

BachDuet : A Deep Learning System for Human-Machine Counterpoint Improvisation

Christodoulos Benetatos¹, Joseph VanderStel², Zhiyao Duan¹

¹Department of Electrical and Computer Engineering, University of Rochester

²Eastman School of Music, University of Rochester

NIME 2020

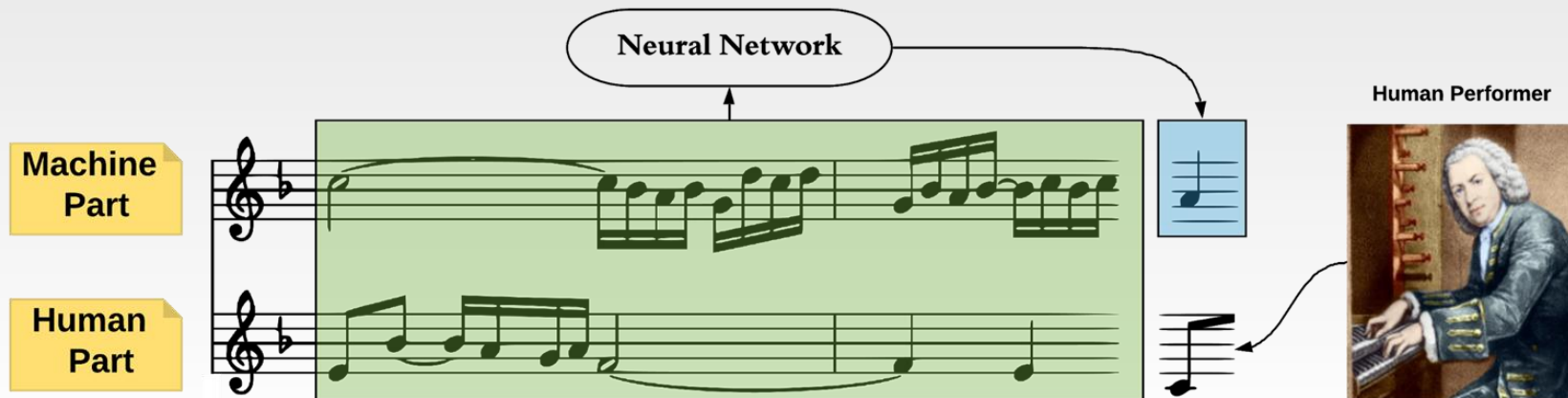
21-25 July, Royal Birmingham Conservatoire



