The Virtual Conductor: Learning and Teaching about Music, Performing, and Conducting

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Abstract

The Virtual Conductor is an artificial conducting system that uses real-time audio analysis of music played by musicians and uses this analysis to animate a virtual human that acts as a conductor. The analysis detects the tempo and the dynamics of the music, compares the results with the score and the intentions of the conductor and modifies the conducting behavior when the musicians deviate from the desired performance. The architecture of the system is presented and we explore the use of the conductor system for tutoring and rehearsal purposes.

1. Introduction

We introduce some opportunities we see for the use of novel technologies in music education, now and in the future. Not in substituting the human artistic work, but rather in tools supporting the training of musicians and e.g. in cases were some skills become rare or underdeveloped and media can support in certain musical processes.

We think that technology can play two major roles in music education. Firstly, technology can supplement and support skills of parents and teachers essential to the musical development of children (singing songs together, playing musical games, etc) that are becoming rare or underdeveloped or for which time lacks. Note that such technology should not replace those skills but rather be accompanied by initiatives that encourage the development of such skills, like the Dutch 'Music on the Lap' (http://www.muziekopschoot.net/) program that targets the parents as much as the children. Secondly, technology can make music education more efficient by taking time consuming, less creative, essentially 'practice' activities and offering them in a context in which students can master them individually, leaving more time for teachers to focus on the communicative/creative skills of music. In particular this role of technology in music education is targeted in our virtual conductor project.

2. Exploring the use of conductor systems

We have designed and implemented an artificial conductor [1,2] that is capable of leading, and reacting to, human musicians in real time. The conductor is a virtual human projected on a large screen in front of the orchestra (see Figure 1). He knows which piece of the music must be conducted, and it is able to translate this knowledge to the right conducting gestures. He listens to the music as it is played by the human musicians. Advanced audio processing algorithms are used to determine what the musicians are playing, and how well. Based on that information the conductor can adapt his conducting movements to give corrective feedback. Currently the artificial conductor can give feedback, through his conducting gestures, on the tempo with which the musicians play and on the dynamics with which they play.

Such an artificial conductor system can be used in several ways. We can envision this conductor to be developed further as a rehearsal conductor. The time in which a conductor can work with a single ensemble is often limited; when an artificial conductor could be used to rehearse the more technical aspects of a piece of music this would leave the human conductor more time to work on the creative and expressive musical aspects of a performance. Furthermore such a limited conductor could be used for small groups of children in a school of music to explore aspects of ensemble play: the conductor provides some structure and support, but the children would still work mostly in a self-reliant and autonomous way.

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Figure 1. The virtual conductor leading a student rehearsal

Another focus for further development of such technology could be the student conductor. As a reflective tool, the system could show good examples as well as examples of typical conducting mistakes, allow the student conductor to experiment with ways of conducting a passage while playing along on a piano or other instrument to see how it feels for the musicians, etc. In combination with the complement of this artificial conductor, namely an artificial orchestra such as the one displayed in the Vienna House of Music [3,4], a system could be envisioned that detects his or her mistakes and graphically shows them to the student in combination with the correct way of conducting.

3. Interaction between virtual conductor and musicians

How to model the interaction between conductor and orchestra? In a first version of the conductor [1] the conductor only indicated the beat and no other signals were given to the orchestra. The conductor listens to the orchestra and when the musicians deviate from the correct tempo the conductor tries to guide them back to the right tempo. Not by behaving like a metronome, but by following the musicians and smoothly lead them back to the correct tempo. This version of the conductor is mainly based on real-time beat tracking. It allows student musicians to become aware of their errors and to correct them without being obliged to interrupt the performance.

This is a basic requirement for an artificial conductor. The conductor should be able to match the actual playing behavior of the musicians with the required beat, tempo and the notes that have to be played according to the score of the music to be played.

Hence, extremely important for tutoring purposes, but nevertheless, it is just a first step towards a conducting system that resembles real-life interaction behavior of a human conductor and that allows students to learn from interaction behavior displayed by different conductors. That is, in order to make a next step to the applications mentioned in the previous section, the conductor should be able to display other signals to the musicians in his conducting gestures. These signals indicate the conductor's intentions about the play style of the orchestra or particular instruments, e.g. by raising a hand or pointing at a group of instruments.

