Conducting Collective Instruments : A Case Study

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ABSTRACT

According to the tradition, music ensembles are usually lead by a conductor who is the responsible to coordinate and guide the group under a specific musical criteria.

Similarly, computer ensembles resort to a conductor to keep the synchronization and structural coordination of the performance, often with the assistance of software.

Achieving integration and coherence in a networked performance, however, can be challenging in certain scenarios. This is the case for configurations with a high degree of mutual interdependence and shared control.

This paper focuses on the design strategies for developing a software based conductor assistant for collective instruments. We propose a novel conductor dimension space representation for collective instruments, which takes into account both its social and structural features.

We present a case study of a collective instrument implementing a software conductor. Finally, we discuss the implications of human and machine conduction schemes in the context of the proposed dimension space.

Keywords

collaborative interface, music performance, conducting software, multiplayer, musical control, collective instrument, network music, laptop orchestra

1. INTRODUCTION

As opposed to the traditional conception of a musical instrument as an autonomous, individual entity, collective instruments are devices intended for multiple performers and with some level of interdependence between their actions. Collective instruments thus break away from the traditional paradigm of music instruments (1 player → 1 instrument → 1 sound).

A natural environment to develop and perform with such instruments is a computer network, which provides the required interconnection possibilities. Performers playing collective instruments must cope with a level of interdependence not previously encountered in musical ensembles. Because of their inherent complexity and lack of individuality, playing collective instruments is often perceived by performers as playing with a sort of autonomous "live entity" from which they must learn to *expect the unexpected* [13].

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Even if such uncertainty can be of artistic interest by itself, we believe that a truly engaging performative experience asks for a deeper understanding on the dynamics of the collective instrument being played. However, being able to collectively drive an interdependent music system in a coordinated way may prove to be deceptively complex, even for highly skilled and trained performers.

This paper presents the motivations and strategies to face when implementing a software based conductor. It is intended as an assistant for performers to achieve a higher degree of coherence and integration when playing with collective instruments. The paper is organized as follows: Section 2 presents a historical review of collective instruments and how they have been conducted. Section 3 proposes criteria for the characterization of software-based conductors for collective instruments. Finally, Section 4 presents and evaluates a specific case study.

2. NEW INSTRUMENTAL AND CONDUCTION PARADIGMS

In this section, we present and review the most relevant developments and theorizations of collective instruments, we debate and show some examples about conducting computer ensembles and, finally, we propose characterization criteria for software-based conduction of collective instruments based on a computer network.

2.1 Collective Instruments

The concept of collective instruments using networked computers is not new. The League of Automatic Music Composers and later the Hub pioneered the genre of networked music in the 70s up to the 90s. The very notion of The Hub was both a band and an infrastructure to allow collaboration and interdependence between autonomous musical devices[7, 3].

Weinberg's *Interconnected Musical Networks* [14] is a conceptual framework which analyzes the broader field of networked musical devices. It gives a special emphasis to the social implications of the structural topologies of the network.

Barbosa [2] suggests a time/space axis, more formally (a-)synchronicity and (co-)location of the performers, to classify collaborative music systems.

Jorda [9] proposes a number of distinctive features from the point of view of shared collective control in multi-user instruments.

Finally, Hattwick and Wanderley [8] propose a dimension space for collaborative musical performance systems which we will use in the current study.

2.2 Conducting computer ensembles

In traditional instrumental music there exist well assumed contexts for conductors to be accepted as necessary for a successful performance. Negotiation through auditory and visual feedback (in chamber music) or informal turn-taking and hierarchic schemes (in jazz) are typical examples of coordination without a conductor. However, it is accepted that a larger ensemble benefits from having one. A similar trend may be observed in computer ensembles: small ensembles can follow a chamber music approach, but when the number of performers *and* their interdependence increases, some kind of centralized conduction may be required.

Blaine [4] presents a survey on musical collaborative interfaces. He observes a number of idiosyncratic conducting techniques such as distributed leadership and indirect direction through software constrains.

