Affordances and Constraints in Screen-Based Musical Instruments

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ABSTRACT
The *ixi software* is an ongoing interdisciplinary research project. It focuses on the creation of screen-based interfaces as digital musical instruments. The notion of situated cognition is of particular interest as our findings are that an interface always contains compositional ideologies or mental models of musical intentions. The research involves the study of the determining nature of interfaces when used as tools for creative expression. This paper describes the problems of computer music in terms of HCI and discusses our findings in relation to affordances and constraints in screen-based digital instruments.

Author Keywords
Screen-based musical instruments, embodiment, mapping, affordances, HCI.

ACM Classification Keywords
Sound and Music Computing. User Interfaces.

INTRODUCTION

Creating musical tools and instruments for the computer is a hard but interesting endeavour where the field of Human-Computer Interaction (HCI) is of high importance. In fact, it is a case-study of particular concern for HCI due to various reasons:

Space and organisation. Musicians are used to working in studios full of equipment with buttons and sliders, spatially laid out, where the logic of the process of music production is designed with careful attention to the ergonomics of the temporal and spatial workflow. The simulation of the professional studio on the computer screen has been problematic and often resulted in frustrating and dis-embodied work processes for musicians used to the physical devices.

Embodied action. Musicians have trained themselves to play their instruments over a long period of time and in this process the instrument has become almost an extension of their body. Finesse in motor control and knowledge of the subtleties of the instrument define a good instrumentalist. Learning an instrument is a highly embodied action where the musician incorporates knowledge of the instrument and combines that with theoretical knowledge about music. When creating digital musical instruments, much of this embodied knowledge is lost as the instrument is virtual and the control of it can range from a software based control structure, devices such as the mouse or "qwerty" keyboard, or MIDI controllers such as keyboards, wind-instruments or percussion.[1] None of this is found satisfying by musicians, which has resulted in a new research field often called NIME (New Interfaces for Musical Expression)[2] where people try to respond to the limitations in the control of digital instruments.

Time and latency. In few areas of computing is time and latency as important as in music. Latency above 20 milliseconds is noticeable to the musician and can be frustrating when playing a digital instrument. Effective controllers and fast algorithms are very important. In real-time playing, there cannot be any latency when applying effects such as a reverb or a delay and things have to run seamlessly with as little interruption from the technology as possible. Unlike much graphical or video editing software, real-time music instruments cannot wait while the program applies a filter or renders. To make things even more complex, digital musical instruments or sequencers tend to work as parallel streams as opposed to one action performed at a time. Consider the difference in applying a filter in Photoshop and waiting while the algorithm runs to a real-time musical software that could be receiving control

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[1] The limited 7 bit resolution of MIDI (where the resolution is integers from 0 to 127) has proved frustrating for musicians that are used to much subtler interaction with their instrument.

[2] See http://www.nime.org

data from sensors and generative algorithms, interpreting this data to map it for the sound engine which at the same time might be playing various prerecorded sounds, all at the same time.

Unnatural mappings. An interesting fact with digital instruments is that the control device and the sound source are arbitrarily related, unlike in acoustic instruments. The control mechanism used to play the sound always affects the character and the style of the playing. As an example, we might not hear if a piano in a song is real piano or synthesized piano, but we would definitively realise a synthesized trumpet played on a keyboard. Playing a trumpet with three fingers and the mouth is obviously very different control mechanism from the situation when a synthesised trumpet is played on a keyboard where ten fingers are used and there is no mouth "embouchure".

IXI SOFTWARE

ixi software [6][7] started in 2000 as an experimental research project that concentrated on making prototypes for screen-based musical instruments. It began as a response to our discontentment and questioning of the way commercial music software houses build their interfaces uncritically on already established work-processes known from the analog studio or from musical traditions such as score writing and reading. The two-dimensional computer screen and the mouse are good for many things, but not particularly effective for controlling a mixer with hundreds of knobs. We are also interested in the lack of embodiment when playing such screen-based instruments, but in turn we believe that an illustrative and metaphorical interface can provide the player with a platform where musicians can offload some of their cognitive processes and "think" on the surface of the interface.

