Generative AI for Music and Audio

Hao-Wen (Herman) Dong

UC San Diego

About Me

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

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

Academia Sinica — 2017 – 2019
Research Assistant

UC San Diego — 2019 – 2021
M.S. in Computer Science

UC San Diego — 2019 – *present*
Ph.D. in Computer Science (expected)

Yamaha — Summer 2019
Research Intern

Dolby — Summer 2021
Deep Learning Audio Intern

Sony — Summer 2022
Student Intern

Amazon — Fall 2022
Applied Scientist Intern

Dolby — Winter 2023
Speech/Audio Deep Learning Intern

Adobe — Summer 2023
Research Scientist/Engineer Intern

NVIDIA — Fall 2023
Research Intern

Introduction


Mumbai, the city of dreams.

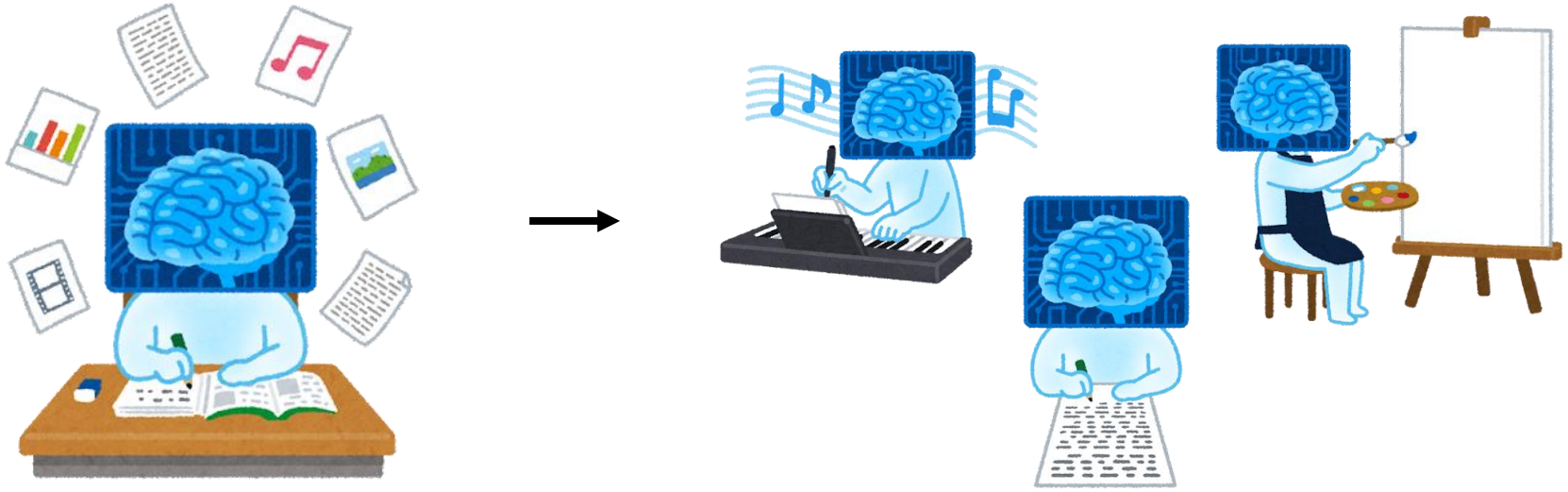
Multimodal Generative AI for Films

Visuals	**Midjourney**
Video	**Runway**
Narration (script)	**ChatGPT**
Narration (voice)	**ElevenLabs**
Sound effects	**Audiocraft**

Sagar Amruth, *Twitter*, https://twitter.com/sagartheamruth/status/1688530899271364608, August 7, 2023.

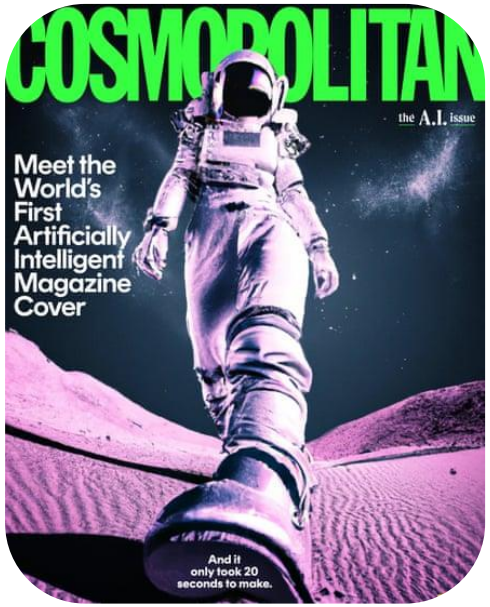
What is Generative AI?

- Generative AI is **AI capable of generating text, images, or other media.**



Generative AI for Visual Arts

AI made a magazine cover



(Source: Cosmopolitan)

AI won an art contest

(Source: CNN Business)

AI won a photography contest

(Source: CNN)

Gloria Liu, "The World's Smartest Artificial Intelligence Just Made Its First Magazine Cover," *Cosmopolitan*, June 21, 2022.
Rachel Metz, "AI won an art contest, and artists are furious," *CNN Business*, September 3, 2022.
Lianne Kolirin, "Artist rejects photo prize after AI-generated image wins award," *CNN*, April 18, 2023.

Types of Audio

Speech

(Source: Wikimedia Commons)

Music

(Source: Wikimedia Commons)

Sound effects

(Source: Wikimedia Commons)

BPJ Media Inc, CC BY-SA 3.0, via Wikimedia Commons.
Vancouver Film SchoolRetouched version by User:Quenhitran., CC BY 2.0, via Wikimedia Commons.
The Blackbird Academy, CC BY-SA 2.0, via Wikimedia Commons.
One Man Films, "One Shot - WAR ACTION SHORT FILM," *YouTube*, September 11, 2022.

Generative AI for Music

Prompt: relaxing and smooth jazz played in a stylish cafe

Prompt: delightful country music with acoustic guitars

Prompt: cinematic and suspenseful orchestral music

Made with Facebook MusicGen (huggingface.co/spaces/facebook/MusicGen)

Generative AI for Sound Effects

Text-to-audio Synthesis

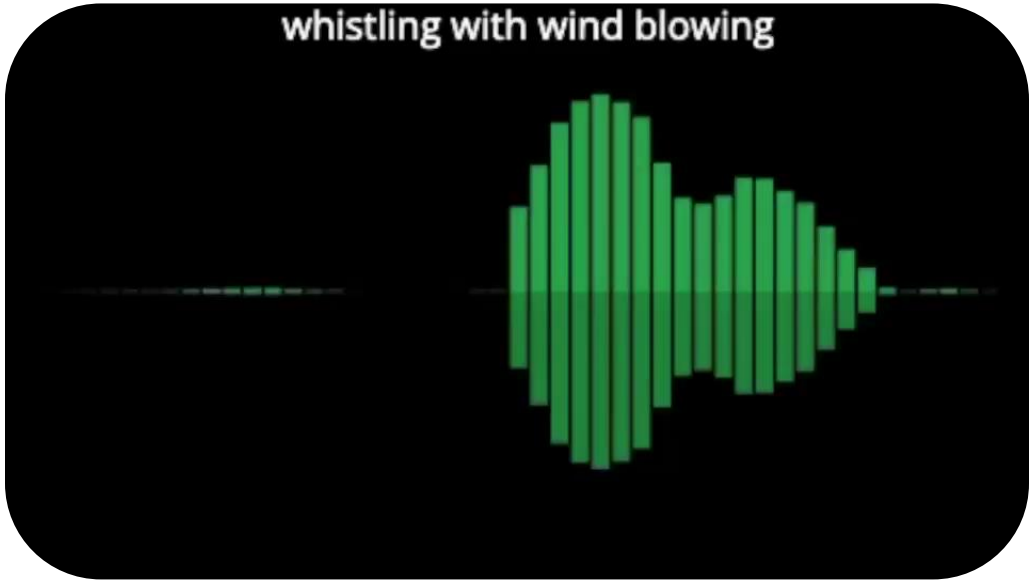
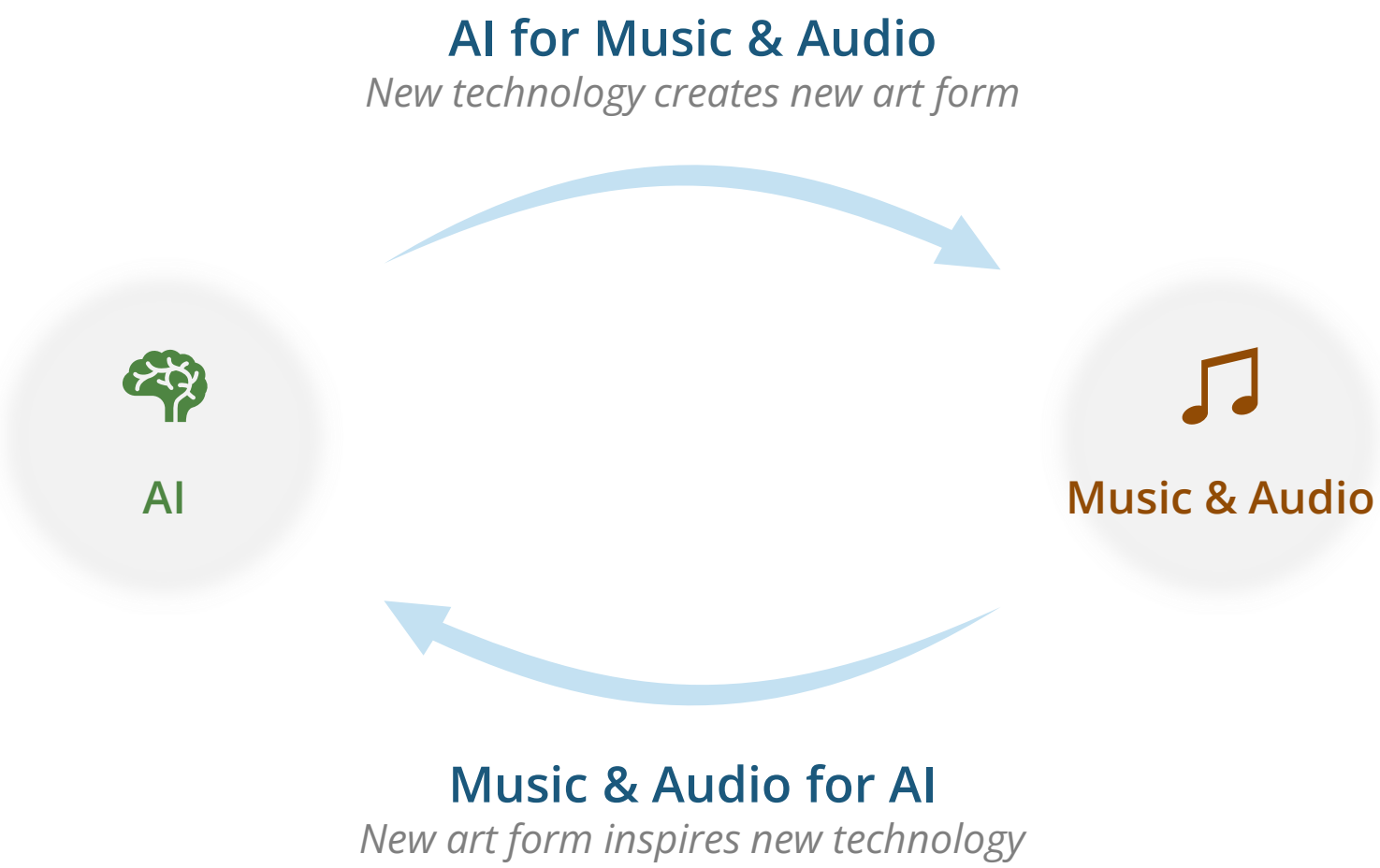


