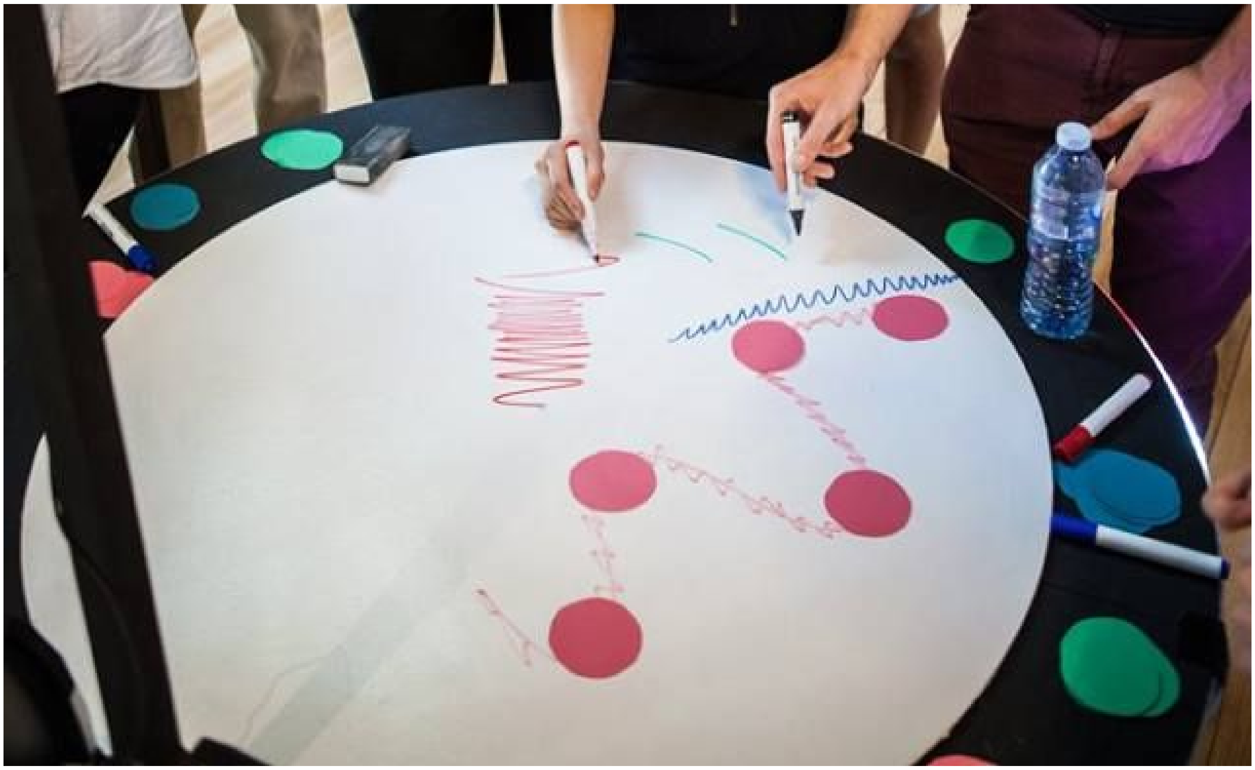

ARTEMIS
THE PROCESS OF DESIGNING AN ALTERNATIVE INSTRUMENT
DECO3000 REPORT

By Domenico Poutanen 43574218

Digital Instruments are systems that bring computational inputs and musical output together. Although they are very rarely seen in public, there seems to be an interest in exhibiting such systems. This report will aim to research the design process when developing a digital instrument, by using an already existing performative installation called ARTEMIS. The aim of ARTEMIS is to gain enough data to create implementations, that would improve the way musicians would learn and compose on ARTEMIS. This data will then be used to conclude a structure to the design of a digital instruments.

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Table of Contents

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Introduction

DECO300 Interactive Experience Design - music collaboration is a special topic course provided by Stephen Viller of The University of Queensland, which follows from DECO3850 Physical Computing and Interaction Design. This course enables students to design what was known to be future iterations of their musical projects created from DECO3850. The aim of the course is to collaborate with the School of Music to iterate on the project. In which that it meets the standards of musicians with a variety of expertise. Where within the course a/multiple musician will have to perform in front of a live audience.

ARTEMIS is a collaborative musical interface. Where users are able to turn their drawings into music. Within Physical Computing ARTEMIS was created with the inspiration of new interfaces for music expression with a focus on music collaboration. ARTEMIS is equipped with a circular whiteboard where the drawing detection is detected in a sonar like fashion. Where colours determine what instrument is being played, and the position determines the pitch. Where the drawings position on the radius configures the pitch. Where the closer to the centre of the circle the drawing is, the higher the note. If it's more closer to the edge of the circle, it will resemble a low note.

