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individual listeners walk along a self chosen path within
smartphones has opened a vast area of new possibilities
composed files, and the unique characteristics of
realtime processing of both ambient sound and
the Liberation Route. This new combination of GPS,
users of the app.

7. download Walk With Me app:
6.  http://rjdj.me
5.  www.thelefthandpath.net
4.  www.hpl.hp.com/mediascapes/
3.  www.accessibility.nl/projecten-en-
sensorbased-integrated-mobile-phone-
site-specific hotspots
Figure 6. site-specific hotspots

6. CONCLUSION
Site-specific sound art has been around for several
decades, but now developments in technology can have
individual listeners walk along a self chosen path within
a composed sound environment. The Walk With Me app
[7] has been operational since 2011, and has been
devised for numerous places, such as Berlin, London and
the Liberation Route. This new combination of GPS,
realtime processing of both ambient sound and
composed files, and the unique characteristics of
smartphones has opened a vast area of new possibilities
for contemporary composers. And it does invite new
additions using a whole array of parameters, from
strength of light to the intermediate distance between
users of the app.

7. REFERENCES
1.  www.mendeley.com/research/shamus-a-
instrument/#
2.  www.hpl.hp.com/mediascapes/
3.  www.accessibility.nl/projecten-en-
publicaties/games-apps-installaties/demor
4.  www.davosoundscapes.ch
5.  www.thelefthandpath.net
6.  http://rjdj.me
7. download Walk With Me app:
http://itunes.apple.com/id/app/walk-with-
me/id461519712?mt=8

1 The Future of Music: Credo (1937)
2 Chris Cutler’s kit description: http://www.cutler.com/cutler/
3 Audio Example: Tony Oxley - Innos
http://www.discogs.com/Tony-Oxley-Innos/release/659887
4 http://www.icsrim.org.uk/augdrum
5 http://recherche.ircam.fr/equipes/temps-
real/nrnb69/proctime2006_364.pdf
6 http://www.korg.co.uk/products/wavedrum/whd/

THE AUGMENTED DRUM KIT: AN INTUITIVE
APPROACH TO LIVE ELECTRONIC PERCUSSION
PERFORMANCE
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ABSTRACT
This paper aims to outline some aspects of ongoing
research towards the development of a computer-
mediated electronic augmentation of a traditional four-
piece jazz drum kit. The highly customised instrument
consists of a traditional drum kit mounted with triggers,
contact microphones, speakers, and bespoke software.
The acoustic kit becomes part of the control interface of
the electronics with the use of various machine listening
techniques, and mapping strategies. Firstly, I will present
an introduction to the history of the drum-kit as a
constantly evolving instrument, supported by examples,
and I will also discuss its relationship with the computer.
Secondly, I will expound the aims of the research and
the technical details of the setup, along with some of the
modes of interaction methods for sound transformations
through examples. Finally, I will evaluate the success of
the system and its use so far, along with possible future
directions.

1. INTRODUCTION
"Percussion music is a contemporary transition from
keyboard-influenced music to the all-sound music of the
future." - John Cage

The drum kit as an instrument has two very distinct
characteristics: firstly, anything can be considered to be
percussion. From gongs and cowbells, to a prepared
snare drum, any sound making object can be
incorporated into the percussionist’s sound palette.
Secondly, the evolution of the drum kit tells of a history
of inventions and augmentations, in order to make a
single percussionist capable of having at their disposal a
wider range of sounds simultaneously. The hi-hat, the
snare of the snare drum, the bass drum pedal and the
cymbal stands are a few obvious examples. Also, within
orchestras, the percussion section has been one of the
first places for sonic experimentations, with pieces such
as Edgard Varèse’s Ionisation [4] incorporating anvils and
sirens. In the free improvisation scene, some of the
best examples of instrumental expansions come from
percussionists, such as Chris Cutler and Tony Oxley.
These improvisers were also among the first to use
amplification and real-time electronic sound
transformations as part of their setup.

In this respect, it could be argued that the drum kit
has some similarities with the computer as a
performance instrument. The two share the fact that they
can be highly customised and adapted to the specific
needs of the performer. As with the percussionist, the
laptop artist builds their instrument by assembling
different modules and instruments that fit their aesthetic,
programming their own effects or modifying existing
ones. Custom-made cymbals and bespoke software
environments, paint cans used as drums, or noise-gate
modules used with extreme values as real-time sound
processing effects, can all be seen as different
applications of the same ideas of customisation and
repurposing.