Reinecke's ethnographic study[11] of the Princeton Laptop Orchestra illustrates some relevant challenges and design strategies for collective musical coordination in computer ensembles.

2.3 Conducting collective instruments

According to the discussions presented above, we conclude that collective instruments with some kind of interdependence cannot be conducted like an ensemble made of individual performers. In this latter scenario the ensemble retains strong individual identities which can be addressed much as when dealing with traditional instrumentalists. In a collective instrument, however, this strict resource ownership becomes more diffuse. Mutual control and shared resources blur single identities. A conductor may struggle in finding who was responsible of what and in determining who would best contribute to a desired result.

Aesthetic reasons may motivate the use of conductors in networked performances. The League, for example, advocated for a radically democratic approach to computer ensemble performances, typically avoiding any consistent collective pre-planning or leadership [7]. In their performances with The Hub, however, a number of conducted collective instruments were developed [3]. Some of those exhibited the simplest approach into an effective conduction of a collective instrument: the direct control through a very salient, high-level parameter, from which performers can derive their materials. High coherence and directionality could be achieved thanks to this hierarchic one-way interaction.

Nevertheless, this approach may be unfeasible with a higher degree of interdependence. Without the former top-down design, a collective instrument will be driven by the multiple interaction between resources shared and manipulated by the whole ensemble.

3. CHARACTERIZATION OF SOFTWARE CONDUCTORS FOR COLLECTIVE INSTRUMENTS

In this section, we analyze the relevant dimensions to characterize a conducting software, putting them in the perspective of a conducted collective instrument.

Figure 1 shows our suggested conductor dimension space for collective instruments. Clockwise, the first three dimensions (Depth, Intrusiveness, Authority) deal with the social dynamics of the conduction process, whereas the last three (Subject, Decision, Evaluation) describe the internal logic of the conductor.

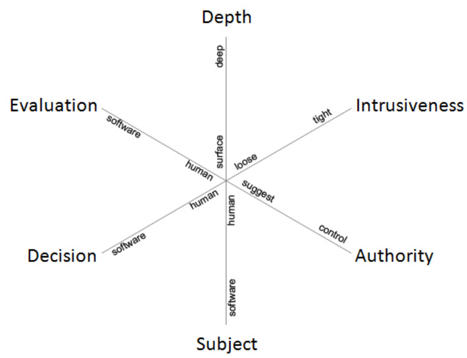


Figure 1: Our suggested Conductor Dimension Space for Collective Instruments

Authority: How does the control take place. Different control strategies (or *leadership styles*) are possible here from a social perspective, from gentle coaching to absolute *control and command* schemes. Our conductor software can passively monitor the performance. It can make as well active suggestions to performers. Ultimately, it could take control over the performance.

Depth: The level of the conduction. A conductor system may provide some accessory tools to help in the coordination process. Otherwise, it can take advantage of a deeper understanding of the dynamics of that precise performance system, possibly dealing with higher level musical constructs.

Intrusiveness: How much to conduct. Much like in a traditional conducting, our system can seek to perform a permanent control, dealing with every fine minutiae in the performance. Or it can deal with occasional, less invasive actuations, leaving other performative decisions to performers.

Decision: Who makes the decisions. There are two distinct decision points in a conduction act: setting a target and then planning the actions required to achieve it. We must decide to whom both decisions will belong: either to the software itself -pure software-based conduction-, or deferring them to a human conductor -computer mediated human conduction-..

Subject: Who/what is being conducted. Our conductor can address its commands directly to individual performers or to the instrument itself, for example modifying the mapping or the network topology to indirectly shape the performance. Shifting the controls from performers to software (see below) will have profound impact on the performative experience.

Evaluation: Who evaluates. Being an advanced kind of adaptive control system, musical conduction effectively sets up a feedback loop in which the collective behavior is continuously evaluated to plan the forthcoming actions. This evaluation phase may be purely software-based or may contain any degree of human contribution.

The suggested axes form a continuum from a purely non intrusive, high-level human conduction style (low values) to a completely automated and exhaustive software based conduction (high values).

