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Invisible Territory: Sonifying the game of Go

Abstract

In this paper we explore issues of developing a sonification of the game of Go, and then adapting the sonification for use in an interactive "musification" featuring Shakuhachi, the Japanese end-blown flute, as a primary instrument for interaction and as a sound-source for the sonification. Our approach to sonification seeks to establish a mapping from data to sound which preserves the symbolism and the aesthetics of the game, as well as present the data embodied in a specific game record in a form that is as transparently comprehensible as possible. The final mode of presentation explored here takes a musical form incorporating live improvisation by a human performer, in order to promote an accessible and "humanised" result.

1 Introduction

The game of Go (or Wei Qi) has attracted considerable attention from the Computer Science community as a challenge task for artificial intelligence, primarily because the problem space of the game is significantly larger than other similar game-playing tasks (e.g. chess). Go is played by two opponents on a wooden board (Goban) marked with a grid (typically 19x19, although smaller sizes boards are also common), each player using a set of identically shaped pieces (or stones), one black the other white. Once placed on the board, stones are not moved, unless under the rules of the game, they are determined to be 'dead', in which case they can be removed.

The game consists essentially of two players using the pieces to mark out territory (and capture enemy stones). When the players mutually agree that no more territory can be gained, the game is over and the player with the most territory wins. There are approximately $2.1*10^{170}$ possible board configurations for any given game (compared to chess which has between 10^{43} and 10^{50} legal board positions), however due to the rules of the game these configurations tend to contain recognizable patterns.

As well as being a challenging problem for AI, Go is a candidate for exploring multimodal human-computer interaction, particularly sonification, for a number of reasons:

- Go requires players to recognise as well as recall patterns of play;
- there are a very large number of computer-readable records of Go games freely available and Go players now commonly use computer mediated replay of historical games to improve their skill, understanding and appreciation of the game;
- the large feature space of the game makes memorisation of board positions impractical for game study;
- the pattern-based nature of the game provides a natural basis for emergent musical motifs, which may serve as an aid to study.

This last point is the underlying hypothesis for the work at hand. Earlier work on using sonification for the interpretation of trends such as clustering and correlation (Flowers, Buhman, & Turnage, 1996) and on the value of sonification in creating engaging learning experiences (Kramer, 1994) supports such an idea.

By exploring multi-modal forms of interaction with Go records, we hope to find ways in which the computer-mediated study of Go can be enriched. In this first approach, we focus primarily on 'engaging' the viewer of a historical game in ways that go beyond the purely 'analytical' study of board positions so as to develop a deeper grasp of the narrative of the gameplay and an appreciation for significant events in the development of the specific game.

In the following section we take up various functional and aesthetic requirements for our approach, and then turn our attention to issues of design, implementation and evaluation before presenting some conclusions and thoughts for future research.

2 Assessing the terrain: requirements for a sonified Goban

2.1 Go aesthetics and symbolism

There is an aesthetic sensibility and traditional etiquette surrounding the game of Go, as well as a degree of symbolism and mystique. Despite the

game being a competition, based on the concepts of territory and war, in its highest forms it is seen as a form of collaborative creativity between the two players. High ranking players care as much about the style of their game play as winning, and would often rather lose elegantly than win ungraciously. This is perhaps best summed up in a remark by Kawabata from his work "The Master of the Go Tournament" (Kawabata, 1972):

> "The game is over, Mr Otake has spoilt it with his embedded move, as if he had smeared ink on a picture we had painted together". The master had composed his tournament like an aesthete; it seemed to him that black had just been smeared on the work, in short a work of art, at the most exciting moment. The game of Black on White, as carefully thought out as a work of creation, takes on its forms. The movement of the spirit is found in it, a harmony like that of music. All is lost when a wrong note is sounded, when one of the two musicians launches alone and without warning into an eccentric cadence. One of the adversaries, insensitive to the humors of the other, can spoil a perfect game.

