Using the Voice to Design Ceramics

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Abstract. Digital technology makes new possibilities in ceramic craft. This project is about how experiential knowledge that the craftsmen gains in a direct physical and tactile interaction with a responding material can be transformed and utilized in the use of digital technologies. The project presents SoundShaping, a system to create ceramics from the human voice. Based on a generic audio feature extraction system, and the principal component analysis to ensure that the pertinent information in the voice is used, a 3D shape is created using simple geometric rules. This shape is output to a 3D printer to make ceramic results. The system demonstrates the close connection between digital technology and craft practice.

Keywords: Experiential knowledge, design method, CAD, generative 3d software, interaction audio features.

1 Introduction

This project builds on McCullough's [1] idea about a close connection between digital work and a craft practice, and that the hand and brain activities related to computer technology may be analogous to practical activities where tacit knowledge, according to Polanyi [2], is involved. McCullough's research is based on studies of crafts; design processes and tools related to fundamental human activities. The results of these studies are related to the artist Bernard Leach's [3] idea about crafting and execution as a unity that is intuitive and humanistic - *One Hand, One Brain*. Thus McCullough suggests that computer systems should be developed much more from the user's perspective (here, the designer) to utilize tacit knowledge.

The overall field of this research is about integration of digital technology in the field of 3D design, especially in fields rooted in arts and craft such as ceramics. In this case it is about how experiential knowledge of craftsmen is transformed and utilized in the use of digital technologies. Specifically, the project focuses on the development and exploration of a digital interactive design tool that uses voice as input and 3D physical form as output by rapid prototyping. As the voice is among the main communicative and expressive parts of the human, this project, which we call SoundShaping, is made to investigate what the voice is capable of creating in 3D ceramics.

Firstly, this concept implies the study of the interaction between the designer using voice as input and a real time dynamic and responding 3D graphics. Secondly, it

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focuses on the output in 3D physical form, i.e. actual and real, a form that can be viewed, touched, and thus examined from different angles. This part is done with digital-based 3D printing in order to obtain ceramic items from the digital tool. The project distinguishes itself exactly by the combination of interaction and 3D tangible form.

The approach is driven by a desire to *humanize* the use of digital technology in the field of design. By humanizing we mean that the involvement of the body is being exploited in the use of digital technology—and that it is reflected in the product. It can be hand gestures, body movement, or as in this project the voice, that forms the basis for an interaction through digital technology.

This approach is seen as a contrast to the predominantly use of mouse click and typing in numbers, which does not utilize the body as a tool to accentuate the design with digital technology.

The article reports from the first stage of the technically, artistically and experimentally development of this design tool, which is done in collaboration with students from ad:mt at Aalborg University in Esbjerg.

2 Field of Research

The overall research field is characterized by a creative use of equipment within digital technologies, e.g. the work from the research cluster Autonomatic [4] that explores the use of digital manufacturing technologies in the creative process of designing and making three dimensional objects. One example is Drummond Masterton's [5] intense process of testing CNC milling, adjusting large segments of machine code and changing or making tools for the machine to use. This work is seen as a transformation of how a silversmith might use a range of hammers and stakes to create a certain form or texture (according to Bunnell [6]). Another example is Tavs Jørgensen [7] use of CAD programs that enable production of flat patterns from which prototype models are constructed. The methods is similar to that used for traditional origami models, but the complexity of the shapes means that they could never have been realized without the use of IT tools. The complexity of the shapes is contrasted by the simplicity of the plaster moulds used to cast the ceramics pieces [7]. These are examples that integrate manufacturing with digital technologies in a way that builds on a craft tradition.

An overlooked area within the field of ceramics is the experiential knowledge that the ceramicist gains in a direct physical and tactile interaction with a responding material. Manuel de Landa [8] describes it as …*a form that we tease out of those materials as we allow them to have their say in the structures we create*, and Leach [3] as ….*a living embodiment of the intention*… Hansen [9] argues that this experiential knowledge of craftsmen can be transformed and utilized by the use of digital technologies. It is knowledge based on tacit knowledge experienced from an experimental, explorative and tactile interplay with a physical material. This approach, that Hansen calls the *interactive material-driven designing,* is characterized by two layers. Firstly the craftsman developing his own material and technique, and secondly by examining the potential of the material by interacting with it and being attentive to its response. This is about an intimate relationship between the designer and the material, which is reflected as a unique artistic fingerprint in the final artefact.

