POLYPHONIC AUDIO SCORE FOLLOWING:

THE OTEMO CASE

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ABSTRACT

We will describe the use of the *antescofo* score follower [1,2] in the context of the production of *Otemo* for solo vibraphone and electronics. During the research and production periods preceding the realization phase of this piece, we have influenced the development of this piece of software by a close interaction with the developer. We have intensively tested the score follower with live tests and recordings. We then describe the successful implementation of the system during the concert. To conclude, we will make an assessment, and envisage future works to improve and generalize the new score follower.

1.   INTRODUCTION

This document describes a musical research project on *polyphonic score following* using *Antescofo~* [1,2] undertaken in 2009. The project had a strategic and important goal: the first use in concert of an audio score following system on a polyphonic instrument, the vibraphone. The success of the project would represent an important step in the score following history, meaning that we can simplify the exploitation of pieces using "midified" instruments (piano, vibraphone, …) and simplify the creation of future interactive musical works. Despite technical objectives, the project was supposed to culminate to an *etude* for vibraphone and live-electronics programmed at AGORA 2009 by composer Vassos Nicolaou.

The goals of this project was two folds:

1. To test polyphonic recognition capabilities (polyphonic real-time score following)
2. To exploit the musical capabilities of *Antescofo~* and its use in the context of musical writing and composition; especially with regards to real-time tempo synchronization.

2.   STATE OF THE ART

In the first ages of score following (before 1984) : only midi instruments could be followed. Example are pieces such as[1]:

- Boulez : *Explosante Fixe* …(flute, first version),
- Manoury : *Jupiter* (flue, first version),
- Manoury : *Pluton* (piano).

In a second phase, the progress of real-time DSP and pitch tracking algorithms allowed the following of monophonic instrument using audio and in real-time:

- Manoury : *Jupiter* (second version),
- Manoury *En echo* (voice),
- Durieux *Devenir* (clarinet).

Since a few years, it was possible to follow instruments with a light level of polyphony (i.e. the violin family) using the FTM version of score follower (*suivi~*):

- Boulez : *Anthemes II* (violin),
- Manoury : *Partita I* (alto).

But until now it was impossible to imagine the following of highly polyphonic instruments.

This project focused on the research and development of *Antescofo~*, a realtime score follower capable of detecting polyphonic events and decoding the realtime tempo of the performance.

3.   CONTRIBUTIONS

This project resulted into the following developments in the *Antescofo~* system, reusable by other composers/projects:

o   Implementation and validation of the polyphonic follower in *Antescofo*.

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[1]   A list of *Antescofo* repertoire is available at: http://imtr.ircam.fr/index.php/Scorefollowing_Repertoire

- o Implementation and validation of a *pedal mode* that reduces resonance during realtime performance and suitable for instruments with sustain pedal (piano, vibraphone, etc.)
- o Implementation of a polyphonic mode integrated within *Antescofo* in its electronic score language. This new syntax (called *GFWD*) automatically synchronizes with the tempo of the performer for events whose time span is greater than a single event.
- o Implementation and consideration of tools for adapting the performance/instrument to the score follower (calibration, tuning, harmonic adaptations).
- o Overall optimization of the system for realtime use.

4.   RESEARCH PERIOD

The research period started in October 2008 and ended in June 2009.

We organized some working sessions with the vibraphone player, Daniel Ciampolini or with gathered recordings in november, december 2008, january and march 2009, to simulate and experiment with the experimental polyphonic score follower *Antescofo~*. This was coupled with research and development of the software that continued until the premiere date (17 june 2009).

Since the project was coupled with a musical production, besides technical objective, we had to take into account practical considerations for the use of this score follower in a concert situation such as score preparation, calibration, etc.

5.   MUSICAL IDEAS

Figure 1. excerpt of test score for *Otemo*

Prior to the composition of *Otemo*, Vassos Nicolaou wrote some musical examples exploiting important features of polyphonic score following and some typical features of the score anticipator, such as:

- Repeated notes, tremolos.
- Use of the pedal, with all of the vibraphone keys resonating, resulting in a highly polyphonic signal.
- Detection of tempo changes intensively used.
- Synchronization and representation of the accompaniment part.

To this regard, the score was composed having in mind a virtual accompaniment, where an orchestral score is accompanying the vibraphone in real-time. This orchestral score constitutes the core of the live electronics, which in some cases will not be heard directly by the audience but used for live sound generations and processing. The score excerpt of Figure 1 shows one such study where the vibraphone part will be accompanied in real-time despite all tempo changes by the MIDI counterparts in the orchestral score.

