Pocket gamelan: developing the instrumentarium for an extended harmonic universe

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Abstract

This paper describes a 3-year project that seeks to explore tuning systems and to develop instruments appropriate for the audition and performance of music composed in just intonation tunings. The project is a response to the transformation in computer music that has been enabled through the introduction of wireless technologies and is also motivated by a desire to enable performance by large numbers of non-expert performers playing music based on just intonation using hand-held or wearable instruments. Possible scenarios together with musical algorithms are presented and illustrated with examples from creative works written to clarify the parameters of musical instrument design.

1 Introduction

The last half of the twentieth century witnessed an unprecedented transformation in the way musicians create, produce and distribute their work. Much of this change can be attributed to the revolution in electronics. Within the last decade the marriage of digital electronics and communications technology has brought about a paradigm shift from desktop to mobile computing. Such a transformation has made it possible to achieve an unprecedented degree of musical interaction between performer and listener. The same transformation makes it possible to reinstate the tuning diversity that once existed in music, a diversity that gradually became lost in the process of technological development.

1.1 Just intonation

Just intonation tuning is an attribute of diverse tuning systems that developed in early civilisations and which still survive in various contemporary musical cultures and folk traditions throughout the world. Just intonation tunings are characterised by a vast palette of non-uniform musical intervals. The size of each interval can be described using the natural harmonic series. The development of western harmonic music over the past three centuries coincided with the gradual disappearance of just intonation tuning and the eventual dominance of a single tuning system based on twelve equal divisions of the octave. Because their difference tones are in phase, just intervals sound purer and stronger than their closest 12-tone equal tempered approximations.

1.2 Just intonation revival

In the 20th century, composer and instrument-builder Harry Partch (1900-1974) revived interest in just intonation. Through his reading of the theoretician Helmholtz, Partch gained a new understanding of early Pythagorean theorists and formulated a new theoretical basis for western harmony based on just intonation (Partch, 1949). Other composers have also been attracted by qualities of tunings found in a broad range of traditions including Pythagorean, Indian, Celtic, Persian, Arabic, North African, Indonesian and Chinese. Many of these composers found it necessary to develop new software (Polansky, *et al.* 1993; Scholtz, 1993) or build new purpose-built musical instruments, both electronic (Dudon, 1994; Favilla, 1994) and non-electronic (Fullman, 1993; Drummond, 1997) in order to create music using their own particular variety of just tuning.

On-going development of tuning theories by other theorists (Wilson, 1975 (1); Chalmers, 1993; Sethares, 1998) has established new connections between diverse music traditions and current musical experimentation. Wilson's theories and instrument designs, embracing historical tunings used in various epochs and in many parts of the world (Wilson, 1975(2); 1986), have made an impact in several areas of contemporary composition as exemplified in the work of experimental electronic composer and instrument-maker Burt (Burt, 1996), rock guitarist Catler (Catler, 1996), composer-performer and instrument-maker Grady (Grady, 1996), and film music composer Taylor (Taylor, 1997).

Musical terrain now being opened up calls for a completely different approach to musical instrument design. A forerunner of such an approach can be found in the work of Bischoff, Gold and Horton (Bischoff *et al.* 1977), composers who built one of the first known musical instrument networks for live performance, and the Hub (The Hub, 1994) whose instrument designs challenged accepted notions of performance and compositional authorship.

The Tupperware Gamelan (Schiemer, 1999), a set of sixteen mobile analogue instruments built between 1977 and 1983, exemplified a similar design philosophy. Such an approach offers new modes of performance through a set of musical instruments with a simple user interface suitable for performance by groups of non-expert performers. Today's global networks present new opportunities to extend rich tuning resources identified by Partch and at the same time extend current standards of music performance practice.

2 Pocket Gamelan project

The aims of the Pocket Gamelan project are:

to create a prototype network of mobile instruments for performing music free of the tuning constraints associated with conventional music performance interfaces;

to use this prototype to explore current developments in tuning theory using new performance paradigms.