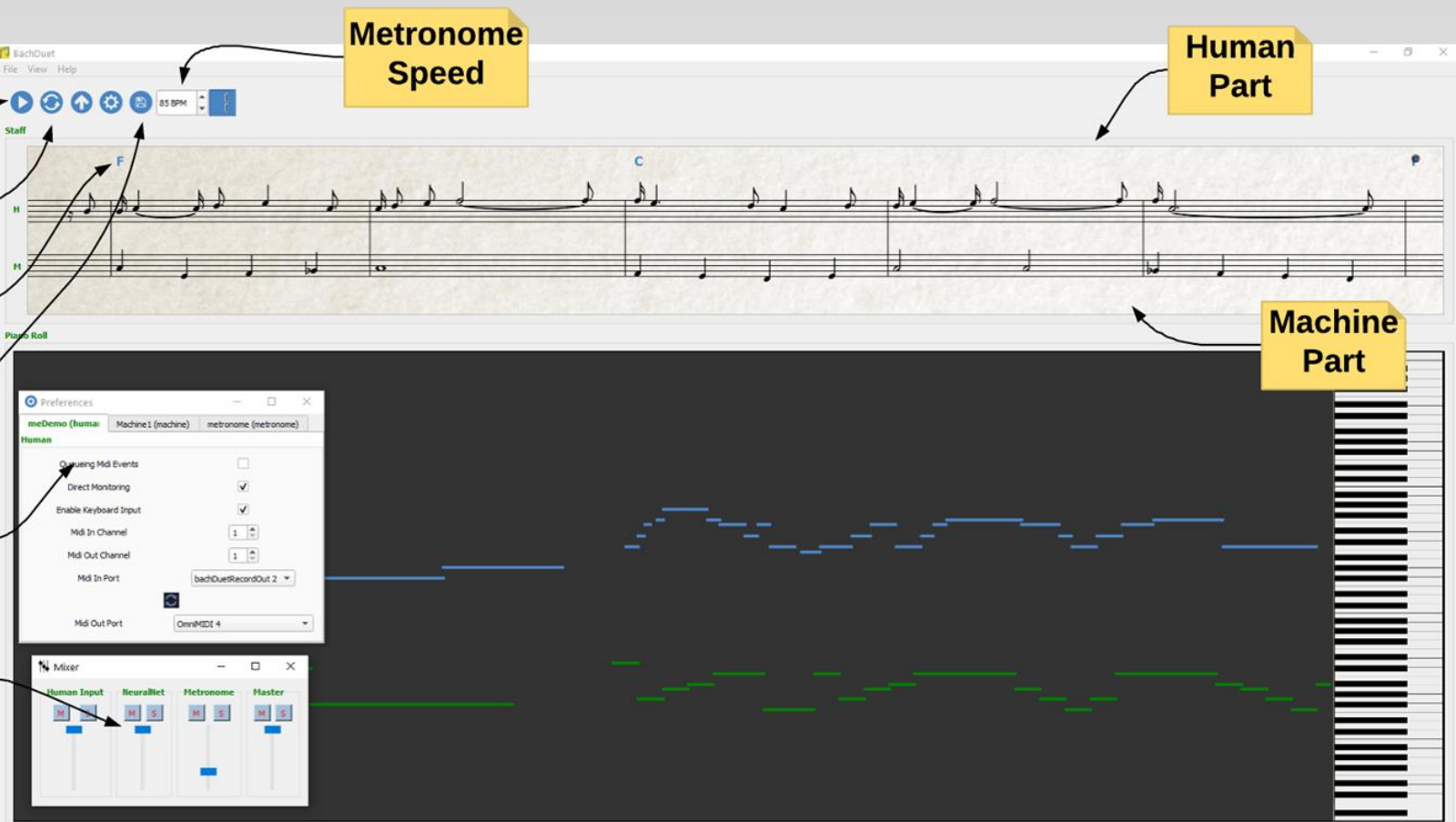
Proposed System

BachDuet enables a human performer to improvise a counterpoint duet with a computer agent in real time.

- Input: Human musician's monophonic performance on a MIDI keyboard
- Output: The machine's monophonic performance in real time generated by an RNN.



Graphical User Interface



The screenshot displays the BachDuet software interface, which includes a main score window and two smaller utility windows. The main window shows a musical score with two staves, a piano roll, and a keyboard view. The utility windows are 'Preferences' and 'Mixer'. Callouts in yellow boxes point to specific features:

- Play/Pause**: Points to the play/pause button in the top toolbar.
- Memory Reset**: Points to the memory reset button in the top toolbar.
- Key Indicator**: Points to the key indicator button in the top toolbar.
- Save to xml**: Points to the save to xml button in the top toolbar.
- Metronome Speed**: Points to the metronome speed control in the top toolbar.
- Human Part**: Points to the top staff of the musical score.
- Machine Part**: Points to the bottom staff of the musical score.
- Preference Settings**: Points to the Preferences window, which contains settings for 'meDemo (human)', 'Machine 1 (machine)', and 'metronome (metronome)'. The 'Human' section includes options for 'Generating Midi Events', 'Direct Monitoring', 'Enable Keyboard Input', 'Midi In Channel', 'Midi Out Channel', 'Midi In Port', and 'Midi Out Port'.
- Channel Mixer**: Points to the Mixer window, which shows volume sliders for 'Human Input', 'NeuralNet', 'Metronome', and 'Master'.

VI

The image displays a screenshot of a music software interface, likely a Digital Audio Workstation (DAW). The top portion shows a musical score with two staves of music, featuring various notes and rests. Below the score is a MIDI piano roll visualization, which is a dark area with a keyboard graphic on the right side. The piano roll shows two horizontal lines: a blue line representing the melody and a green line representing the accompaniment. The blue line starts at a higher pitch and moves downwards, while the green line starts at a lower pitch and moves upwards. In the bottom-left corner, there is a small inset video showing a person's hands playing a keyboard instrument.

Motivation - Goals

- Lack of improvisation culture in classical music
- Classical musicians either are not trained to improvise, or cannot find other people to improvise with
- Hopefully, BachDuet can be used both for education and entertainment purposes

