Autopia: An AI Collaborator for Gamified Live Coding Music Performances

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Abstract. *Live coding* is "the activity of writing (parts of) a program while it runs" [20]. One significant application of live coding is in algorithmic music, where the performer modifies the code generating the music in a live context. *Utopia*[3] is a software tool for collaborative live coding performances, allowing several performers (each with their own laptop producing its own sound) to communicate and share code during a performance. We propose an AI bot, *Autopia*, which can participate in such performances, communicating with human performers through Utopia. This form of human-AI collaboration allows us to explore the implications of computational creativity from the perspective of live coding.

1 Background

1.1 Live coding

Live coding is the activity of manipulating, interacting and writing parts of a program whilst it runs [20]. Whilst live coding can be used in a variety of contexts, it is most commonly used to create improvised computer music and visual art.

The diversity of musical and artistic output achievable with live coding techniques has seen practitioners perform in many different settings, including jazz bars, festivals and algoraves -an event in which performers use algorithms to create both music and visuals that can be performed in the context of a rave. What began as a niche practice has evolved into an international community of artists, programmers, and researchers. With a rising interest in "creative coding", live coding is well positioned to find more mainstream appeal.

At algoraves, the screen of each performer is publicly projected to create transparency between the performer and the audience. The Temporary Organisation for the Permanence of Live Algorithm Programming (TOPLAP) make it clear how important the publicity of the live coder's screen is in their manifesto draft: "Obscurantism is dangerous. Show us your screens" [18].

A central concern when performing live electronic music is how to present "liveness" to the audience. The public screening of the performer's code at an algorave is often discussed in regards to this dynamic between the performer and audience, where the level of risk involved in the performance is made explicit. However, in the context of the system proposed in this paper, we are more concerned with the effect that this has on the performer themselves. Any performer at an algorave must be prepared to share their code publicly, which inherently encourages a mindset of collaboration and communal learning with live coders.

1.2 Collaborative live coding

Collaborative live coding takes its roots from laptop orchestra/ensemble such as the Princeton Laptop Orchestra (PLOrk), an ensemble of computer based instruments formed at Princeton University [19]. The orchestra is a part of the music research community at the University and is concerned with investigating ways in which the computer can be integrated into conventional music making. PLOrk attempts to radically transform those ideals [19]. Each PLOrk meta instrument consists of a laptop, multi-channel hemispherical speaker and a variety of control devices such as game controllers, sensors amongst others [19]. The orchestra consists of 12-15 students and staff ranging from musicians, computer scientists, engineers and others and uses a combination of wireless networking and video in order to augment the role of the conductor [19].

UK based live coding ensembles such as the Birmingham Ensemble for Electroacoustic Research (BEER) based at the University of Birmingham have taken influence from ensembles such as PLOrk, but differ in terms of the way they integrate communication and collaboration within the ensemble. The ensemble was formed in 2011 by Scott Wilson and Norah Lorway [22] and began as an "exploration of the potential of networked music system" for structured improvisation[22]. The ensemble works primarily in the SuperCollider (SC) language[4] and the JITLib (Just in Time Library)[5] classes in SC for basic live coding functionality [22]. In terms of ensemble communication and coordination, BEER uses Utopia (Wilson et al 2013), a SuperCollider library for the creation of networked music application which builds on the Republic quark[6] and other such networked performance systems in SuperCollider. Networked collaboration in live coding was present from the inception of live coding where multiple machines are clock-synchronized exchanging TCP/IP network

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[3] https://github.com/muellmusik/Utopia

[4] https://github.com/supercollider/supercollider

[5] http://doc.sccode.org/Overviews/JITLib.html

[6] https://github.com/supercollider-quarks/Republic

messages [5]. Utopia aims to provide a more modular approach to networked collaboration, featuring enhanced flexibility and security over other existing solutions. It also provides an efficient way to synchronize communication, code and data sharing over a local network. Unlike an ensemble such as PLOrk which uses a human conductor such as in a traditional orchestra, Utopia eliminates the need for this, allowing for a more streamlined shared approach, where performers collectively make musical decisions.

2 Motivation

2.1 Computational creativity

Using an AI bot within the context of a networked live coding performance, is an idea that builds on a study undertaken by McLean and Wiggins [12], regarding live coding towards Computational Creativity.

Computational Creativity can be described as the aim of "endowing machines with creative behaviours" [15], and systems designed to do so can be put to practical uses from simulating and automating existing human processes (creativity as it is), to discovering novel outcomes (creativity as it could be) [15], which could be valuable to the "scientific study of creativity" [21]. In the context of this proposal, we are concerned with the latter.

The McLean and Wiggins study [12], highlighted a view among live coding practitioners that the code resulting from their practice contains an element of the programmers style, and that "many feel they are not encoding a particular piece, but how to make pieces in their own particular manner" [12]. This is a sentiment that is echoed by Wiggins and Forth [21] in the following statement:

"In a manner akin to the extended-mind theory of consciousness [3], the live coder becomes attuned to thinking with and through the medium of code and musical abstractions, such that the software can be understood as becoming part of the live coder's cognition and creativity" [21].

Through a process of "reflexive interaction" [21], the human performer(s) and artificial agent each influence the actions of the other. Entering into a "complex feedback loop" [8], the artificial agent becomes an "imperfect mirror" of the human performer(s) [21]. We propose that through the analysis of the artificial agent's behaviours, we can extend our understanding of what constitutes "valuable" musical output, while challenging existing dogmatic approaches to live coding practice, and techniques relating to the chosen programming language (SuperCollider), where the formalisation and subsequent manipulation of syntax trees can provide new insight to the language's potential. Finally, it can provide insight into the nature of creativity in general, by analysing emergent behaviour from the bot.