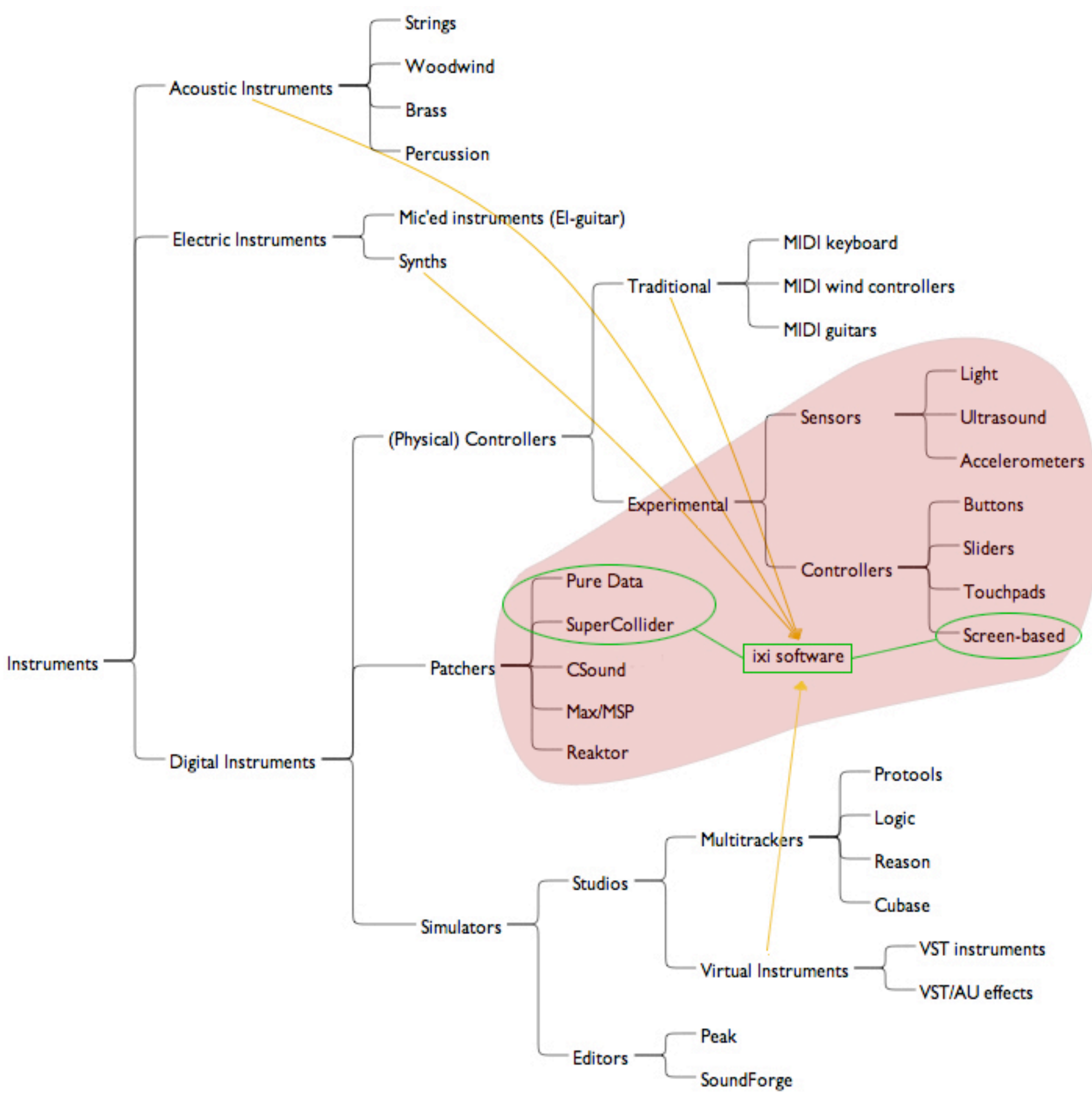

Figure 1. The coloured field is the area in which we work, the circles outline the specific technologies that we use and the lines are areas that contain knowledge and solutions that inspire our work.
(This map is not intended to be exhaustive, so the details of acoustic and electric instruments are omitted. A more detailed list of sensors and controller types could be added, but does not serve any purpose in this context)

