Octonic: An Accessible Electronic Musical Instrument

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Abstract

The rationale behind the design and development of an accessible stand-alone musical instrument is described. Intended for use in improvised music within a community music setting, the Octonic is a non-contact diatonic electronic musical instrument. Building upon established touch-free approaches to musical interaction, the instrument offers polyphony and expressivity and is designed to be free-standing, intuitive, simple in operation and affordable. The functionality of a current working prototype is presented along with observations based on testing across different user groups.

Keywords

Accessibility, music, interactivity, improvisation, infrared

1 Introduction

Where there is a potential for artistic collaboration, there is also a potential for such engagement to enhance an individuals experiences of social inclusion. In this respect, music offers a great variety of opportunities to individuals of all levels of ability. It would also be fair to say that the concept of creating a musical idea is readily available to us all; we can easily think of a sound or imagine a melody. However, the nature in which we might externalise perhaps even the simplest of these musical ideas can quickly begin to present barriers. The successful control of many traditional musical instruments will, to a great extent, rely on the music-learner or performer having well developed fine-motor skills such that the interface with which the performer interacts with music (the musical instrument itself) can be often a significant obstacle to individuals with restricted mobility.

1.1 Community Music and Improvisation

Although formal approaches to music education may focus on the building of instrument specific technical skills and the associated theoretical knowledge, there are other, perhaps more flexible approaches, that place significant emphasis on individual needs. Echoing the thoughts of influential improvisers such as Bailey (1992) and Nachmanovitch (1990) who tell us that artistic creativity can be considered as a form of ‘play’, community musicians use improvisational approaches within their practice to facilitate group music making as a form of social interaction. There are numerous well established approaches that can be adopted for this purpose e.g. Stevens (1986) or Moser and McKay (2005), where improvisation and ‘play’ are at the very heart of shared musical activities. We are encouraged to consider all sound as ‘music’ and to liberate ourselves from the formal constraints of form and structure, being more responsive to the immediate changes around us and how we might respond to the sounds we are exposed to. They help us to break down barriers and in doing so they also embrace the notion of technology as an effective means of achieving this. There are a number of assistive or adaptive technologies in regular use within a community arts context and this article discusses these whilst presenting the rationale, design and ongoing development of a dedicated musical instrument within a similar vein.

1.2 Performance behaviours and 'ownership'

Before considering some of these alternative technologies, it is worth considering the different ways in which we might manufacture and control musical ideas by assistive means as there are consequences to be aware of in terms of participation and 'ownership'. This is a concept that Healey (2005) identifies as having the potential to compromise the relationship between musician and sound. It might be possible to design a system that produces complex and exciting musical patterns or textures with great ease but it might be questionable as to what degree the 'musician' has control within this process. For example, pressing a switch to begin a sequence of timed musical events ceases to be musically interactive after the process has begun. In contrast, pressing a switch repeatedly to sound notes within a sequence one at a time places some aspect of 'ownership' with the performer.

With this in mind, Malloch et al. (2006), suggest that digital music instruments can be categorised within three distinct modes of performance behaviours: skill-based, rule-based and model-based. Of these, the mode of musical interaction-behaviour most similar to that of playing a conventional musical instrument lies within the skill-based domain. The implication is that the user will be interacting in real-time in response to a continuous audio-stream. The other two models of musical interaction-behaviour operate at increasingly abstract levels of interaction with the user's interactions being less and less involved in terms of ownership.

2 Assistive Music-technologies

There are two key hardware systems in regular use within the UK that are specifically aimed at bridging the gap between an individual's desire to interact with sound and the physical and cognitive barriers that can obstruct that same desire. Although there are numerous technologies that can provide proportional readings relative to a user's actions, both of the systems described in the following sections offer a non-contact or 'hands-free' approach to interaction and are recognised as being fun and subsequently highly motivational for individuals who work with them.

