Realtime Simultaneous Tempo Tracking and Rhythm Quantization in Music

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Abstract

This demonstration will show how a probabilistic model for modeling timing deviations is used in expressive music performances to perform tempo tracking in realtime. A switching Kalman filter calculates the optimal estimate of the tempo using the prediction from a mathematical model and the measurement from a realtime performance. Using a particle filter various hypotheses are tested to determine what interpretation of the score fits a given performance best. This allows us to perform tempo tracking on a musical performance of which the score is not known in advance. In the demonstration session the effectiveness of this approach is shown in a live/realtime performance on keyboard.

1 Introduction

One of the most challenging topics in the field of computer music is that of interactive music performance systems. These systems are able to 'listen' to the actions of a musical performer and generate responses in realtime. However, because of the diversity of the domain, for example: different genres, polyphony, fluctuating tempo, this task has proved to be rather difficult and has been split up in a number of subtasks. In this demonstration we will show our succesful implementation of two of these subtasks, namely tempo tracking and rhythm quantization.

In tempo tracking we try to determine the tempo of a piece of music. As this tempo is not likely to be constant throughout a performance, the program follows or tracks the tempo as the music progresses. However, because the interpretation of the tempo depends on the underlying score, and this score is unknown to the system, we also need to determine which score fits the performance best. This last task is known as rhytm quantization.

In this demonstration we will show how our system is able to automatically determine the tempo of a musical performance in realtime.

2 Description of demo system

The setup of this demonstration consists of a MIDI capable computer and MIDI keyboard. As a musician performs on the keyboard the timestamp at which each key is pressed is send to the computer in the form of a MIDI message. These timestamps, also referred to as onset times, are used by the system as observations in its estimation of the tempo. By combining these observations with the results of a linear dynamical system model for tempo, the Kalman filter is able to calculate the optimal estimate of the tempo. However, the problem here is that because the performed score is not known by the system, it will also have to find which score fits the given performance best. To see this problem you have to realize that four quarter notes played at a constant tempo will generate completely different onset times than four eighth notes played at the exact same tempo. A particle filter is used to keep track of the most likely interpretations, while the most likely interpretation is used for calculating the tempo [2, 1].

The system demonstrated is the result of a master thesis at the University of Amsterdam (UvA). It was written in C++ by Tim van Kasteren, the underlying probabilistic model was developed by Taylan Cemgil

and the project was supervised by both Taylan Cemgil and Ben Kröse. The system will be most useful to musicians either amateur or professional. It can be used in its current form, or could be used as the basis of numerous applications such as educational music software or interactive music performance systems.

The total demonstration will last approximately 15 minutes.

References

[1] A. T. Cemgil. *Bayesian Music Transcription*. PhD thesis, Radboud University of Nijmegen, 2004.

[2] Tim van Kasteren. Realtime tempo tracking using kalman filtering. Master's thesis, University of Amsterdam, 2006.