NOTATING EXPERIENCES: A NEW SYSTEM FOR VISUAL DOCUMENTATION IN INSTRUMENT DESIGN

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ABSTRACT

In the community of Digital Musical Instruments (DMIs), documentation surrounding iterative interactions and the creation of mappings is largely absent from DMI projects beyond the recording of a performance or subsequent evaluation with a performer. This is because the performance or interactive experience with the instrument is often viewed as the end point for a DMI project, and the description of a mapping or open-sourcing of software considered the 'score'. This paper outlines the creation of a visual notation based on unique interactions with the AirSticks, a gestural musical instrument. These notations expand on the concept of descriptive notation, creating a form of retrospective score and record-keeping for instrument designers. By capturing the intimate experiences and musical collaborations that contribute to the iterative design of the instrument, it is concluded the notation system provides an avenue for critical analysis that will aid the further development of DMIs.

1. BACKGROUND

1.1 Documentation for Digital Musical Instruments

The need for longevity in Digital Musical Instruments (DMIs) has been highlighted in the instrument design community by the likes of Calegario et al. as an important and often overlooked factor in the design process [1].

There is a shared feeling in DMI communities that the large number of new interfaces presented each year will only result in a few instances of generalised, replicable instruments [2], with the rest falling into the category of what Calegario et al. refer to as "...once-interesting but now-unplayable interfaces..." [1]. Replication thus serves as an important design consideration to validate conclusions drawn across the community and to ensure instruments are played by different people over time.

Increased use of documentation [1] and published construction and design processes [3] are often cited as examples of processes that might aid in the longevity of instruments. However, these processes of documentation continue to be rarely used by instrument designers, and when present, usually take the form of code repositories or raw recordings of a performance [1], both of which are often seen as the end-point of the instrument design process.

Notation presents itself as one overlooked opportunity that might be used to document interactions with Digital Musical Instruments in new ways.

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1.2 The AirSticks Community

The AirSticks (seen in Figure 1) are one example of a DMI, with a community of programmers, hardware and software designers, composers, performers and improvisers working around it. They are a custom-designed DMI for gestural music making, combining Bluetooth Low-Energy technologies to give low-latency wireless control over MIDI or OSC, reconnecting movement, sound and visuals with the transparency and expressiveness of acoustic instruments.

The AirSticks community has created a wide variety of musical pieces, interactions and experiences for a diverse array of players. In particular, we are interested in interrogating the iterative and collaborative nature of our design, which draws deeply from practice-based research methods.

Figure 1. The AirStick, a Digital Musical Instrument.

In the context of an instrument used by many musicians in different ways, a key challenge for us has been capturing and notating these diverse experiences beyond the standardised documentation outlined in Section 1.1.

We first draw on past work to investigate what notation might look like in this context.

2. RELATED WORK

2.1 Prescriptive notation

In his book *Sonic Writing*, Thor Magnusson describes a dichotomy of musical scores – "descriptive" and "prescrip-

tive" [4]. Prescriptive scores are those which provide instructions on what to 'do', prescribing actions that may not necessarily reflect the sonic result.

Electronic music has a rich history of prescriptive notation ranging from sets of text instructions (such as Steve Reich's *Pendulum Music* [5]) to code scores [6] to prescribing parameters like dynamics and reverb [7].

In the field of DMIs, prescriptive notation has typically been used to specify how a performer should move to create sound, such as describing interactions with a touch interface [8] or motion controller [9].

Whilst we can draw from vocabularies of prescriptive DMI notation, we seek a notation that describes, not prescribes – that is, instead of creating notation *for* a participant, we aim to create notation *describing* the movements and sound produced while using the AirSticks.

2.2 Descriptive notation

Descriptive notation represents the sonic outcome of a work, typically used for analysis or discussion purposes.

This category of notation has been explored widely in electronic music, whether it be for archiving the creative process and knowledge captured in composing electronic and electro-acoustic works [10] or adding extra detail around a electro-acoustic score [11].

Section 1.1 discussed the lack of documentation in the field of DMIs, and this conclusion can be extended to the lack of descriptive notation. Of course, documentation can be said to be a form of descriptive notation, with examples like documenting creative developments [12] or publishing a clear design processes [3].

Notations that capture the design process and development of a DMI are descriptive in the sense that they provide insight for analysis and discussion around the musical works for and interactions with the instruments, but are not linked to the outcomes of interactions with DMIs – what Small would describe as the process of 'musicking' [13].

