Figure 1: Ensemble Metatone performing with iPads and percussion instruments.

Preserving Musical Performance on Touch-Screens

Charles Martin
Research School of Computer Science, CECS
Australian National University,
Canberra, ACT, 0200,
Australia
charles.martin@anu.edu.au

Henry Gardner
Research School of Computer Science, CECS
Australian National University,
Canberra, ACT, 0200,
Australia
henry.gardner@anu.edu.au

Abstract
Musical performances with touch-screen devices can be recorded by capturing a log of touch interactions. This new-media object can serve as an archive or as a basis for other representations of the musical work. This paper presents a protocol for logging touch-interactions as well as visualisations and gesture-scores generated from logs of a series of improvised ensemble performances on iPads. These objects record the performances for posterity and also allow deeper analysis of musical interactions present.

Author Keywords
improvisation, touch-screen, mobile music, visualisation, machine learning, gesture, archiving

ACM Classification Keywords
H.5.5 [Sound and Music Computing]: Methodologies and techniques.

Introduction
When performing with touch-screen devices, musicians have the opportunity to record the musical work in an extremely detailed form by capturing a log of touch interactions with the devices. In this paper, we argue that this log can form a new media object in its own right, to be used as an archival format and a basis for other representations of the work such as visualisations or

Figure 2: Ensemble Metatone performing *MetaLonsdale* at the ANU School of Art Gallery in October 2013 (left to right: Jonathan Griffiths, Charles Martin, Christina Hopgood, Yvonne Lam).

scores. We will describe the protocol for capturing touch interactions with iPads developed for Ensemble Metatone, a free-improvisation percussion group. Although this protocol was developed for research purposes, visualisations and analyses generated from logged data has formed an important archive of the group's performances of *MetaLonsdale* for four iPads[1]

Representing the Musical Work

It is widely recognised that musical works as well as new media artefacts can have a number of interacting representations [5]. Musical works might be directed by a score; be "thick" or "thin" depending on the the freedom of interpretation afforded the performers; be represented in live performance, studio recordings, or by computer generated renderings; and may be composed or improvised [2]. Combinations of these representations are often collected together form an archive of a musical work.

Free improvised music, where performers do not follow a set musical structure, is usually preserved using only audio and video recordings. While the improvised solos of famous jazz musicians are often transcribed, this is extremely uncommon for free-improvised ensemble performances. For improvised music on touch-screens, a log of touch-interactions captured by the performance suplements traditional recordings and could take the place of a "score" in documenting such performances. While scores are generally used for composition, their use as documentation for new media artworks has been acknowledged [3]. Such a log would also satisfy Manovich's principles for a new media artwork [4]. In particular, the log of touch-interactions is variable, forming the basis for derivative artworks that also represent aspects of the original performance.

Free-improvisation is often a process of gestural exploration, discovering new sounds and responding to other sounds in an ensemble. In audio recordings of these performances, the sonic result of the gesture is captured but the gesture itself lost. While the gestural component of musical performance may not be as integral as in dance or other physical performance, it still contributes to the audience's perception of a work and represents a certain amount of the performers' intention. Although touch-interaction data is not a complete record of performers' gestures it is simple to obtain and easily transformed into other representations of a performance.

Ensemble Metatone and MetaLonsdale

Ensemble Metatone was brought together to study the process of performing free-improvised music on specially designed iPad apps and percussion instruments in Canberra, Australia. The members of the group (including one of the authors of this paper) are all trained in classical percussion with experience as improvisors.

Over a series of studio rehearsals, the group worked with the "MetaLonsdale" app to develop a work which was performed at festivals and events throughout 2013. The studio rehearsals and a public recital were recorded with seperate tracks of audio for each iPad, multiple camera angles, and a log of touch-interactions.

The app used a percussion-inspired interaction scheme allowing performers to access pitched percussion sounds and field recordings. Most of the iPad screen was a performance surface with few graphical UI elements. Tapping the screen produced short sounds at a pitch determined by the location of the tap. Swiping played

[1] The video recording, touch-interaction log, visualisation and score of a performance of *MetaLonsdale* is available online: http://charlesmartin.com.au/blog/2014/1/17/metalonsdale-for-four-ipads.

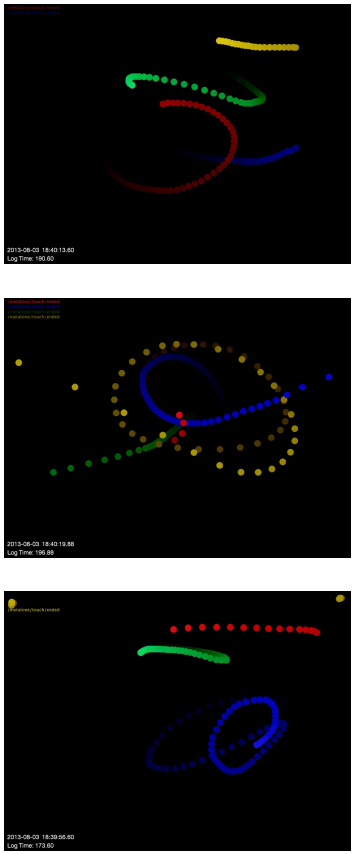

Figure 3: Stills from an animation of an Ensemble Metatone performance. The full animation can be viewed online[1].

continuous field recordings with volume controlled by the velocity of the swipe. The app featured two UI switches that controlled simple delay functions, that repeat tapped notes, and switchable auto-play features, that alogrithmically produced background sounds. A button on both apps allowed the performer to shuffle the available sounds.