2.1 Ultrasonic technologies

The first, and probably the most commonly available technology, is Soundbeam (Swingler, 1998). This uses an ultrasonic sensor to create an invisible 'beam' that is mapped to musical pitches along its length. In many respects, the system implements a gesture-based approach to musical interaction that is reminiscent of the Theremin, an electronic instrument that was developed in the 1920s and that also happens to be accessible in many respects; a point that Magee (2006) makes in reference to its continued use within Music Therapy. The other system, MIDI Creator (Abbotson et al., 1994), allows various types of sensors to be utilised for the same purpose; this includes an ultrasound sensor (MIDI Gesture) similar to that used by Soundbeam. Ultimately, Soundbeam and MIDI Gesture both provide immediate interest by allowing the user to produce and interact with sounds that are triggered by MIDI messages. With this in mind, both systems can be regarded as motivational and accessible music systems where the kinds of interaction encouraged are achievable by individuals with limited mobility. However, both systems use ultrasonic sensors and these can tend to interfere with one another to produce spurious readings when used in even fairly close proximity. Though a number of units might be used simultaneously within a reasonably sized space, there are working constraints as to how closely the units can be placed.

2.2 Infrared technology

A similar approach to both Soundbeam and MIDI Gesture was explored within a musical device called the "Dimension Beam". Originally manufactured by the US company "Interactive Light", this device employed a similar mapping of musical notes to a single 'beam' via MIDI although the underlying sensor technology used was based on infrared light. As with ultrasound, infrared sensors also tend to trigger one another when used in close proximity but this is to a far lesser degree such that sensors can be placed within a few centimetres of each other. Now licensed to Roland as the "D-Beam" this same technology is currently being used as a method of expressive control over one or more sonic parameters in a number of their products.

When working with individuals with severe learning difficulties, such devices can be a particularly intuitive method for exploring and encouraging cause-and-effect style interaction. This was demonstrated most effectively by Brooks (1999) who employed both ultrasound and infrared devices within a virtual interactive space where users with profound learning difficulties took part in stress-relieving exercises; actions were mapped to sounds, images and robotic movement with enthusiastic engagement from the participants. Brooks' system was also configurable to allow individuals with a range of disabilities to engage with therapeutic activities based on their individual needs. A further study (Brooks et al. 2002) incorporated three Dimension Beams as an array, these being connected to a computer running external software to control sound and images.

2.3 Other technologies

The musical instrument project being presented in this article (the Octonic), eventually made use of these same IR sensors and the reasons behind this choice are explained in subsequent sections. However, it is only fair to acknowledge at this point of the discussion that there are a number of other technologies that could be used to achieve differing levels of 'touch-free' interaction. Perhaps the most obvious of these is the type of wireless accelerometer technology now commonly found in gaming devices such as the Wii remote.

In addition to providing information on tilt and rotation, these devices also offer information on relative speed of movement although they do require the user to physically hold one or more remote control devices. In contrast, camera-based motion capture could free the user from the need to hold a device whilst offering a style of interaction more similar to that afforded by both ultrasonic or infrared sensors, though there would be an increased demand in processing power required within the system to capture and analyse one or more video streams for this purpose.

2.4 Making music

The three systems just described (Soundbeam, MIDI-Gesture and the Dimension Beam) can all be thought of as musical instruments where the notes produced are being manipulated to create melodic fragments and rhythms. The type of interaction afforded is flexible to the needs of users with limited mobility; it is also intuitive and fun to work with. However, when systems such as these are considered as musical instruments in this way it becomes important to consider their relative merits within a context of structured music-making activities. In one respect, both systems can provide skill-based performance behaviour but to achieve certain musical outputs (polyphony, expression) they must incorporate rule-based behaviours or they must be configured as arrays.

There are a number of software environments appropriate to this task that are designed to provide access to music composition and performance for users with special needs with perhaps the most noticeable being E-Scape (Anderson, 1996; Anderson, 1999) and MIDI-Grid (Hunt, 1988). Both offer rule-based performance behaviours where a user’s interaction in some way triggers a series of predefined musical events. With MIDI-Grid, these are contained within an on-screen 'grid' where a user can place rhythmic, melodic and harmonic fragments in specific locations. These can then be 'played' by moving a cursor onto a particular object and selecting it. This process can be further enhanced by using novel input devices similar to those described earlier. Although the system is essentially rule-based, it does present interesting opportunities for improvisation as a considerable number of musical objects can be available at any given time. In contrast, E-Scape employs a sequencer style approach to creating musical ideas. As with MIDI-Grid interaction can be enhanced through the use of novel input devices but performance interaction is more focused on the user coordinating the timed playback of a particular sequence of events. For the technically minded, a huge variety of rule-based performance behaviours could be achieved using specialist music programming software such as MAX/MSP. As an alternative to software solutions, a number of units could be configured to work together to increase the combined polyphony and/or expressivity. However, to achieve any of these extra levels of musical complexity, there is an increased demand placed upon the user in terms of complexity of use. Connecting a number of devices together in this way or controlling external software probably lies more within the domain of the technologist than that of the educator and it is this key issue that is the starting point of the design being presented here.