This has meant that the question of 'what happened' in interactions with Digital Musical Instruments has been left largely unanswered by notation, instead taking the form of video or audio recordings.

2.3 Describing experience?

Can we expand the notion of the descriptive score, notating what is *heard*, to a broader definition of notating what *happens*?

Magnusson has aptly described Digital Musical Instruments as "epistemic tools" [14] – experience-driven technology that generates its own ways of understanding and communicating musical knowledge. This is at odds with notation and documentation centering around creative developments and processes, which capture the design experience, but often not the playing experience.

In the same way a descriptive electro-acoustic score (such as Luening and Ussachevsky's *Incantation* [15] shown in Figure 2) might be used for analysis and discussion, so too might a descriptive score that captures movement and sound in tandem be used to unpack interactions with a gestural musical instrument like the AirSticks.

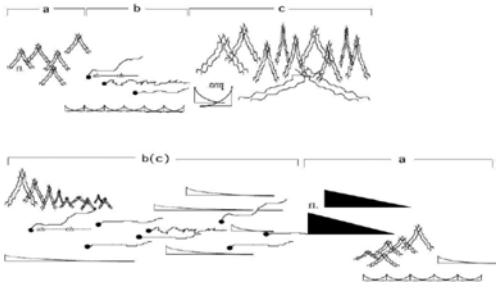

Figure 2. Score from *Incantation* (1953) [15] in [16].

Notation offers us the opportunity to capture and share specific musical work created for individuals in a way that embodies the original interaction, encompassing not just sound generation and basic documentation of a performance, but unique features of a player's movements.

The aim, therefore, is not to produce archival notation that can be used to replicate the experience, though this may be an unintended consequence of the system. Instead, we aim to archive a diverse range of experiences that players have with the AirSticks, conveying 'what happened' in a descriptive notation that offers rich archival content that might be used by others.

There is a lack of approachable and generalised descriptive notation for Digital Musical Instruments, which may be preventing instrument designers from taking full advantage of the potentials of documentation. This project proposes one possible system of documentation by creating a notation system that visualises interactions with a gestural instrument, the AirSticks.

3. THE NOTATION SYSTEM

3.1 Overview

We propose a visualisation system that captures experiences with a gestural DMI, representing movement and sound through a reconstruction of the player's experience.

The term 'experience' is used here as the visualisation does not have to be documenting the act of performance. For instance, the system could be use to capture a player's first time playing the instrument, a new mapping or rehearsal.

The process of creating the visualisations leads to the production of a video, with the end result being a video visualisation of a chosen moment of interaction.

Section 3.2 discusses the variables needed to create the final visualisation, used in the process outlined in 3.3. A case study in Section 3.4 illustrates how this works in practice.

3.2 Capturing AirStick experiences

In order to capture an interaction with the AirSticks, we draw on multiple datapoints to form a snapshot of any given experience. A visualisation of an interaction with the AirSticks can be generated when all of these datapoints are present:

- **Gesture recording** – A recording of the IMU (inertial measurement unit) that includes acceleration and orientation information. The AirSticks receiver software has the ability to record sensor data received from the instrument (seen in Figure 3). This gestural data is saved to a `.json` file, which can be replayed or visualised within the software as if the player was playing in real time.

- **Audio recording** – Audio recording of the sound generated from the AirStick interaction.

- **Video recording** – Video recording of the AirStick interaction.

Figure 3. Gesture recording inside the AirSticks receiver software.

These datapoints all inform the creation of a visualisation system, outlined below.

3.3 Technical process

Central to the visualisation is how movement is mapped to video. In order to form a spatiotemporal representation, the motion of the AirStick is displayed much like a rhythmic gymnastics ribbon – that is, there is a clear sense of movement and change over time, visualising a window of time instead of a discrete coordinate, shown in Figure 4.

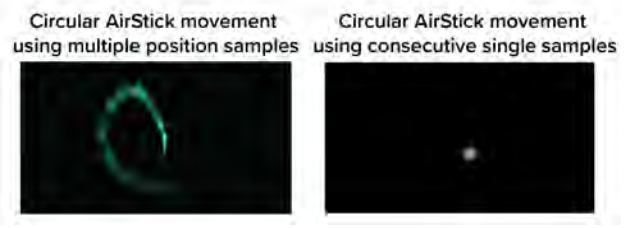

Figure 4. Comparing visualisations of coordinates over time.

This effect is achieved through the Adobe After Effects particle system *CC Particle Systems II*, which generates particles at defined X and Y coordinates over time, providing a 'trail' of movement data in disembodied graphic form.