Clearly, such an aesthetic provides a challenge with respect to finding a suitable sonification, particularly an interactive one, but as such it also provide very useful boundaries within which to work.

The origins of Go also indicate a certain association with concepts of Chinese philosophy that add significant symbolism to the game.

> [Here] duality is inherent . . . reflecting Nature itself. The processes are composed of opposites seemingly working against each other: day-night, summer-winter, male-female, birth-death. Games were played to bring harmony to those forces continuously fighting for ascendancy . . . the thrust and parry of the polarities characterized by the Chinese yin as the female principle and yang as the male. (Shotwell, 2002)

In addition to the aspect of yin and yang and the balancing of natural forces, the Go board was also associated with both celestial and earthly space, and may have found its origins as a form of recording time:

> The three hundred and sixty intersections correspond to the number of days in a year. Divided into four corners like the four seasons, they have ninety intersections each, like the number of days in a season. There are seventy-two intersections on the sides, like the number of five-day weeks in a year. (*ibid.)*

Hence, the metaphorical dimensionality of the game extends in many directions, encompassing both Time and Space, the seasons, and the balance of yin and yang.

These associations suggest that a sonification should express aspects of temporal spatialization, as well as a sense of the dualistic tension between the opposing players that nevertheless resolves as a form of unity or harmony at the conclusion of the game.

2.2 Shakuhachi

A primary consideration in many approaches to sonification is in the design of the representative sounds to be used. In considering the aesthetic background to Go, we sought to find a sound source that was complementary and reflected as many of these aesthetic features as possible. Shakuhachi, the Japanese end-blown flute, was chosen.

The Shakuhachi is an end blown wind instrument with a distinctly Japanese sound. Traditionally the five-holed instrument is in D, with the natural notes playing a pentatonic minor, although with breath, fingering and instrument angle variation a full scale can be played, as can tones outside the Western octave system.

The instrument has links to the Zen meditative tradition, with a traditional canon – the Honkyoku, or *Original Sound*, pieces – passed down through different schools of Shakuhachi but originating from the Komuso monks who traveled throughout Japan in the Edo period. Many of these monks were former Samurai, strengthening the link between Go as a strategic game of area domination, and Shakuhachi as a reflective practice of focused meditation.

One of the features of the Shakuhachi is the accidental harmonic notes produced from the distinctive mouthpiece – unlike most other wind instruments there is no mechanism to *guide* the breath over the sound producing angle. Thus, although the instrument is monophonic, there are hints of notes that weave through a Shakuhachi performance. This effect brings to mind the *potential* moves that are considered, but discarded, during play, while the monophonic melody mirrors the linear turn-taking performance of a game.

2.3 Interactivity: Play and Replay

Like all strategy-based board games, a full appreciation of Go comes not just from playing but also from replaying games – particularly historical games played by Go masters. Thus we can refer to *players* of a game of Go, and the *viewer* of such a game. Strategy is part evaluation and part intuition, with the human aspects of the opponent clearly affecting the decisions made during a game. This is recognised not just in Go, but also in other strategic games such as chess, as in the instruction guide

book (Benko, 1991) that teaches strategies to address the player, rather than the board. Appreciation, therefore, is part ability and part experience and requires more than logical skills of calculation.

The sonification of Go described in this paper is not for Play, but for Replay. In the typical Replay scenario, a visual representation of the game's progress is used for the rational, evaluative cognitive processing by the viewer. In seeking to extend this mode of interaction, the sonification of the board positions is not for evaluation, but to engage the viewer more deeply in the game. It is intended to heighten the experience that leads to greater appreciation, and subsequently improved ability.

We propose two modes in which the sonification can be engaged:

- passively, in which the replay of game events triggers corresponding sound events, with advancement through the game being controlled either automatically by the computer or by keyboard or mouse input from the user;
- interactively, in which the viewer takes a more active role in the sonification by providing audio input as well as listening to the audio output.

