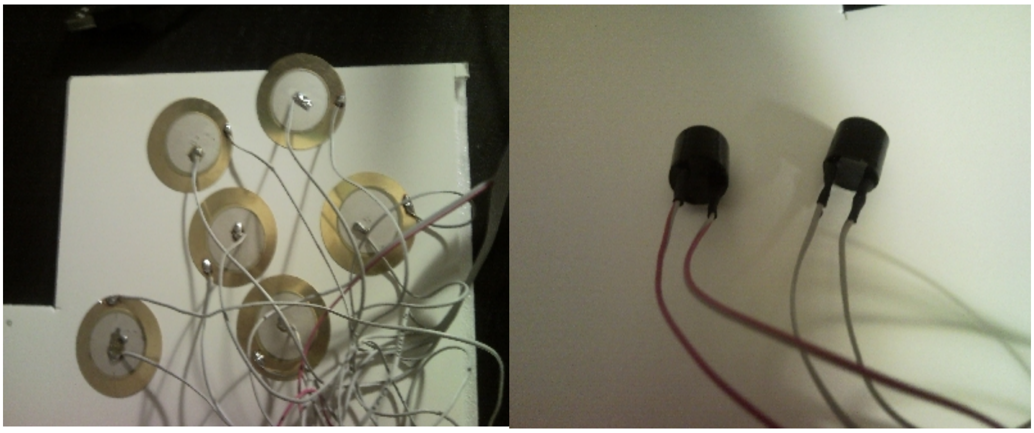


Figure 2. Piezo-electric devices (left) and buzzers (right).

4.2 Creating melodies with arduino

For each side the cube can be leant against a surface, a different musical square wave set was composed for the six piezoelectric devices/twitters and two buzzers. One of these sides/sets remains silent suggesting that this side can be used to begin and finish the composition/interaction. The other “sounding sides” are equivalent to parts (A, B, C, D, E) whose order is driven by the visitor. For this project, I use the term “set” referring to a melodic-percussive structure that is in constant variation. It is the product of piezoelectric devices/twitters and buzzers performance. The same frequency group, shown in “Table 1”, was used in every set, even though different transposition, permutation and omission were applied.

Table 1. Group of frequencies shared by every set.

131 Hz	65 Hz	247 Hz	196 Hz	185 Hz	165 Hz

A *for* loop that read the group of frequencies (nota) with the same duration (dur) was written for each set. Next code shows an example from set 4.

```
for (int pin = 2; pin < 8; pin ++) {

    int mel []={0, 0, 131, 65, 247, 196, 185, 165 };

    tone (pin, nota, dur);
```

Each loop executes the group of frequencies in different ways. In order to play transposed notes and cause short tempo pauses *random* operators were implemented. Little sequences are successively being executed with another *for* loop. Next code shows an example from set 5.

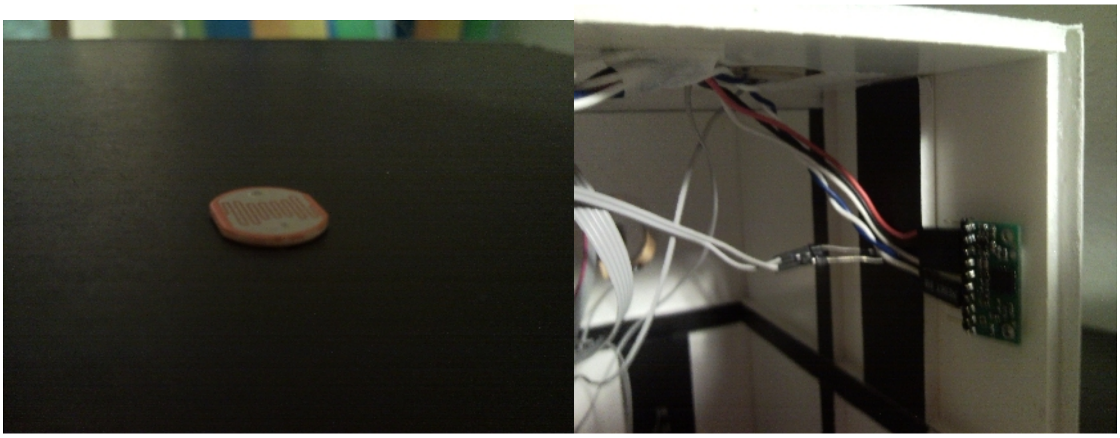
```
for (int pin = 2; pin < 8; pin = pin++) {

int notas [] = {0, 0, 65, 287,65, 65,65,  65 };

for (int arp = pin[notas]; arp < 800; arp+=arp*(pin/pin+1)) {
```