2. AIMS OF THE RESEARCH
This research aims to develop a highly personalised
electronically augmented drum kit, making use of the
computer as the main augmentation device. In contrast to
simple sample triggering (as employed by conventional
electronic drum kits) the electronic part of the kit is
designed to interact with all performance elements and
variations, maintaining the responsive qualities of the
acoustic instrument. Previous work towards
electronically augmenting percussion was taken into
consideration, for example An Augmented Snare Drum
and The Augmented Djembe Drum, as well as recent
commercial products such as the Korg Wavedrum.
It was decided, however, that the system would be purely
based on an acoustic drum kit, using mostly live audio
for the extraction of control data. Although continually
a work in progress, this required lengthy periods of time
dedicated to practice and improvisation, without
changing the system, in order to learn its extended
capabilities intuitively. As jazz saxophonist Ronnie Scott
put it, there was an effort to "become as close to the
instrument, as familiar with it, as possible. The ideal
thing would be to be able to play the instrument as one
would play a kazoo" [1]. Performing with an augmented
instrument, or indeed with any acoustic instrument and
live electronics, can be challenging, mostly due to the
need to learn new gestures which are often alien to the
acoustic instrument. Pauline Oliveros describing the rise of complexity of her setup wrote “I experienced a new kind of performance frustration - how could I control multiple parameters of sound simultaneously during improvisation when my hands and feet were too busy to access other controls” [3]. Even though such problems can be considered during the design stages of the handmade instruments (for example, the use of a rubber electronic pad would be more natural to a drummer for the input of control data instead of a slider), many control processes can be designed to be managed in the software realm with the use of machine learning techniques, partially eliminating the need for the use of MIDI controllers for all parameters.

A central point in the development of the augmented drum kit was its use and evaluation in different improvisational contexts. Being able to quickly access any sound or texture produced by the instrument in order to be able to improvise spontaneously with other musicians was one of the main tests for the system to be considered successful. Another important aspect was to make the electronics aesthetically relevant to acoustic percussion, and gesturally connected to the physical performance. The audience should be able to sense the relationship between the drummer’s gestures and electronics to some extent, keeping the physical cause and sonic effect not always entirely, but usually clearly obviously connected. The electronic sound was designed to enhance the drum-kit’s acoustic properties, as well as to contrast them, always attempting to maintain one coherent electroacoustic instrument.

3. TECHNICAL ASPECTS

This section describes some of the basic hardware and software details of the augmented drum kit, along with some of the modes of interaction.

3.1 General Description

The software is programmed in Max/MSP and consists of distinct sound processing modules. These can be roughly divided into 1) Live sampling and buffer manipulation 2) Performance based sound synthesis 3) Spectral Morphing. The patch can work in three different modes: 1) Free: in this case the performer can turn modules on and OFF on the fly with the use of a nano/pad MIDI controller. 2) Listening: here the patch listen to the acoustic sound and collect data. 3) Control: the performer initiates the start of the performance and processes turn automatically ON and OFF after predetermined amounts of time. The performer has the option to pause the time line in order to stay longer within a section. The third mode was combined with vibrotactile feedback and a local network between two performers, leading to the development of NeViS (2), a networked cueing system for improvisation. It was used most notably for the performance of Socks and Amo at NIME1 2011, a work for hybrid piano and the augmented drum kit.

3.1 Inputs

The signal inputs of the patch can be generally divided into two categories 1) inputs used only for control data; 2) inputs used for sound processing and some control data. Controllers and microphones used include:

- 4 drum triggers mounted on each individual drum (Figure 1), 1 contact microphone attached on a cymbal or metallic spring (Figure 4), 1 drum pad, 1 Korg nanoPad MIDI controller, 1 expression pedal and 1 switch pedal.
- 2 DPA microphones attached on the drummer’s wrists, or up to 4 x AKG clip microphones.

![Figure 1. Triggers attached on the drum frames](image)

Each of the control data inputs can affect each of the electronic sound modules in different ways. However, every set of inputs has a specific type of acoustic sound behaviour in mind. The drum triggers are used for onset attack detection on the individual drums, and envelope following with a quick attacks and decays. The contact microphone attached on the cymbal or spring can be used for longer amplitude envelopes as the spring can keep vibrating for a longer period of time after its excitation. The same applies to the cymbal. These are used for producing longer amplitude envelopes for certain processing modules, making the spring and cymbal themselves physical amplitude controllers.