Within this report ARTEMIS will be used within multiple testing session, to gain data that will generate what further implementations will be used to meet the musicians needs. This will be used in conjunction of learning how other projects within the digital instrument community develop their systems. To conclude the correct features and factors should be addressed and tested to conclude what to look for when implementing a digital instrument.

Background Research and Analysis

Research Argument

The process of designing a digital instrument will be discussed within this document. The following research topics are defined to give a better understanding of what mechanism are needed to be addressed when implementing a digital instrument.

Digital Instrument Framework

To get a better understanding on how to implement a digital instrument, a framework is needed. Martin L. Griss (1997) concluded that frameworks are critical for systematically improving software and meeting business needs. The frameworks commonly used within digital systems is agile, which will be used to describe the framework throughout this document. Although agile frameworks are only used when the developer has a clear idea on what mechanisms within their system. Where No up-front design, bad design is given within the top ten problems with agile development methodologies (Begel & Nagappan, 2007). Where the others problems defined are due to developer personal issues. So to conclude an agile framework for digital instruments would have a higher chance of succeeding. If the design mechanism were defined for a standard or even successful digital instrument.

Types of Digital Instruments

To get a better understanding on how each mechanism functions a simple definition of some types of digital instruments will be given. This will give information on how each type of digital instrument implements these mechanisms. Below are instruments taken from New digital musical instruments (Miranda & Wanderley, 2006):

Gestural Instrument: This is given when an instrument includes the physical computational components such as haptic and tactile controllers (where their gestures are recorded) and motion trackers. This is to enable the user to give gestural input within a system. An example of a gestural instrument is given within Yago de Quay Interactive dance (De Quay & Bounajem, 2017), as the system converts the user's bodily movement to control sound and visuals.

Sensor Instruments: This type of instrument includes any sensor, as long as the sensor is used to implement sound data that is transferred to music. These sensors can include camera, motion, and even depth sensors. An example of a sensor instrument is SensorBand (Karkowski, Heide & Tanaka, 1997), where the user is able to control sound by how much weight they put on the stretch sensors. ARTEMIS falls under this type of instrument, as it uses a camera for input.

Biosignal Instruments: Biosignals are rarely used when producing digital instrument. Bioinstrument use biological signals from any living being to control how sound is being emitted. BioMuse (Tanaka, 1992) is a system that translates biological signals such as Electromyography (EMG), Electroencephalogram (EEG) and Electrooculography (EOG) to change different aspect of a single note.

Design Mechanisms

Sergi Jordà (2004) explored the interactions between multiple digital instruments and concluded that efficiency is what differentiated between good and bad digital instruments when it comes down to learning and composing. They also included a formula to measure this efficiency:

$$Instrument\ Efficiency \uparrow \frac{Music\ Output\ Complexity * Performer\ Freedom}{Control\ Input\ Complexity}$$

These can be translated into mechanism within a digital instrument. Where the improvement of output and performer freedom, and limiting the complexity of the input. Will ultimately maximize performance efficiency when learning the instrument:

Input (control complexity and performer freedom): The Input that can be processed by the digital instrument has no restriction. As a single piece of input can simply be processed as a drum beat. Although for a successful instrument, the performer will have to express. Which determined by 3 factors (Arfib et al ., 2005) Pitch control: Where the user is able to change the pitch of the note being played, Navigation/ Manipulation: This applies to systems that use preset music that the user controls. Lastly, Expressive Dynamic Behaviour: Where the user is able to dynamically express and compose music within the system, where it's not a static experience. By addressing these factors and considering Sergi Jordà (2004) formula above. Minimizing the complexity of how the user controls the input (this could be caused by convoluted data input methods), and maximizing the freedom the user is able to perform. This will overall increase the efficiency of the instrument.

Output (complexity): All instruments should have a musical output that correlates to what data is being produced within the input. Although Sergi Jordà (2004) formula includes that music output complexity is a core factor in how efficient an instrument is. He does explore within Digital Instruments and Players: Part II–Diversity, Freedom and Control (Jordà, S. 2004). As complexity governs how linearity or predictable an instrument is. This can be combined within his formula:

$$Instrument\ Efficiency\ \uparrow CompDiff * \frac{MusicOutputComp * PerformerFreedom}{ControlInputComp}$$

$$CompDiff : \frac{Min(MusicOutputComp,\ ControlInputComp)}{Max(MusicOutputComp,\ ControlInputComp)}$$

Complexity difference should denote a discount factor towards the performers freedom. As there should be a one to one nature to how the intruments function when considering the complexity of input and output. Where this allow the user use and learn the instrument more efficiently. Complexity difference is calculated by dividing the min by the max, to gain a floating point value between 1 to 0. Where if the complexity of both are equal the discount factor would be 1.

