THE MUSIC PAINT MACHINE
A multimodal interactive platform
to stimulate musical creativity in instrumental practice

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Abstract: Interactive music systems offer new possibilities to support instrumental music teaching by providing a corporeally grounded experience as a basis for understanding music and music playing. In this paper we introduce the Music Paint Machine, a device that enables music performers to make a painting on a computer screen by playing their instrument. It is hypothesized that using this application stimulates understanding and creative use of musical parameters.

1. INTRODUCTION

Music Education in Flanders (Belgium) has recently been the subject of an in-depth study, commissioned by the European Community (Bamford, 2007). An important conclusion of this study is the dominance of a cognitive-emotional approach to music, i.e. meaning is attributed and verbally described on the basis of structural analysis. Another important conclusion is that current teaching methods do not sufficiently stimulate musical creativity. To address these shortcomings, we propose the use of human computer interaction applications.

In music education and more particular in instrumental studio teaching, the use of computers to support the teaching and learning process is growing but is nevertheless still in a rather early stage. Computers are used to make and analyse recordings (e.g. intonation, mistakes), the World Wide Web is used to provide information and to communicate outside the lessons (e.g. website, electronic learning environments), and software is developed for student assessment. Furthermore the use of music notation software is widely spread in music education. An important and recent development is the design and implementation of tools that support the learning process by measuring the instrumental gestures and posture of for example string players (e.g. Fober, Letz, & Orlarey, 2007; Ng, Larkin, Koerselman, & Ong, 2007; Schoonderwaldt, Hansen, & Askenfeld, 2004; Schoonderwaldt, Rasamimanana, & Bevilacqua, 2006) and clarinettists (Wanderley, 2000; Wanderley, Vines, Middleton, McKay, & Hatch, 2005).

Far less common in instrumental music teaching, even almost nonexistent, is the educational use of interactive music systems. Although a variety of these technological applications have been used for quite some time in performances, they have not yet found their way into the domain of musical instrument teaching. Interactive music systems could, however, address current issues regarding motivation and creativity in music education (Bamford, 2007). Interactive music systems provide an experiential basis for learning in which methodically designed learning paths can be combined with more exploratory ways of learning to play a musical instrument.

In this paper we introduce such an educational interactive music system, the Music Paint Machine. This is a technological application that enables music students to make a painting on a computer
screen by playing their musical instrument. It aims to provide a way to address current pedagogical concerns, without intending or pretending to be a “deus ex machina” that solves all the problems of traditional approaches to (instrumental) music education.

The present paper is organized as follows: first, we explain the theoretical background; second, we outline the concept and the technical setup. We then continue with a discussion and a description of an experimental framework to be implemented in the near future.

2. THEORETICAL FRAMEWORK

The conceptual design of the Music Paint Machine is the result of a strong interaction between theoretical investigation and the first author’s twelve years of experience as a clarinet- and chamber music teacher in Flemish Part-time Music Education. In this section we briefly outline the theoretical background that provided a top down strategy for the design of this application. It consists of the Embodied Music Cognition research paradigm, a flow perspective on music education and a Deleuzian/Guattarian view on education.

2.1 Embodied Music Cognition

The Embodied Music Cognition paradigm acknowledges the embodied nature of the musical mind (Leman, 2007). What happens in the mind depends on properties of the body and therefore body and body movement have an impact on meaning formation. Musical meaning is not solely based on a perceptual analysis of musical structure but to an important degree also on bodily action. The musical signification process has its roots in the mirroring of action and perception according to the individual’s action oriented ontology (i.e. things that exist for a subject from the viewpoint of a certain action). Structural and semantic aspects of the music are translated into the world of experience of the musician based on the associations with his own movement repertoire.

An important aspect of embodied music cognition is the multimodal nature of musical involvement and expression. Visual, auditory and haptic/proprrioceptive perception can strongly interact. One modality can, for instance, disambiguate information in another modality; different modalities can provide a means of calibration for one another and a percept from one modality can even override that of another modality (Ernst & Bültzhoff, 2004). Most importantly, these interactions are mostly unconscious and they are spontaneous. Music can therefore not be studied as merely sound (Schutz, 2008); it should be studied as a multimodal phenomenon.