Hansen's conclusion is that such an approach to designing is utilized with digital technology, when the designer develops his own digital *material* [9]. If the designer is not able to develop his own digital *material*, he should collaborate with relevant specialists to make this possible. This project constitutes such collaboration.

A parallel to the idea of a responding material is to be found in the generative potential within digital technologies. It means that the computer is able to produce results based on input. An important development in this field of design can be referred to the animation techniques introduced by Greg Lynn and the experimental use of diagrams introduced by Peter Eisenman during the nineties (according to Sevaldson [10]). This is also about a focus on how interrelated forces in a complex dynamic system works as a kind of *abstract machine* [11], which is utilized as part of the design process.

The aspect of interaction within digital technologies is well known in the field of interaction design and event based productions such as computer games, interactive art installations, performance etc. Such a use employs the digital technology as part of its own medium and makes up a clear distinction from a tool [12] that is the purpose of this project.

An example is the interactive dance-architecture Sea Unsea [14], which takes place on an interactive stage informed by a camera interface (by motion capture). The performers' movements affect a sonorous field of sound and explore, attracting, repulsing and entwining their bodies and voices within an evolving patterns of a swirling hypnotic synthetic sea (CITA 2011) [13]. Another example is World Ripple by Ståle Stenslie [15]. World Ripple builds sculptures out of emotions rendered real. It is an invisible, immaterial sculpture made sensually *senseable* by a tactile, wireless, mobile bodysuit with a binaural sound system. The sculptures are triggered by GPS coordinates.

Thus the digital tool is about connecting the aspect of interaction with a generative responding potential material through digital media. This integrates digital technology in design practice in a way that utilizes the experiential knowledge about the design process of craftsmen, and thus the intimate relationship between the designer and the material. This is what we call humanizing the digital technology as a tool for 3D design.

Such a research firstly is about an experimental development of a generative digital responding material in a close relation with a programmer or suchlike. Secondly it is about examining the potential by interacting with the body (in this case by the voice) and being attentive to the response. These are two coherent and interrelated issues; it is in the light of this interaction that the generative digital responding material is developed and programmed.

3 Experiment

In this research we employ the *research through design* methodology (Frayling [16]), which for our purpose is defined as an experimental design practice that is part of the design research and contributes empirical data. The method is explorative and experimental, which in this study means that the research questions and empirical series of experiments are produced and developed in the process of research. This approach is seen as a *reflection on action* similar to Schön's ideas [18]. The method begins with a definition of a frame for carrying out experiments, which is defined by the overall research question. This approach is inspired by Binder and Redström's [19] notion of *exemplary design research*:

> *It is 'exemplary' in the sense that it enables critical dissemination primarily by creating examples of what could be done and how, i.e. examples that both express the possibilities of the design program as well as more general suggestions about a (change to) design practice.*

The intention with this paper is to give an insight into one of these experiments in this frame and the potential it may exhibit.

Sound is invisible, but when it hits the ear membrane, it is *translated* into intelligible sound by the brain using neuronal signals. We are interested in the idea of a translation of the audio, but a subjective translation to a three-dimensional form, which can be seen and touched as a kind of physical memory and that reflects the audio experience.

The subjective translation is viewed as an artistic fingerprint, which motivates the interactive process and the artistic intention. The translation is seen as a responding generative 3D graphic that transforms the designer's audio input. Interaction is an unpredictable and surprising process that motivates an exploratory and experimental process for the designers and researchers.

3.1 Overview

The SoundShaping system overview can be seen in figure 1. It consists of an *Audio Feature* estimation module, a *PCA* module to extract the most important information from the audio features, a *Shape Creation* module, and the *3D print* module.

In this work, we consider the voice as an expression of information through the use of vowels and consonants [21], and as an expression of emotions [22] through the prosody, i.e. the use of mainly pitch and loudness contours. The *Audio Feature* module extracts intuitive features with a clear relationship to humans, such as pitch and loudness, but also less intuitive features, such as spectrum. In the case of a craftsman using this system, two situations may arise, 1) the craftsman uses intuitive features, such as pitch/loudness, e.g. by singing, or 2) the craftsman does not use these features, but expresses the voice differently, e.g. whispering. If 1) then the craftsman has potential for conscious control of the shape that is created, but in the case of 2), the craftsman has lost the conscious control of the system, because the system does not respond to that category of features and/or other non-intuitive features are used. In order to increase the potential for utilizing any expression of the voice as well as retaining the possibility of a conscious control of the system, the PCA [23] module is introduced. This module extracts pertinent information from the voice, which may be expressed differently from time to time, but the output of the PCA is supposed to reflect the intent of the craftsman, no matter how he or she expresses the voice.