Output can also accompany the music being generated. The 3 input factors Pitch Control, Navigation/ Manipulation and Expressive Dynamic Behaviour, could also be accompanied by another output other than audio. This could range between visual, tactile feedback or even scent.

Keywords: Digital Instrument, Mechanism

ARTEMIS

Previous Design

Previously the ARTEMIS was a product of another course called DECO3850 Physical Computing and Interaction Design Studio. Where students build physical installations that abide to a genre given. The genre for ARTEMIS was Music Expression. ARTEMIS was designed to allow users to collaborate using an expressive interface. Below is a description of what input and outputs were displayed for users at the end of DECO3850:

Input: Colour detection is what governs the main input that ARTEMIS has. Where a circular whiteboard is placed on a table, while a camera is suspended from a stand attached to the table. The camera the detects any color other than white on the whiteboard and calibrates it to an instrument. The input from these colours come under 2 of the 3 factors discussed in the input mechanisms. Pitch control and Expressive Dynamic Behaviour. Where pitch is determined by the position of the colour being detected, relative to the radius of the circle. Where the closer the colour is to the centre of the circle the higher the pitch. The closer the colour is to the circumference of the circle the lower the pitch.

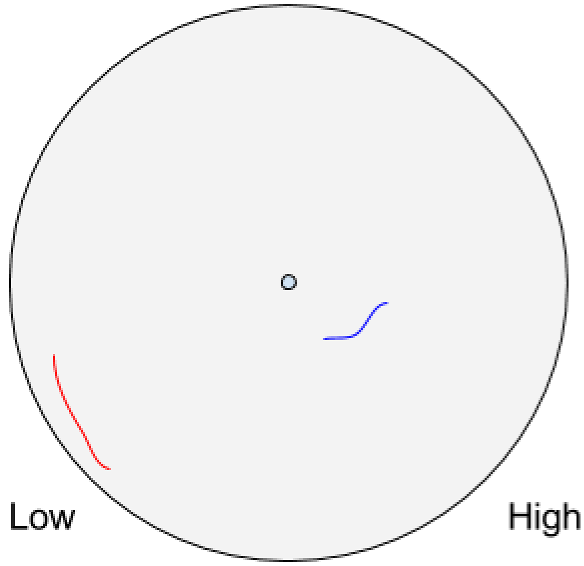

Figure 1: Image showing how the ARTEMIS functions.
The left hand red line shows a low note.
The right hand blue line shows a high note.

The colour also determines the instrument being played. Where during the previous build Red was guitar, blue was drums and green was bass.

Output: There were two features that determined ARTEMIS' output. One being the sound outputted itself. This would be determined by the factors described within the input section. Another output is the LED lights, as they were used to show where ARTEMIS is reading and changed color depending on what color is being read.

Prototype One Testing Method

The aim of DECO3000 is to further develop on ARTEMIS to meet the needs of musicians with a variety of expertise. With ARTEMIS already producing the input and output of a digital instrument. The future iteration is to simply allow user to learn and experience ARTEMIS more efficiently. By this we tested with four music students with varying backgrounds. Although this testing session wasn't professional in a sense of structure, the data obtained was used to implement features that positively affect ARTEMIS. Below are samples of dictated phrases made from the music students that were focused on:

Student One: It would be nice to change the drawings on the fly, maybe making a sheet that we can move over ARTEMIS and it would play that piece… Then we can make another one.

Student Three: Even a template that shows where the pitch changes would be great... It's really difficult to determine where the pitches change.

The students were also concerned that the whiteboard color detection wouldn't work within the auditorium they were performing in. On the matter of what student three said. The difficulty of changing the pitch was a problem. Which is due to how complex the input is.

New Implementation

Prior to the performance there were a few deadlines given to ensure that the new implementations for the performance would be met. Below are said deadlines and a description on how they impacted the performance. The performance is analysed by the musicians sheer ability of learning to compose with ARTEMIS. Some of these deadlines weren't met, however the process on why they weren't implemented will be discussed below: Note: due to some limitations created by external users. The ARTEMIS wasn't able to function to it full potential. This was due to some colours weren't able to be detected by the camera.

