Downbeat

EECS 452: Digital Signal Processing Design Lab – Fall 2019

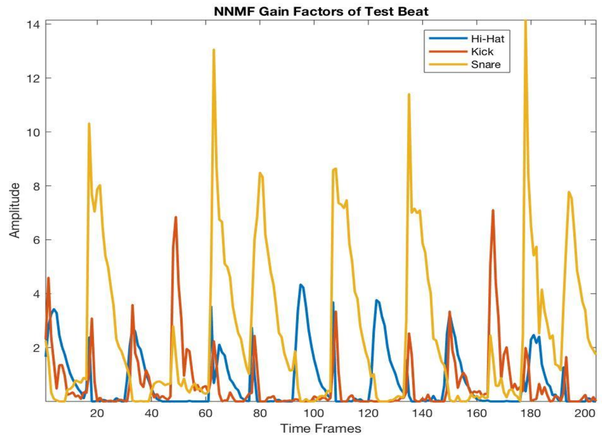
Damon Anderson, Michael Halloran, Cat Kenzie, Prakash Kumar, Bryan Rabotnick

ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY OF MICHIGAN

Raytheon

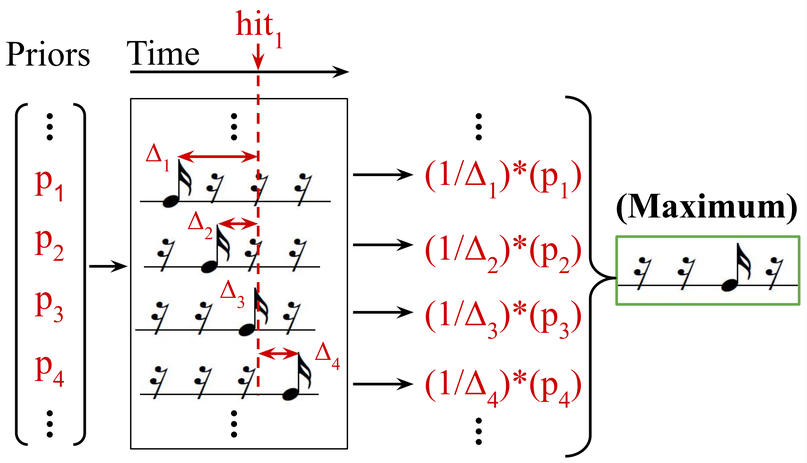
1. Classification (Audio → Times)

The classification algorithm uses a separation-based approach of non-negative matrix factorization (NNMF) to determine onset times of drum kit hits. The NNMF is performed on overlapping spectral frames of the input audio signal, using a basis matrix calculated before runtime samples of each piece of the drum kit. The resulting gain envelopes (see figure below) are analyzed by thresholding the onset intensity, the gain decay rate, and the half-wave rectified derivative of the logarithm of the envelope to distinguish a real transient from a false positive.



2. Transcription (Times → Score)

The transcription algorithm analyzes incoming onsets every beat. All beat patterns are assigned priors, and the optimal beat is chosen as the maximum of one over the average distance between beats patterns weighted by its corresponding prior.