In this case, the sequence executes partials of each note until 800 Hz. The melodic material executed by the piezoelectric devices is joined by the buzzers, they reinforce each attack with a short percussive onset that is sent from digital and PWM pins. Next code shows an example from set 1.

```
analogWrite(8, -1);
digitalWrite (9, -1);

tone (pin,nota,dur);

int del = dur*1.30;
delay (del);

analogWrite(8, 0);
digitalWrite (9, 0);
```

4.3 Input

As it was mentioned, sensors help identify on which side the cube was leant, see “Fig. 3”. To do that, a photo-resistor were adapted on five of the six cube exterior surfaces. The script defines a threshold that is constantly compared with each of the five analog input values. When the cube is leant on one of its sides, luminosity goes down on this photo-resistor, and so, corresponding set is executed.



In order to include other kind of movement to the object, a LPR-503 AL biaxial gyroscope was implemented as seen in “Fig. 3”. This device provides the rotation rate in its X ad Y axes, when the object sporadically turns around, the gyroscope reports a drastic change in the analog input flow. This measure was useful to provide variations in each set. Turning around the cube causes an acceleration / deceleration event in tempo, as well as, a disruption in the loop that reads the group of frequencies. This is showed in next example, where the gyroscope value temporary changes notes duration.

```
int dur = 1000+(dataX*random (2000, 4000));
```

5. Analyzing the results

The cube sound output got a defined musical roll within the environment. The shared group of frequencies, the regular pulse and the implemented sound techniques leaded to a common sonority for all the sets. At the same time, omissions and permutation in the order of execution in piezoelectric devices and buzzers generated variations in the musical material. The balance between unpredictability and repetition leads to what this project designates as “defined musical conditions”.

The inputs establishes e relations between musical material and cube qualities, in this case, geometric ones. Besides, the input creates an interactive territory for the visitor. THC can be seen as an independent agent that has its own place in a musical context, furthermore, it establishes connections with visitors and other agents. With these two qualities, THC reaches an equilibrium state that is related, in a purely metaphorical way, to an emotional state of self-governed autonomy (happiness). A video showing THC operation can be seen at http://vimeo.com/20513743.

5.1 Future Development

This project intends to build a group of objects that, besides autonomy, establishes other kind of musical relations such as interdependence. It will allow my research to observe some collaborative traces involved in music performance. THC will participate along with other agents in a local network where information flows towards a common musical goal. Another musical agent will be able to autonomously modify its behavior when warning about THC change of state. Meanwhile, THC will react to a requisition or demand made by another agent. At the moment, a musical agents local network is being created with X-Bee modules, thereby, THC will have this future implementation.

6. CONCLUSION

At the end of the day, in order to confer some autonomy to an object, the election of a box was not by chance. It is related to laboratory activity, as Bruno Latour remarks: “... we will watch the closure of the black boxes and be careful to distinguish between two contradictory explanations of this closure, one uttered when it is finished, the other while it is being attempted”. [Latour, 2000:31]”. Before the closure of the box, the main problem is functionality, after do it, rises music problems. Here is that I need to open the box again and again. In THC project, the functional object is the laboratory, in which, musical operations, adaptations and reflections will be posed.

7. Acknowledgements

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