Interactive music systems use sensing technologies and software applications that enable users to explore and creatively exploit the multimodal nature of corporeal intentions and expressive articulations, while being engaged in music. Accordingly, interactive music systems facilitate gestural and multimodal involvement with music. Therefore their use in instrumental teaching can contribute to a more embodied approach to instrumental music education as opposed to a prevailing cognitive-emotional approach. By using applications that stimulate full corporeal engagement in music, students learn to understand the bodily basis of musical meaning.

2.2 Flow experience

Flow experience is an optimal experience in which an individual is completely immersed in an activity and fully concentrated on the task at hand. It is characterized by a sense of control and pleasure based on a subjectively experienced match between challenges and skills (Csikszentmihalyi, 2008).

The integration of flow theory in the didactic process allows a teacher to monitor the cognitive, affective and motivational condition of a student. Moreover it provides strategies to respond adequately to these conditions. Taking a flow perspective on instrumental teaching places students at the centre of the didactic process, gives them autonomy and provides a powerful learning environment in which students can develop into creative and engaged musicians (Nijs, 2008).

Interactive music systems fit very well into a flow model on instrumental teaching. They contribute to the creation of a powerful learning environment that facilitates flow experience (Addessi, Ferrari, Carlotti, & Pachet, 2006). They can be designed to provide a possible match between challenges and skill on every level, i.e. from beginner to expert. They enable setting clear goals and provide unambiguous feedback based on the data of the sensing technologies. In this way interactive music systems produce the necessary conditions for a flow experience.
2.3 Deleuze & Guattari

In traditional instrumental music education learning outcomes are planned, monitored and assessed according to predefined standards that are methodologically and hierarchically structured into a learning curve. The focus is on music as product. Too often, this “tree-structure” (Deleuze, Guattari, & Massumi, 2004) of predefined learning goals leads to a didactics of transmission and reproductive imitation in which lessons are individualistic and teacher controlled (Olsson, 2009; Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003). Students undergo the teacher’s direct instruction rather passively and their desires are disciplined by templates of for example right posture, the teacher’s views on music, by given problems and fixed solutions.

From a Deleuzian/Guattarian point of view, teaching is about “being attentive to the conditions under which something new is produced” (Olsson, 2009). The focus is on music as a process (“becoming”). Students and teachers meet around a problem and learning takes place in between them (Olsson, 2009). Both teachers and students can engage in explorative and experimental listening and playing without really knowing where they are heading. Learning and teaching is more about constructing the problem together rather than treating a specific problem as a given that needs to be addressed in a certain way to be solved (Olsson, 2009).

New interactive music systems fit very well into a Deleuzian/Guattarian approach to music education. They enable to go beyond established problems and their solutions by providing the means to approach problems from a different perspective and even reinvent them on the one hand, and on the other hand they provide new ways to understand them. They create potentialities, events as a line of flight from existing codes and habits and thereby offer new possibilities to creatively engage in music.

To conclude, interactive music systems based on mediation technology support the integration of the latest findings on the nature of music cognition into instrumental music didactics. Thereby they are a potential support to new paradigms in music education that aim at transcending the Cartesian dualism ingrained in traditional music education by appealing to an action-oriented and subject-centered approach in which music is considered as both process and product (Elliott, 1995; Bowman, 2005).

3. THE MUSIC PAINT MACHINE

3.1 Concept

The Music Paint Machine is an interactive music system that introduces movement and experimentation in musical instrument teaching and practice by providing experiences that combine different artistic forms of expression, i.e. play music, make a painting and move. It allows music performers to make a painting by playing music. The painting takes shape by combining musical features (i.e. pitch, loudness, playing style) and body movement (i.e. moving the upper body, trigger sensors with feet on a dance mat). In this way the musical instrument does not function as a mere substitute for a paintbrush.

