A Framework to Evaluate the Adoption Potential of Interactive Performance Systems for Popular Music

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ABSTRACT

Popular music plays a central role in the lives of millions of people. It motivates beginners, engages experienced musicians, and plays both functional (e.g. churches) and non-functional (e.g. music festivals) roles in many contexts. Forming and maintaining a popular music ensemble can be challenging, particularly for part-time musicians who face other demands on their time. Where an ensemble has a functional role, performing music of consistent style and quality becomes imperative yet the demands of everyday life mean that it is not always possible to have a full complement of musicians. Interactive music technology has the potential to substitute for absent musicians to give a consistent musical output. However, the technology to achieve this (for popular music) is not yet mature, or in a suitable form for adoption and use by musicians who are not experienced with interactive music systems, or who are unprepared to work in experimental music or with experimental systems (a particular concern for functional ensembles). This paper proposes a framework of issues to be considered when developing interactive music technologies for popular music ensemble performance. It explores aspects that are complementary to technological concerns, focusing on adoption and practice to guide future technological developments.

1. INTRODUCTION

Popular music is an important type of music owing (at least partly) to its easy accessibility to listeners and performers. Its ubiquity is evidenced by Dannenberg's analysis of a weekly concert listing [1] where 80% of the events listed fall into the broad category of popular music. The term "popular music" defies easy definition (see [2]) but can be seen to encompass a range of genres (categories such as blues, rock, or country [3]) and styles (musical features within the genre [3]). It is characterised by a number of features [1, 4, 5]:

- an improvised musical surface,
- mostly steady beats,
- partially-specified scores (e.g. lead-sheets or chord lists) [6],
- and sectional (rather than strictly notational) organisation and arrangement of the music.

On a spectrum of interactive music systems, those for popular music could be seen to address a space between experimental and/or freely improvised music on the one hand, and classical score following on the other [1]. This has been identified as a fertile middle-ground for systems that can operate in a semi-constrained, "common practice" musical environment [1]. The purpose of such systems may vary from augmenting performances with additional instruments, to controlling effects in response to the music [4], or having the computer step in for absent musicians (the computer as performer [1]). It is the latter application to which this paper is primarily addressed. Dannenberg terms this area Human-Computer Music Performance (HCMP) [1].

It may seem unnecessary to develop technology to replace absent musicians since there are other options e.g. rearrangement, re-orchestration, or rescheduling of the concert. However, in some contexts (particularly functional ones such as church bands), there is insufficient time or expertise to substantially rearrange or re-orchestrate the music successfully, and rescheduling is not an option because of the constraints of the broader community (e.g. the need for a Sunday service at the same time every week). The aim of such groups is to produce music of consistent quality and sound at every "performance" thus requiring the full ensemble to be present. This is akin to the "performance perfection" approach of ensembles such as Cirque du Soleil [7]. Performance is not always the right term for ensembles playing in functional contexts since the musicians would be likely to see their playing as an act of religious devotion for example. However, since they are likely to approach the music-making with the same ethics and commitment as concert musicians, the term will continue to be used here.

Church music ensembles that play contemporary Christian popular music (termed "Praise and Worship" music [8]) are an ideal case to consider for benefiting from HCMP systems. They naturally embody many of the challenges that such systems must address: frequently changing lineups of musicians and instrumentation, last-minute changes

due to unexpected absence, popular music with all the characteristics described above, functional music drivers of consistency and quality, and highly variable standards of musicianship. Despite this, there has been relatively little work looking at the potential application of interactive music systems in this context. There has been broader increasing interest in understanding ICT use in churches and other religious contexts (see, for example, the work of Wyche et al. [9] and Bell [10] discussing the wider use of technology in congregational and devotional life) but little in the area of live music performance, despite its central role in much Christian worship (recent exceptions including Hartje [8], Mann [11], and Gold and Dannenberg [5]). This is not due to technological illiteracy (many churches use data projection systems, PA, and electronic music stands and distribution) but perhaps because the state of the art in interactive music systems is not yet mature enough for deployment under the time and resource constraints of many churches. Although these ensembles encapsulate clearly many of the challenges for HCMP, the issues are not unique to the church context: almost any music ensemble playing in this genre (particularly if the musicians are not engaged full-time) may have similar needs and constraints.

