Static Analysis of Performance Parameters for Music Scores

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Context : Music performance is by nature non deterministic : it is well known that two interpretations of the same music score, where all the notes and their durations are specified, can differ significantly, in particular wrt temporal aspects. However, despite the temporal variability, several musicians playing together manage (in general) to make the music sound "as expected", using various synchronization strategies (mostly implicit). In the case of mixed instrumental/electronic music, where a computer has to play together with musicians in realtime, the synchronization strategies must be formally specified, which is not an easy task (see e.g.[6]). The goal of the internship it to help composers in specifying interaction in mixed music by providing them with procedures for the static analysis of the temporal behavior of written scores.

Antescofo [1] is a system used in performance for interpreting electronic music scores in realtime synchronization with a live musician. It is capable of following the performance of the musician, decoding in realtime its position within its score and its current tempo (pace) [4], and of synchronizing this performance with computer realized elements. The music scores currently used in Antescofo, consist essentially in the specification of sequences of musical *events* to be recognized (from the performer audio stream in input) and of electronic *actions* to be output by the computer in response. Various strategies are also proposed for specifying synchronization between events and actions and for error handling [5]. These specifications can be seen as a special kind of timed systems where the delays (between an event and an action or between two successive actions) are expressed relatively to the recognized tempo (which changes at each element detected). **Objectives :** The subject of this internship is the development of static analysis techniques for antescofo score specifications, in order to determine the possible behavior that may occur during a performance. The goal is to give both the composers and the performers indications of what can be expected from the system according to parameters related to the performance (tempo variations, missing notes...).

We propose to follow an approach similar to the so called *inverse method* of [3], implemented by Etienne André in the tool IMITATOR [2]. This method permits to infer constraints on the timing bounds (parametric delays) in timed automata guarantying the same execution trace as for given reference values for the delays. In our case, the parameters should represent the tempo, and the constraints should restrict the tempo variations, indicating the degree of freedom in interpretation guarantying the expected realtime behavior of the system. We may also need, for musicality reasons, to relax the notion of same execution trace to some equivalences.

The objective is have a formal description of a procedure for the above problem, to validate on some real examples of scores and, if time allows, to implement it on a prototype based on IMITATOR.

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