3 Assistive technology in special needs education

During a series of visits to special needs schools in the North of England, a number of significant observations were made. Most notably, it was observed that even though many schools owned specialist music technology of the types just described (hardware and software), very little was in use in day-to-day classroom activities. As a result, the type of musical activities observed tended to be quite basic, focusing on singing and clapping and not affording much opportunity for the participants to exhibit either spontaneity or autonomy; with both concepts being key to improvised music.

Feedback from educators suggested the following aspects as being influential on the type of activities that might be considered and how or whether specialist technology might be used. Firstly, not many of the teachers regarded themselves as music specialists but were still likely to be involved with coordinating musical activities. Secondly, and connected with this last issue, where assistive technologies were available they were commonly perceived as being 'specialist' and therefore requiring additional skills and knowledge beyond those associated with music. Thirdly, where technology was available it was typically as a shared resource such that reserving or locating the equipment was seen as being troublesome. In this respect, the specialist resources were seen as being expensive, prohibiting them from being more freely available in a number of classrooms at the same time. Lastly, it was also suggested that perhaps a single individual would be seen as being the 'specialist' in this respect; if anyone was to run a session using the equipment it would usually be this person.

In discussing these apparent issues with special needs educators, it seemed there would be a place for an alternative novel musical instrument; one that is ideally entirely dedicated in its capability, and therefore particularly simple to use and operate. The feeling being that the user should be able to turn it on and immediately produce sound. It was also recognised that the gesture based interaction techniques employed by the existing systems is both intuitive and fun to engage with. Any new ‘instrument’ would probably benefit from adopting a similar approach but the instrument would still need to affordable enough to allow a small number of units to be available at any one time. Most importantly, it was also. recognised that any new instrument should not be regarded as a replacement, simply another instrument to be used in conjunction with any others that might already be available in much the way that we might value access to a guitar as well as access to a flute.

These observations were significant in identifying an apparent need for an alternative approach but it has been of additional importance to consider the types of musical interactions and tasks that might be expected of such an instrument. In reflecting on how these might (or might not) be achieved with other systems and to what extent the user or performer remains in ownership a set of design 'inclusions' could be identified.

4 Musical tasks

At the most basic of levels, the building blocks of western music can be regarded as pitch, harmony and rhythm. However, the combination of pitch and rhythm provides us with melody and the layering of pitches provides us with harmony and it is typically the combination of these two along with rhythm that are used when making specific reference to musical ideas. However, the types of musical instruments that we use and the way in which we perform with them also provides us with expressive qualities such as timbre and loudness. Indeed, the level of expression afforded by one instrument in comparison to another can be just as significant as the different types of musical task that either can achieve. In terms of accessibility and music, it would be desirable for any enabling-instrument to be as flexible as possible in terms of the different types of musical task that can be achieved whilst also offering considerable expressive control.

4.1 Common musical tasks

One quite fundamental musical task would be to copy or improvise a rhythmic pattern. For this task, the sound used does not need to be pitched but the player does need to be able to move freely from one sound to another at specific times. If a rhythmic task is performed but the sounds used have pitch, then the task becomes melodic. Melody will typically be associated with tonality and a musical key. Lastly, if more than one pitch is played at the same time the task can be thought of as harmonic. An instrument’s ability to produce harmonic sounds is limited by its polyphony. For example, a flute is monophonic, producing only one note at a time whereas a standard guitar is six note polyphonic allowing chords to be sounded. A basic requirement for an instrument to be expressive would be that individual notes can be sounded at different levels of loudness. On some acoustic instruments, the loudness of a sustained note can be changed over time which is a particularly expressive quality. Additionally, it is often possible to alter the timbre of a note by adjusting the way in which it is played, again, this is a very expressive quality and one that can also be regarded as desirable.