3.1.1 Learning Goals

1. Stimulate creativity through playfulness with musical parameters

An important element of musical creativity is playfulness with musical parameters (Deliège & Wiggins, 2006; Sloboda, 2000). Due to the dominant cognitive approach to music in Part-time Music Education, musical parameters are often not really “experienced” but rather “controlled”. The combination of playing, moving & painting leads to a better understanding of these parameters by providing a corporeally grounded experience as an experiential basis for learning and by stimulating students to experiment with these parameters. The introduction of visual feedback makes users forget the technicalities of playing their instrument and affords them to immerse in an action-perception loop and intuitively respond to what happens on the screen.

2. Develop confidence and skills to improvise

For students in the department of classical music, the question to just play something from scratch is often one of the most difficult things to ask for. Even when they succeed in overcoming a common initial hesitation, it remains difficult to “invent” music. They constantly repeat the same rhythm or the same melodic contours. The Music Paint Machine offers the opportunity to learn to “let go” and play something from scratch by providing a more familiar “thing” to do: painting or drawing. The introduction of visual feedback therefore facilitates improvisation. The focus is no longer on the improvisation, thereby freeing the mind from
worry and self-doubt. Everybody can paint or draw something. It even can become a challenge to paint complex, beautiful or funny pictures by playing the musical instrument. In this way students can gain confidence and audacity to improvise.

The Music Paint Machine can also be used to develop improvisation skills. According to Welch and Adams (2003) improvisation in music is fostered through encouraging the learning of basic musical elements. Therefore improvisation skills are based on building blocks of simple musical behaviours that should be practiced. The development of these skills starts with exploration of all the possibilities to create sound (Kratus, 1991; Scott, 2007; Volz, 2005). The Music Paint Machine provides an excellent way to encourage music students to explore but additionally allows going beyond the mere exploration of the basic musical parameters. We strongly believe that this application can help a student to develop throughout the different levels of improvisation and thus acquire the skills to creatively improvise (Kratus, 1991).

3. Develop embodied musicianship

Musicianship is a multidimensional form of knowledge, i.e. based on different kinds of knowledge such as formal or declarative knowledge and informal knowledge or practical common sense (D. Elliott, 1995). But in essence it is procedural knowledge, rooted in practice and invariably embodied (Bowman, 2000). Acknowledging the embodied nature of music cognition means acknowledging the bodily basis of musical knowledge and understanding.

An important aspect of musicianship is listenership (D. Elliott, 1995). Listening to music (both when performing or not) is a “hearing-as”, the foundation of which is the body (Bowman, 2004). What we hear is translated into a so-called action oriented ontology, i.e. a repertoire of movements that are sedimented in our body schema through an action-perception coupling and provide a reference against which musical meanings can be attributed (Bowman, 2004; Leman, 2007). Listening and musical understanding therefore can be refined through the use of body movements (Pierce, 2007).

The Musical Paint Machine integrates body movements in its mapping. Therefore it can be used to stimulate the process of corporeal articulation, i.e. corporeally expression of the moving sonic forms of the music (Leman, 2007). Its modes of use (see further) provide an experiential basis at the centre of which is body movement. By using the body, music students can explore the possibilities of their instrument and experiment with movement and musical parameters. Through specific drawing tasks, movements can be used to elicit bodily understanding of certain musical elements such as phrasing, dynamics and articulation (transition between notes or not).

Furthermore, the Music Paint Machine offers the possibility to represent movement and sound in a common visual stimulus. Accordingly it is well suited to discover, explore and exploit the multimodal nature of musical expression and involvement. By combining movement, sound and visuals, it can turn learning to play music into a “gesamt-erfahrung”, i.e. a multimedia event in which different forms of artistic expression are combined and lead to a multimedia output. Through a creative and playful use of musical parameters, based on the integration of sound, movement and visuals, a proficient user can turn this output into an artistic creation, a kind of twenty-first century “gesamtkunstwerk”.

3.1.2 Didactic benefits

1. A tool for pedagogic documentation

Pedagogical documentation is a tool for participatory and formative evaluation (Dahlberg, Moss, & Pence, 1999; MacDonald, 2007). It aims at visualizing and understanding what is going on during a lesson and what the child is capable of without any predetermined framework of expectations and norms.