Image-to-audio Synthesis

Liu et al., "AudioLDM: Text-to-Audio Generation with Latent Diffusion Models," *ICML*, 2023.
Dong et al., "CLIPSonic: Text-to-Audio Synthesis with Unlabeled Videos and Pretrained Language-Vision Models," *WASPAA*, 2023.

My Research


AI for Music & Audio
New technology creates new art form
AI
Music & Audio
Music & Audio for AI
New art form inspires new technology

My Research

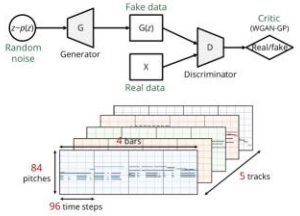
Generative AI for Music & Audio

Empowering music and audio creation with machine learning

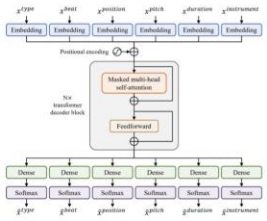
Multitrack Music Generation

Advancing deep generative models for multitrack music

MuseGAN
(AAAI 2018)



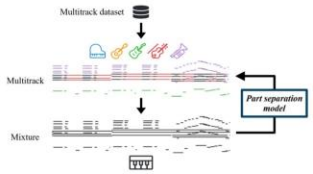
MMT
(ICASSP 2023)



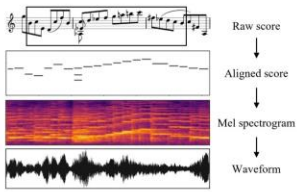
Assistive Music Creation Tools

Developing AI-augmented assistive music creation tools

Arranger
(ISMIR 2021)



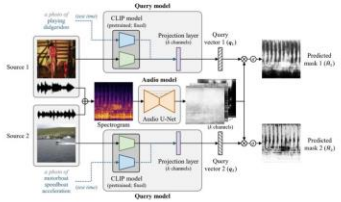
Deep Performer
(ICASSP 2022)



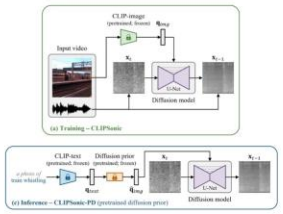
Multimodal Learning for Audio & Music

Learning sound separation and synthesis from videos

CLIPSep
(ICLR 2023)



CLIPSonic
(WASPAA 2023)



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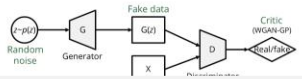

MMT
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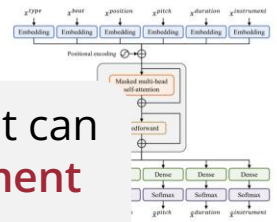

First deep neural net that can **generate multi-instrument music from scratch**

Assistive Music Creation Tools

Developing AI-augmented assistive music creation tools

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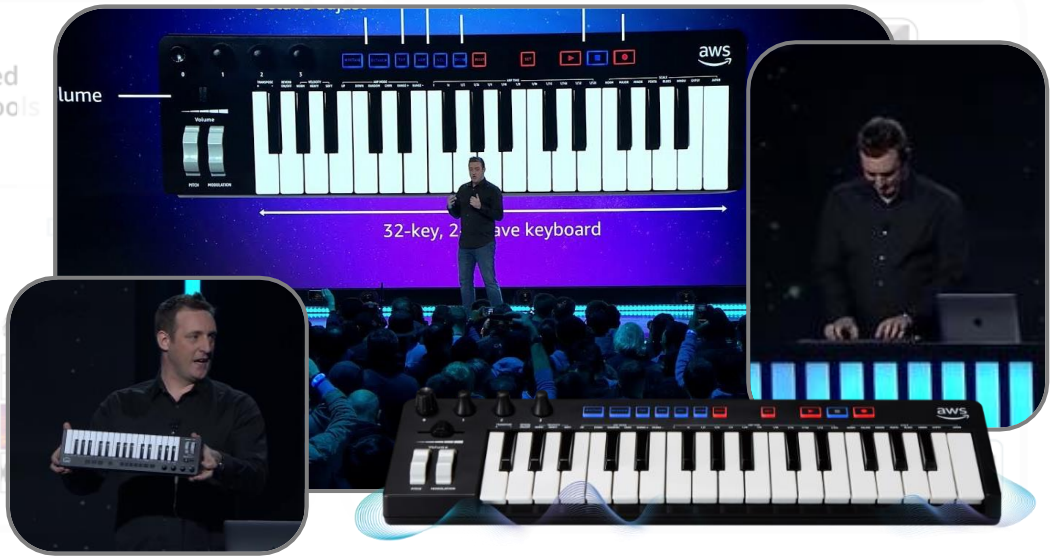
(ISMIR 2021)

Multimodal Learning for Audio & Music



Featured in Amazon AWS DeepComposer

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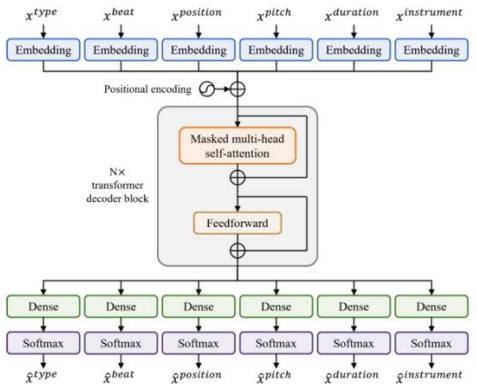

Will be discussed later!

Orchestral music generation

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CLIPSonic (WASPAA 2023)

Automatic instrumentation

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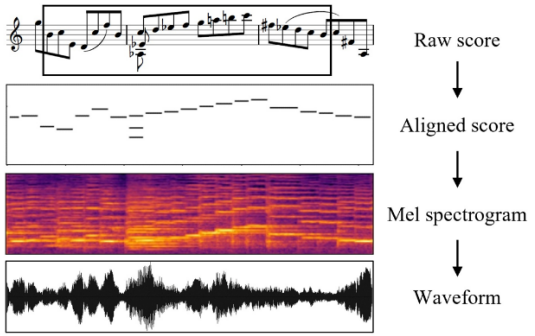

Score-to-audio synthesis

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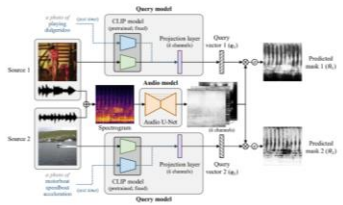
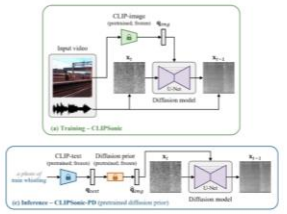
(ICLR 2023)



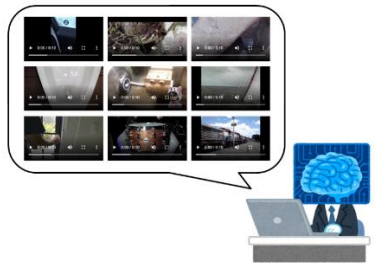
CLIPSonic
(WASPAA 2023)



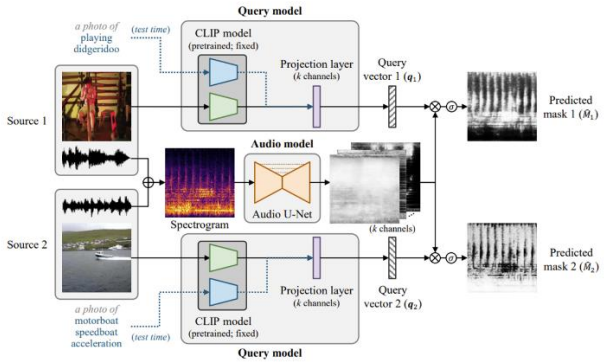
My Research

Multimodal Learning for Audio & Music

Learning sound separation and synthesis from videos



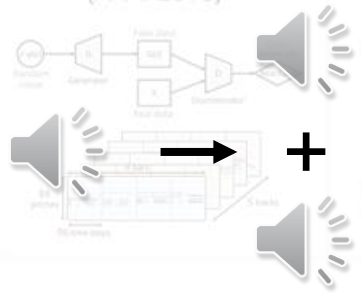
CLIPSep
(ICLR 2023)



Text-queried sound separation

CLIPSonic
(WASPAA 2023)

First text-queried universal sound separation model that can be trained **using only unlabeled videos**

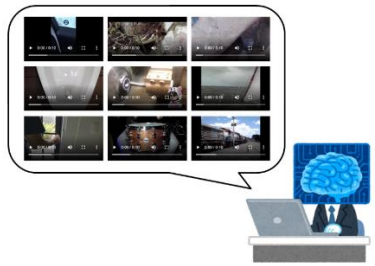


Query:
"*playing harpsichord*"

My Research

Multimodal Learning for Audio & Music

Learning sound separation and synthesis from videos



CLIPSep (ICLR 2023)

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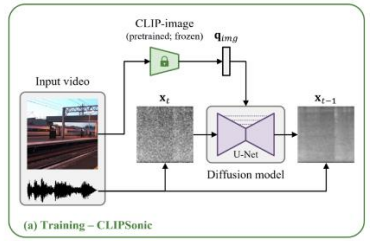

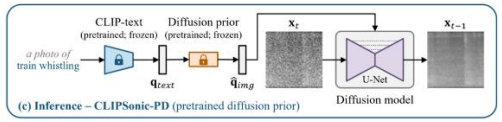

Text-to-audio synthesis

Will be discussed later!