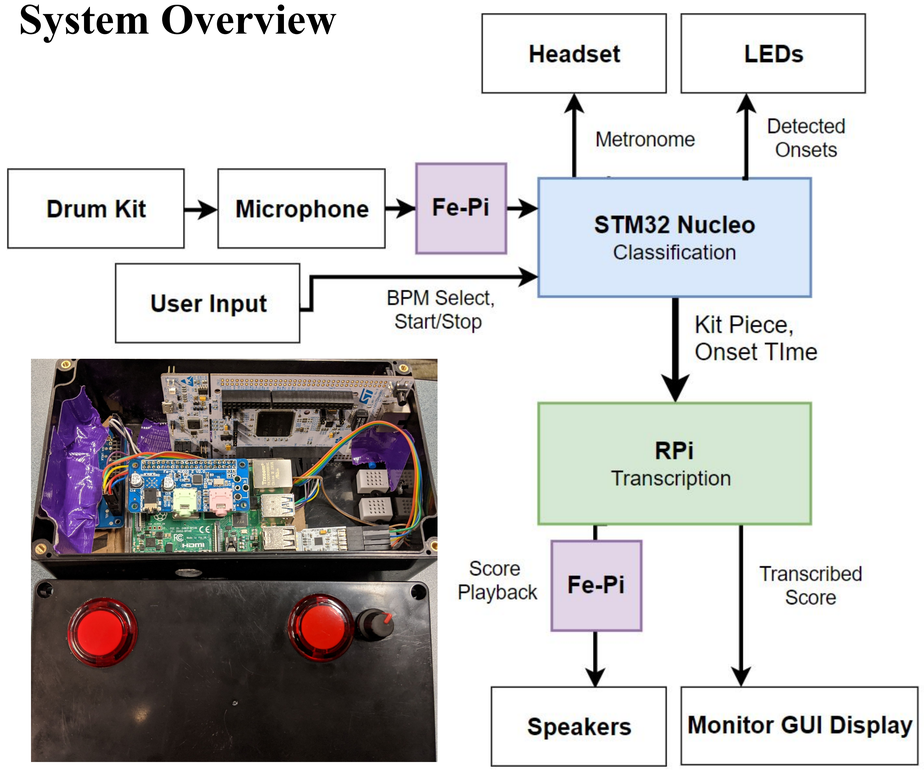


Motivation

Transcribing drum hits by hand is time-consuming and existing automatic solutions require complicated, multiple-input setups. Downbeat processes a single audio track of drumming in real-time to generate corresponding sheet music by:

1. classifying hits of different pieces of the kit
2. transcribing onset times to musical notation

System Overview



User Interaction

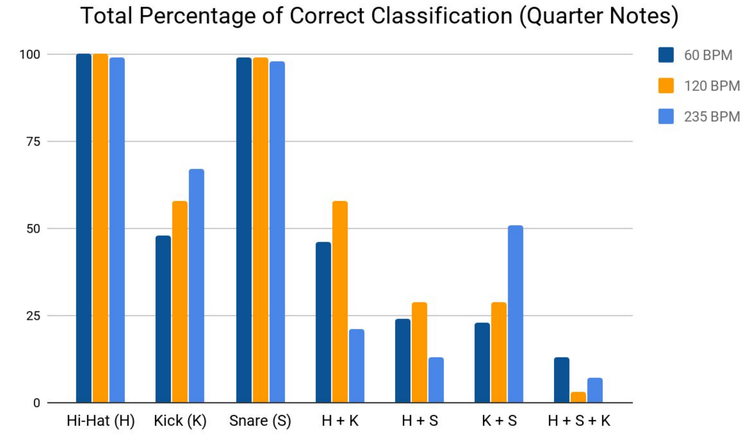
GUI is synthesized using the GUIDO music notation framework. Audio playback is synthesized from pre-recorded drum samples and follows the generated score, allowing the user to hear system performance. Interrupt handled hardware buttons initiate start/stop of classification and playback, and the potentiometer sets BPM.

References

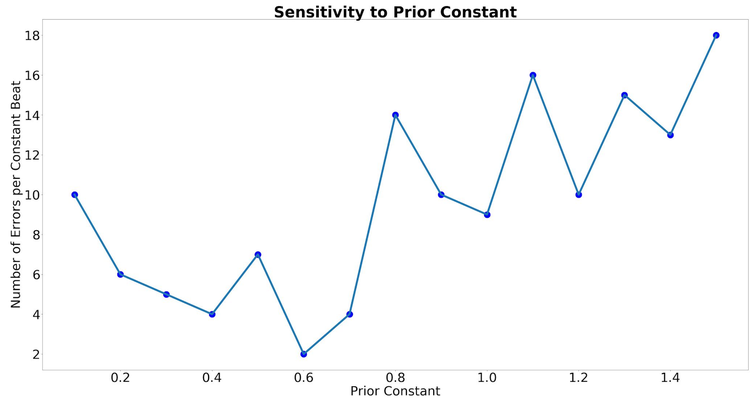
[1] G. Papanikas, "Real-time Automatic Transcription of Drums Music Tracks on an FPGA Platform," MSE dissertation, Dept. Informatics Mathematical Modelling, Univ. Denmark, Lyngby, Denmark, 2012.

[2] A. Cemgil, "Monte Carlo Methods for Tempo Tracking and Quantization", Journal of Artificial Intelligence Research, 01/03

Results



Performance for the kick drum was noticeably worse than for the hi-hat and snare. Performance also degraded when multiple pieces were played simultaneously. False onsets were generally correctly rejected, however rejection error increased with the addition of the tom and crash.



The prior constant dictates the likelihood of complex beats. A high constant encourages complex beats and a low constant restricts the output to simpler beats. The number of transcription errors shows a minimum between those two extremes.

Next Steps

- Handle rudiments and more drum kit pieces
- Allow dynamic BPM tracking and arbitrary meters
- Add training functionality to GUI
- Record longer takes

Acknowledgments

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