4. A CASE STUDY

Conducting strategies for laptop ensembles are tightly dependent on the instrumental and performative paradigms involved. The following conducting software, currently being developed by the Barcelona Laptop Orchestra[1], will

[1] `http://blo.cat`

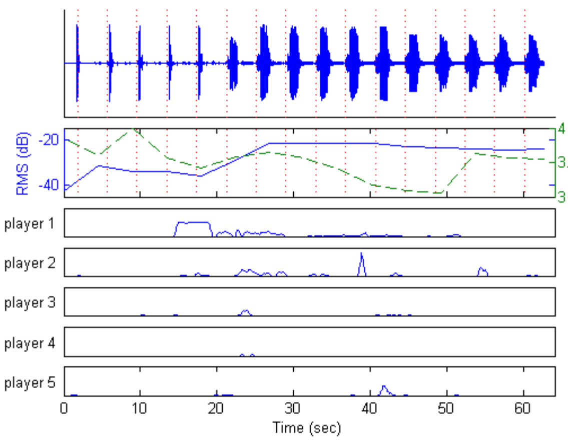


Figure 2: A 60s excerpt from a La Roda performance. Top to down: audio recording, turn-averaged spectral centroid & rms, monitored user activity. *Birmingham Network Music Festival, 2012*

hopefully exemplify the motivations, challenges and implications of the incorporation of an automated conduction software into a collective instrument.

4.0.1 La Roda

La Roda[2] is a collective instrument which the Barcelona Laptop Orchestra has been performing with for the last four years. It was conceived as a musical analogy to the popular *Chinese Whispers* children's game. La Roda consists of a turn-based iterative sound processor, in which performers gradually mutate a sound snipped with their custom made effects. This configuration proved to be rather flexible, being played from electroacoustic venues to more mainstream electronic music events.

Strong individuality is kept with very idiosyncratic processes tied to single performers. The high interdependence between them comes from the fact that instruments are linked in a loop configuration, with a single shared sound stream flowing from one player to the next.

As *La Roda* is implemented centrally, we can capture and analyze the relationship between performer's actions and timbrical evolution (see Fig. 2)

Conducting *La Roda* may be made explicitly or through computer mediation. The most obvious automatable control parameters are the turn sequence, duration and player order. Providing overall texture/gesture indications to players is usually done through verbal indications.

However, global directions can be easily disrupted because of the accumulative behaviour and heterogeneity of processors involved in the instrument , leading irreversibly to an unplanned timbrical evolution (see Fig. 3)

4.0.2 A conducted La Roda

A more formal approach was devised to better control the individual effects and the ensemble as a whole. We turned the instruments into globally controlled adaptive effects (see [1, 12]).

Four simple effects were used for this preliminary study: a gain, a frequency shifter, a notch/peaking filter and a low/hi shelving filter. Each effect offered two distinct control parameters to the user. The procedure comprised a training and a prediction, similar to those described in [5, 6]

[2]henceforth removed for anonimity

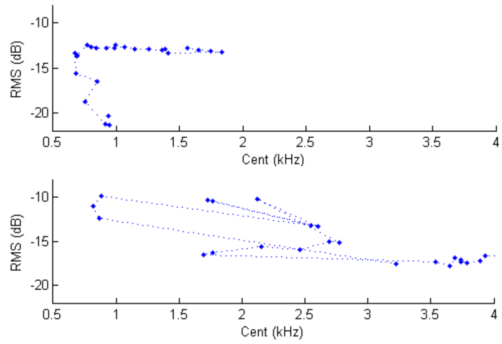
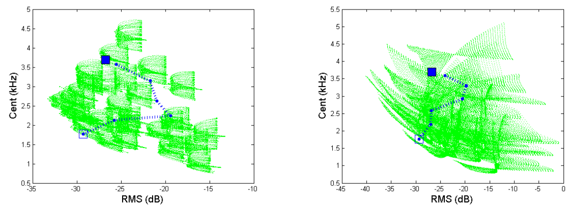


Figure 3: A coordinated shift towards low frequencies.*Live at MWC, Barcelona, 2013* (top). A jagged timbrical evolution.*Live at Sonar Festival, Barcelona, 2013* (bottom).