The sonic interface is intended to provide a bridge between the replay requirements (advancing the game) and the sonification of the game's performance, building an audio narrative that reflects the game positions *and* the viewer's understanding and interpretation of how the game is playing out. The sonic interaction and Goban sonification provides a multi-modal experience in which the visual and auditory modes of engagement which we suggest is more engaging for the viewer than in a system where the visual representation is progressed through key presses or the use of a mouse or scroll wheel.

The interaction of viewer and game replay is also intended to be of use to a wider audience. Observing such an interaction allows an audience to not only perceive the moves of a game, but also to get an insight into the engaged response of the viewer performing with the Replay. A different viewer may interact with the sonification in different ways, replaying a game in a different feel, responding to the interpretation of the game with a different Shakuhachi performance. Different human sonic interpretations of a Go game, recorded in this way, can be seen as soundtracks to the narrative of game play.

In the implementation discussed here, a Shakuhachi has been used for audio input, although arguably any suitable monophonic sound source could be used. We do not claim that Shakuhachi is the ideal interface for every user of the interactive mode of the sonified Goban, but in as much as we are seeking to explore engagement with the Replay in a multi-modal setting as well as produce potential 'soundtracks' of the Replay, it is not unreasonable to use a musical instrument as a means of expressively engaging with the machine.

In this respect, the interactive sonification becomes a 'musification', a topic to which we return in Section 4, but first we discuss various aspects of implementing the 'passive' sonification mechanism that forms the basis for the interactive one.

3 Tactics: designing the sonification

In developing an audio representation of Go, our aim is to be faithful to (and complement) the aesthetics of the original source material.

In this respect, the sonification should:

- represent the spatial and temporal aspects of the game;
- preserve the symmetry of the Goban and the individual pieces, while respecting their duality or yin/yang nature;
- represent the emergent patterns of the pieces as the game evolves.
- represent the interactive nature of the game.

We now take up each of these criteria in detail.

3.1 Time and Space

These are perhaps the easiest aspects to approach, as they can be interpreted somewhat literally. The game has an inherent temporal sequence of moves which define the progress of the game. Likewise, each move in the game can be used to contribute to the overall sequence of audio events in the sonification.

One detail that is typically lacking in the records of historical Go games is the timing of each move. Moves can be quick and decisive, or may require considerable thought and time before being made. The game records preserve only the sequence, erasing some of the drama of the game as it was played. We will return to this aspect in our discussion of interactivity.

Not only are stones placed on the board in sequence, they are placed in specific positions. In this respect, it is rather obvious to treat the game grid as the sound stage on which audio events take place, using spatialisation techniques to place each audio event in the position corresponding to the represented game event.

Since we are focusing here on a *sonification* of the game, rather than a visualisation, one goal is to offer the audience the opportunity to *hear* the game being played out around them, as if they themselves are sharing the same physical space as the pieces being played - bringing the audience *into* the game.

A further aspect of space, or in fact, territory, in Go is the concept of *liberties*. A stone may only be placed on the board if it will have at least one

empty space immediately adjacent to it, i.e. a liberty. Stones of the same colour which are adjacent are said to be connected, and can share liberties, which is to say if one stone in the group has a liberty, all the stones in that connected group are 'alive'.

We can use the audio-spatial metaphor of reverb as a simple representation of liberties. For each move made, the virtual 'roomsize' of the reverb can be set according to the number of liberties at that board position: if the stone has the maximum number of liberties available, the roomsize will be large; the fewer the liberties, the smaller the roomsize. In this respect, the listener gains some sense of how much 'breathing space' is available to each stone as it is played. Expansive moves which open up new territory will sound 'large' while battles fought in close quarters will be more confined.