Implicit in much of the foregoing discussion is the primary notion of an ensemble as the music-making context. This does not rule out soloists performing with interactive music systems, but from the perspective of this work, this is seen as a special case rather than the norm. Ensembles are a critical element of popular music learning methods with peer-directed learning and group learning playing a primary role both for beginners and more experienced musicians [12]. Thus interactive music systems for popular music must be capable of operating in this context with flexibility, robustness, and musical awareness. They may offer opportunities to accelerate the learning of popular music skills.

The popularity of products like GarageBand [13] and Band in a Box [14], and the increasing number of heavily downloaded music apps for smartphones suggests that there is high demand for consumer-level music technology and a willingness to experiment with new applications, yet HCMP systems are scarce in practical use. Existing systems do not typically address the HCMP context fully (for example, the sectional rearrangement facilities in recent versions of Band in a Box cannot react to gestural cue norms of particular ensembles, or improvise in response to unplanned vamps or repeats) but this is perhaps not the whole story. This paper explores non-technological factors and risks in the potential adoption of HCMP technology with the aim of guiding future research so that it can address the non-technological context as well as the technological challenges involved, and thus bring HCMP to practical use more quickly than might otherwise be achieved. A framework is presented that is designed to support interactive music system designers in examining their systems from both technological and non-technological perspectives to increase adoptability and adoption, and guide the future development of technological solutions to aid adoptability.

The remainder of this paper is organised as follows. Section 2 describes a general model of innovation diffusion and relates it to the broad issues here. Section 3 discusses HCMP systems and their characteristics. Section 4 presents the core contribution of the framework of issues to be considered for HCMP adoption. Finally, Section 5 concludes.

2. INNOVATION DIFFUSION

Studies of innovation diffusion identify a number of factors in the decision to adopt, or otherwise, a new innovation. Wejnert [15] divides these into three groups: characteristics of innovations, characteristics of innovators, and the environmental context. The first category deals with the balance between public and private consequences, and benefits vs. costs. The second considers a range of variables relating to the innovator themselves: societal context, familiarity with the innovation, status, socioeconomic factors, social standing, and personal characteristics. The third group deals with issues such as geographical setting, societal culture, political conditions and globalisation.

The present paper does not attempt to derive complete traceability between this diffusion framework and the HCMP issues here but the framework usefully informs the subsequent discussion. In particular, the second two groups of the framework are likely to be more related to specific application contexts for HCMP (e.g. the set of factors involved in adoption by a church vs an amateur blues band would depend on the people involved and the values they hold) and thus are not considered directly here.

Before going further, it is important to separate the experimental music context from the common practice one. In the experimental context, there is a symbiotic relationship between the creation of new music-making technology and its use in creating new music. This could be seen as technological determinism (in that a new music-making facility is created and composers and performers explore its potential and limits). This is a virtue in experimental and new music settings but from a common practice perspective, robustness is probably a more significant concern since the music is not attempting to push boundaries of form or timbre. In experimental music, potential adopters are likely to be relatively familiar with the innovation and prepared to accept risk in both adoption and use (since their audience are also prepared to accept such risk).

The HCMP context is different. The consequences of adopting an HCMP system may be private initially (in Wejnert's terms, since the adopter here might be seen at the level of, say, a church) but subsequently public if sufficient diffusion is achieved. The cost-benefit decision is more finely-balanced. If it is accepted that many ensembles who would benefit most from HCMP have limited resources, then the financial cost must be low. However, the potential cost in terms of system failure (especially in a functional context) may be seen as too high without very significant benefit to balance it. In particular, the egalitarian nature of many popular music ensembles may render other factors such as the power of an individual to impose an innovation on others (seen as an important pro-innovation factor by Wejnert) less effective.

Innovation diffusion considerations can be illustrated with reference to other areas of music technology also. Taking music-making apps as an example, the impact of adopting a new app is primarily on the adopter themselves (a private consequence). Wejnert [15] suggests that spatial and temporal contiguity between the potential adopter and the innovation (in this case, the app) is a significant factor; this factor is supported in practice by the virtually instant access provided by app stores and 3G networks. Other effects on such a decision include pressure of social networks, something also well supported by the app-store and associated recommender models. Cost-benefit decisions are also relatively easily seen in this context: apps cost very little and there is low-risk in trying them, thus innovation diffusion is promoted.

In summary, although clearly all the aspects of Wejnert's framework will play a role in the potential adoption of HCMP systems in performance practice, the subsequent discussion will assume consequences of the adoption decision to be on the boundary between private and public , and will consider mainly the cost-benefit balance from a music practice standpoint, since without this being appropriate, the other issues may have less effect.