(a) (b)

Figure 4: Two different Roda effects playing alone, automatically driven to the same target. The green dots are the training data.

A 30min random performance was generated. We then extracted 30 2-second random audio slices, processing them through each of the four effects. We sampled the control parameters in 50 steps. For each file we extracted a number of low level audio descriptors, analyzing in 2048 sample frames and 1024 sample hopsize and averaging the result.

All the previous training stages were performed offline. The next steps take place during an actual performance. We started with an initial set of descriptors (from the unprocessed audio file) and the desired target descriptors (as requested by the conductor). Then we retrieved the most suitable effect parameters on a turn by turn basis. A simple K-Nearest Neighbor matching proved to be a good starting point. As an example, see in Figs. 4(a)&4(b) two distinct effects gradually mutating a sound file to the same target.

On a multiple player scenario, the system infers which combination of effects and parameters better match the desired target descriptors. A closer match can be achieved by predicting with some turns in advance. By injecting the parameters into the system, we effectively put the whole instrument under direct control of the conductor. One can now dynamically set new targets, even on different descriptor spaces, as shown in Fig. 5.

A number of improvements are currently being worked on: devising a better predictive model, dealing with intra-turn gesturality and controlling the rate of convergence.

4.0.3 Preliminary evaluation

Some preliminary tests were carried out in order to evaluate the new conducted instrument with human players. The conduction module could be activated at will, otherwise performers could play manually. Let's compare the Conduction Space for both configurations (see Fig. 6): the Conducted La Roda allows for a greatly unified control at the expense of individual performative choices. Indeed, we

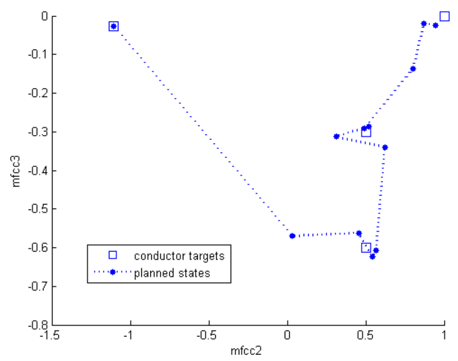


Figure 5: A collective, software driven Roda performance. The players follow different targets as provided by the conductor. Targets are defined by a pair of MFCC coefficients.

transformed a freely collective sound exploration into a deterministic combinational game in which performers only have to blindly follow the indications.

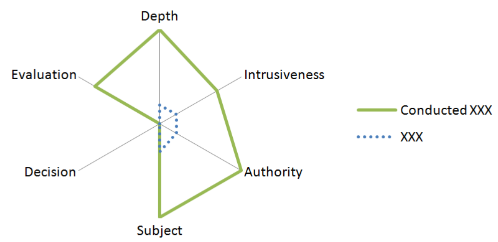


Figure 6: La Roda and conducted La Roda, Conductor Dimension Space

In the original La Roda the human conductor provided high level orientations. Players felt in complete control of their actions, if not of the global outcome. Not surprisingly, the automated system proved to be a less engaging experience.

Performers, when the *automatic pilot* was switched on, adopted a passive role. If parameters were only suggested, some tried to accurately follow it anyway. Creative interaction came unexpectedly from some players trying to defeat the system by ignoring the suggested parameters and forcing it to plan a new route. In both cases, collective awareness was drastically reduced.

5. CONCLUSIONS

The former example shows how a software-driven conduction can be incorporated into a Collective Instrument. It is just a proof of concept, not yet intended to be used in the context of a real performance. Neither the fascination for unexpected behaviours nor the fascination for super-human coordination strategies are good receipts for engaging performative experiences.

A promising use of software conductors in Collective Instruments would be in initial rehearsals. They can be valuable to guide novices in the strategies of group collaboration and interdependence. As performers develop collective awareness and strategic thinking, a more loosely monitored, *laissez-faire* conduction style could be preferred [10].

6. ACKNOWLEDGMENTS

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