The prototype mobile instrument network will be one in which each mobile unit is easy to play, quick to learn and produces audible tones that are microtonally tunable. Each unit will be battery-powered and able to take advantage of new developments in mobile digital computing. Each unit is a hand-held sound source that is played by pressing buttons. Players have the freedom to move each sound source while performing.

2.1 Performance scenarios

Three performance scenarios for the Pocket Gamelan have been identified.

Scenario 1. The first scenario is one where each unit is used in a continuously variable tuning mode with pitches chosen by each performer. Such a work is realised in the manner *of The Great Learning Paragraph 7* (Cardew, 1969) composed for a large amateur a capella vocal ensemble, where preferred intervals chosen by each performer play a significant role in the process that shapes this work.

Scenario 2. The second scenario involves locally triggered note events or sequences of note events where the pitch of each note is pre-tuned. Such a work is similar to works created using MIDI technology. The user activates musical sequences locally on the handset by pressing buttons.

Scenario 3. The third scenario is an extension of the first two scenarios except that buttons pressed locally activate commands that affect other clients in the network.

In the first two scenarios, user operations only affect sound on the local handset; in the third scenario, user operations affect the sound on other handsets.

The difference between music created using MIDI systems and music created using this technology is the degree of mobility and autonomy that a mobile instrument gives to each player. The extent to which this affects performance of music is limited only by the ways in which performers are allowed to move as part of the performance and the kinds of spaces where a performance is presented.

Whereas desktop computing tends to concentrate the means of producing music in the hands of a single user, mobility offered by this technology introduces new possibilities for musical interaction between members of an ensemble. 'Gamelan', in the title, is a musical metaphor for this kind of group interaction.

3 System development

The Pocket Gamelan project will take three years to develop. There are three stages:

3.1 Stage 1: J2ME prototype

A software prototype of a mobile musical instrument will be developed around the java programming language using a new mobile technology known as Java 2 Micro Edition (J2ME). J2ME is used in hand-held appliances such as palm pilots and mobile phones. It allows communication between a web server and multiple clients.

The software prototype will be developed using a J2ME-compatible evaluation module. At the time of writing, the preferred development platform is the Motorola MC9328MX1, while the preferred mobile handset is the Motorola A830. Both use the Dragonball MX processor which features a 200 Mhz 32-bit RISC core, together with on-chip peripherals such as USB, Bluetooth, I^2S, Smartcard interface and an MMX co-processor capable of supporting JPEG movies.

The evaluation module provides an environment for testing and debugging the J2ME software prototype. Its tools include java classes and a working version of the miniature J2ME operating system known as the K Virtual Machine -- or KVM. The KVM provides a vital link between java software and physical hardware. It will be adapted to provide software hooks necessary to support the performance scenarios described above. This must be developed in a low-level language such as C or assembler.

Tuning will be implemented at this level using the variable sampling increment technique with interpolation (Moore, 1987). Csound source code for audio algorithms involving look-up tables (such as Oscil, Foscil, Loscil, Buzz and Pluck) provide working examples of how to implement this feature. Csound, which uses fixed-point arithmetic, also offers source code examples to overcome a current limitation of J2ME, namely its lack of support for floating-point arithmetic.

Bill Alves, one of many composers who have contributed to the development of Csound

(Boulanger, 2000), will collaborate on a J2ME implementation of tuning in the third quarter of 2002.

Software development will enable each mobile unit to function both as a control device and as a sound source. The software prototype will generate program code to run on ready-made target hardware (described in stages 2 and 3) and will be written to accommodate continuously-variable pitch control required for scenario 1 or a predetermined number of preset pitches defined in each scale required for scenario 2. The software prototype will also accommodate a broad range of scales tuned in JI.

Tuning resources used to develop this feature of the software prototype include a microtonal keyboard called the *MicroZone* and public domain tuning freeware editor/librarian/analysis software called *Scala* (Op de Coul 1992).

Microzone. The MicroZone, an 810-note keyboard based on design patents of Wilson (Wilson, 1961; 1967), will be used to audition JI tunings for comparison with tunings produced on the J2ME software prototype. Stephen Taylor, a composer who has worked closely with Wilson in beta-testing the first Microzone keyboard, will visit the University of Wollongong during the third quarter of 2005, to test J2ME tuning implementations.