3.2 Symmetry and Duality

Symmetry is found in Go both in layout of the board, and in the similarity of stones themselves. The nature of the game also brings a certain symmetry to play, with opening moves often taking place in opposing corners of the board. Duality is most clearly present in the contrasting colour of the game pieces: black vs. white. Underlying this duality is the emergent co-dependency and unity the opposing forces ultimately share. This can been seen in the way that seemingly disparate stones reveal themselves as being intimately connected as the shape of the game develops.

In applying these concepts to the sonification, we sought to map various parameters of the game (such as board position) in a symmetrical way. The symmetry of the stones is represented by using the same basic sonic material for each - they are all derived from the same timbral source (a sampled Shakuhachi note).

Duality comes from differing pitch mappings for black and white stones, as well as differing timbral qualities. In the passive sonification, the basic pitch for all moves is mapped according to the distance from the centre of the board. Moves by black are mapped to be lower in pitch than white. In addition, the sound of black stones is 'coloured' by affecting the harmonic content of source sample through phase vocoding.

In the interactive version of the sonification, pitch mappings have the same basic values but are modified relative to the pitch of incoming audio from a human musician in order to be responsive to the interaction. White stones are mapped higher than the incoming audio input, while black stones are mapped lower. The degree of pitch modification is determined by the stone's position on the board.

3.3 Patterns

A significant feature of Go is the emergence of patterns in the placement of stones as the game progresses. New moves are made within the context of existing stones on the board, and stones do not change position (unless they are captured and removed from the board). In this respect the configuration of the board remains relatively static (compared to games like chess) and the history of moves literally accumulates as the game progresses.

In order to represent this, we introduce a third information stream into the sonification to represent recent moves (in addition to the two streams representing the placement of individual black and white stones respectively). This is rendered by repeatedly looping over the last 10 moves of the game. The pitch of these game events is separated from the current moves by being lower in pitch, and, in the interactive sonification, unaffected by the incoming audio input (and thus stable).

3.4 Implementation

The sonification has been implemented as a Max/MSP patch, utilising a number of readily available component patches and externals. The basic data flow is shown in Figure 1.

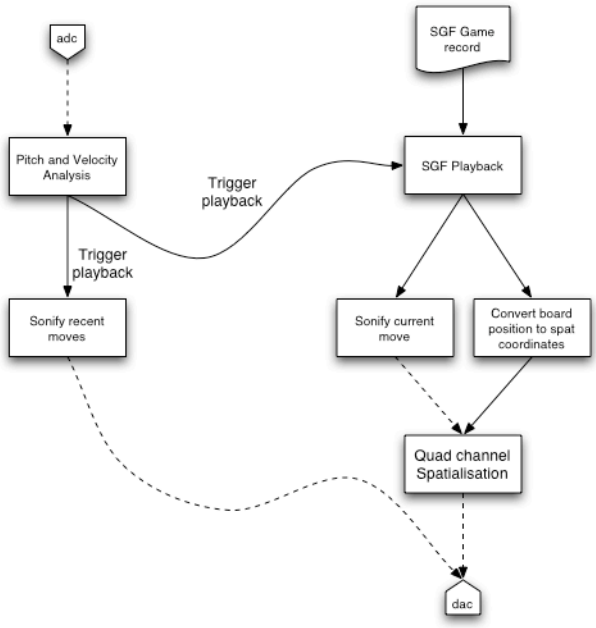

Figure 1: Basic data flow in the Max/MSP patch

Shakuhachi pitch tracking is handled by Tristan Jihan's `pitch~` external (based on Miller Puckette's `fiddle~`). Spatialisation of sound events is based on the `spat4` external included with Max/MSP. Simple polyphonic sampler patches (based on a pre-recorded Shakuhachi sample) are used to generate sound events for the current move. Timbral 'colour' is applied to the sound events for black

stones by use of Eric Lyon and Christopher Penrose's phase vocoder external, `pvoc~`.