6. SCORE PREPARATION

Given the musical idea presented previously, the overall score of the piece consists of a vibraphone part and the accompaniment virtual orchestral. In order to prepare this score for *Antescofo~*, Serge Lemouton wrote a software for converting the score written by the composer in Finale to the Antescofo text format. This program, *miditoAscore*, written in java is now distributed with *antescofo* through its website[2].

7. OTEMO

Otemo is in 3 parts, exploiting different characteristics of the integration with antescofo:

- A : highly polyphonic section, sudden tempo changes. In this section, the vibraphone solo is accompanied by 2 virtual vibraphonists
- B : a less polyphonic section
- C: very fast and rhythmic section, requiring very precise synchronization.

The piece was performed during the Agora Festival (in a concert subtitled « Segui ») by Daniel Ciampolini, on the 17 June 2009 in the Musée d'Orsay's Auditorium.

Part B was followed successfully. We had a crash at beginning of section C but we could resynchronize it so quickly that it went quite unnoticed! The crash was identified as a multi-threading problem and was corrected for later use.

For the more polyphonic part (A) we had to supervise, retrigger and resynchronize the system manually from time to time.

8. TEST MATERIAL

Because we used two different vibraphone models, we noticed that the system was highly dependant on the instrument timbre and its dynamic. It was absolutely necessary to carefully calibrate and adjust the timbre model in antescofo.

During the rehearsals, we have accumulated a lot of recordings of the piece (on both instruments) , allowing systematic system tests. It is possible to improve the system performance using this recordings.
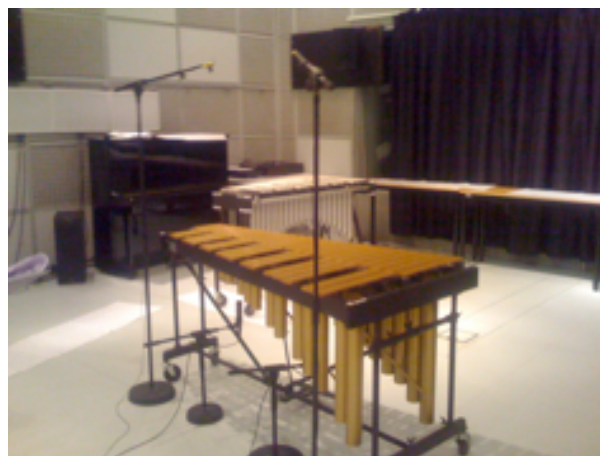
- **Figure 2.** 3,5 octave Yamaha Vibraphone in Ircam studio.

We have also recorded several recordings of the vibraphone part of the whole piece played during rehearsals just before the concert in Musée d'Orsay.

It is possible with this recording set to establish a systematic test procedure to validate the system robustness. They can be further included into the Mirex evaluation database[3].

9. FUTURE PERSPECTIVES

Figure 3. *Otemo* in *NoteAbility Pro*.

We can take advantage of the expertise acquired during during this musical experiment to identify necessary future improvements of the system:

- Stability
- Automatic calibration
- Integration with Keith Hamel *Noteability* score notation software.

This system can be used in the context of existing pieces to simplify their implementation and concert performances:

- Kenji Sakai : *Astral* …
- Vassos Nicolaou: *Orbit* (for piano and electronics)
- Michael Jarrell : *Rhizomes* (two pianos, percussion and electronics)
- Philippe Manoury : *Neptune* (2 vibraphones, marimba and electronics)
- Philippe Manoury : *Pluton* (Piano)

10.   CONCLUSION

This experiment was the occasion of
- a sensible improvement in the stability and usability of score following (or anticipation) systems
- the occasion to produce an original musical work in the vibraphone repertoire.

The composer found some new ideas and inspiration while he was imagining the possibility of antescofo®.
He express this in this terms : "My piece would have been completely different without antescofo. It was the occasion for me to develop some new musical concepts"

11.   ACKNOWLEDGMENTS

12.   REFERENCES

[1] Arshia Cont. *«ANTESCOFO: Anticipatory Synchronization and Control of Interactive Parameters in Computer Music"*, Proceedings of International Computer Music Conference (ICMC), August 2008, Belfast, Ireland.
[2] Arshia Cont. *A coupled duration-focused architecture for realtime music to score alignment*, IEEE Transactions on Pattern Analysis and Machine Intelligence, 2009 (in press).