Met Requirements

Input improvements: Color calibrations was a negative towards the functionality of ARTEMIS. As white board markers are reflective and natural lighting wouldn't allow the camera to color detect. This when introducing artificial lighting in most setting, would allow shadows and blind spots (Light reflecting 100% and making white) confuse the camera. This then replaced the reflective whiteboard and markers, with coloured paper and objects. Not only did this feature allow users to consistently interact with ARTEMIS without any calibration issue. The objects are able to be adjusted in an equal time frame when placed. Where markers would need to be wiped out. This also allowed user to change their composition easily, where previously the user would have to guess where their original drawings were. This covered one of the student's request on how they can change compositions easily when performing on ARTEMIS.

Analysis: The performers initially used the circle cut outs (objects) given to them, and improvised a simple piece. They also used the circles in conjunction to make a static beat and melody to play in the background. While they use the circles to accompany said static piece. This showed within the new formula created within the design mechanism that the complexity of the input was decreased to match the output being produced. Which overall increased the efficiency of ARTEMIS.

A few days after the performance ARTEMIS was invited to the innovation showcase. Where individuals from a wide variety of professions were invited to see innovative projects made by the students of The University of Queensland. During the showcase we were exhibiting and observing non-musician users interactions with ARTEMIS. Which concluded that users were more drawn to using the markers as created a simple static piece and moving around the objects to experiment in conjunction with said piece.

Professionalism: Although this does not cover any of the student's request. Previously the aesthetic design of ARTEMIS didn't match a performing design. Our task to change this was to give it a new paint job. Where it would fit into a performing theatre. In the end the color chosen was theatre black, below is a comparison between the two designs.

Figure 2: left side previous ARTEMIS design, right side New Design.
Note: the colored paper are the objects.

Analysis: Although this didn't change how musicians interacted with ARTEMIS in the terms of learning and composing, users within the innovation showcase would be more drawn to interact with ARTEMIS based on its new design. This is compared to its previous designed showcases, which can be found within Emotional Expression Through Collaborative Performative Installations (Poutanen, 2017).

Scrapped Implementations

Two implementations that were scrapped in between development of new implementations. Were the template that would imitate the design of a music score sheet. Where the users would have an easier indication on where the pitches would change when they would add objects or draw on the ARTEMIS' whiteboard. Another scrapped feature was the layered pre-composed music sheets. These would act as a pre-determined music piece that would be able to place and play on the ARTEMIS. Both of these ideas were scrapped due to the reflectiveness on the whiteboard and the pre-composed music sheets.

As these features were being implemented first. The addition of non reflective object would of been integrated into these scrapped implementations, so that they would work with ARTEMIS. This would be achieved by having the pre-composed pieces be a circular velcro based system, that would allow the users to place fabric that would be the main source of color being detected. This in conjunction with a music sheet styled layout that would assist the user in pitch differentiation, will ultimately allowed the performers to simply compose their own music before hand.

Conclusion

As stated by equalizing the input and output complexity, would allow the instrument in question to become more efficient. Initially ARTEMIS had a more complex input system, due to users having limitations when changing their piece slightly. Where the output complexity was determined by the separate positions of the colour being detected. By implementing objects that the user is able to move around slightly, the complexity if the system's input is decreased which overall improves the efficiency of the instrument. Further making it more easier to learn and compose for.

This concludes that implementing the design mechanism in conjunction towards the new formula created. Will ensure that the digital instrument being developed will have enough efficiency, that any user is able to learn and compose:

$$Instrument\ Efficiency\ \uparrow CompDiff * \frac{MusicOutputComp * PerformerFreedom}{ControlInputComp}$$

$$CompDiff : \frac{Min(MusicOutputComp, ControlInputComp)}{Max(MusicOutputComp, ControlInputComp)}$$

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Appendix

Figure 1:

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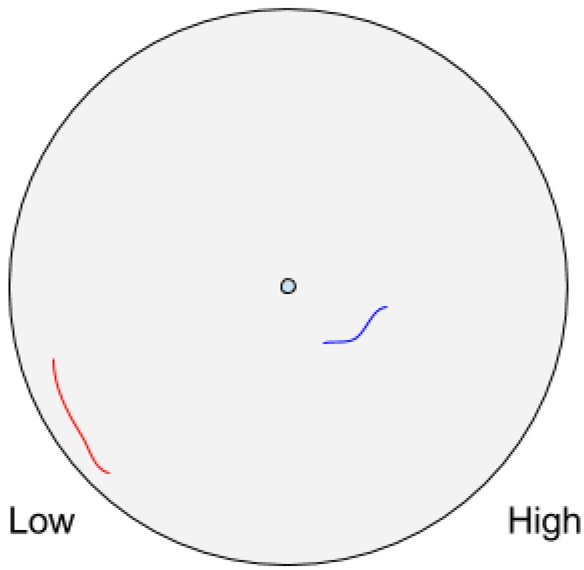

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