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Multitrack Music Generation

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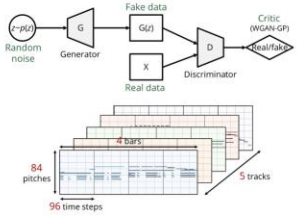
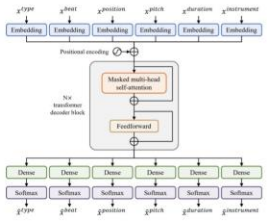
(AAAI 2018)



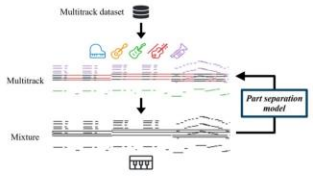
MMT
(ICASSP 2023)



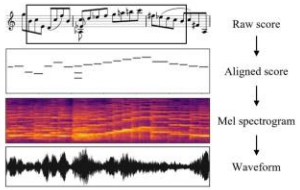
Assistive Music Creation Tools

Developing AI-augmented assistive music creation tools

Arranger
(ISMIR 2021)



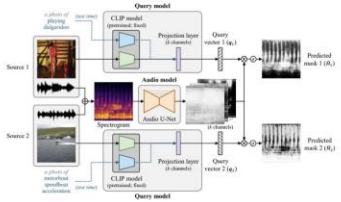
Deep Performer
(ICASSP 2022)



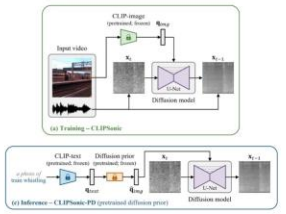
Multimodal Learning for Audio & Music

Learning sound separation and synthesis from videos

CLIPSep
(ICLR 2023)



CLIPSonic
(WASPAA 2023)



My Research

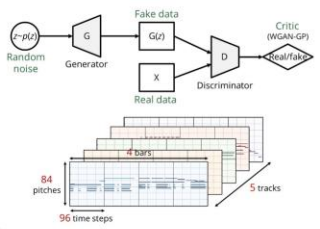
Generative AI for Music & Audio

Empowering music and audio creation with machine learning

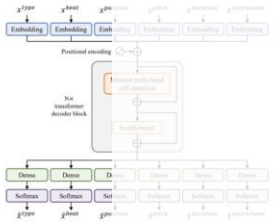
Multitrack Music Generation

Generating new music contents automatically

MuseGAN
(AAAI 2018)



Multitrack Music Transformer
(ICASSP 2023)



Assistive Music Creation Tools

Assisting humans to create and perform music

Arranger
(ISMIR 2021)

Deep Performer
(ICASSP 2022)

Multimodal Learning for Audio & Music

Learning sound separation and synthesis from videos

CLIPSep
(ICLR 2023)

CLIPSonic
(WASPAA 2023)

Multitrack Music Transformer

Hao-Wen Dong Ke Chen Shlomo Dubnov Julian McAuley Taylor Berg-Kirkpatrick

University of California San Diego





UC San Diego

Overview

Generate orchestral music

- of diverse instruments
- using a new compact representation
- with a multi-dimensional transformer

(Source: Vienna Mozart Orchestra)

Related Work (Transformers for Music Generation)

Model	Multitrack	Instrument control	Compound tokens	Generative modeling
REMI [5]				✓
MMM [10]	✓			✓
CP [6]			✓	✓
MusicBERT [15]	✓		✓	
FIGARO [11]	✓			✓
MMT (ours)	✓	✓	✓	✓

	Average sample length (sec)	Inference speed (notes per second)
MMM [10]	38.69	5.66
REMI+ [11]	28.69	3.58
MMT (ours)	**100.42**	**11.79**

Longer samples!
Faster inference speed!

Huang and Yang, "Pop Music Transformer: Beat-based Modeling and Generation of Expressive Pop Piano Compositions," *MM*, 2020.
Ens and Pasquier, "MMM : Exploring Conditional Multi-Track Music Generation with the Transformer," *arXiv preprint arXiv:2008.06048*, 2020.
Hsiao et al., "Compound Word Transformer: Learning to Compose Full-Song Music over Dynamic Directed Hypergraphs," *AAAI*, 2023.
Zeng et al., "MusicBERT: Symbolic Music Understanding with Large-Scale Pre-Training," *Findings of ACL*, 2021.
von Rütte et al., "FIGARO: Controllable Music Generation using Learned and Expert Features," *ICLR*, 2023.

Representation

- We represent a music piece as a sequence of events

$$\mathbf{x} = (\mathbf{x}_1, \ldots, \mathbf{x}_n)$$

- Each event $\mathbf{x}_i$ is encoded as

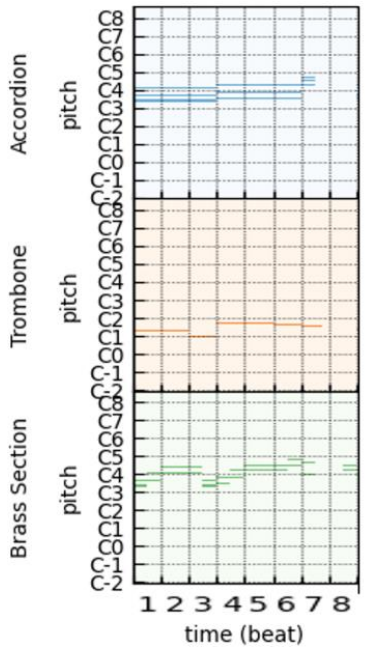
$$\mathbf{x}_i = (x_i^{type}, x_i^{beat}, x_i^{position}, x_i^{pitch}, x_i^{duration}, x_i^{instrument})$$

Specify note & instrument information

5 event types

- Structural
  - Start of song
  - Start of notes
  - End of song
- Data
  - Instrument
  - Note

Representation (An Example)



Structural events

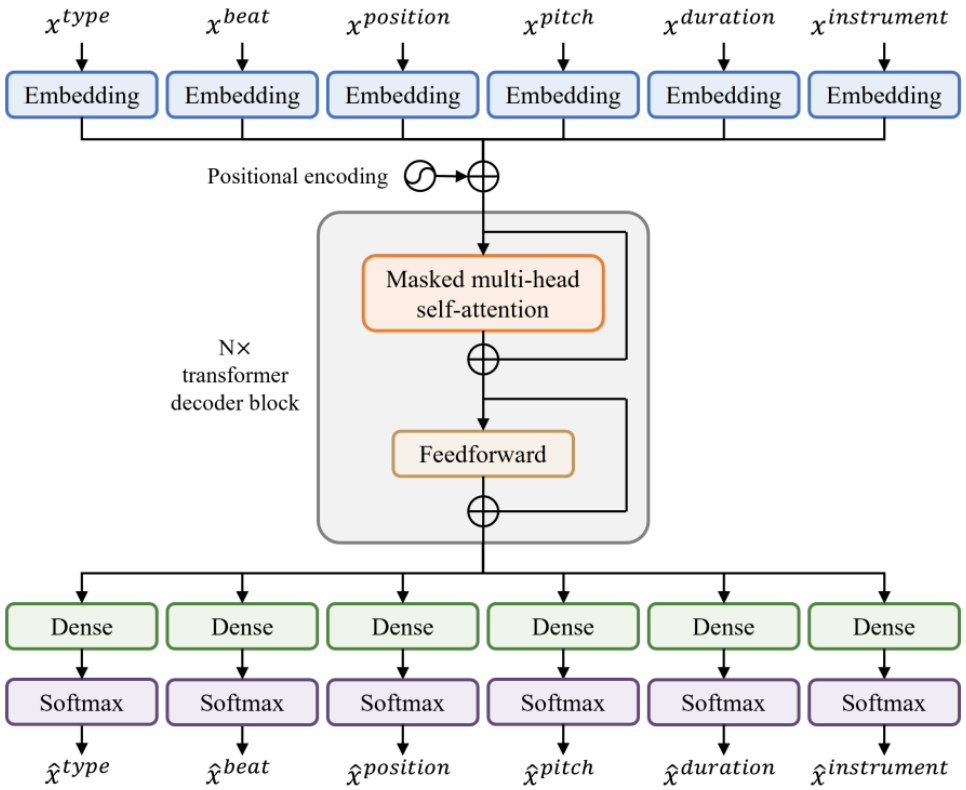
```
(0, 0,  0,  0,  0,  0)   Start of song
(1, 0,  0,  0,  0, 15)   Instrument: accordion
(1, 0,  0,  0,  0, 36)   Instrument: trombone
(1, 0,  0,  0,  0, 39)   Instrument: brasses
(2, 0,  0,  0,  0,  0)   Start of notes
(3, 1,  1, 41, 15, 36)   Note: beat=1, position=1,  pitch=E2, duration=48, instrument=trombone
(3, 1,  1, 65,  4, 39)   Note: beat=1, position=1,  pitch=E4, duration=12, instrument=brasses
(3, 1,  1, 65, 17, 15)   Note: beat=1, position=1,  pitch=E4, duration=72, instrument=accordion
(3, 1,  1, 68,  4, 39)   Note: beat=1, position=1,  pitch=G4, duration=12, instrument=brasses
(3, 1,  1, 68, 17, 15)   Note: beat=1, position=1,  pitch=G4, duration=72, instrument=accordion
(3, 1,  1, 73, 17, 15)   Note: beat=1, position=1,  pitch=C5, duration=72, instrument=accordion
(3, 1, 13, 68,  4, 39)   Note: beat=1, position=13, pitch=G4, duration=12, instrument=brasses
(3, 1, 13, 73,  4, 39)   Note: beat=1, position=13, pitch=C5, duration=12, instrument=brasses
(3, 2,  1, 73, 12, 39)   Note: beat=2, position=1,  pitch=C5, duration=36, instrument=brasses
(3, 2,  1, 77, 12, 39)   Note: beat=2, position=1,  pitch=E5, duration=36, instrument=brasses
          ...                ...
(4, 0,  0,  0,  0,  0)   End of song
```