4.2 Abstract music

Much of the discussion on musicality so far has focused on the formal notions of melody, rhythm and harmony but we must not forget the potential for using quite abstract sounds in music making. The manipulation of 'concrete' or synthetic sound is not the absolute domain of the experimental musician. As described earlier, improvisers working in the community music setting will often encourage participants from non-traditional music learning backgrounds to consider any sound as having a music potential. Effectively, anything we have around us with which we can produce sound offers the potential for that source to be an 'instrument'. With this in mind, it was also recognised that the design of a novel accessible musical instrument might benefit considerably by facilitating the production and manipulation of abstract sounds.

5 The Octonic Project

The central aim of the “Octonic” project has been the design and realisation of a musical instrument that can afford complex levels of expression and interaction whilst also fulfilling the inspirational role that can be instrumental in attracting and maintaining a user’s interest. At its most basic level it should operate as a motivational musical toy, an object that encourages users to interact because of the connection between the actions they are making and the sounds being produced (cause-and-effect). As identified earlier, this would have direct application within an educational setting for users with severe learning needs. At a higher level, it should be capable of more structured musical interactions such that users can shape and develop simple but coherent musical ideas (melodies, rhythms and simple harmonies). At a higher level still, it should operate as a performance tool that can facilitate more complex levels of musical and expressive control. In addition, the instrument should be as accessible as possible, being flexible and adaptable enough to respond to different levels of mobility and dexterity on the part of the user. It should also be intuitive to use and simple to operate. Finally, it was also recognised that the overall cost of the instrument should be regarded as significant within the design process.

There would be advantages to be gained from such a system. Practitioners working in educational and/or community-based settings would have the potential to use a single instrument with users across a broad range of physical and cognitive abilities. This is also advantageous to education providers where specialist technology can often be very expensive; the more flexible the system is, the more likely that it can be used in a variety of settings. If the system is intuitive to use and simple to set up, it is likely that more staff will be able to easily use the equipment with an increased potential for autonomy on the part of the learner within educational activities. Key issues explored within the design process have been musicality, usability, accessibility and affordability.

5.1 Musicality

As was discussed earlier, the more polyphonic an instrument is the more capable it will be in terms of producing rich and potentially complex harmonies. However, even being able to sound two notes simultaneously provides the basis for introducing a simple major or minor interval; this alone, can be enough to reinforce the tonality of a musical idea. With this in mind, it was identified that the instrument should be two-note polyphonic at minimum but with a view to increasing this figure if possible.

At minimum, it would be desirable to have control over the loudness of the notes being played with the instrument. However, many musical instruments allow dynamic control within the life of a single note (wind instruments in particular). For example, a saxophonist can sound a note and then control the loudness with increased or decreased airflow; this can also change the timbre of the sound being produced. This is a particularly expressive musical effect and yet one that is simple and intuitive to understand. It was decided that at minimum, the instrument should be able to achieve different levels of volume but that the possibility for dynamic change in the tonal quality of the sound should also be explored.

5.2 Usability and accessibility

The two devices described earlier (Soundbeam and MIDI Creator) both carry significant learning-curves in terms of acquiring an adequate understanding of how to operate, adapt and expand the system. This is an observation that has been offered by educators prior to the design process and has also been echoed further during the testing process. The feeling appears to be that these systems are not used as frequently as they might be as there may only be one member of staff within a school or institute who is fully knowledgeable in their usage. However, the gesture-based approach to triggering sounds offered by these devices appears to be both intuitive and flexible in terms of facilitating access for users with limited mobility. Traditional musical instruments tend to require high levels of dexterity in terms of control and movement of individual fingers; they often require the use of both hands in this way. With this in mind, it was decided that a gesture-based approach to interaction where one or more hands (wrists, arms etc) could be used to play individual notes would be highly desirable but that the general complexity of the system should be kept as simple as possible.

As described earlier, the Wii remote provides an efficient means of gaining quite detailed information on the orientation and relative speed of a user's movements. However, the device must either be held by the user or instead be somehow attached to the user's body. Within the context of this project, 'holding' could be regarded a undesirable for users who are likely to have mobility issues and 'attaching' could introduce the potential for the technology to become intrusive if not cumbersome. It is also conceivable that a camera-based approach to motion capture could be adopted but such technology might also present an added risk of introducing additional layers of complexity into the set up and operation of the system.