Novelty

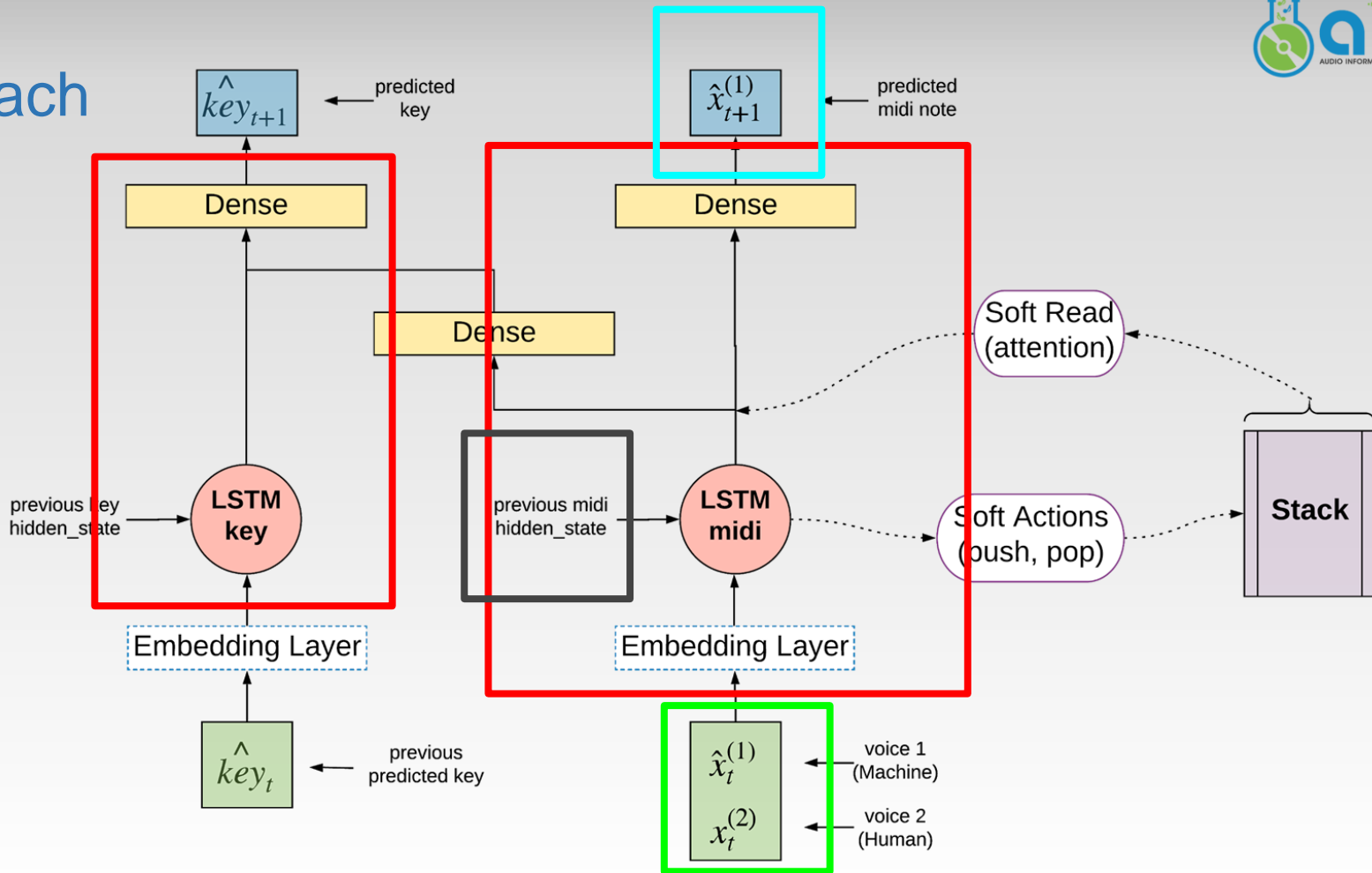
- Very few interactive classical music systems
- Most interactive music systems support the "call & response" interaction mode^{1,2,3}

¹ J. A. Biles et al. GenJam: A genetic algorithm for generating jazz solos. ICMC (1994)

² Y. Mann. AI duet. <https://experiments.withgoogle.com/ai/ai-duet>, (2016)

³ F. Pachet. The continuator: Musical interaction with style. JNMR (2003).

Approach



Subjective Tests

- **Group 1** (user study)
 - 13 musically trained participants
 - Above average keyboard and improvisation skills
 - Played with BachDuet (HM task) and with another human (HH task)
 - Answered a questionnaire about their experience
- **Group 2** (Turing listening test)
 - 48 musically trained participants
 - Listened to a random selection of duets from Group's 1 HH and HM tasks
 - Predicted which duets were HH and which were HM
 - Rated the quality of duets on a scale from 1 (dislike) to 5 (like)

Results

- **Group 1** (user study)
 - Things they liked
 - The GUI is intuitive and the visualization is very accurate
 - BachDuet's output is consistent with the Chorale style
 - The machine and the human have relatively equal roles in the improvisation
 - Most users think BachDuet can improve their improvisation skills
 - Things the disliked
 - The key prediction can be improved
 - Most users rated higher their interaction with another human(8.6/10), than with BachDuet (8/10)

Results

- **Group 2** (Turing listening test)
 - The HM duets received better (3.64/5 vs 3.54/5) but not statistically significant rating
 - Participants could not easily differentiate between HH and HM duets

true\predicted	HH	HM
HH	45.3%	54.7%
HM	48.1%	51.9%

HH vs HM clips



Human vs Machine
Human vs Human
(BachDuet)



Limitations

- 1) Fixed tempo
- 2) Trained on limited data
- 3) Only MIDI is supported (not Audio)
- 4) Impersonal type of interaction

Conclusions

- 1) Duet counterpoint improvisation is a feasible but not easy task for classical musicians
- 2) Users find BachDuet a good partner for duet improvisation
- 3) Listeners can't distinguish between HH and HM duets