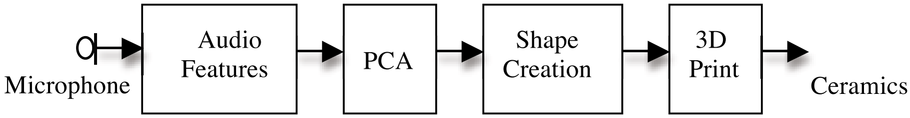

Fig. 1. Overview of SoundShaping system

To decide what the resulting shape has to fulfil, it is needed to look at the purpose. In this research we want to investigate the use of 3d digital designing in ceramics. The 3D print technique is based on the use of a Z Corp 3d powder printer [17], which is changed to use ceramic powder. This technique allows us to print the 3D geometry directly in ceramics. Thus the 3d print has to fulfil the general requirement for firing a ceramic artifact. A ceramic artifact needs to have strong walls, which can resist the heat since the ceramics softens during firing. At the same time the walls should not be too thick since this produces cracks during firing. Thus it is a matter of the construction. The artifact should not be too curved and have a certain strength to support itself, a hollow inside with walls is useful. These requirements had to be fulfilled.

3.2 Audio Features

It is necessary to know what kind of parameters to be used to describe the audio. It is on the basis of the audio parameters an idiom and a dynamic interactive graphics is developed and programmed. Audio can be described using temporal and spectral envelopes that give an overview of the quality of the sound. Furthermore, dependent if the sound is voiced or unvoiced, more parameters can be used to describe the sound in more detail. In this work, the MIR toolbox [20] is used as the basis for audio feature extraction. The *Brightness*, *Roughness*, and *RMS* (loudness) features are used to capture the specific features, and the *Chromagram* is used to capture pitch information. These features capture mainly the prosody - emotional expressions [22] of the voice. The *Spectrum* captures detailed spectral information, and the *MFCC* captures the spectral overview, the spectral envelope. These features capture mainly the information expressed by the consonants and vowels [21]. A frame length of *50 ms* seems to work well in this context.

All in all, the audio features consist of a few hundred values for each frame (time step). In order to lower this number, and to ensure that the most pertinent information from the audio is used, the Principal Component Analysis (PCA) [23] transformation is used on the audio features. This ensures that the output variables are uncorrelated and account for as much of the variability of the voice as possible.

3.3 3D Graphic

The experiment is based on 6 variables (N), and time as a feature. The 3D digital geometry is seen as one object, which evolves in the length over time. The position of the centre is determined by N=1, N=2 and time (figure 2 left). The cross section is determined by N=3, N=4, N=5 and N=6 (figure 2 right), which are connected with a parameterized curve. To make sure there is variation in all shape dimensions, the variables (output of the PCA) are normalized in order to have equal standard deviations.

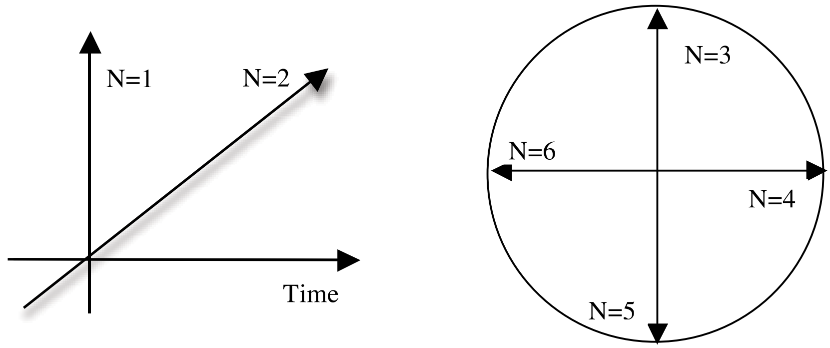

Fig. 2. The position of the evolving 3d geometry is determined by N=1, N=2 and time (left), and the cross section of the 3d geometry is determined by N=3, N=4, N=5 and N=6