5.3 Affordability

Specialist technology within the educational setting is often expensive and this factor alone can impact on whether individuals are exposed to a particular experience or not. It was decided that one of the aims of the project should be to try and keep the overall cost of the instrument as low as possible. One key aspect that was identified as being significant within this was the choice of technology to be used for sensing movement. Ultrasonic sensors can have considerable range and accuracy, however, they are also particularly costly unless considered within the context of mass-production. In contrast to using this type of technology, it was decided that the project should explore possibilities for the use of low-cost infrared sensors.

5.4 Design

The current working prototype is based on the Sharp GP2Dxx series of infrared (IR) distance measuring sensors (Figure 1). These are particularly versatile sensors that are commonly used in robotics for detecting objects within a limited field or 'beam'. Discussion on the relative merits of IR sensors is provided by O'Sullivan and Igoe (2004) and also by Miranda and Wanderley (2006). Essentially, each sensor unit includes an IR transmitter-receiver pair that provides continuous feedback on whether an object is within the 'beam' of the sensor. Although these have a shorter range than ultrasonic sensors they are less costly, more self-contained and have less tendency to interfere with one another. GP2Dxx sensors are available as digital output devices (providing logic-high or logic-low according to a distance threshold) or as analogue output devices (providing a voltage that represents the distance from the object to the sensor). These units are low-cost and require minimal additional electronics making it relatively easy to incorporate a number of them into an array. The unit in use within the current system provides analogue output for distances in the range 10cm to 80cm.

For the initial system, eight sensors were attached in line to a light-weight curved-frame with the sensor 'beams' orientated upwards in front of the performer's body (Figure 2). This curved layout is for practical reasons rather than aesthetic as infrared sensors of this type can have a tendency to trigger neighbouring units that are in close proximity if their beams overlap. The curvature of the frame aids in pointing the sensors away from each other slightly such that the distance between any two can be kept to a useable size (approximate to a hand's width). The overall height of the frame above its base is 22 cm and the overall span between the extreme sensors is 92cm with a distance of approximately 14cm between neighbouring sensors.

A programmable microchip was used to run software that maps the change in voltage onto standard MIDI note and/or controller messages. The system can be regarded as being eight note polyphonic as all sensors are read and acted upon independently of each other. In the preliminary stage of the design (as shown in Figure 2), the aim was to simply demonstrate the potential for the instrument and to gather feedback that could be fed back into an iterative design process. With this in mind, it made good sense to focus on the layout, interactivity and musicality rather than the method in which the sounds were produced or the manner in which the main microchip would communicate with sensors and/or sound source. Ultimately, the original design brief suggested that these should all be housed within a single body (a final prototype is described later in this article) but for the first working version sound was achieved using external software being triggered by MIDI messages.

5.6 Functionality

In both early and more recent versions of the Octonic, the device can be used in two different ways depending on the nature of the hardware it is controlling. In its first mode (*instrument*), the system simply transmits Note-On and Note-Off messages accordingly as an object enters or leaves a beam, these have a velocity (loudness) that corresponds to the distance from the sensor to the object (finger, hand, arm etc.). The pitches produced are currently taken from pre-defined scales and modes that are mapped from left to right (lowest pitch to highest pitch). In this mode, the Octonic can be thought of as a diatonic instrument where each note is a specific step within one of a number of available scales (major, natural minor, harmonic minor, pentatonic, blues, dorian, mixolydian etc.). Although, these scales are currently predefined, it would not be difficult to introduce some level of user programming to this aspect. In the current version, *instrument* is the default mode along with a scale mapping of C major starting at middle C.

In its second mode (*controller*), the Note-On and Note-Off messages are still transmitted but there is an additional stream of controller messages available whilst the object remains within the beam. These change accordingly as the object is moved closer or further away from the sensor. The additional messages can be mapped onto expressive parameters (volume, tone) depending on the nature of the sound source being controlled.

