DEMONSTRATION OF "MUSIC PLUS ONE" — A SYSTEM FOR ORCHESTRAL MUSICAL ACCOMPANIMENT

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Past work on musical accompaniment systems [1], [2], [5], [3], [4], [6], [7], has focused mostly on generating MIDI or other sparsely-parameterized accompaniments for live musicians. MIDI is is particularly well-suited to piano and percussion music since, in these cases, the MIDI representation captures much of the interpretative quality of the performance. Most other acoustic instruments are considerably less deterministic and their MIDI equivalents are currently much less convincing. We present here a system that generates a complete *orchestral* accompaniment that *follows* a live player and *learns* and assimilates the player's interpretation through a series of rehearsals. Unlike our previous efforts, this system creates the accompaniment by synthesizing, in real time, an orchestral accompaniment using an actual audio recording.

Our system contains three separate modules called "Listen," "Predict" and "Synthesize" which perform tasks analogous to the human's hearing of the soloist, anticipating the future trajectory, and actual playing of the accompaniment.

Listen is based on a hidden Markov model that tracks the soloist's progress through the musical score. Each note in the score is modeled as a series of states, while the note models are chained together in left-to-right fashion to form the hidden process. Listen can be used "off-line," to estimate the onset times of each note in the score given the entire acoustic data file, or "on-line," by delivering real-time onset time estimates. In the on-line version these estimates are delivered with as little latency as the local ambiguity of the acoustic data will allow.

Predict models our prior and learned notions of musical interpretation through a collection of hundreds of Gaussian random variables whose dependency structure is expressed by a belief network. The observable variables correspond to the note onset times estimated by Listen as well as the known accompaniment onset times. These variables are connected through a layer of hidden variables corresponding to unobservable quantities such as local tempo and rhythmic stress. During a rehearsal phase we learn the musical interpretations of soloist and accompaniment by estimating parameters for the distributions of the hidden variables using the EM algorithm. During live performance this module anticipates the future musical evolution by computing the most likely time of the next unplayed accompaniment note given all currently observed variables. Thus our future predictions are constantly being reassessed as new information is observed. These predictions form the basis on which the accompaniment is synthesized.

The Synthesize module begins with a digital recording of the orchestral accompaniment playing without the soloist. In our experiments we have used "Music Minus One" recordings which are created for the purpose of providing canned accompaniment for a live player. Our playback of this recording will be warped in a time-variable way consistent with the real-time analysis of the live player's acoustic signal, as estimated through Listen, and the learned musical interpretation, as represented in Predict. This is accomplished through a phase vocoder. The phase vocoder synthesizes a time-varying trajectory through the orchestral performance by simulating the local frequency content, computed through a short-time Fourier transform, while preserving the phase continuity from frame to frame for each frequency.

We will provide a live demonstration of this system.

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1. REFERENCES

[1] Dannenberg R. "An On-Line Algorithm for Real-Time Accompaniment", *Proceedings of the International Computer Music Conference, 1984* ICMA, 1984.

[2] Dannenberg R., . Mukaino H. "New Techniques for Enhanced Quality of Computer Accompaniment", *Proceedings of the International Computer Music Conference, 1988* ICMA 1988.

[3] Vercoe B., Puckette M. "Synthetic Rehearsal: Training the Synthetic Performer", *Proceed-*

ings of the International Computer Music Conference, 1985 ICMA 1985.

[4] Baird B., Blevins D., Zahler N. "Artificial Intelligence and Music: Implementing an Interactive Computer Performer", *Computer Music Journal* vol. 17, no. 2, 1993.

[5] Grubb L, and Dannenberg R. "A Stochastic Method of Tracking a Vocal Performer", *Proceedings of the International Computer Music Conference, 1997* ICMA, 1997.

[6] Raphael C. "A Probabilistic Expert System for Automatic Musical Accompaniment," *Journal of Computational and Graphical Statistics*, vol. 10 no. 3, 487–512.

[7] Raphael C. (2002), "A Bayesian Network for Real-Time Musical Accompaniment," *Neural Information Processing Systems (NIPS) 14* 2001.