The possibility to display intentions distinguishes the first version of the virtual conductor from the second one. Intentions and corresponding signals of different conductors have been studied and added to the conducting gestures repertoire of the virtual conductor [2]. A conducting schedule is now generated from the score enriched with the conductor's intentions about playing style. From the conducting schedule the animations are generated. The architecture allows real-time deviations from such an enriched score based on the playing of the orchestra (e.g., to give corrective feedback). The architecture, illustrated in Figure 2, basically contains three modules:

- A perception module that is responsible for analyzing the score and the music played by the orchestra to extract useful information such as the beat, the dynamics, etc.
- A cognition module that, based on this extracted information, generates intentions (determines what the conductor wants), converts these intentions to actual gestures, and puts these gestures in a conducting schedule.
- An animation module, which takes the gestures from the schedule and animates them.

4. Evaluating the virtual conductor

No controlled experiments with the Virtual Conductor were performed. However, we studied the literature on conducting (e.g., [5]), we held interviews with several human conductors, and we analyzed (and annotated) a set of video recordings of performances and rehearsals. Three conductors of amateur orchestras were interviewed. All three conductors worked with amateur orchestras most of the time, and these interviews were mainly used to get a good overview of intentions and rehearsal structures.

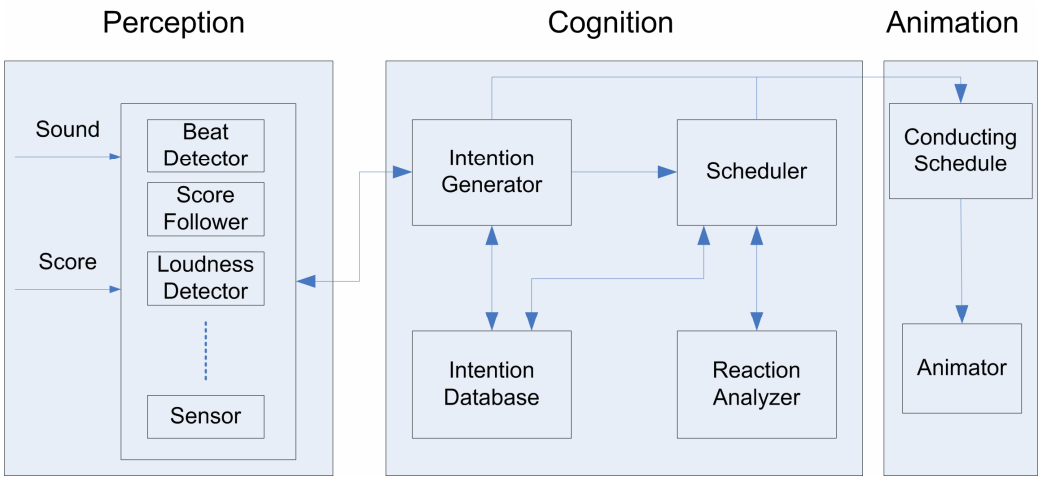

Figure 2. Global architecture of the Virtual Conductor

Four videos of human conductors were studied. We made two recordings of an amateur accordion orchestra and an amateur symphony orchestra (both conductors were also interviewed). We also studied recordings of two professional orchestras. One recording was of Carl Maria Giulini rehearsing Bruckner's 9th symphony with the Stuttgart Symphony Orchestra [6], and the other one was a video of Carlos Kleiber conducting the Vienna Philharmonic Orchestra [7].

Armed with this knowledge we asked musicians to perform with our virtual conductor. We observed their performance and we also had human conductors judge the interaction of our virtual conductor with the musicians. We adapted the behavior of the conductor to these judgments [2], making the conducting behavior more robust. Musicians considered it fun being conducted by the Virtual Conductor.

5. Conclusions and future research

Presently we are in the process of expanding the Virtual Conductor with functionality for rehearsing. The Virtual Conductor should be able to lead a rehearsal and provide some kind of useful feedback to the musicians about their playing. For this goal, a study was done on orchestral rehearsals. How do conductors rehearse and what are adequate strategies for rehearsing? As in the case of displaying intentions, the cognition module and the overall architecture of the Virtual Conductor have been designed with the flexibility to incorporate these strategies.

Acknowledgements

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