In view of its pedagogic goals, the Music Paint Machine can be used as a tool for reflective discussion by providing the students with a myriad of possible outputs of their (artistic) creations as pedagogic documentation. The comparison between drawings and music can reveal different aspects of the student’s playing (e.g. how creative a student deals with musical parameters) and of the learning process. Not only is it possible to compare different paintings over a certain period of time, but thanks to the software that is implemented in the Music Paint Machine, it is also possible to (re)view each play session in different representation modes, by including or excluding the time dimension and by changing the view between different angles (see section 3.2.2). This enables teacher and student to discuss features of music playing such as amount of movement (e.g. use of many colours indicating a lot of movement with the feet), ways of moving (e.g. more vertical then horizontal), correlations between sound, visuals and movement and the like.
The Music Paint Machine can thus contribute to the development of bodily awareness (embodied music cognition), to the demand for clear goals and feedback (flow experience) and to the visualization of learning processes (Deleuze/Guattari’s deterritorialization or making visible of becoming).

2. A tool for student assessment

The Music Paint Machine can be regarded as an “artistic” measurement tool. It provides both teachers and students with a kind of pedagogical documentation that appeals to imagination more than an analysis based on objective measurement data. However, the possibility to also provide objective data allows one to compare artistic output and objective measurement. This comparison might reveal interesting aspects of the students learning process by revealing the link between product and process.

Furthermore, students can store their creations and include them in a portfolio. Or they can be put on the wall of the classroom. This enables peer evaluation which is an underestimated but very valuable component of an efficient evaluation system (Nijs, 2008). A teacher can even give students the assignment to publish each month one artistic creation using this game in the portfolio. In this way it is possible to map the progress of the student as visualized in his artistic creations.

3. A motivator

The Music Paint Machine contributes to the development of intrinsic motivation to play the instrument by increasing the fun factor of instrumental music lessons or practice sessions at home. It provides an opportunity to step out of the schoolish character of musical instrument lessons.

It offers or can be used to offer challenges that can easily be adapted to match the skills of the player. Moreover, by introducing body movements into the game, it addresses the whole body thereby enhancing the corporeality of the experience. This has a major influence on the probability of having a flow experience. The Music Paint Machine enables events that increase the body’s capacity to act while playing music and thereby it can bring joyful experiences (Massumi, 2002).

It can also motivate students, by enabling peer assessment when e.g. artistic creations are put on the wall of the classroom or when put in the part of a students portfolio that is accessible to everyone (e.g. by using Flickr) (e.g. N. Elliott & Higgins, 2005).

3.1.3 Modes of use

The Music paint Machine can be used to support the learning of particular musical content or to improvise and creatively explore musical parameters and related possibilities of the musical instrument. Therefore we conceive of two main modes of using the Musical Paint Machine. A first mode is the exploratory mode. Students grow familiar with the application and thereby develop the necessary skills for the second mode. However the exploration of the application is not only a leg up to the second mode. Experimenting with the application can become a fun thing to do. Moreover when students get acquainted with it, their attention can shift from the necessary actions of handling the technology to what is happening on the screen. Consequently, they can focus on painting and start using the Musical Paint Machine creatively.

The second mode entails the use of the Musical Paint Machine in function of particular learning processes. In this mode the application can be used to support different phases in the learning curve of a student. By giving students specific tasks and asking for certain results in the painting, teachers can adopt a corporeal approach to the music. This means that in this play mode a certain amount of pedagogical constraints are integrated to direct the use of the Music Paint Machine both in classroom setting and at home.

3.2 Description of the system

Figure 1: overview of the system.
3.2.1 Hardware

Computer

The computer used in the development phase is an off the shelf Mac Book Pro. In time any standard computer, desktop or portable, can be used.

Colour dance mat

The hardware of the multicolored dance mat consists of 12 pressure sensors (contact switches), 4 extra switches (situated on top of the mat) and a USB interface which are all integrated in the MDF floor plate. A cover presenting a twelve-colour wheel hides the hardware and makes choosing colours in the game clear. Stepping on a colour activates the pressure sensor underneath. The pressure sensors are constructed from 2 CDs covered with aluminum foil. On the back of these CDs, the wires are held together with the aluminum foil and electric conducting glue. The back is covered and protected by a securely fixed CD. A 4cm isolating adhesive tape, placed in the middle of these sets of double CDs, keeps the sets at a distance of about 3mm.