Instrument events

Note events

Multitrack Music Transformer

- A multi-dimensional decoder-only transformer model
  - Predict six fields *at the same time*
- Trained autoregressively
  - Predict the next event given past events



Three Sampling Modes

Unconditional generation

Input

```
(0, 0,  0,  0,  0,  0)  Start of song
(1, 0,  0,  0,  0, 15)  Instrument: accordion
(1, 0,  0,  0,  0, 36)  Instrument: trombone
(1, 0,  0,  0,  0, 39)  Instrument: brasses
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(3, 2,  1, 77, 12, 39)  Note: beat=2, position=1,  pitch=E5, duration=36, instrument=brasses
   ...                  ...
(4, 0,  0,  0,  0,  0)  End of song
```

Instrument-informed generation

Input

```
(0, 0,  0,  0,  0,  0)  Start of song
(1, 0,  0,  0,  0, 15)  Instrument: accordion
(1, 0,  0,  0,  0, 36)  Instrument: trombone
(1, 0,  0,  0,  0, 39)  Instrument: brasses
(2, 0,  0,  0,  0,  0)  Start of notes
(3, 1,  1, 41, 15, 36)  Note: beat=1, position=1,  pitch=E2, duration=48, instrument=trombone
(3, 1,  1, 65,  4, 39)  Note: beat=1, position=1,  pitch=E4, duration=12, instrument=brasses
(3, 1,  1, 65, 17, 15)  Note: beat=1, position=1,  pitch=E4, duration=72, instrument=accordion
(3, 1,  1, 68,  4, 39)  Note: beat=1, position=1,  pitch=G4, duration=12, instrument=brasses
(3, 1,  1, 68, 17, 15)  Note: beat=1, position=1,  pitch=G4, duration=72, instrument=accordion
(3, 1,  1, 73, 17, 15)  Note: beat=1, position=1,  pitch=C5, duration=72, instrument=accordion
(3, 1, 13, 68,  4, 39)  Note: beat=1, position=13, pitch=G4, duration=12, instrument=brasses
(3, 1, 13, 73,  4, 39)  Note: beat=1, position=13, pitch=C5, duration=12, instrument=brasses
(3, 2,  1, 73, 12, 39)  Note: beat=2, position=1,  pitch=C5, duration=36, instrument=brasses
(3, 2,  1, 77, 12, 39)  Note: beat=2, position=1,  pitch=E5, duration=36, instrument=brasses
   ...                  ...
(4, 0,  0,  0,  0,  0)  End of song
```

N-beat continuation

Input

```
(0, 0,  0,  0,  0,  0)  Start of song
(1, 0,  0,  0,  0, 15)  Instrument: accordion
(1, 0,  0,  0,  0, 36)  Instrument: trombone
(1, 0,  0,  0,  0, 39)  Instrument: brasses
(2, 0,  0,  0,  0,  0)  Start of notes
(3, 1,  1, 41, 15, 36)  Note: beat=1, position=1,  pitch=E2, duration=48, instrument=trombone
(3, 1,  1, 65,  4, 39)  Note: beat=1, position=1,  pitch=E4, duration=12, instrument=brasses
(3, 1,  1, 65, 17, 15)  Note: beat=1, position=1,  pitch=E4, duration=72, instrument=accordion
(3, 1,  1, 68,  4, 39)  Note: beat=1, position=1,  pitch=G4, duration=12, instrument=brasses
(3, 1,  1, 68, 17, 15)  Note: beat=1, position=1,  pitch=G4, duration=72, instrument=accordion
(3, 1,  1, 73, 17, 15)  Note: beat=1, position=1,  pitch=C5, duration=72, instrument=accordion
(3, 1, 13, 68,  4, 39)  Note: beat=1, position=13, pitch=G4, duration=12, instrument=brasses
(3, 1, 13, 73,  4, 39)  Note: beat=1, position=13, pitch=C5, duration=12, instrument=brasses
(3, 2,  1, 73, 12, 39)  Note: beat=2, position=1,  pitch=C5, duration=36, instrument=brasses
(3, 2,  1, 77, 12, 39)  Note: beat=2, position=1,  pitch=E5, duration=36, instrument=brasses
   ...                  ...
(4, 0,  0,  0,  0,  0)  End of song
```

Only needs to train ONE model!

Example Results

Unconditional generation

Instrument-informed generation

church-organ, viola, contrabass, strings, voices, horn, oboe

4-beat continuation

Wolfgang Amadeus Mozart's Eine kleine Nachtmusik

OttoPilot33, "Eine Kleine Nachtmusik - By My MIDI Virtual Orchestra." https://youtu.be/_g8iCdY34jc

Subjective Listening Test Results

	Number of parameters	Average sample length (sec)	Inference speed (notes per second)	Subjective listening test results			
				Coherence	Richness	Arrangement	Overall
MMM [10]	19.81 M	38.69	5.66	3.48 ± 0.35	3.05 ± 0.38	3.28 ± 0.37	3.17 ± 0.43
REMI+ [11]	20.72 M	28.69	3.58	$\mathbf{3.90 \pm 0.52}$	$\mathbf{3.74 \pm 0.21}$	$\mathbf{3.74 \pm 0.44}$	$\mathbf{3.77 \pm 0.41}$
MMT (ours)	19.94 M	**100.42**	**11.79**	3.55 ± 0.46	3.53 ± 0.35	3.40 ± 0.44	3.33 ± 0.47

2.6x/**3.5x longer** generated samples
(within the same sequence length)

2.1x/**3.3x faster** inference speed

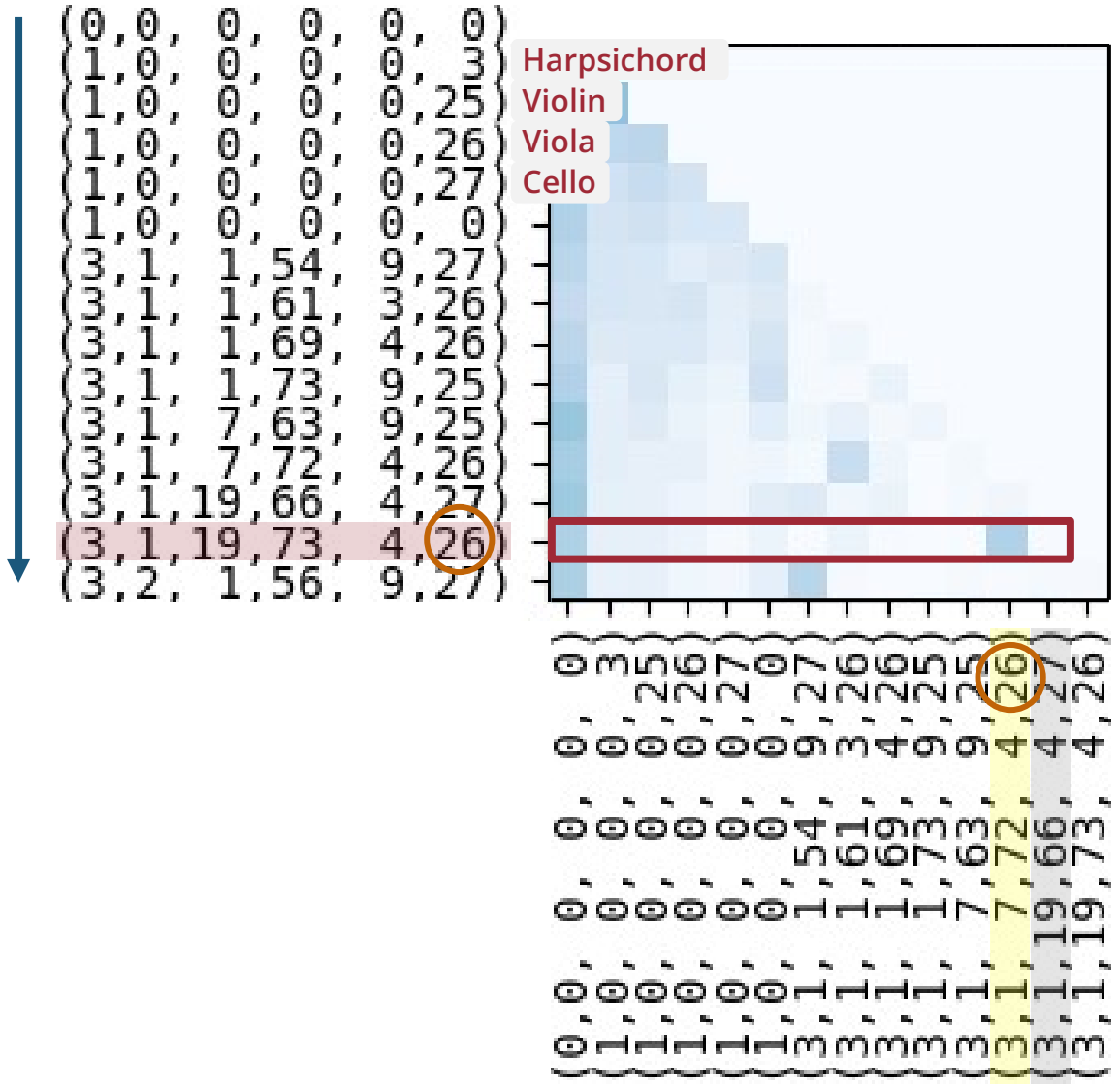
Generated music quality in between MMM & REMI+

Trade-off between speed and quality!

Ens and Pasquier, "MMM : Exploring Conditional Multi-Track Music Generation with the Transformer," *arXiv preprint arXiv:2008.06048*, 2020.
von Rütte et al., "FIGARO: Controllable Music Generation using Learned and Expert Features," *ICLR*, 2023.