The MIDI specification does not allow for individual note volumes to be changed dynamically but it is possible to incorporate this effect using sound programming environments such as MAX-MSP and Reaktor. By considering each note as 'belonging' to a specific MIDI channel, sixteen voice polyphony can be achieved with the dynamic level of each voice being controlled independently. In the early version, this method provided the basis for achieving some level of expressive control. A Note-On message can be used to trigger a sampled pitch or sound, the subsequent controller messages can then be used to alter the sound dynamically. This could be used to alter loudness of an individual note but could additionally be used to alter its tone. In the current version of the Octonic, expressive volume control of individual notes is achieved via an internal sound synthesiser.

5.7 Testing

As described earlier, the central aim of the project has been to design an accessible music controller, one that is easy to play and set up but also one that can accommodate a fairly broad range of user abilities and musical applications. The inspiration behind the project came from observations made on assistive technology for music making in special needs education. With this in mind, user-testing the system with individuals with special needs has formed an important component of the overall testing program. However, it has also been identified that the instrument could be of use within mainstream education and with that in mind, the instrument is being tried and tested within an educational curriculum that includes practical sessions on improvisation. Lastly, the Octonic can also be thought of as an instrument for expressive control of abstract sounds for use within improvised performance by anyone. With this last point in mind, the instrument is also been subjected to testing within an ongoing series of live improvised performances.

5.7.1 Testing in special needs education

A Specialist Teacher for pupils with multiple sensory impairment has been working with a variety of users with differing individual needs using the early Octonic system in its default operating mode (‘instrument’ as described earlier). Feedback has being gathered through close observation of individuals using the controller along with the critical evaluation of additional specialists working in the same environment. Group sizes have been in the order of four or five individuals within a group but with generally only one person interacting with the device at any given time. For the purposes of the initial phase of testing there has been no specific ‘script’ to follow i.e. the testing is not task-specific. Where possible and appropriate, users are simply allowed to improvise with the instrument in which ever way works best for them. This decision was taken partly because the system has been regarded as a musical tool that is essentially for improvisation but also because it was hoped that new methods of interaction might become apparent through users attempting actions that are seemingly intuitive but not currently available. However, it is important to appreciate that the system was being assessed within an active educational programme and, as such, occasional intervention from the observer was acknowledged as appropriate. With this in mind, where an individual has perhaps struggled to comprehend or interact easily with the system it would be was seen as acceptable and appropriate for the individual to be encouraged to attempt a different action; the nature of the difficulties were then noted and recorded.

It has been rewarding to observe that users have been able to exhibit considerable independence whilst improvising with the system and that there is a most apparent eagerness to make music in this way. The ‘fun’ appeal is strong with users returning frequently to play the instruments and try different sounds. A key observation on this has been that it would be desirable to integrate a number of easily accessible switches that change one or two very basic settings e.g. type of sound and/or type of musical scale.

Users have also been observed trying to interact with the system in contrasting ways. For example, one user began by attempting a ‘tapping’ motion towards the sensors and then gradually adopted a more appropriate hand motion above the sensors. Another user, was using a gentle pushing movement towards the sensors which sometimes failed to trigger the sensor. Yet another, began at one end of the instrument with the sensors making a line perpendicular to their body, similar to the strings on a harp. Although the original design of the instrument had a particular style of gesture in mind it must now be observed that there are likely to be a number of alternate styles of interaction that might be more intuitive or, perhaps, physically less demanding depending on the abilities of the user. These are being observed and recorded during the close-observation sessions such that they can be compared and contrasted with one another in future designs.

Some users have also been observed moving their hands towards or away from sensors whilst a note is currently sounding; this is an apparent attempt to alter the character of the sound in some way. As identified earlier, the ability to dynamically change the loudness or tone of a sustained note can be a simple yet very expressive device. Although this feature is available within the system it is not yet a default setting. It seems that if the feature were to be made available in this way that it would be both instinctive and intuitive in operation. By placing an object into a ‘beam’ a sound is produced, if the object is then moved then the tone or volume of sound is affected to some degree. This is an aspect that has been explored further and now does form part of the default setting.

