UC San Diego

iem
**Institute of Engineering
in Medicine**

Towards Automatic Instrumentation by Learning to Separate Parts in Symbolic Multitrack Music

Hao-Wen Dong
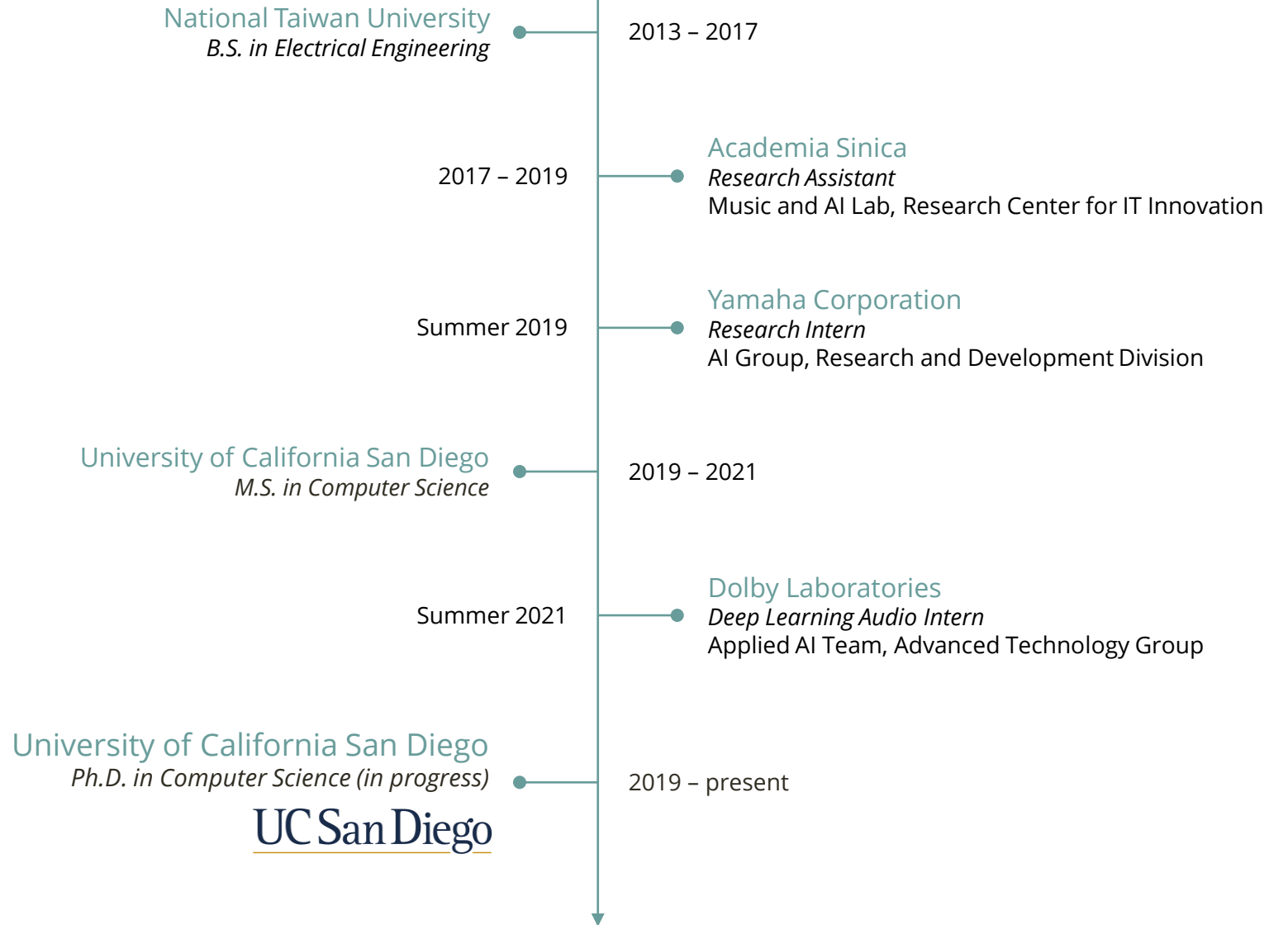
董皓文

Department of Computer Science and Engineering

Advisors: Prof. Julian McAuley and Prof. Taylor Berg-Kirkpatrick
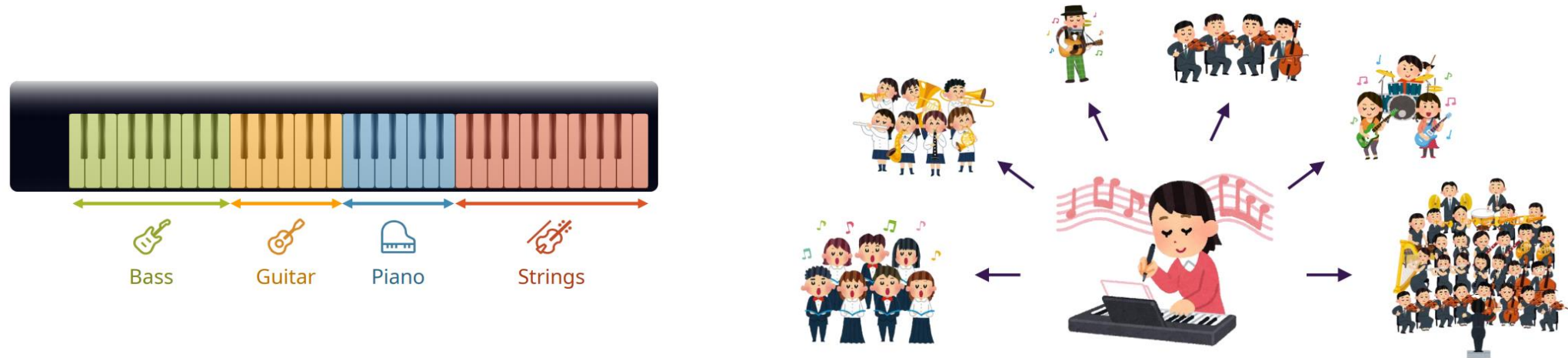
September 25, 2021

About me

Hi, I'm Herman.
I do Music x AI research.
I love music and movies!

National Taiwan University
B.S. in Electrical Engineering
2013 – 2017

Academia Sinica
Research Assistant
Music and AI Lab, Research Center for IT Innovation
2017 – 2019

Yamaha Corporation
Research Intern
AI Group, Research and Development Division
Summer 2019

University of California San Diego
M.S. in Computer Science
2019 – 2021

Dolby Laboratories
Deep Learning Audio Intern
Applied AI Team, Advanced Technology Group