Musical Self-attention

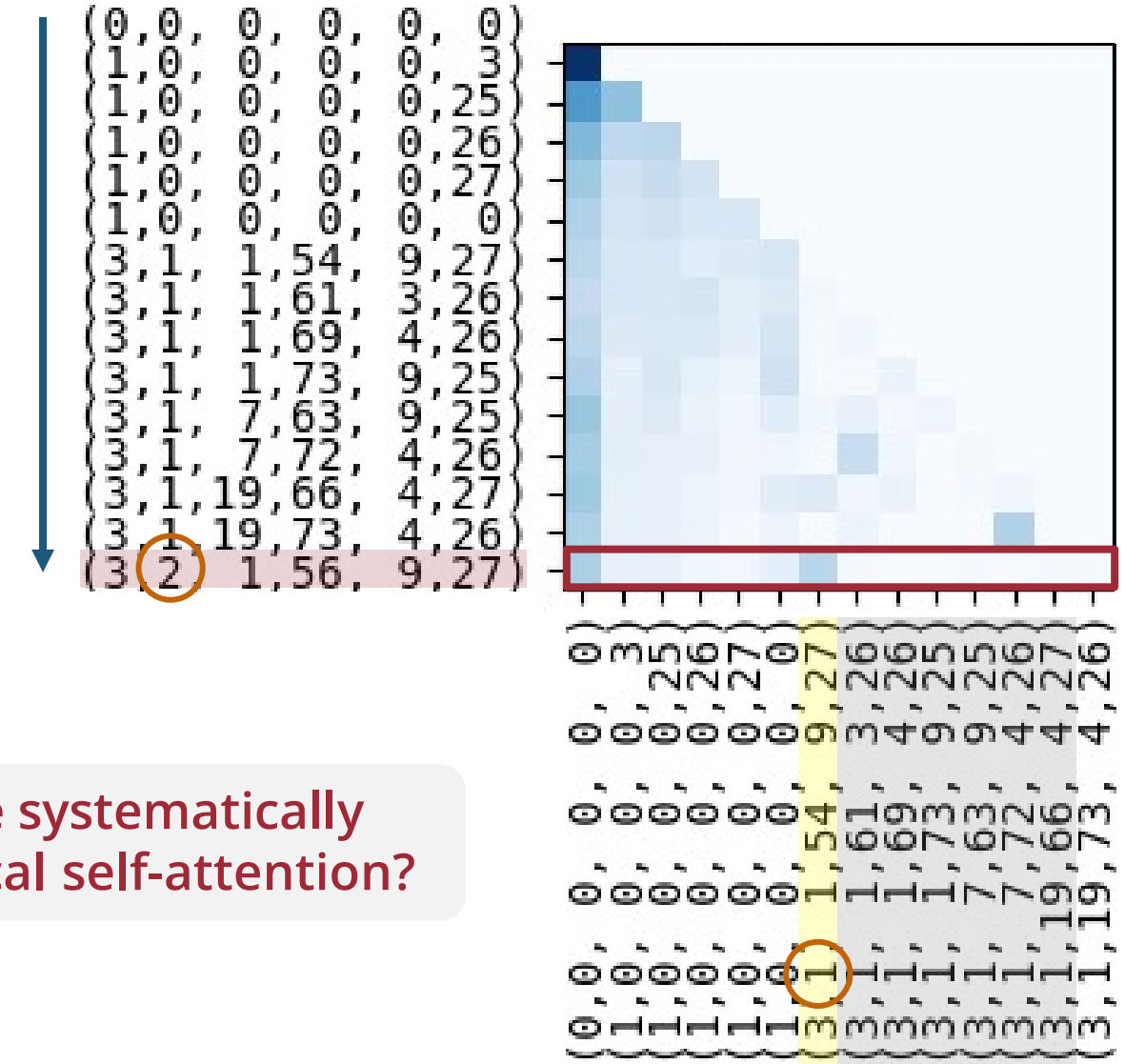
Autoregressive generation



Attend to the last viola note

Musical Self-attention

Autoregressive generation



How can we systematically analyze musical self-attention?

Attend to the first note

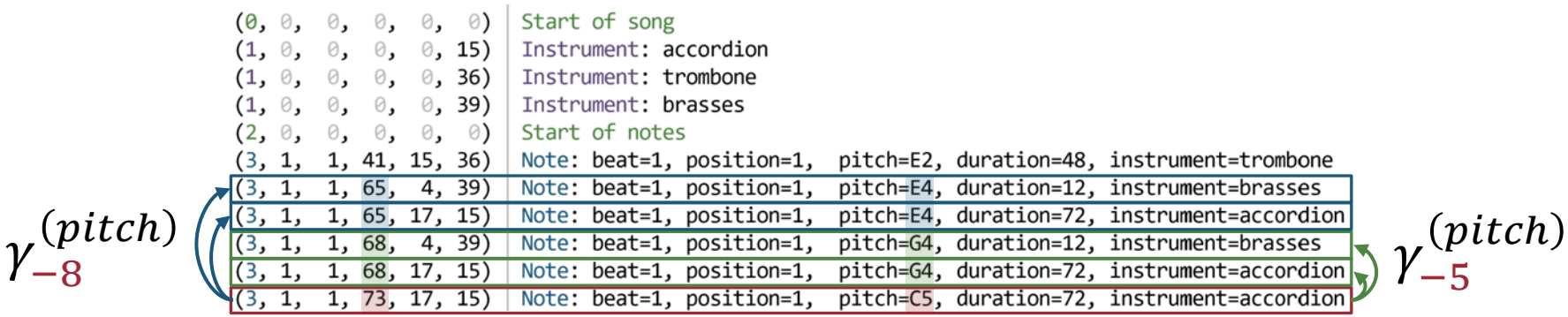
Measuring Self-attention

- Mean relative attention for a field d:

Attention weight

$$\gamma_k^{(d)} = \frac{\sum_{x \in \mathcal{D}} \sum_{s>t} a_{s,t}(\mathbf{x}) \, 1_{x_t^{(d)} - x_s^{(d)} = k}}{\sum_{x \in \mathcal{D}} \sum_{s>t} a_{s,t}(\mathbf{x})}$$

Whether the field value is of difference k



Measuring Self-attention

- Mean relative attention for a field d:

$$\gamma_k^{(d)} = \frac{\sum_{x \in \mathcal{D}} \sum_{s>t} a_{s,t}(\mathbf{x})\, 1_{x_t^{(d)} - x_s^{(d)} = k}}{\sum_{x \in \mathcal{D}} \sum_{s>t} a_{s,t}(\mathbf{x})}$$

Biased towards difference that occurred more frequently!

- Mean relative attention gain for a field d:

$$\tilde{\gamma}_k^{(d)} = \gamma_k^{(d)} - \frac{\sum_{x \in \mathcal{D}} \sum_{s>t} 1_{x_t^{(d)} - x_s^{(d)} = k}}{\sum_{x \in \mathcal{D}} \sum_{s>t} \boxed{1}}$$

Assuming a uniform attention matrix

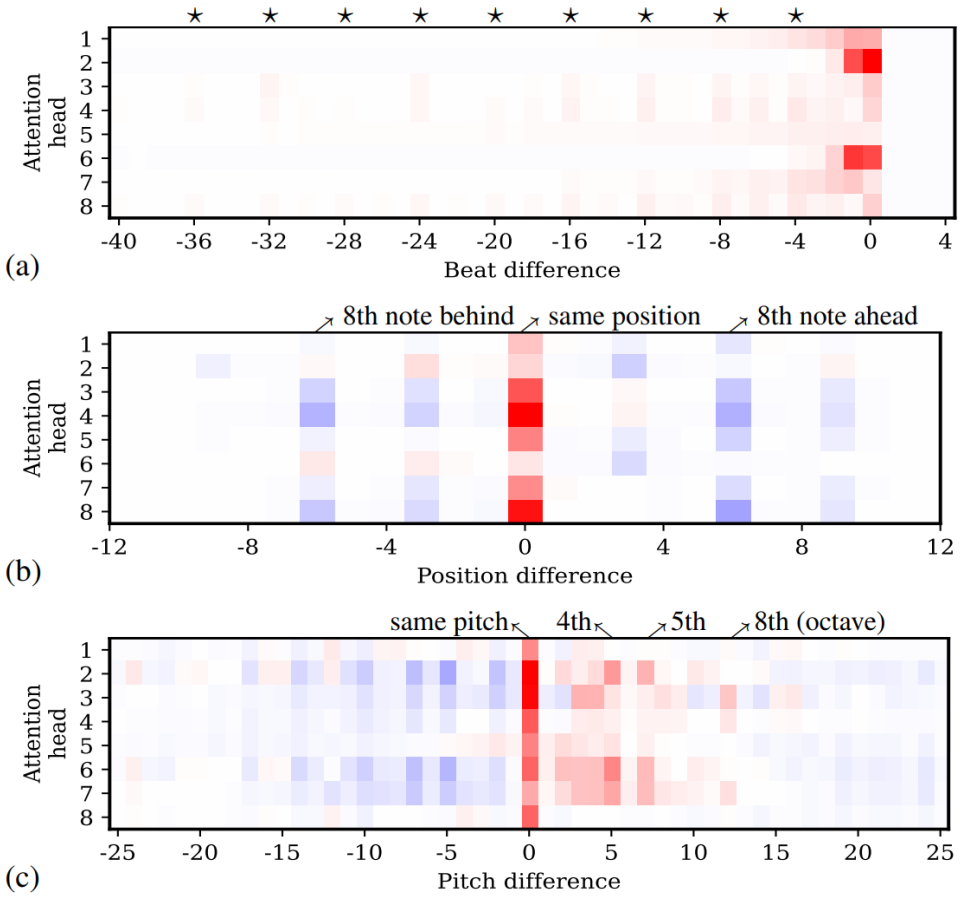
Analyzing Musical Self-attention

The MMT model attends more to notes

- that are $4N$ beats away in the past
- that have the same position (e.g., on-beat and off-beat) as the current note
- that has a pitch in an octave above which forms a consonant interval

MMT learns a relative self-attention for beat, position and pitch.