Our research is concentrated on the GUI as a semiotic space for musical creation, where individual parts of the interface are bound to influence the work processes and compositional ideas of the musician. We are aware of this conditioning of the interface and do not strive to make the interface as general or musically neutral, as that is a futile task deemed not to work. We have elsewhere [8] described the semiotic context of the work and how we analyse the interface elements in terms of agents, contexts and networks into a structural whole of a user, hardware, software and sonic input/output. **Figure 1** illustrates the research area in which we are working.

An interface is created from an interaction model [1] that grounds the work of the interaction designer. A well designed interface helps the user to focus and streamline work processes, orchestration in time and easy development of a mental model that represents the functionality of the software. In this project we have been interested in exploring the nature of the relationship between the compositional ideas of a composer or a musician and the mental model he or she has to build up when using the software. To what extent does the software influence the music and what does the musician do to fight the limitations of the software?

AFFORDANCES AND CONSTRAINTS

In order to analyse the affective power of the interface upon the user, it is useful to resolve using the two partly contrasting terms affordances and constraints. The concept of affordances stems from the work of the perceptual psychologist J. J. Gibson who defined it thus: "The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill" [5]. In Gibson's definition, affordances are the properties of the relationship between the environment and the agent (human or animal). The relationship consists of a mapping between the properties of the environment to the potential actions of the agent. An instrument like the violin affords certain actions to the human that it doesn't afford to the dolphin for example.

Norman [9] introduces the idea of perceived affordances, meaning the properties that the agent perceives as possible actions upon an object. This is a narrower definition of affordances as Gibson claimed affordances existed independent of the agent's perception of them, a view supported in Gaver [4] who talks about perceptible, hidden and false affordances. Norman's view has been influential in the field of HCI as design is largely about providing affordances to the user of the designed object. Such design decisions are culturally conditioned, so something that appears as an affordance to a member of one culture might pass unnoticed to a member of another.

Affordances have also been defined as entirely subjective. In a 1993 paper [10] Vera and Simon define affordances as "carefully and simply encoded internal representations of complex configurations of external objects, the encodings capturing the functional significance of the object." Vera and Simon go on and talk about all human behaviour as social constructs and in terms of musical instruments and the culture of playing them, we can see how the affordances of certain instruments change when they are used in different cultural settings. [11]

Constraints

All tools have their designed usage and transformed usage (when an object is used in a way it was not designed for). Musical instruments serve as a fantastic case-study here, as the nature of music requires the constant re-interpretation of the instrument, the musical tradition and the place and function of the instrument in the tradition. Musical instruments are designed for certain usage and the history of acoustic instruments shows how the evolution of the instrument goes hand in hand with the musical culture which uses the instrument. [2]

Norman's use of affordances is highly related to the idea of constraints. He talks about physical, logical and cultural constraints, but it's the idea of cultural constraints that is of relevance here. "A convention is a cultural constraint, one that has evolved over time. Conventions are not arbitrary: they evolve, they require a community of practice." [9] In this context, the musical instrument has cultural and personal constraints. The trained musician often has problems of breaking the boundaries of the expressive scope of the instrument, and these problems are partly due to the long training he or she has had in the particular musical culture which defines the expressive or imaginative constraints in the player.