Sometimes, the results showed a much-curved and very thin shape, which did not fulfil our requirements. As the voice is a very expressive organ, the resulting shape can be very different. Therefore, many possibilities of parameterization are included, that adjust the resulting rendering. This is utilized to explore and specify the idiom in different categories of sound based on the introductory proposal, e.g. screaming, babbling, talking, singing, etc. and at the same time fulfil the realizable requirements. The options include *Frame size*, choice of *Audio Features*, order of *PCA variables*, *smoothing* length and *curve* parameters. Figure 3 (left) shows a 3D object with smoothing, and the order of *PCA variables* and *curve* parameters options. In figure 3 (right) the same shape is shown as created in ceramics.

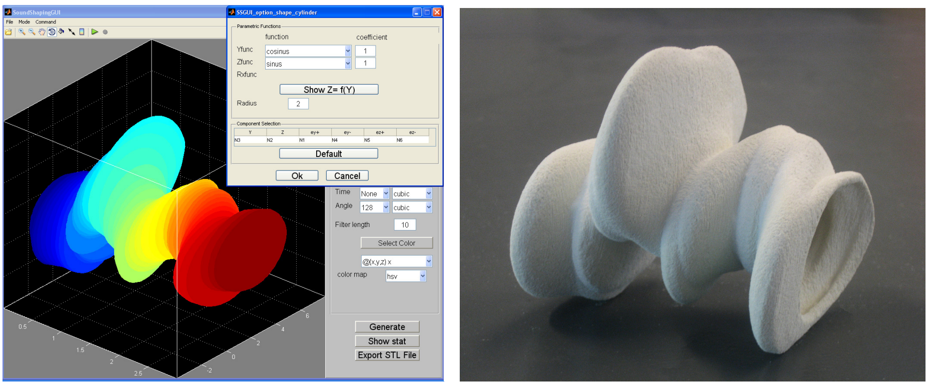

Fig. 3. The SoundShaping interface (left), including curve parameterization and PCA variable order options. The same object created in ceramics is shown right.

This development with parameters makes up an excellent basis to investigate the responding aspect. The exploration of the introductory responding generative system allows adjusting the shape with the voice. At this stage the SoundShaping system creates one object at a time. Each time the PCA is recalculated it creates a shape based on a responding generative system inherent in a complexity within audio features. Thus, with time, the designer explores and obtains the behaviour of the PCA as tacit knowledge. This enables the designer to explore the voice in an individual way and reflects the designers fingerprint in the design.

Such an approach is based on the designer's and the researcher's experiential knowledge, which this project relies on, and permits examining the potential of the material by interacting with it and be attentive to its response.

4 Conclusion

We have in this article introduced an approach to integration of digital technology in the field of 3D designing, especially in fields rooted in arts and craft such as ceramics. The approach is driven by a desire to *humanize* the use of digital technology in the field of design and is characterized by an interaction and a responding 3D graphic that has proven useful to explore and to experiment by interacting with the voice. We have exemplified and discussed this issue based on an experiment.

The experiment was based on the use of a generative system that converts audio into features, and variables (based on PCA) that accounts for the main part of the voice expression. The use of PCA ensures that the craftsman expresses the voice in any manner while still being sure that the output – the 3D object – reflects his/her intent.

A comprehensive and flexible generative system with a parametric user interface was developed. This was utilized to identify different categories of audio, which at the same time was utilized to fulfil our requirements for a ceramic design. The use of PCA showed a potential to generate and reflect a complexity within audio features, which is utilized and transferred to the idiom in the generative system and thus a ceramic design. With further use, the designer gains an intimate relationship to the digital material based on this complexity. The behaviour of the PCA is a responding generative system of which the designer obtains tacit knowledge and utilizes in his own right. This is reflected in the design result as a complexity and a personal fingerprint, as the system using PCA interpret whatever the designer expresses in his voice.

All in all the experiment showed a useful potential at a first stage within the idea of the development and exploration of a digital interactive design tool that uses voice as input, but requires further investigation based on real time interaction. Also our experiment was only based on one 3D model. Other models have to be explored e.g. one which only reflects a frozen moment in a constantly change without time as a feature.

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