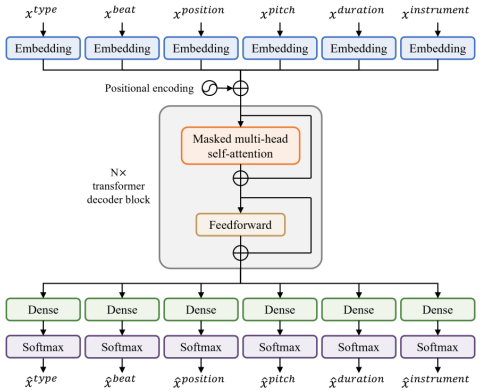
Positive and negative mean relative attention gain



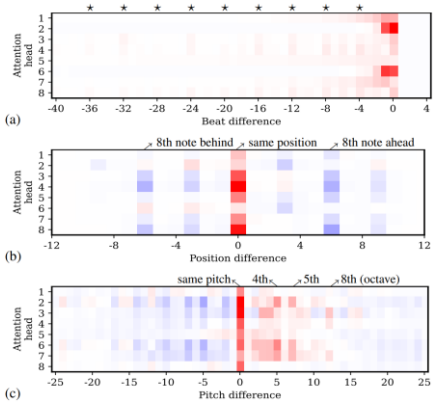
Summary

- Proposed an efficient representation and model for multitrack music generation
- Presented the first systematic analysis of musical self-attention

Multitrack Music Transformer



Musical Self-attention

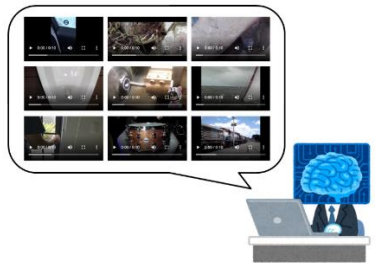


Paper: arxiv.org/abs/2207.06983
Demo: salu133445.github.io/mmt/
Code: github.com/salu133445/mmt

My Research

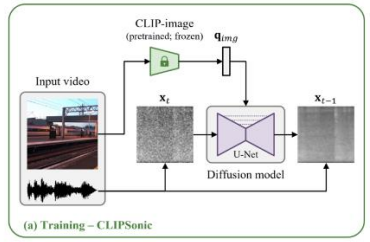
Multimodal Learning for Audio & Music

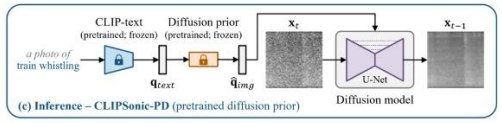
Learning sound separation and synthesis from videos



CLIPSep (ICLR 2023)

CLIPSonic (WASPAA 2023)



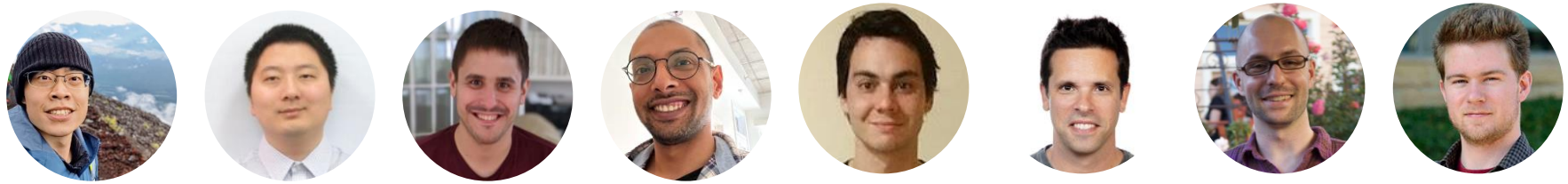


IEEE
WASPAA
2023

CLIPSonic: Text-to-Audio Synthesis with Unlabeled Videos and Pretrained Language-Vision Models

Hao-Wen Dong[1,2]* Xiaoyu Liu[1] Jordi Pons[1] Gautam Bhattacharya[1]
Santiago Pascual[1] Joan Serrà[1] Taylor Berg-Kirkpatrick[2] Julian McAuley[2]

[1] Dolby Laboratories [2] University of California San Diego
* Work done during an internship at Dolby



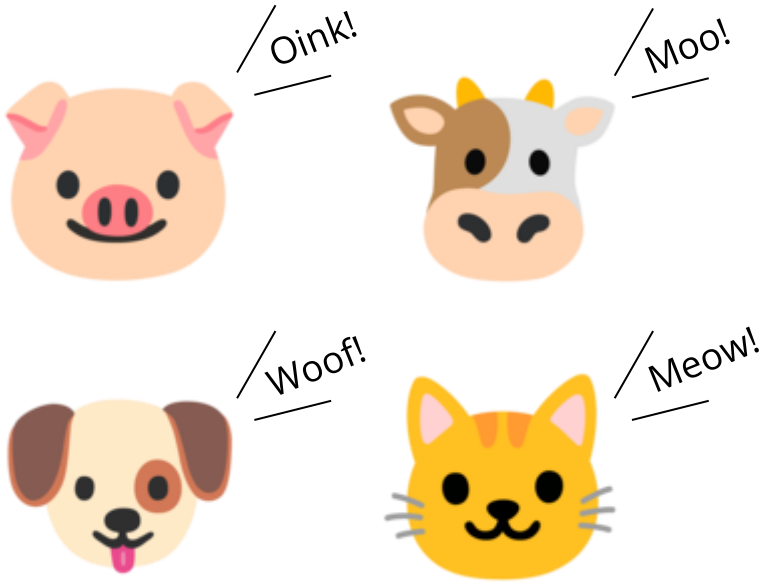
Dolby UC San Diego

Overview – Text-to-Audio Synthesis

(These samples are generated by our proposed model.)

Learning Sounds from Videos

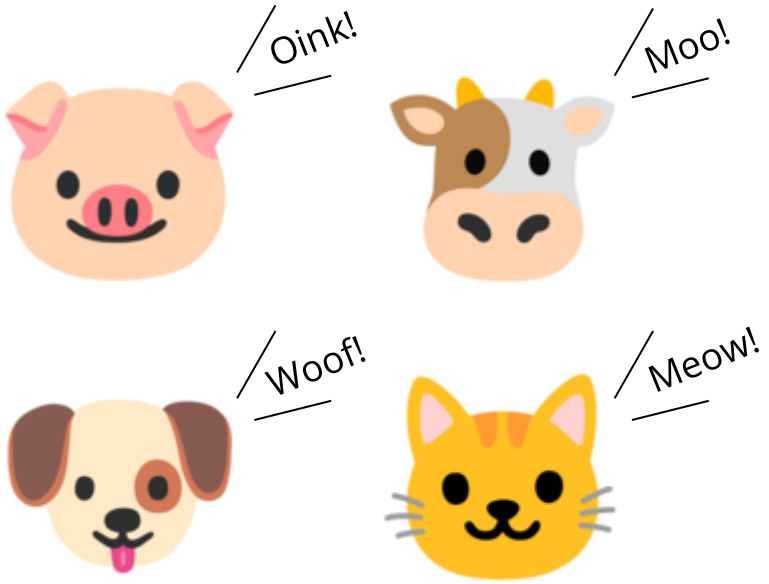
- Watching a dog barking, humans can *associate the barking sound to the dog*
- Can machines learn to synthesize sounds from watching *noisy* videos?



What does the fox say?

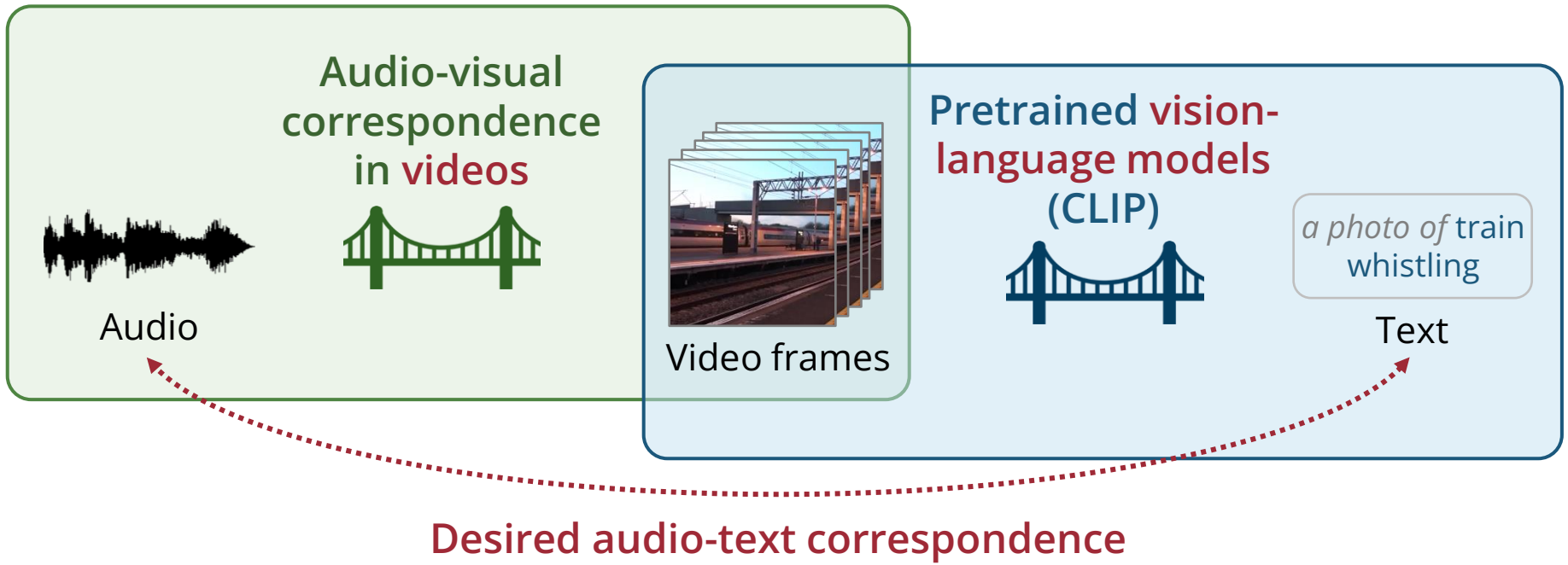
Learning Sounds from Videos

- Watching a dog barking, humans can *associate the barking sound to the dog*
- Can machines learn to synthesize sounds from watching *noisy* videos?



URURU TV, “Excited Fox Noises - Fox Laughing and Squeaking,” *YouTube*, https://youtu.be/XiCdBFDfUTg, 2019.