5.7.2 Testing in mainstream education

A more recent version of the Octonic has been used within a practical education environment with a small number of students on a degree course in Popular Music at the University of Glamorgan, UK. In contrast to testing within a special needs environment, there are elements within this phase of testing that are more task orientated as the students have been working within a set curriculum. This has been mainly achieved within a module that explores improvisational approaches, a subject that lends itself to the notion of working within a community music setting. At a formal level, this might mean using scales and modes against harmonic patterns in a way that demonstrates an appreciation of harmonic function, chord-tones, colour tones, suspension, resolution and so on but in a spontaneous manner; reacting to the sounds of others within a group. For some instrumentalists (e.g. percussionists) this can be demanding and potentially quite daunting. With this in mind, the Octonic has been offered up as an alternative instrument to use within these practical sessions.

The most noticeable observation is quite simple, students who might ordinarily have struggled with engaging in melodic or harmonic improvised musical activities have been able to do so in a manner that is both coherent and seemingly intuitive. With only limited instruction (e.g. how to cycle through scales, how to change sounds) students have been encouraged to engage with the improvisatory activities that are explored within the curriculum. These range from idiomatic 'groove' based sessions to completely abstract or 'free' sessions. Responses from participants have been very positive with one student being able to temporarily migrate from her primary instrument to the Octonic whilst recovering from surgery to her wrist.

5.7.3 Testing through improvised performance

Testing is also being carried out within a series of ongoing live improvised performances by users without specific needs. In contrast to the previous two approaches to testing, the focus here has been on the triggering and subsequent manipulation of real and synthesised sounds within free improvisation; an example performance is currently available on the internet (Challis, Smith and Wiblin, 2008). One aim of this approach to testing is simply to monitor how well the system performs (e.g. sensitivity, usability, reliability, interference etc.) within the context of specific live performance activities. However, as with user testing in a special needs setting, it has also been hoped that the use of improvisation will produce feedback that might not be achieved by more task-specific testing. For example, where a performer is in control of a particular sound-object they may wish to introduce any number of changes from the main properties of that initial starting point (altering tone, loudness, granularity, spatial quality etc.). The movements and gestures the performer perceives as intuitive may actually lead to outcomes that are undesirable or unexpected. Such conflicts between *actual* and *desired* outcomes are observed and recorded following any new performance. Unsatisfactory levels of response and sensitivity with the software and hardware have been identified as part of this approach to testing. The approach has also been beneficial in assessing the overall layout and shape of the instrument by encouraging performers to explore extremes and boundaries such that an optimum spatial layout can be achieved. This live improvised approach to testing will be continued alongside the other two more formal approaches for the duration of the project.

5.8 Current progress

The Octonic has now moved from being a temporary frame with external sound source to a stand-alone robust prototype with its own sound source and amplification (Figure 3). This is obviously much more in keeping with the original design brief as suggested by special needs educators. It is now self-contained, highly portable and potentially very low cost if the units were to be mass-produced.

6 Conclusion

In recognising an apparent desire from special needs educators for an alternative accessible musical to those currently available, a prototype electronic musical instrument "The Octonic" has been developed. Offering expressive polyphonic control of up to eight notes or sounds, the instrument is designed to be intuitive to use, simple to operate and inexpensive to produce. Operating as a standalone instrument with internal sound source and amplification, it employs an array of infrared sensors to provide two-dimensions of interaction (horizontal and vertical) with users triggering sensors by way of one or two hands (or arms). The central aim of the project has been to design an accessible means of engaging with improvised musical activities for users with special needs. However, it has also suggested that such a device is likely to have potential in any setting where music is being created and explored spontaneously. Both the design and testing process have allowed for this breadth of application and the results from testing in contrasting areas has produced promising results.

As a result of testing across contrasting groups, some fundamental modifications have been made to the prototype to address a number of key issues. The size and layout of the sensor array and frame have been adjusted to reduce the overall height and span such that it is easier to reach the sensors at each extreme. The software has also been redesigned to improve the response and sensitivity with which a user's movements are monitored. Simple enhancements have also been included to allow the user to quickly change sounds and move between a variety of musical modes.

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Biography

Dr Ben Challis is a composer, performer and technologist. With research interests that embrace the notion of design-for-all within music-performance, he has worked on various projects that explore alternative modes of interaction with sound and music for people with specific individual needs. As a performer, he works with these same technologies, exploring their creative and expressive potential within free-improvisation. As a composer he has composed scores for film and theatre productions. He is a Senior Lecturer and Joint Award Leader in Popular Music at the University of Glamorgan, ATRiuM.