Ultimately, our motivation can be summarised in the following quote: "When the computer becomes a conversation partner, or a boat rocking us in unexpected directions, we may find that the technologies we build become more useful, more musical, more interesting than our original conceptions" [8].

2.2 Gamification

There has been work on the use of gamification to facilitate creativity [9]. This generally draws upon the idea of *flow* [7] — the idea being that flow is important to creativity, and that including some game-like elements in a creative software or process can help to put users into this flow state. Taken further, this leads to the idea of *casual creators* [6] — creative tools whose interface is designed to promote a "playful, powerful, and pleasurable" user experience (unlike more traditional creative software where "powerful" would take precedence over the other two). Aiming for playfulness in this context can also promote curiosity and experimentation [13].

Gamification has also been studied in the context of collective creativity [16]. There are obvious analogies between collaborating on creative tasks and playing a multiplayer game, and the ideas used in the latter to foster collaboration (or, in some cases, competition) may prove useful in the former. For instance, the Female Interface Research Ensemble (FIRE) based at the University of Birmingham, used Utopia and gamified collaborative approaches in their algorave performance during The New Interfaces for Musical Expression conference in 2014 in London, UK [11]. As another example, Nilson [14] proposes a number of game-like exercises, many of them collaborative and/or competitive, to be used by live coders in a practice context.

We propose taking a gamified collaborative creative environment and adding a "bot" — an AI agent which interacts in the same way as a human would. Bots in multiplayer games are often used as sparring partners for offline practice matches, or to make up the numbers when not enough human players are available for a game, however the fact that the play style of bots is different to that of humans tends to change the dynamics of the game. We are interested in studying whether the same is true for a collaborative live coding performance — how does the introduction of one or more bot performers change the dynamics of the performance?

3 The bot

In order to truly participate in the performance in the same way as a human performer, the bot must carry out two AI tasks: participating in conversation through the Utopia chat interface, and generating and running SuperCollider code. For the former we will draw on well-established chatbot technology; for the latter we will use genetic programming (GP) [10]. SuperCollider code generally makes heavy use of nested function calls and mathematical expressions, often involving several numerical constants that can be tuned, and so we hypothesise that the language lends itself well to a GP approach.

The bot will implement the Template-Based Object-Oriented Genetic-Programming algorithm [17] in CSharp, set to automatically construct SuperCollider code from a series of pre-defined templates. These templates, are built using a genetic sequence, which is used to select the initial template, usually a single line of SuperCollider code which has been broken into its constituent parts, as strings. The variables used in these templates are filled in as values read directly from the genetic algorithm or as variables created at an earlier point in the automatic construction of the code.

This occurs in 3 phases: an initialization phase, which generates a series of initial sine waves, a modification phase which alters those waves and an execution phase which plays the generated sounds. Each of these phases corresponds to its own library of templates. The generated code can then be re-

trieved using JavaScript, at which point it may be inserted into, and executed by SuperCollider.

Code can be generated in a batch and bred together, representing a generation. A call can be made which takes two agents (genetic sequences which may be used to generate SuperCollider code) and breed them together using a simple genetic crossover algorithm to produce a new, offspring agent. Using this technique, multiple generations of agents may be generated which can be used, with selection, to breed against a fitness function.

The GP algorithm will run continuously, and at each generation the fittest individual will be executed through SuperCollider. When other (human) performers execute code and it is shared through Utopia, the GP system will add the code to its own population, to introduce variety to the gene pool and allow Autopia to build upon what the other performers are doing. In the spirit of live coding performers sharing their code, as discussed in Section 1.1, the bot's screen (showing the code it is evaluating and executing) will be projected so that the audience can see it.

Any evolutionary computing approach requires a fitness evaluation function. We propose to evaluate the fitness of individuals in the population through a basic machine listening process: individuals will be run through a second instance of SuperCollider, and the system will perform a frequency analysis (i.e. Fourier transform) on the resulting audio output. This will be compared to a frequency analysis of the audio output being produced by the other performers. The more similarity in frequency characteristics between the two, the higher the fitness. As a first step this should at least weed out those population members which produce undesirable results (such as silence or white noise), though clearly the refinement of the fitness measure is a fruitful line of future work. Collins [4] suggests a number of more sophisticated machine listening approaches which may prove useful, and provides a JavaScript library implementing several of these techniques[7].

To introduce an aspect of gamification and to further enhance the GP system's fitness evaluation, we will add a voting-based points system to Utopia. A similar idea to this was already tested in Republic. This will allow participants (both humans and bots) to vote each other up and down, giving them feedback on their contributions (and for the bot, explicitly shifting the fitness evaluation towards the preferences of the other performers).

4 Conclusions

Using AI in the context of live coding is relatively new and unexplored. The idea of AI collaborators has been well explored in Computational Creativity, including in musical contexts, however the process used by the AI can sometimes be opaque to observers and is almost certainly quite different to the process used by human performers. By combining AI with live coding we hope to overcome this — humans and bots are participating at the same level and in the same way (i.e. by manipulating code) — bringing the human-AI ensemble closer to liveness. This also goes towards achieving the goal, set out by the Birmingham Laptop Ensemble [2] in their manifesto, of "integration, collaboration and the blurring of the distinctions between, composer-performer-collaborator in a democratic non-authoritarian ensemble" [1].

The state of flow is clearly desirable in creative activities. The use of gamification can potentially be a powerful way of getting participants into this flow state, as well as the idea of voting borrowed from multiplayer games helping to facilitate the goals described above. The effect of introducing a bot performer on the human performers' flow state is less easy to predict — our hope is that the bot will act as a "conversation partner" [8] and thus provide inspiration during a performance.

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