Scala. Scala has an archive containing over two thousand scales including both JI and other non-12-tET, both historical and experimental. Scala scripts will be implemented to create java applets that allow J2ME devices to access these resources as audio, MIDI and synthesis programs in MPEG-21 format (Bormans and Rump, 2000). MPEG-21 was considered important for J2ME musical applications because it has ramifications for composition and particularly for performance, publication and distribution.

3.2 Stage 2: Mobile phone handset

A mobile phone handset is used as a ready-made hardware target for testing J2ME applications developed in stage 1 allowing them to be tested specifically for compliance with J2ME protocols for wireless devices (CLDC, 2000). These protocols hold the key that will allow musical applications to migrate to the domain of wireless computing.

3.3 Stage 3: Multiple handsets

J2ME prototype development undertaken in stages 1 and 2 will be tested on multiple identical mobile phone handsets. Each unit will be sprung-mounted in a container to absorb mechanical shock associated with handling of instruments.

Prior to performance, J2ME programs associated with both scenarios are loaded into each mobile unit and saved into flash memory. Program code, along with wave-tables required for audio synthesis are loaded into each mobile unit. In future, this will be achieved using either infra-red link, bluetooth or eventually, telephone connection. Additionally, in the third online scenario, each unit will receive control data broadcast from a server during performance. Data will be broadcast in MIDI format supported by MPEG-21. As individual clients communicate control information to the server, they will in turn affect the broadcast of MIDI control information.

3 Tuning applications

Transposed Hexanies (Schiemer, 2000-0001) and *Tempered Dekanies* (Schiemer, 2001) are recent compositions that provide a useful model for potential tuning applications of the Pocket Gamelan. Both compositions use combination product sets (CPS) tunings (Wilson, 1986). While both works are realised in Csound the tuning implementation in each work can be described in terms of scenarios 1 and 2.

3.1 Scenario 1: example 1

The chorusing algorithm in *Tempered Dekanies* lends itself to scenario 1. By using the controls on a mobile handset users detune the pitch of a single sustained note. The pitch could be varied either directly, or by adjusting a microtonal pitch envelop. An ensemble of handsets played in close proximity would produce audible beating similar to the Csound example but which is affected by the participants as they move from place to place.

3.2 Scenario 2: example 2

The transposition algorithm in *Transposed Hexanies* lends itself to scenario 1. Even with limited triadic harmony available in a 6-note CPS scale, the transposition algorithm introduces considerable variety that can be supported in a mobile computing environment where memory capacity is an issue.

4 Other implementations

The quality of the sound need not be limited by the size of the handset. As new hands-free phone accessories appear, these may even take the form of an item of clothing with the handset in the pocket after the manner of Mark Havryliv's *The Singing Jacket* shown in figure 1. The jacket produces pulse-width modulated audio through piezo-ceramic speakers woven to the garment fabric in response to the wearers' movements.

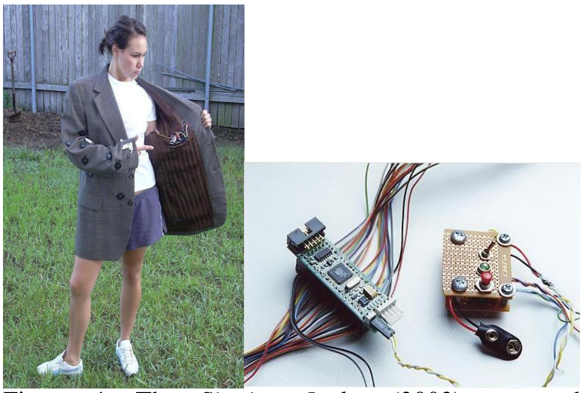

Figure 1. The *Singing Jacket* (2003) a sound installation designed, built and tested by Mark Havryliv. Sensors located at movable parts in the jacket allow the wearer to affect the sound algorithm.

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