The USB interface is a hacked numeric keypad. The twelve contact switches replace the button switches of the original keyboard matrix.

Motion sensors

The movements of the user are captured by a Wii motion plus attached to the torso, with a flexible strap that doesn’t hinder breathing.

Screen

To facilitate an immersive action perception loop it is best to project the visualization on a larger screen by means of a projector. However, the Music Paint Machine can also be used with a PC screen.

3.2.2 Mapping and Feature Extraction

The software for The Music Painting Machine is developed in MAX/MSP and the visualisation is done in jitter, using the integrated OpenGL engine.

The player is presented with a canvas, which is in fact an orthographic 2D view of a virtual 3D world.

Mapping Body Movement

The canvas that is either portrayed on a display or projected on some surface, reflects the player’s movement and choices of colour. The pressure sensors, embedded in the dance mat, give the player the opportunity to choose the drawing colour. A set of 12 basic colours is available and this initial colour’s saturation can be dynamically controlled by moving the torso either forward (more saturated) or backwards (less saturated). The movement of the torso also determines the X-position of the paintbrush on the screen. The Wii remote, strapped to the chest, is used to capture leaning forward and backward (pitch) and turn left or right (roll).

Figure 2: self-made contact switches.

Mapping Musical Features

All other drawing commands are determined by musical features. The vertical position of the paintbrush on the canvas is determined by pitch. A sustained note produces a horizontal line, while a melody produces a curved line that follows the melodic contour. The thickness of the paintbrush is determined by the loudness of what is played. The louder a user plays, the thicker the brushstroke becomes.

Loudness and pitch are currently tracked by the max/msp analyzer~ object. However a new pitch tracker is being developed in collaboration with ELIS (Ghent University).

Presentation modes: visualizing the time dimension

As already mentioned, the X-position and Y-position of the painting brush are determined by feature extraction, leaving the Z-axis untouched. In the Music Paint Machine, this Z-axis represents the time you spend playing. While playing, the player is presented with a two dimensional view, without any indication of time, giving him the opportunity to explore his musical painting to the fullest. When he’s done playing one of the additional top switches on the dance mat enables the player to change his viewpoint, to gain access to the third dimension, representing time that is plotted on the Z-axis. For
instance, rotating the presented image by 90 degrees over the Y-axis reveals a coloured melodic contour over time. This kind of representation can be used to further analyse the performance, either alone or with the teacher. One of the other available representation modes is an animated replay of what is drawn, either playing alongside the music or with the music muted.

4. DISCUSSION

Visuals versus sound

In traditional approaches to instrumental music teaching, visual representations of music or musical elements are, due to a strong focus on music as a product, most often limited to the score and personal annotations in the score (e.g. to mark important passages, to stress expressive features). New approaches to music education however recognize the multimodal nature of musical engagement and understand the importance of seeing music as a process. Accordingly, much more attention is attributed to learning processes and processes during music playing. Visual support and feedback are used for example to learn to play an instrument (e.g. Tobin system), to support home study (e.g. Vemus), to analyse playing technique by visualizing movement trajectories (e.g. I-maestro) and to explore new ways to represent and attribute meaning to music (Reybrouck, Verschaffel, & Lauwerier, 2009).

Interactions between auditory and visual processing can occur regardless of the level of relevancy between them (Hidaka et al., 2009), so presenting congruent visual feedback maximises the possibilities of visual feedback augmenting the process of musical creation. Despite growing evidence that supports the effectiveness of visualization as a didactic tool, traditional instrumental music teachers remain sceptical towards the integration of visual feedback. They often argue that visual feedback interferes with listening and with learning to audiate (i.e. the ability to hear and comprehend in one’s mind the sound of music that is not or may never have been physically present (Gordon, 1997)). Existing objections against the use of visual feedback are grounded in some misconceptions or a misunderstanding of the nature of music and musical understanding. Besides interfering with one another, visual and auditory stimuli can reinforce each other (Ernst & Bültthoff, 2004; Lipscomb, 2005). Their combination can enhance learning processes (e.g. Forsythe & Kelly, 1989; Rogers, 1991) and musical experience (e.g. Davidson, 1993; Frego, 1999). This is in line with findings that the connection between auditory, visual and tactile stimuli is essential for the development of musical perception (Gembris, 2006).