Summer 2021

University of California San Diego
Ph.D. in Computer Science (in progress)
2019 – present

UC San Diego

Automatic instrumentation

- **Goal**—Dynamically assign instruments to notes in solo music

Hao-Wen Dong, Chris Donahue, Taylor Berg-Kirkpatrick and Julian McAuley, "Towards Automatic Instrumentation by Learning to Separate Parts in Symbolic Multitrack Music," Proceedings of the 22nd International Society for Music Information Retrieval Conference (ISMIR), in press, 2021.

Overview

- Acquire paired data of solo music and its instrumentation
  - Downmix multitracks into single-track mixtures

- Train a part separation model
  - Learn to infer the part label for each note in a mixture

- Approach automatic instrumentation
  - Treat input from a keyboard player as a downmixed mixture
  - Separate out the relevant parts
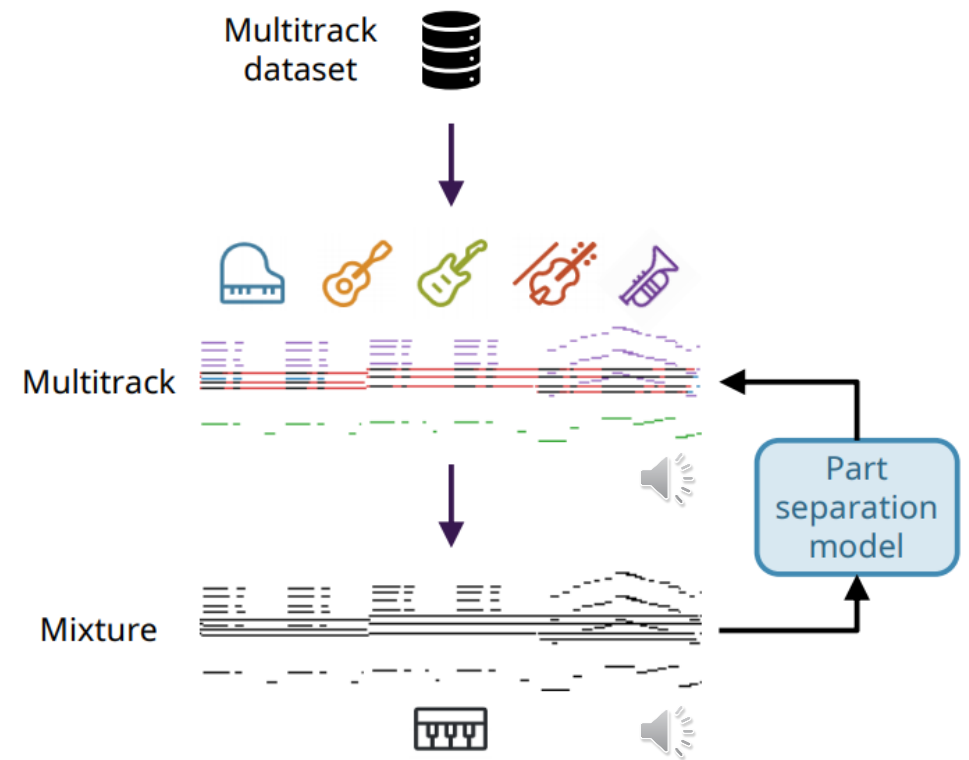
Data