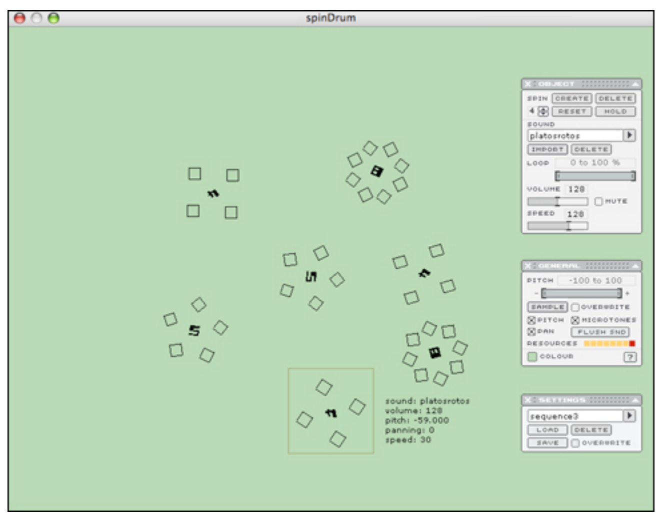

Figure 2: SpinDrum. Each wheel contains from 1 to 10 pedals. The wheels rotate in various speeds, and when a pedal hits top position (12 o'clock) it triggers the sample or sends out OSC info to the soundengine. This allows for the creation of complex polyrhythms. The X and Y location of the wheels can affect parameters such as pitch and panning.

Affordances and constraints in ixi software

The instruments that can be found under the generic name ixi have all been designed from a certain interaction model [8], and experience shows that people find it easy to move from one application to another when they have become acquainted with the basic concepts and design ideas of one of them. These instruments are all limited and their design is very much a play with affordances and constraints. As opposed to acoustic instruments, the screen-based digital instruments are not of physical material so all mappings from a GUI element to the sound can be arbitrarily designed. This arbitrariness is even more apparent as there is hardly a tradition for creating such instruments. The metaphors we use in ixi software are new in a musical context and deliberately have no musical reference. (such as depicting keyboards, strings, notes, etc) The decision to exclude metaphors from the world of music comes from the aim to get away from the cultural constraints that are connected to the historical instruments or their parts.

There are innumerable problems when designing interfaces for digital instruments. The research area we deal with in ixi is just a micro-perspective of that whole field. As seen on Figure 1 we are concentrating on creating pattern generators in the form of screen-based interfaces that control sound engines written in SuperCollider or Pure Data.[3] This mapping is arbitrary as in all digital instruments, but the situation is even more complex here as the interface is logically detached from the sound engine. The ixi interface is a standalone controller – like the MIDI controllers - that sends control information through the OSC protocol [7] to the sound engine. The mapping can therefore be changed to suit the needs of each musician.

The concept of "embodiment" is central to phenomenology, and in the field of HCI, tangible computing has become a solution to the abstract nature of the relationship between the human and the computer. It is helpful to create physical control devices to control synthesis and other parameters in computer music, but again we have a construction where the mapping is arbitrary as there is no "correct" way of coupling gesture and sound. This creates a situation where people can become good at playing those instruments, but where the notion of virtuosity, as used in acoustic instruments, does not have the same meaning. We are aware of this "problematic" nature of digital instruments and are not aiming at solving this situation. For us the constraints of the ixi applications are obviously the lack of physical control over them (they are controlled by using the mouse and the keyboard of a normal computer). More importantly, each application has certain affordances and constraints defined by the behaviour of the interface elements and their relationship to each other and the environment in which they exist. That is where the expressive scope of the instrument lies.

[3] www.audiosynth.com and www.puredata.org

CONCLUSION

The research element of ixi software addresses the question how affordances and constraints of a certain instrument can open up for different mental models in the musician and therefore yield new compositional practices. Each of our applications generate structures in different ways and planned future research involves sending out formal questionnaires to the users of the software, in order to find out how a tool has changed their work practices. Further work involves researching how the idea of embodiment fits into the field of screen-based musical instruments as the mind-body dualism does not fit well with the view that cognition does not happen solely in the head [3] but is rather situated in the environment - or the relationship to the environment - in which the agent acts.

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