Therefore we believe the Music Paint Machine in many ways can fulfil a complementary role to existing systems or didactic methods. Not only does it complement traditional approaches by supporting the current use of visual feedback, it also complements existing applications that provide visual feedback. Most of the currently used applications are based on visualizing objective data (e.g. Bevilacqua, Guédy, Schnell, Flety, & Leroy, 2007; Ferguson, Moere, & Cabrera, 2005; Ng et al., 2007). The Music Paint Machine provides a combination of artistic visualization and objective data. As has been explained in this article, this is valuable for music education. But it also has an important benefit for using it as a research tool.

A tool for research

The shift from disembodied to embodied music cognition has important consequences for music research. Aiming at an integrated approach that combines subjective and objective measurement methods, the embodied music cognition research paradigm involves important shifts and expansion of methods (Leman et al, submitted).

The Music Paint Machine is an application that is tailored to the embodied music cognition paradigm. It enables to investigate tool related experiences (shift from subject to user), it can easily be used in a classroom or at home (shift from lab to ecological setting) and when used in a classroom setting it will reveal aspects of the role of social interaction with teachers and peers (shift from individual experience to social interaction). An important aspect of the Music Paint Machine that contributes to the ecological validity of experiments in which it is used, is its potential to engage users in a strong sensation of immersion and make them forget they are doing an experiment. Moreover, due to a focus on artistic creation by playing and moving, users do not have the impression of being measured and analysed, which can lead to non-representative measurements. What appears on screen is nor a visualization of objective data, nor an exact capturing of movements and posture. It is, on the contrary, a creative output that appeals to imagination.
Because of its combination of artistic and objective measurement data, the Music Paint Machine also contributes to the expansion of methods that accompanies the aforementioned paradigm shift. It enables the combination of subjective and objective measurement through the implementation of state of the art monitoring technologies. Furthermore it deals with the transfer between modalities. Experiments with the Music Paint Machine can contribute to existing research on cross-modality and the precise coupling of different modalities (Naveda & Leman, in press).

The Music Paint Machine can be used to do research on instrumental music teaching but also for related performance topics such as the influence of the relationship between musician and musical instrument on embodied interaction with music and the importance of freedom of movement for musical expressiveness.

5. CONCLUSION AND FUTURE WORK

In this paper we have outlined the theoretical framework and the conceptual design of the Musical Paint Machine, an interactive music system that enables students to create real-time visualizations of the music they play. Furthermore we discussed possible didactic benefits and our expectations regarding the use of this application.

From the theoretical point of view, this interactive music systems holds promising potential. Not only does it support the introduction of new didactic methods, it also offers a wide range of research opportunities in the field of music education and performance.

Of course, empirical validation of the theoretical elaboration is necessary and awaiting.

The realization of a prototype is currently ongoing. Once it is operational, the application will first be tested and further refined in collaboration with different instrumental music teachers.

Next, we will start a series of experiments to probe the users’ experience. In a first phase participants will be teachers, in a second phase they will be students.

Based on these experiments and on a close collaboration with instrumental music teachers, specific tasks will be designed that contribute to a corporeal approach to instrumental music teaching. A series of experiments will be conducted in several instrumental music classes to test the didactic efficacy of these tasks.

The current prototype will be the basis for the further development of the Music Paint Machine as a layered assemblage of diverse components. Among these future components will be (1) a tool that measures expressivity and thus complements the “artistic” pedagogical documentation with objective analysis (e.g. Mota, Campolina, & Loureiro, 2009), (2) a component with additional sensors that enable the assessment of posture and (3) a tool that enables the extraction of sound features to provide students feedback on sound quality. Furthermore we envision a third play mode in which the Music Paint Machine interacts with its user by adding visual or auditory stimuli. Such a play mode will have a positive effect on the user’s experience but will also enable new didactic applications.

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