- Four datasets of diverse genres and ensembles

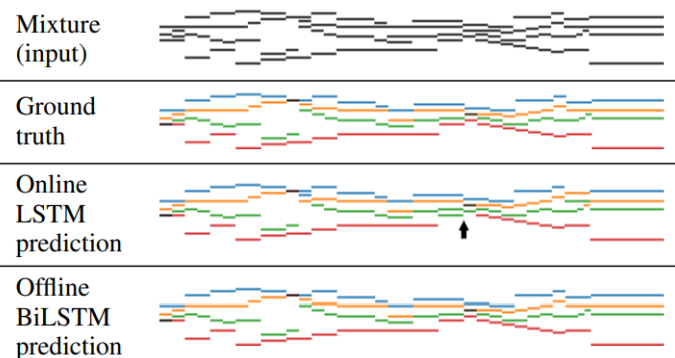| Dataset	Hours	Files	Notes	Parts	Ensemble	Most common label
Bach chorales [31]	3.23	409	96.6K	4	soprano, alto, tenor, bass	bass (27.05%)
String quartets [32]	6.31	57	226K	4	first violin, second violin, viola, cello	first violin (38.72%)
Game music [33]	45.05	4.61K	2.46M	3	pulse wave I, pulse wave II, triangle wave	pulse wave II (39.35%)
Pop music [34]	1.02K	16.2K	63.6M	5	piano, guitar, bass, strings, brass	guitar (42.50%)

Models & input features

Models

- Deep sequential models
  - Online: LSTM & Transformer Encoder
  - Offline: BiLSTM & Transformer Decoder

- Baseline models
  - Zone-based algorithm
  - Closest-pitch algorithm
  - Multilayer perceptron (MLP)

Input features

- time—onset time (in time step)

- pitch—pitch as a MIDI note number

- duration—note length (in time step)

- frequency—frequency of the pitch (in Hz)

- beat—onset time (in beat)
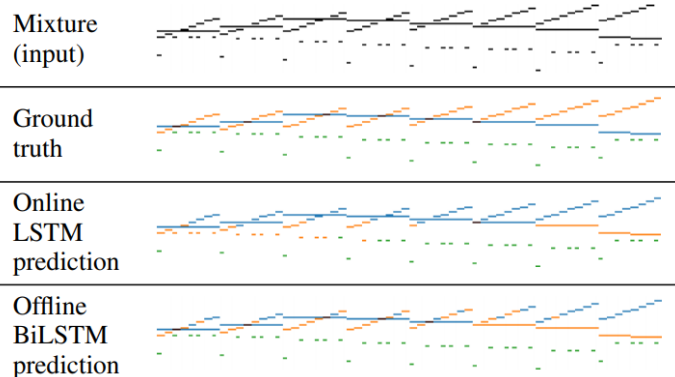
- position—position within a beat (in time step)

Qualitative results

Pop music

Mixture (input)

Ground truth

Online LSTM prediction

Offline BiLSTM prediction

(Audio available. [1] Colors: piano, guitar, bass, strings, brass.)

These examples are all hard cases!

Bach chorales

Mixture (input)

Ground truth

Online LSTM prediction

Offline BiLSTM prediction

(Audio available. [1] Colors: piano, soprano, tenor, bass.)