A specific example encompassing all of the features described above is the granular synthesis module. The drum triggers provide information on the density of the physical performance, affecting the granular grain density. Also, when hits on the snare drum exceed a certain level, the granular density is maximized for a few milliseconds creating bursts of grain clouds with every hit. Finally the type of drum (bass drum, snare drum, multiple drum pads) determines the grain pitch. The piezo microphone acts as the amplitude envelope for the module, so in order for the aforementioned effects to be audible, one needs to keep exciting the cymbal or spring. Inevitably, the short inputs and controls are applied to the modules. Thus in combination, even though it is not entirely obvious how the electronic sound is affected, it is clear to the uninstructed observer that there is a strong connection with the acoustic performance.

The drum pad is used to freeze all of the control data of the active modules. This was employed to solve the problem of maintaining constant interaction between the acoustic performance and electronic sound. During improvisations, I often required the electronic sound to stay at the same place while the acoustic performance could go elsewhere, or move around for a while without affecting the electronics. The term freeze here does not refer to spectral freezing, but to unchanged control data, retaining the current character of the electronic sound. A hit on the pad would make the active modules stop responding to the acoustic performance (for example keeping very dense granular synthesis granules regardless of the acoustic performance). After this, if new modules are initiated, they will be responsive until the detection of a new hit on the pad, maintaining unresponsiveness.

Despite the use of triggers for expressive control over the electronic sound, there was a need for specific control over certain parameters where the outcome could not rely on machine listening processes or combinations of gestures. For example, being able to force the volume of the overall sound to zero, and starting or stopping sampling processes at specific points of the performance would have to be controlled more directly. For such reasons, an expression pedal and a foot switch were incorporated into the system. The sustaining pedal was used in multiple ways (above simple mapping of it’s 0-127 expressive range), according to its value and speed of value change: Action A (Boolean), when its value is 0; Action B (Boolean) when its value is 157; Action C (Boolean) when the pedal is idle for more than 300 milliseconds; the actual value of the pedal.

After extensive experimentation with mappings and rehearsals it is now possible to control a very significant amount of data intuitively with a single pedal. For example, Action C is used to turn the overall sound volume up or down (with ramps) when there is no new incoming data from the pedal. Whenever I want a very sudden cessation of the electronic sound, I simply have to take my foot off the pedal. This gives a significant sense of control when performing. If I need to access other controls, and have to take my foot off the pedal but do not want the electronic sound to stop, I can hit the pad as described above, and the current control data (which includes the pedal) will freeze, making it possible to maintain the desired amplitude while moving away from the pedal.

The switch pedal is used mostly for sampling, and can be perceived as a functional gesture. Even though it affects the overall electronic sound, this does not happen directly (as in the case of the drum triggers). The effects only become apparent after the sample is triggered, such as the expression pedal, triggers or pizzio. This could be likened to functional gestures of the acoustic performance such as changing drumsticks, turning the drum snares on, or changing the tuning of the floor tom during the performance. The fact that 1 change drumsticks will not affect the sound unless I hit the drum.

3.2 Sound diffusion

After discussions with Swiss percussionist, composer and improviser using live electronics, Christophe Fellay, in March 2011, I decided to adopt a localised speaker approach, rather than sending the sound to a wider stage PA which isolates the electronic sound from the direct acoustic sound. The idea being that the electronic sound is a part of the instrument, and thus it should be close to the acoustic source. Of course, depending on the venue, the whole electroacoustic sound could be reinforced further by a pair of overhead microphones, but this should be something to be decided according to the needs of each performance. This approach also helps to have a sonic experience closer to that of the audience. Being able to perform comfortably while feeling inside the electronic sound is one of the most important aspects when improvising with an augmented acoustic instrument. Expanding this idea further, I placed a third speaker below the floor tom that would create diffuse sound and resonate the tom membranes (Figure 2).

![Figure 2. Feedback floor tom](image)

By placing objects on top of the vibrating tom, such as small rocks, rice, twigs or chopsticks, it became possible to create slowly evolving feedback by the bounces. Also, by pressing the skin with different amounts of force and on different positions, different feedback overtones and amplitudes are generated. Apart from the range of sounds being produced, one of the most important features is the physical control of the electronic sound. Performing on the feedback floor tom could be described as a physical struggle to maintain a balance between complete feedback and complete silence.
acoustic instrument. Pauline Oliveros describing the rise of complexity of her setup wrote “I experienced a new kind of performance frustration - how could I control multiple parameters spontaneously during improvisation when my hands and feet were too busy to access other controls”[3]. Even though such problems can be considered during the design stages of the hybrid kit (for example, the use of a rubber electronic pad would be more natural to a drummer for the input of control data instead of a slider), many control processes can be designed to be managed in the software realm with the use of machine learning techniques, partially eliminating the need for the use of MIDI controllers for all parameters.