Leveraging the Visual Domain as a Bridge



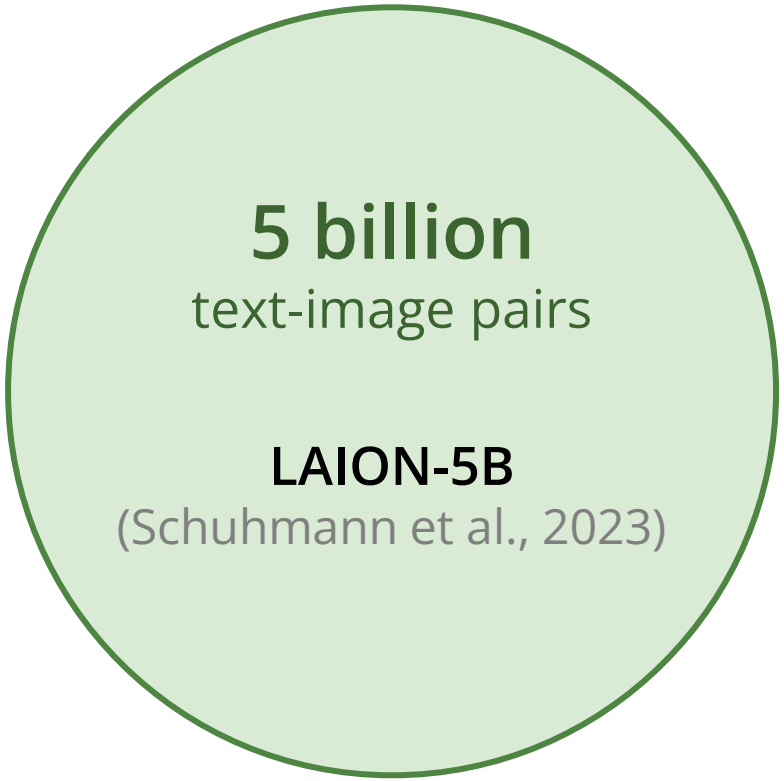
No text-audio pairs required!

Scalable to large video datasets!

Why NOT Text-audio Pairs?

YouTube videos!

500 hours of videos uploaded per minute



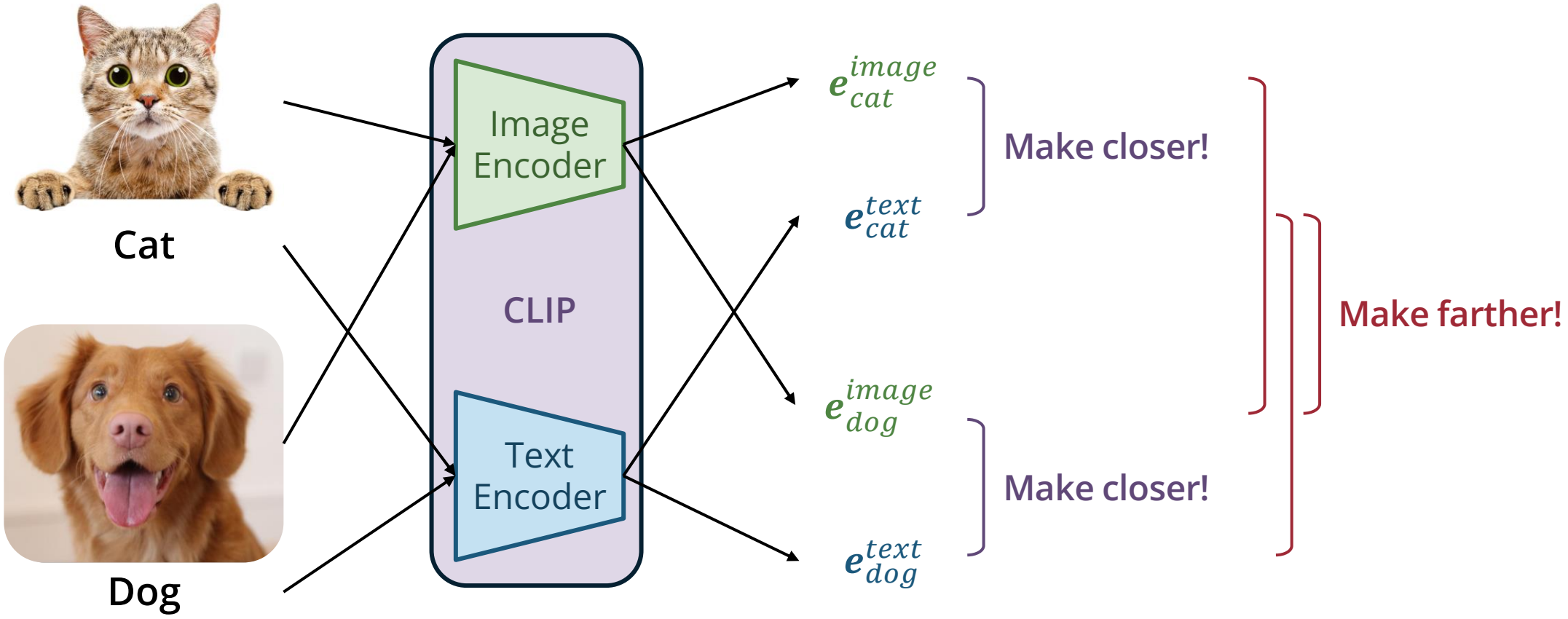
0.6 million
text-audio pairs

LAION-Audio-630K
(Wu et al., 2023)

Schuhmann et al., "LAION-5B: An open large-scale dataset for training next generation image-text models," *NeurIPS, Datasets and Benchmarks Track*, 2023.
Wu et al., "Large-scale Contrastive Language-Audio Pretraining with Feature Fusion and Keyword-to-Caption Augmentation," *ICASSP*, 2023.

CLIP (Contrastive Language-Image Pretraining)

- Learn a shared embedding space for images and texts via *contrastive learning*

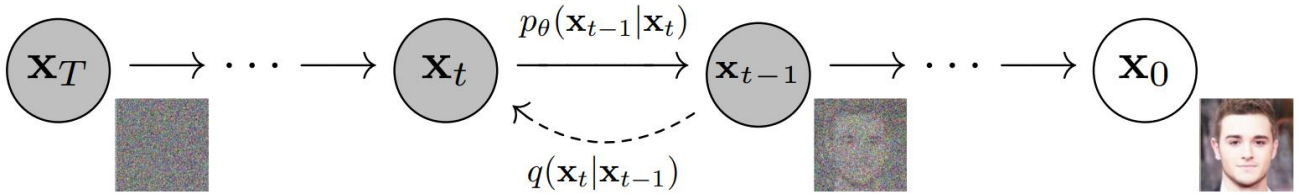


Radford et al., "Learning Transferable Visual Models From Natural Language Supervision," *ICML*, 2021.

Diffusion Model

Add noise gradually

(Forward diffusion process)



Remove noise gradually

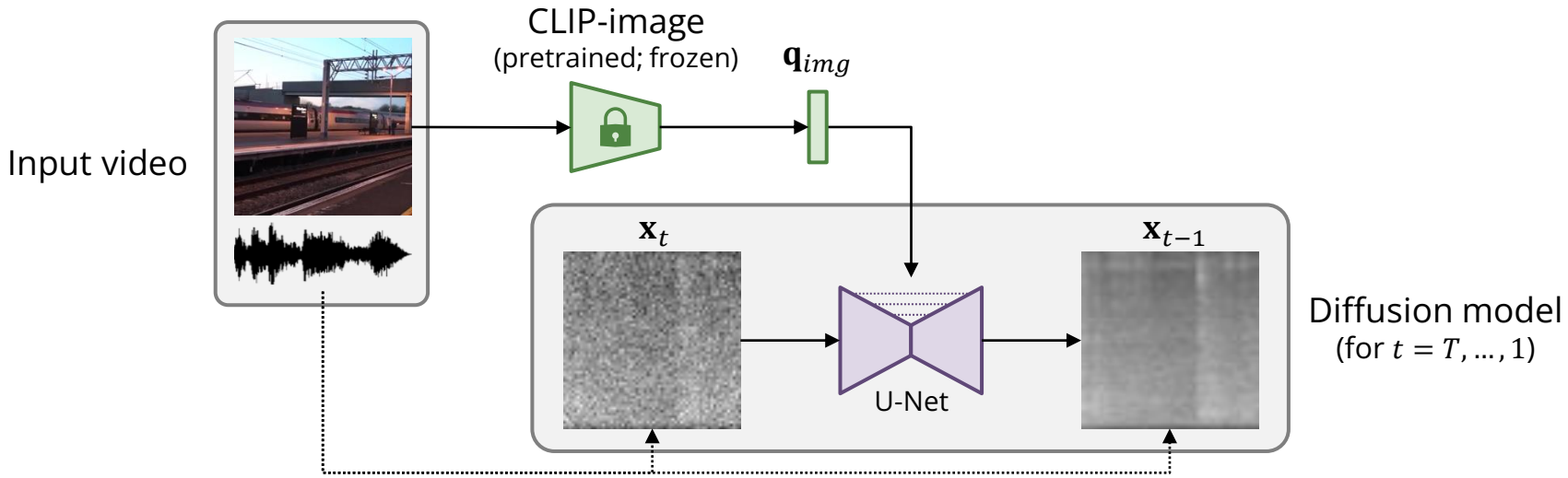
(Backward diffusion process)

Input **Output**

Ho et al., "Denoising Diffusion Probabilistic Models," *NeurIPS*, 2020.