3. HCMP SYSTEMS

Before considering how an HCMP system might be adopted, it is important to first define the general characteristics of such a system. Dannenberg presents a series of predictions of the likely capabilities of future HCMP systems [1] summarised below. They will:

- explicitly recognise static and dynamic scores,
- work with multiple music representations,
- stylistically generate music in addition to using pre-recorded data/audio,
- use extended notation for music structure,
- allow arrangements and performance planning to be specified,
- co-ordinate multiple media,
- use beat detection and integrate multiple information sources,
- track measures,
- and synchronise using sections of scores.

These predictions capture the likely form of HCMP systems that will be able to participate in live ensembles but do not address the broader issues of getting those ensembles to accept the technology (except inasmuch as the successful implementation of all of the above would be required to demonstrate the fundamental viability of the technology to a potential adopter). Similarly, Hsu and Sosnick's framework [16] for evaluating interactive music systems is strong on assessing the musical behaviour of systems, but does not address the broader adoption context.

Very few HCMP systems exist at present. There are many extant technologies available that could form part of a complete HCMP implementation (for example, the many beat trackers and chord estimators that have been developed). However, even where public implementations are made available, they are not typically at the level of a complete system for end-users but often take the form of Max/MSP externals and/or open source software. The closest implementations to full HCMP systems are those of Dannenberg et al. and Liang et al. who have presented two systems for particular aspects of HCMP. The first is a virtual string section for a jazz orchestra [17] where the computer was cued by foot pedal in the playing (and realtime stretching) of pre-recorded string parts. The second is an active music notation interface where notation display is co-ordinated with performance progress [18].

4. THE FRAMEWORK

The assessment framework is now presented. It is divided into three sections: issues relating to adoption and use, those relating to performance situations, and ethical issues. The intention at this stage is not to attempt a quantification of the criteria but simply to expose the issues for discussion and refinement.

4.1 Adoption and Use

4.1.1 Performance Technology Experience

The level of experience that the potential adopters have with technology in general, and music technology in particular, will play a key role in the likely adoption of an HCMP system. Increased experience will lower perceived risk (and thus cost in the diffusion model), regardless of the capabilities of the candidate system. Bad early experiences may work against this however.

4.1.2 Trust in the Technology

A critical moment in any performance takes place just before the first note is played. In an ensemble context, this is the moment where the leader places great trust in the rest of the ensemble that they will follow direction and synchronise appropriately. An ensemble containing computers must be similarly trusted (and trustworthy). Again, early experiences with the system during testing and rehearsal will play a large role in establishing trust (as indeed such sessions do for human players) and thus lower the perceived risk (in terms of failed musical experiences) and perceived cost (in terms of effort to create and ensure synchronisation).

4.1.3 Interaction Design

It is important to consider the overall design of the interaction of the ensemble with its computer systems. This goes beyond the user interfaces for each individual system and requires an understanding of the interaction dynamics of the players, both human and computer. Benford [19] explores these ideas in the context of collaborative musical instrument design, identifying the need for complex multi-channeled interaction between players. To some extent this

will contribute to the perceived trustability of the new technology.

4.1.4 Offline Ease of Use

This is a relatively broad criterion relating to the general offline ease of use of the candidate system in preparing scores and arrangements. The system's user interface may need to be specialised to particular genres or performance practices to lower perceived cost.

4.1.5 Specialist Technology Requirements

Since natural interaction with the ensemble is paramount, gesture capture is likely to play an increasingly significant role in allowing the computer systems to be part of the ensemble without increasing load on the musicians in terms of control and co-ordination. It is important that the hardware required for gesture capture is non-specialised, low-cost, and commodity-oriented. This will help to increase availability (strengthening the broader social effects of the diffusion model), reduce cost, and lower barriers to experimentation for resource-constrained ensembles.

4.2 Performance

Performance-related issues are linked more closely with the system capabilities summarised by Dannenberg [1]. Those described here address aspects not required for "core" HCMP functionality but that may affect adoption.

4.2.1 Leading and Following

Leader and follower relationships in popular music are fluid and change at multiple levels of granularity during performance (e.g. at fine granularity leaders might instantiate "call and answer" patterns or melodies between instruments, or in jazz performance leadership and arrangement may follow the activity of the current soloist in the ensemble, changing when they complete their solo) . It is important that HCMP systems are aware of this and do not prescribe particular performance structures or practices since this would be likely to increase perceived adoption risk, particularly in functional contexts where musicians may feel a responsibility to deliver music in a particular style that includes this fluidity and spontaneity.