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A specific example encompassing all of the features described above is the granular synthesis module[5]. The drum triggers provide information on the density of the physical performance, affecting the granular grain density. Also, when hits on the snare drum exceed a certain level, the granular density is maximized for a few milliseconds creating bursts of grain clouds with every hit. Finally the type of drum (bass drum, snare drum, etc) determines the grain pitch. The piezo microphone acts as the amplitude envelope for the module, so in order for the aforementioned effects to be audible, one needs to keep exciting the cymbal or spring for some time. The inputs and controls are applied on the two modules. Thus in combination, even though it is not entirely obvious how the electronic sound is affected, it is clear to the uninstructed observer that there is a strong connection with the acoustic performance.

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Despite the use of triggers for expressive control over the electronic sound, there was a need for specific control over certain parameters where the outcome could not rely on machine listening processes or combinations of gestures. For example, being able to force the volume of the overall sound to zero, and starting or stopping sampling processes at specific points of the performance would have to be controlled more directly. For such reasons, an expression pedal and a foot switch were incorporated into the system. The sustain pedal was used in multiple ways (above simple mapping of its 0-127 expressive range), according to its value and speed of value change: Action A (Boolean), when its value is 0; Action B (Boolean) when its value is 127;  Action C (Boolean) when the pedal is idle for some time (with ramps), according to its amount of data intuitively with a single pedal. For example, Action C is used to turn the overall sound volume ON and OFF (with ramps) when there is no new incoming data from the pedal. Whenever I want a very sudden cessation of the electronic sound, I simply have to take my foot off the pedal. This gives a significant sense of control when performing. If I need to access other controls, and have to take my foot of the pedal but do not want the electronic sound to stop, I can hit the pad as described above, and the current control data (which includes the pedal) will freeze, making it possible to maintain the desired amplitude while moving away from the pedal.

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The augmented drum kit (Figure 4) was presented both in solo and collaborative settings in numerous festivals, most notably: Sonorities, NIME, BEAM, Dialogues, Soundings, and Network Music Festival. It was also used for the recording of a live solo improvisational album, *Ferricite*.

Although always a work in progress, the modes of interaction and control have remained successfully unchanged for a significant period of time and there are no plans to change the framework in the near future. Even though the actual sound processing modules may change (in the same way that a cymbal can be replaced), or be expanded on by the addition of more features, or indeed become more efficient, the control system is not likely to change soon. Having developed the augmented drum kit over several years, the instrument feels extremely intuitive and allows me to perform in a wide variety of situations with the same expressiveness and response as I would have with a purely acoustic instrument.

Figure 4. The Augmented Drum Kit

4. CONCLUSIONS

The augmented drum kit (Figure 4) was presented both in solo and collaborative settings in numerous festivals, most notably: Sonorities, NIME, BEAM, Dialogues, Soundings, and Network Music Festival. It was also used for the recording of a live solo improvisational album, *Ferricite*.

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| 1. Start (in cue following mode) |
| 2. Stop (in cue following mode) |
| 3. Pause (in cue following mode) |
| 4. Edit Cues (in cue following mode) |
| 5. Current cue section name as assigned by 4 |
| 6. Overall sound density |
| 7. Master audio level |
| 8. Current cue section bar: time elapsed |
| 9. Processing module active |
| 10. Processing module active with control data |
| 11. Processing module active with controls responding to the acoustic performance as specified by the non-greyed bottom square |
| 12. X-Y Control from the Korg NanoPad |
| 13. Current sampled buffer visualisation |
| 14. The black vertical line represents the present loop playback position |
| 15. Processing module inactive |

REFERENCES


[5] http://www.lucollandenmail@gmail.com

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Figure 4. The Augmented Drum Kit

5. CONCLUSIONS

The augmented drum kit (Figure 4) was presented both in solo and collaborative settings in numerous festivals, most notably: Sonorities, NIME, BEAM, Dialogues, Soundings, and Network Music Festival. It was also used for the recording of a live solo improvisational album, *Ferricite*.

Although always a work in progress, the modes of interaction and control have remained successfully unchanged for a significant period of time and there are no plans to change the framework in the near future. Even though the actual sound processing modules may change (in the same way that a cymbal can be replaced), or be expanded on by the addition of more features, or indeed become more efficient, the control system is not likely to change soon. Having developed the augmented drum kit over several years, the instrument feels extremely intuitive and allows me to perform in a wide variety of situations with the same expressiveness and response as I would have with a purely acoustic instrument.