A gesture recording from the `.json` file is tracked in the AirSticks receiver software, producing a set of of two-dimensional coordinates over time. These coordinates are then assigned to the particle generator in After Effects, and synchronised audio so they may be used in tandem for the visualisation.

To create unique visualisations for different contexts, variables within the particle system are altered based on variables extracted from data collected during interactions with the AirSticks, outlined in Table 1.

Particle variable	Interaction variable
Shape	Brighter sound from audio recording equates to a sharper, line-like particle; duller sound equates to softer, spherical particle (calculated using Spectral Centroid using the Librosa python package [1])
Size	Noisier sound from audio recording equates to larger particle; cleaner sound equates to smaller particle (calculated using Zero Crossings using the Librosa python package)
Colour	Feature colour extracted from video of the interaction using colour picker
Velocity	Average amount of 'energy' in the AirSticks (average acceleration over 50 sensor cycles)

Table 1. Particle system variables controlled by interactions.

Once the particle system variables have been entered into *CC Particle Systems II*, the generator produces particles at the AirStick coordinates over time. The visualisation is then exported alongside the audio that was capture alongside the AirStick movements, creating a holistic spatiotemporal representation of the movement and mapping. This process is outlined in Figure 5.

The technical process and assignment of standard variables means that a visual vocabulary of interactions is formed, with the end result being a series of visually distinct notations that summarise the interactions with the AirSticks, as seen in Figure 7.

3.4 Case study

To illustrate how the system has been used in practice, it is useful to focus on a particular AirSticks mapping.

Andrew is a member of a physical theatre group that the AirSticks team produced individual mappings for as part of a theatre production in June 2021.

The interaction designed for Andrew evoked the metaphor of a 'drumming goldfish' – a high-energy drumming mapping that triggered rhythmic sequences of heavy rock drumming mapped to the change in acceleration of the AirStick.

[1] https://librosa.org/doc/latest/index.html

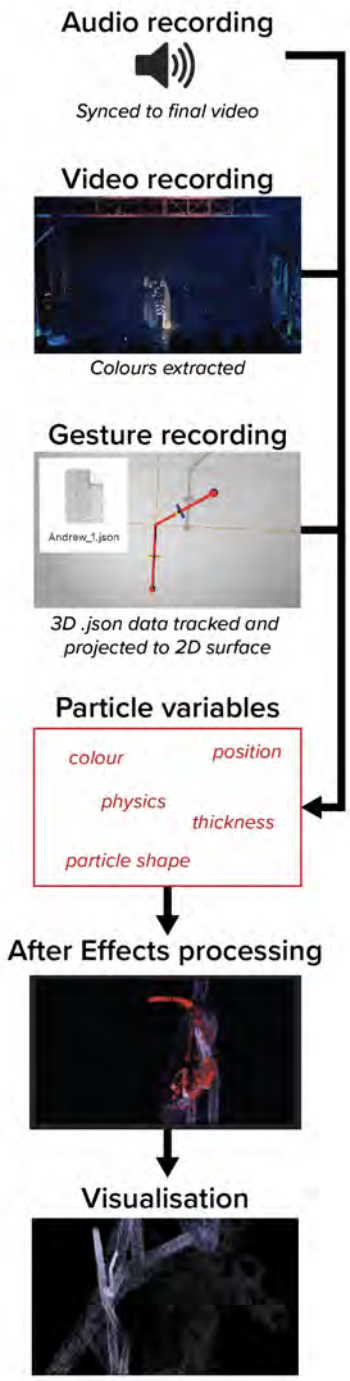

Figure 5. The process of visualisation.

Andrew's final performance was chosen for visualisation as we had audio, video and gesture recordings of the interaction. Combining the recordings, the particle was set to a purple colour extracted from the lighting state in the video, with the bright sound of the cymbals (and thus a higher Spectral Centroid) leading to a sharp line for the particle shape. The extreme range of Andrew's movements meant the velocity of the particle system was high (creating a spraying effect), and the noisier timbre of the drums (and thus more Zero Crossings) meant a large particle size, all shown in Figure 6.