Reverb is applied prior to spatialisation, using the Freeverb VST plugin. For each move, the room-size of the reverb is keyed to the number of liberties immediately available at that board position. In the current implementation, liberties shared by the group (rather than directly available to the individual stone) are not calculated, although this is planned for future development.

4 Invisible Territory: an improvisation for Shakuhachi and sonified Goban

Moving beyond the approaches outlined above for sonifying Go, which may be utilised in a passive form, we now turn our attention to the use of a sonified Goban in a more interactive setting, in which we introduce a human player improvising on Shakuhachi. As mentioned in Section 2.3, this approach may be more correctly termed a 'musification' rather than a sonification, since elements of the mapping from data to sound have been modified for what amount to artistic reasons. Nevertheless it has been argued that strict sonification can be reasonably 'filtered' to suit a more musical mode of presentation that is more easily comprehended (Childs, 2002), and given our goal of using the interactive sonification for the purpose of deeper engagement and general appreciation, rather than detailed analysis, this approach seems reasonable.

The approach is not unlike other sonification-based pieces, such as Ping Melody (Janicki, 2003) and SoundWIRE (Chafe et. al., 2002) which work with computer network traffic, but seeks to be more tightly bound to the historical aesthetics rather than physical models of the source in order to achieve a complementary artistic result. The use of live Shakuhachi to drive the sonification brings a further set of aesthetic and physiological constraints to the task, in order, as suggested by Garnett (2001), to promote an accessible and "humanised" result.

Like Ping Melody (and unlike SoundWIRE), Invisible Territory utilises a solo human performer as a means of driving the sonification, which might otherwise remain unengaging for an audience.

A game is, by its nature, interactive, and it is this aspect which adds interest. In terms of Replay, if we were to approach the sonification of a historical game, then from both the viewer's and a potential audience's perspective, we are doing little more than playing back a sequence of pre-recorded events. The fact that the audio events may be created in real time is of little relevance.

Garnett (2001) challenges computer music composers to re-embrace the human, and particularly the human performer, as a means of grounding computer music and making it accessible and approachable, and as a way of re-engaging with the human tradition of music making and making meaning through music.

To this end, it seems fitting that, in the absence of live Go players, there is some form of live human interaction with the sonificaiton. Although such a requirement is not inherent in the sonification itself, it is one way of re-introducing an element of temporal dynamics that is lost in the game record, by allowing a human interactor to control the phrasing of playback that otherwise would become mechanical and likely unengaging.

We can also go further than mere control of sequence playback and introduce a genuine element of tension between the human and machine as 'players' in a musical game. At this point we move from a pure sonification of the Go game to music in the form of an improvisation that is based around the sonification.

4.1 Musical gestures as a means of control

For the purposes of the 'musification', the Max/MSP patch was modified to respond to the following aspects of the human player's performance:

- variation in pitch
- variation in amplitude
- duration of phrases

The first of these gestures allows the performer to control the rate of playback of the game, with more frequent pitch changes resulting in more moves being played back.

The amplitude of the input is mapped to the amplitude of the game-generated sound events.

The duration of a phrase (in this case, simply a sequence of notes without a rest between them) determines the number of cycles that the 'recent patterns' channel will go through.

These gestures combine in ways that follow both the development of a typical Shakuhachi piece and a typical game of Go. Shakuhachi pieces frequently start with long opening notes with little ornamentation. As the piece develops, it may become faster, more dynamic and with much more frequent alternations in pitch.

Go games typically start with standard opening moves to establish basic ambit claims for territory, which then develop into more complex confrontations as the claimed territory is disputed. As these battles are resolved, the overall pattern of the game emerges and fewer areas of dispute are found, until both players agree that no more territory can be gained, and the game is declared over.

A long note without pitch variation will trigger a 'response' from the recent patterns channel, while triggering few (if any) new moves. Such a gesture is

akin to reviewing the board and considering what move to make next. Frequent alternations in pitch, ornamentation and the like, produce faster Replay, evoking the *drama* of the battles fought in the middle game (even if the actual game play at that point may have been carefully considered).