Capturing Data

Touch interactions were transmitted as OSC messages over a Wi-Fi network from the four iPads to a laptop. Messages from touches in the performance area were sent with the location of the touch and velocity. Touch-down events were denoted with a velocity of zero while touch-ended events were represented with a different OSC address. Messages were also sent when the button was pressed or a switch was moved in the UI. A logging application on the laptop assigned timestamps to each message and wrote it to a text file for later analysis.

This scheme for logging touch-interactions (see table 1) was chosen to study the process of improvising with iPad instruments and not necessarily for replaying performances. It does not capture other touch "state" variables such as a unique identifier for each touch. It also does not attempt to keep track of OSC messages that might be delayed or lost, or network communications that took place between the iPads. However, the log is extremely useful as a recording of interaction with the instruments and can be transformed into other representations of the performance. While the logs were created for research purposes they also serve as representative artefacts of the performance along with the audio and video recordings.

OSC Address	Parameters
/metatone/online	device
/metatone/touch	device, X, Y, velocity
/metatone/touch/ended	device
/metatone/switch	device, switch, position

Table 1: Scheme for OSC messages from the Metatone iPad apps. The switch message was also used to record presses of the UI button in the app.

Animations

To understand the structure of the improvised performances we wanted a visual representation of the performers' touch gestures to watch alongside the audio and video recordings of each performance. A Processing sketch was produced that read the captured log files and rendered an animation of all four players' touches in the space of one iPad screen with different players distinguished by colour. The sketch also draws a date and time stamp on each frame as well as text notifications of switch and button messages.

The resulting animations presents an entirely new view of the performance which was not visible to the performers or audience on the day. As all the touch movements are layered in one performance area it is immediately clear when performers mimic each other, form sections, or experiment with a new musical idea. From the researcher's point of view, the animation also gives a "performer's perspective" on touch interaction, allowing us to connect patterns of touches with musical gestures that the performers discuss after rehearsals.

Tracking Gestures as a Score

Interpreting the gestures of musicians improvising on touch-screen instruments was a research goal of working with Ensemble Metatone. One approach to this has been

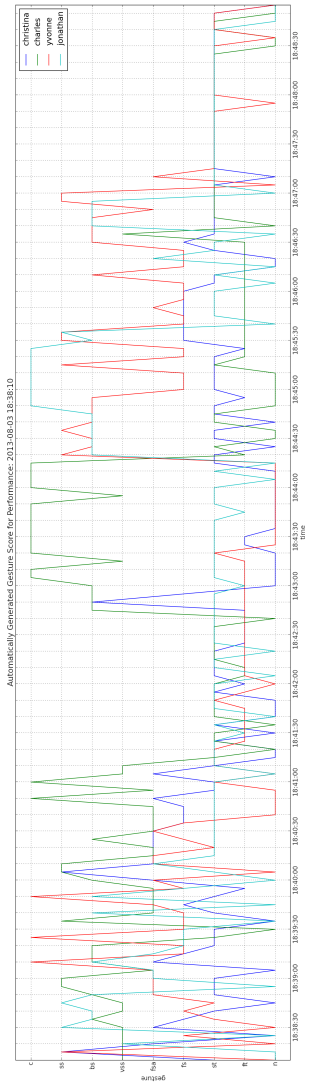

Figure 4: An automatically generated "gesture score" for the *MetaLonsdale* performance on 3-8-2013.

the application of machine-learning algorithms to logs of touch-interaction. After the initial rehearsal series took place, a vocabulary of touch gestures was developed from qualitative analysis of the rehearsals and discussions among the performers. From this vocabulary, examples of each gesture were recorded and the resulting log used to train a Random Forest Classifier algorithm [1]. Five second windows in the logs are used to calculate feature vectors which are classified by the algorithm. While research into how this technique can be applied in live performance is ongoing, the classifier is able to produce an interpretation of recorded performances as a "score" of gestures. In figure 4, each performer's gesture is given by the coloured lines which can move between the nine possible gestures in the vocabulary. Graphical scores like figure 4 are common in contemporary music and the representation of a performance as a sequence of gestures recalls descriptions of free-improvised music as "transitions" and "attractors" [6].

The scores produced so far are already helpful in understanding at a glance the overall flow of a performance. In this way they may be more useful archival documents of a performance than, for example, a still photograph of the stage setup.

Conclusions

By logging touch-interactions in Ensemble Metatone's performances on iPads we recorded aspects of the musical work that are not accessible in traditional archives of free-improvised music. The logs also allow further insight into the gestural nature of performance on touch-screens. In particular, animations of the performers' touches aided the development of a vocabulary of gestures. Graphical "gesture scores" following this vocabulary were generated from the logs automatically using a Machine-Learning algorithm.

These alternative representations have allowed a more comprehensive archive of performances and one that affords more insight into the performers' gestural and musical intent and ensemble interactions as well as their sonic output. As more performances are logged, it is hoped that these representations will allow us to track the group's musical developments or different approaches taken with future touch instruments. The representations could also be used in performance as visual accompaniments for the audience or displayed to the players as real-time feedback.

References

[1] Breiman, L. Random forests. *Machine Learning 45*, 1 (2001), 5–32.

[2] Davies, S. *Themes in the Philosophy of Music*. Oxford University Press, 2005.

[3] MacDonald, C. Scoring the work: Documenting practice and performance in variable media art. *Leonardo 42*, 1 (2014/01/15 2009), 59–63.

[4] Manovich, L. *The Language of New Media*. MIT Press, 2002.

[5] Rinehart, R. The media art notation system: Documenting and preserving digital/media art. *Leonardo 40*, 2 (2007), 181–187.

[6] Stenström, H. *Free Ensemble Improvisation*. PhD thesis, University of Gothenburg, 2009.