The final visualisation was a high-energy video that showed

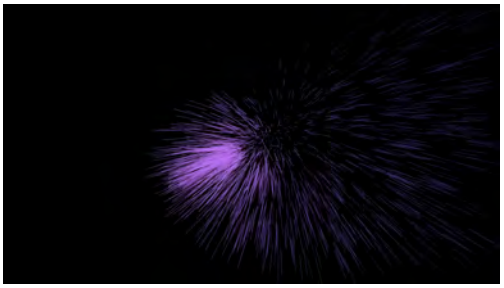

Figure 6. Screenshot from visualisation of Andrew's mapping.

a strong causal link between larger movements with the AirStick and the drumming. It also illustrated Andrew's dynamic range of movement, with large splashes of particles occurring on dramatic waves of the arm.

This visualisation was then displayed alongside snippets of additional information such as photos from rehearsal, video from the theatre performance, and quotes from Andrew himself, drawing on a rich catalogue of documentation (screenshot seen in Figure 8). This complete set of documentation was used to display ten different interactions by ten performers in the physical theatre group, creating a catalogue of interactions that could be compared and analysed further.

The notation of Andrew's experience is an example of how the visualisation system presents a fuller picture of 'what happened' in a series of interactions that involved many players in a theatre group with many different mappings, movements and sound worlds.

4. DISCUSSION

4.1 Utility of new systems

Why is a retrospective notation that visualises interactions with DMIs useful?

By creating a system of documentation and notation that captures interactions with the AirSticks, we are building a body of knowledge that reveals different aspects of 'what happened' when a diverse range of people used the instrument. This is particularly relevant in the context of discussions in Section 1.1, which note the lack of clear documentation that might hinder longevity of DMIs.

High-resolution capture and creative visualisation of of gestural data adds integrity to the design and contribution of the AirSticks, separate from code snippets or recordings of performances. In line with advances in data visualisation and the growing relevance of creative representations of data [17], the system offers a unique archival perspective on a new technology.

These visualisations cannot and should not be used to replicate the interactions themselves – they do not prescribe to a prospective player how they should play the AirSticks, and nor do they offer instruction as to how future interactions should occur.

Instead, using visualisation to diversify the prevalence of richer documentation means that more instrument designers and players might learn from or expand upon an

Figure 7. Screenshots from visualisations of a range of interactions with the AirSticks.

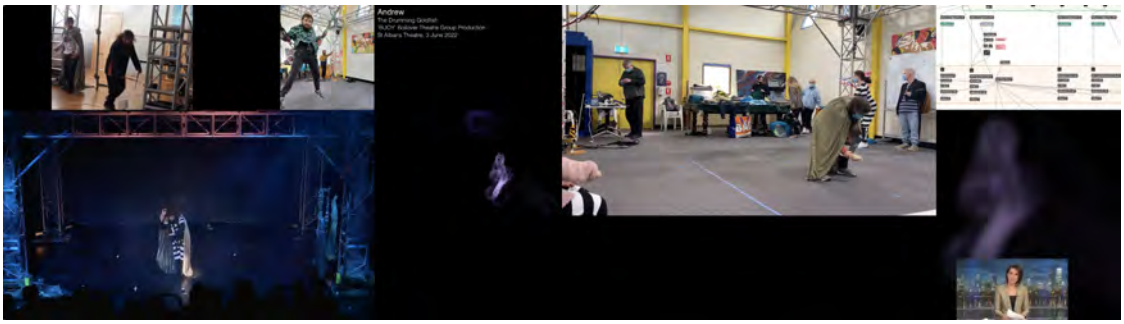

Figure 8. Screenshot of additional documentation shown alongside Andrew's visualisation.

archival system that provides insight into how players interact with new instruments. Expanding the concept of descriptive notation to encompass experiences with a gestural DMI is a logical next step that fills a gap in the iterative process of instrument design, providing an avenue for critical analysis that will aid the further development of DMIs.

4.2 Future work

This paper presents a possible system of documentation by creating a notation system that visualises interactions with a specific gestural instrument.

The natural next step for a system such as this one is to expand its use to other DMIs. The ability to test the notation on other DMIs, and collect evidence as to how it contributes to the longevity of DMIs would be an invaluable addition to the instrument design community.

One barrier to this extension would be data integrity and compatibility problems that DMIs are often faced with – for instance there is no gestural data 'standard' that can be exported from each DMI, and nor do they necessarily interpret or map gestural data the same way [1]. Additionally, not all DMIs are gesture-based, and the need for alternative data that can be captured with other DMIs may arise.

Another natural step for the notation system would be to target development in the area of interactivity so that the documentation could communicate the knowledge embedded within the playing of these 'epistemic tools' [14]. This might involve a more interactive system of documentation, perhaps allowing the viewer to play the mapping whilst also watching what happened when someone else played.

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