4.2.2 Gesture Understanding and Vocabulary

The gestural norms of the ensemble and style must be understood and respected by HCMP systems to avoid the cost of changing to an HCMP approach outweighing the potential benefit for an adopter. Prior to the development of systems for gesture capture, it is likely that studies will be needed to catalogue the practices and gestures used in particular sub-genres and contexts of popular music. For example, in praise and worship music, it is common for various hand signals or spoken cues such as the first line of the next desired section to be used to change the structure during performance. In that context, the particular cues used would be specific to the musical work. Adopters would need to be confident that the system they are evaluating does not change their performance practice but can understand and interpret their gestures (physical, musical, or verbal) in this way.

4.2.3 Additional Effort Required from Performers

Related to the previous criteria, it is important, particularly for players of lower ability, that the HCMP system does not demand anything more from them in performance than to play their part in the ensemble. If the system demands additional concentration, it is likely that a perceived cost will be incurred (in the form of lower-quality musicianship) and thus the system will be rejected.

4.2.4 Musical Recovery Ability

Since it is likely that however well a system fulfils the other criteria laid out here, at some points there will be musical failure (e.g. loss of synchronisation, misreading a cue and playing the wrong section), so it is important that an HCMP system can demonstrate musically-appropriate recovery. This may be as simple as stopping and waiting to be recued, however, this would increase the load on performers and it might be appropriate to provide other feedback indication (either at failure points or always) to communicate to other performers that the system is lost. This fits with Benford's findings relating to the need for complex interaction and feedback [19]: the computer should not be excluded from this part of the ensemble's communication.

4.2.5 Performance Practice

Performance contexts have their own practices regarding the ordering of music, styles of playing, and likely spontaneities (e.g. certain songs that may follow one another). These may be genre-specific, locality-specific, and even specific to particular band leaders and ensemble line-ups. For example, certain songs and song fragments in praise and worship music have become commonly used as unplanned bridges into and out of vamp sections during extended sung worship sessions. Similarly, Benford et al. found that a shared knowledge of musical repertoire is important in sequencing tunes in Irish folk music [20]. It is important that HCMP systems learn and respect such conventions of the ensemble, locality, and genre to prevent genericity becoming a perceived cost of adoption.

4.3 Ethical Issues

The ethical issues in this section relate more to the broader context of HCMP than to a particular adoption decision. Nonetheless they should be considered.

4.3.1 Risk of Replacement

There is a risk that a highly successful HCMP system might be deployed even when there are human musicians available to play. Although there may be economic reasons for an organisation to take this approach, it is undesirable. If the innovator perceives this as a risk and is affiliated more strongly to the musicians than the organisation, then this would be a barrier to HCMP adoption. However, if the innovator is affiliated more strongly to the organisation

and has the social status referred to in Wejnert's diffusion framework [15], they may be able to force adoption.

4.3.2 Reduction of Training Opportunities

Somewhat related to the previous issue, there are some contexts in which an ensemble may be prepared to accept lower-quality musical performance for a time in order to allow inexperienced musicians to learn the norms of their ensemble and genre. There is a risk that organisational pressure for consistent output would lead to the deployment of HCMP systems in place of the inexperienced musicians. Again, the balance of power and status of the innovators may be a determining factor.

4.3.3 Disruption to Organisational Practice

The final issue to consider is how the practice of the ensemble's umbrella organisation may be disrupted (even if only temporarily) by the introduction of HCMP. This may be a more significant issue for functional music where there are dependencies on the music beyond the ensemble itself.

5. CONCLUSIONS

This paper has discussed Human-Computer Music Performance systems and the potential and requirements for them to be used in different performance contexts. The particular context of contemporary church bands was used to exemplify the issues but HCMP systems have far broader applicability and could be used by both amateur and professional ensembles in a variety of ways. A framework was presented that examined issues that relate to the potential adoption and use of HCMP systems. The framework is situated in the context of innovation diffusion factors, identifying aspects of such systems that may inhibit or promote adoption. Future work will include further refinement of the framework through symposium discussion of the issues, more detailed mapping of innovation diffusion models to this context, the development of measurement criteria to aid developers, and application to developing systems.

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