String quartets

Musical score

Mixture (input)

Ground truth

Online LSTM prediction

Offline BiLSTM prediction

Game music

Mixture (input)

Ground truth

Online LSTM prediction

Offline BiLSTM prediction

(Audio available. [1] Colors: pulse wave I, pulse wave II, triangle wave.)
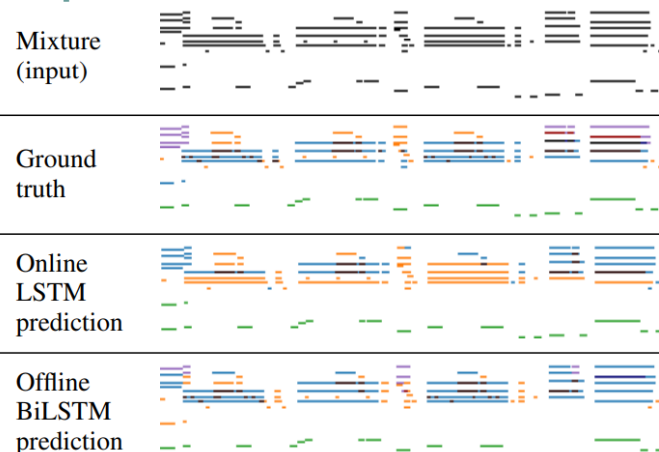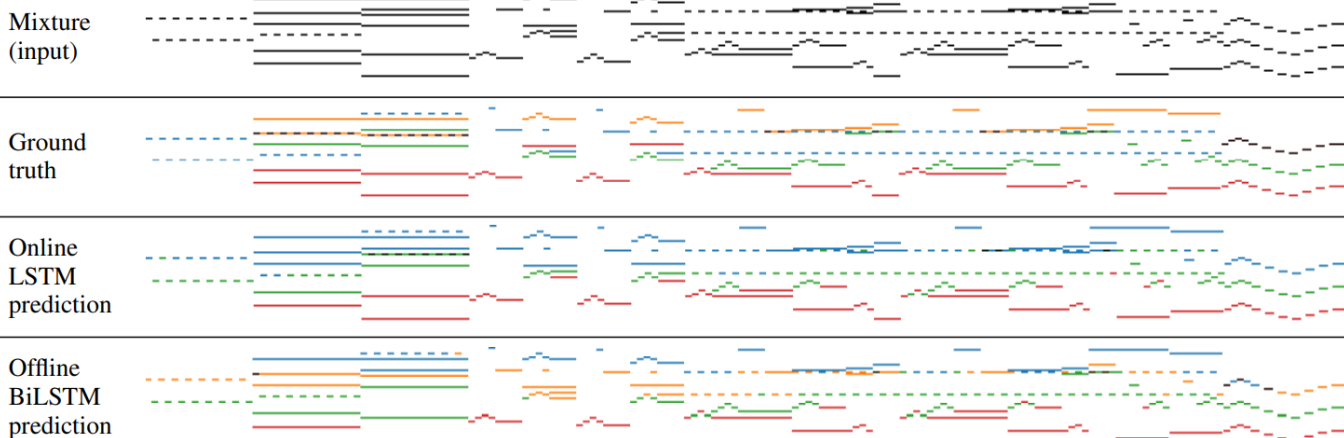
(Audio available. [1] Colors: first violin, second violin, viola, cello.)

Quantitative results

- Proposed models outperform baseline models

- BiLSTM outperforms LSTM

- LSTM models outperform their Transformer counterparts

Model	Bach	String	Game	Pop
Online models				
Zone-based	73.14	58.85	43.67	57.07
MLP [9]	81.63	29.85	43.08*	33.50*
LSTM	**93.02**	**67.43**	**50.22**	**74.14**
Transformer-Dec	91.51	57.03	45.82	62.14
Zone-based (oracle)	78.33	66.89	79.54*	†
MLP [9] (oracle)	97.59	58.16	65.30	44.62
Offline models				
BiLSTM	**97.13**	**74.38**	**52.93**	**77.23**
Transformer-Enc	96.81	58.86	49.14	66.57
Online models (+entry hints)				
Closest-pitch	68.87	50.69	57.14	47.45
Closest-pitch (mono)	89.76	42.82	49.91	32.28
LSTM	**92.70**	**62.64**	**62.11**	**74.19**
Transformer-Dec	91.17	62.12	56.73	67.19
Offline models (+entry hints)				
BiLSTM	**97.39**	**71.51**	**64.79**	**75.59**
Transformer-Enc	93.81	56.72	54.67	67.23

Demo

- The proposed models can produce alternative convincing instrumentations for an existing arrangement

Original

LSTM without entry hints

BiLSTM with entry hints

(Audio available. [1] Colors: piano, guitar, bass, strings, brass.)

Summary

- Proposed a new task of part separation

- Showed that our proposed models outperform various baselines

- Presented promising results for applying a part separation model to automatic instrumentation

Future directions

- Generative modeling of automatic instrumentation

- Unpaired automatic instrumentation

- Large-scale pretraining for symbolic music models

Acknowledgement

- This is a joint work with Chris Donahue, Taylor Berg-Kirkpatrick and Julian McAuley.

- I would like to thank the J. Yang and Family Foundation for supporting my PhD study with the J. Yang Scholarship.

Thank you!