5 Evaluation

Our evaluation at this stage is based on use of the patch in its interactive form as a 'musification', rather than as a pure sonification. Furthermore, the evaluation is informal, in as much as the system has not been trialed with independent subjects. It should be noted that while both authors are Shakuhachi players and Go players, the development of the Max/MSP patch was done entirely by Mark Pedersen, while testing of the patch was done by Ralf Muhlberger, and in this respect the nature of the sonification and interaction mechanisms were largely unknown by Ralf at the time of testing. With respect to the passive sonification, we discuss our plans for more a formal evaluation in Section 6. Limiting our attention in this way, we considered two main criteria for evaluating the approach used:

- that the resulting performance should in some way reflect the symbolism and aesthetics of Go, as well as convey discernable information about the specific game being sonified, and in this sense, be a "valid representation" of the game.
- that the quality of the interaction between the human and computer performers is such that both the human performer and the audience is "engaging", in the sense of capturing attention and conveying meaning.

In terms of the validity of the sonification, we note that during trial performances, the quadraphonic sonification of board positions did enhance the participant's perception of being 'inside' the space of the board game in a way that a visualisation alone does not. The uniform mapping of pitch based on distance from the centre of the board highlighted the similarity of moves, even when the moves are being played in different quadrants of the board, and also served to show the development of the game as the pitch of sound events generally changed as the game progressed from opening moves on the edges of the board to the middle game.

However, without independent verification by users with a clear information need, it is difficult to assess just how transparent or informative the sonification is. Likewise, judgment of the aesthetic quality of the sonification with respect to Go requires independent input from experienced players of the game. This is left for future work.

In terms of the degree of 'engagement' the interactive sonification produced, this is best viewed in terms of the specific aspects of the quality of the interaction:

- how well does the system respond to musical gestures by the human performer?
- how easy is it to generate the control gestures? (i.e. how naturally do the control gestures fit the 'language' of the Shakuhachi)
- does the system also 'push back' or initiate gestures which draw a response from the human performer?

Shakuhachi in the traditional meditative performance style is an interaction with the surrounds. External sounds are recognised as having a place in the world, and thus in the piece played and ultimately in the player. During trial performances with the system, we found that the responses from the sonified Goban were natural and complimentary to the normal style of Shakuhachi performance.

In this respect the sonification did not distract from engagement with the game Replay, but rather prompted engagement through exploration of the possibilities of the sonic interaction. The tension between the Shakuhachi player's input and the Goban's sound events produced by pitch offsetting was noticed during trial performances, and did shape the responses of the human player. More importantly however, the interactive sonification was found to (subjectively) heighten engagement with the Replay of historical game records, which were displayed visually while the participant was interacting with the system.

The system was found to be responsive to control gestures, however the control of Replay was rather coarse-grained at times, especially with more expressive Shakuhachi playing, as it became difficult to predicted exactly how many moves would be made and how quickly they would be made in response to rapid pitch fluctuations in the input. We expect that this aspect of control could be improved with practice and with fine tuning of the Max patch to the input conditions.

6 Conclusions and Future Work

This paper describes our exploration of a Shakuhachi inspired sonification of the game of Go, and the suitability of Shakuhachi as a sonic interface for an interactive 'musification'. The interaction paradigm appears to support a stronger, more holistic connection between the Viewer of a game Replay and the Replay system, and in future work we will investigate the benefits such an engagement offers for increasing the user's understanding and appreciation of a game.

The passive sonification is designed to give a transparent representation of game moves with particular emphasis on assisting the recognition of similar patterns of game play, which may be useful while Replaying games for study. A follow-up hypothesis is that sonification of a live game may help with the intuitive understanding and engagement

during game play. A formal evaluation of the sonification in these aspects is planned for future work. If successful, we may see Go masters of the future deep in thought, and wearing headphones.

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