Training – Image-queried

- We train an image-to-audio synthesis model using a diffusion model on mel spectrograms and a pretrained CLIP-image encoder



Inference – Zero-shot Modality Transfer (CLIPSonic-ZS)

- We first explore using a pretrained CLIP-text encoder directly

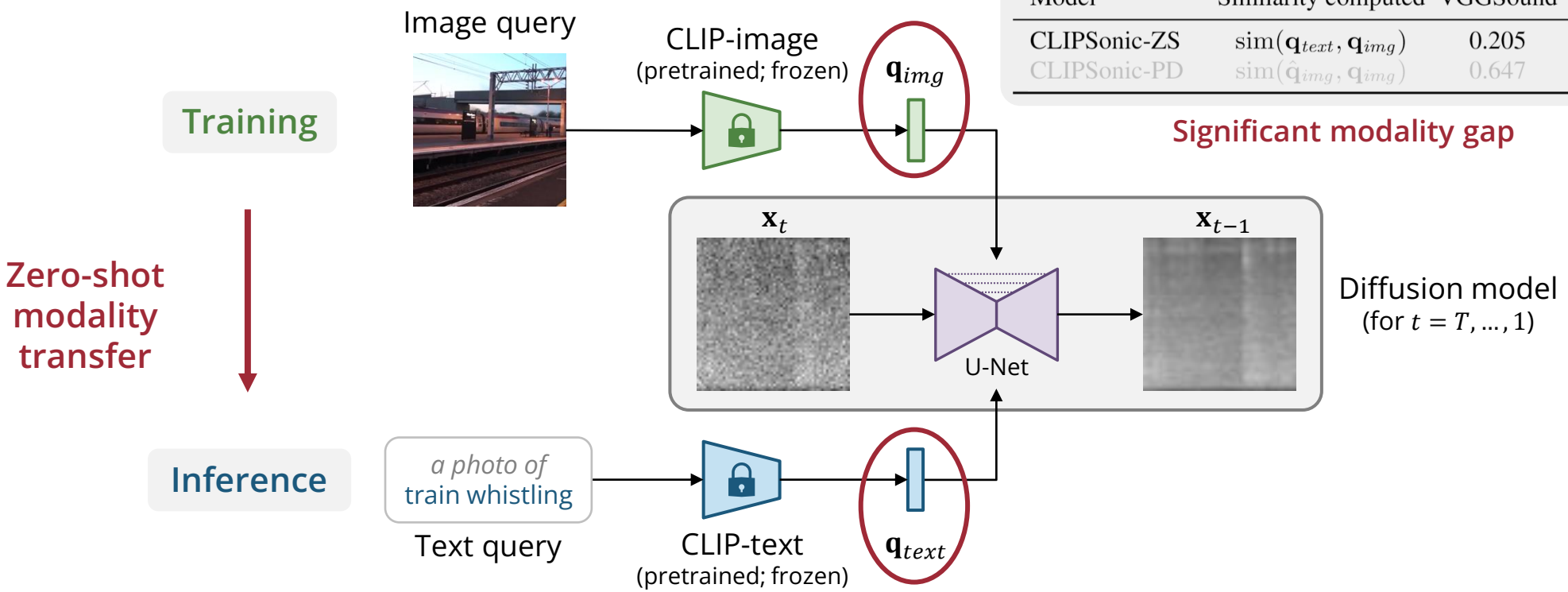


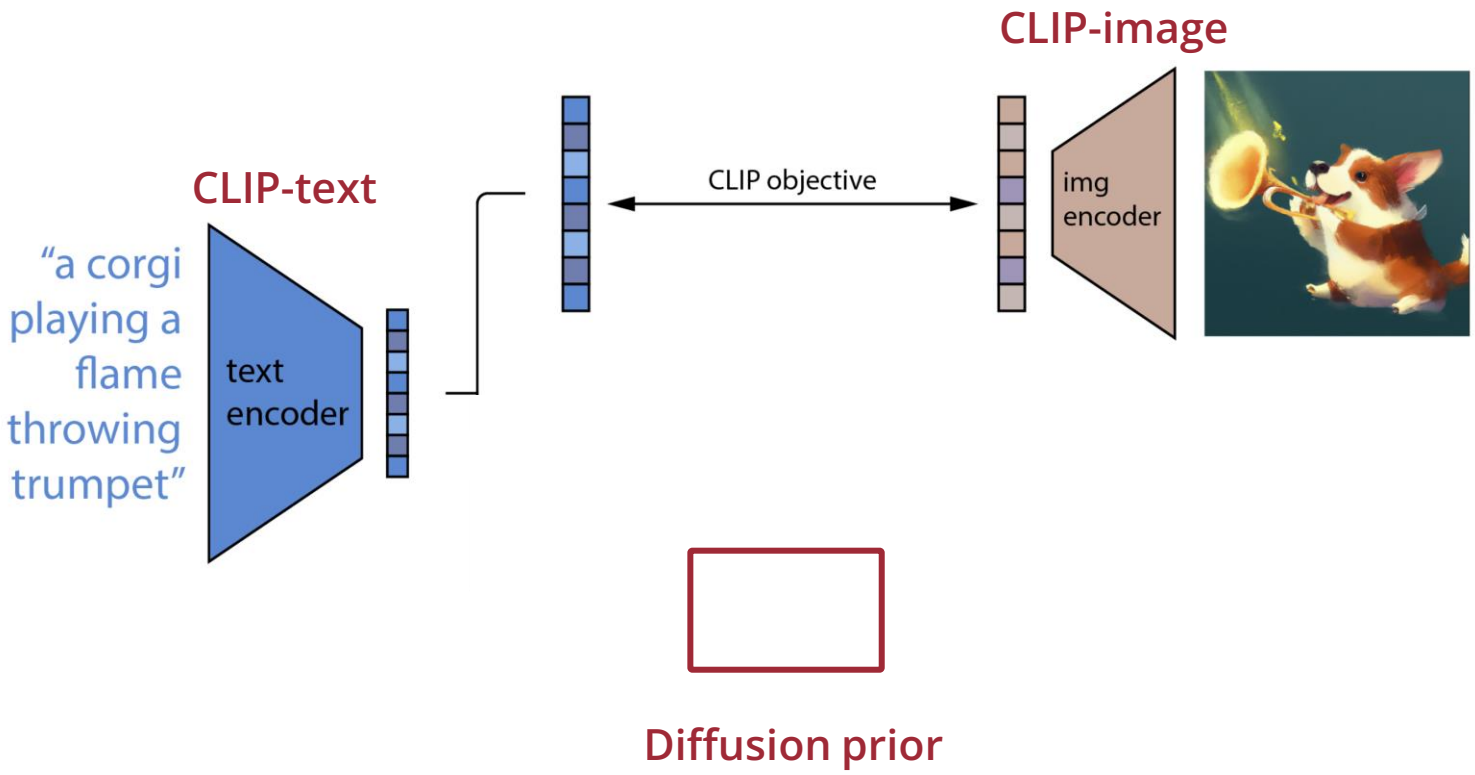
Table 2: Cosine similarities between various query embeddings.

Model	Similarity computed	VGGSound	MUSIC
CLIPSonic-ZS	$\mathrm{sim}(\mathbf{q}_{text}, \mathbf{q}_{img})$	0.205	0.245
CLIPSonic-PD	$\mathrm{sim}(\mathbf{q}_{img}, \mathbf{q}_{img})$	0.647	0.720

Significant modality gap

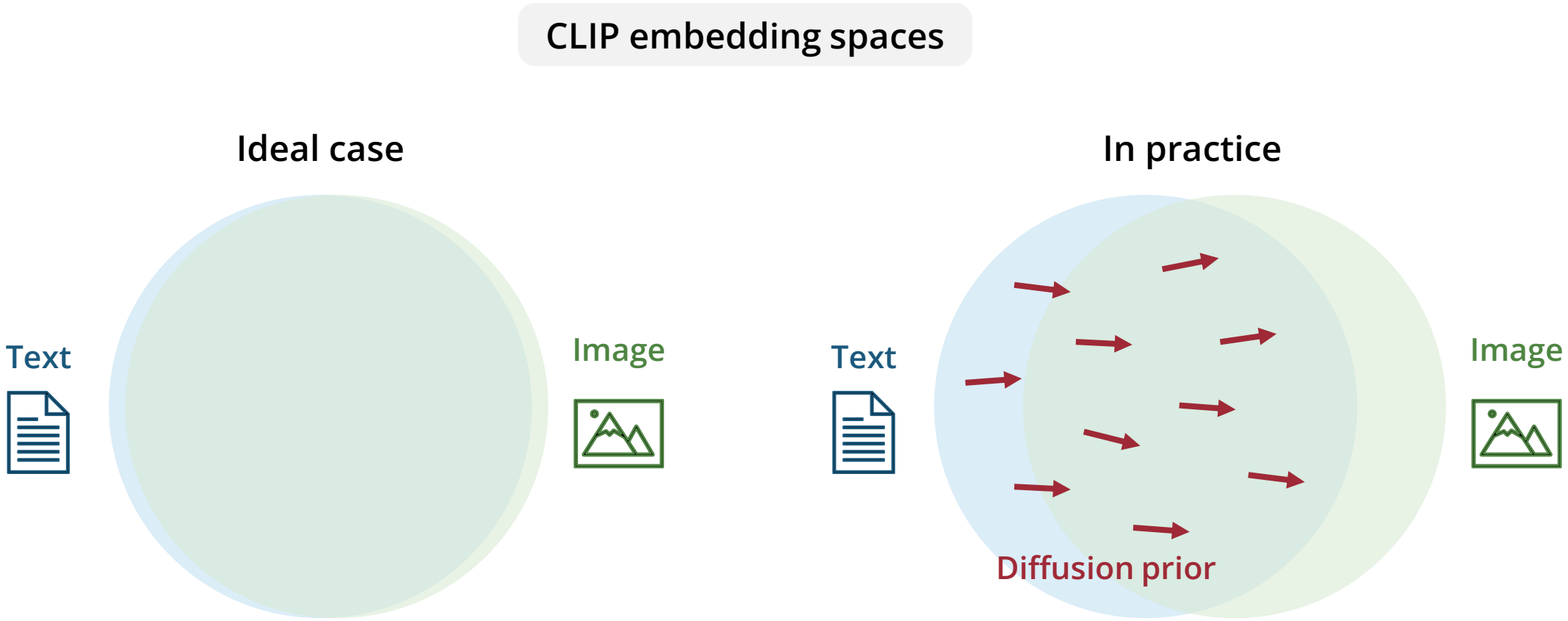
How to overcome this modality gap?

- We leverage a pretrained diffusion prior model (Ramesh et al., 2022)



Ramesh et al., "Hierarchical Text-Conditional Image Generation with CLIP Latents," *arXiv preprint arXiv:2204.06125*, 2022.

Diffusion Prior (Ramesh et al., 2022)



Ramesh et al., "Hierarchical Text-Conditional Image Generation with CLIP Latents," *arXiv preprint arXiv:2204.06125*, 2022.

Inference – Pretrained Diffusion Prior (CLIPSonic-PD)

- We then explore using a pretrained diffusion prior model (Ramesh et al., 2022)

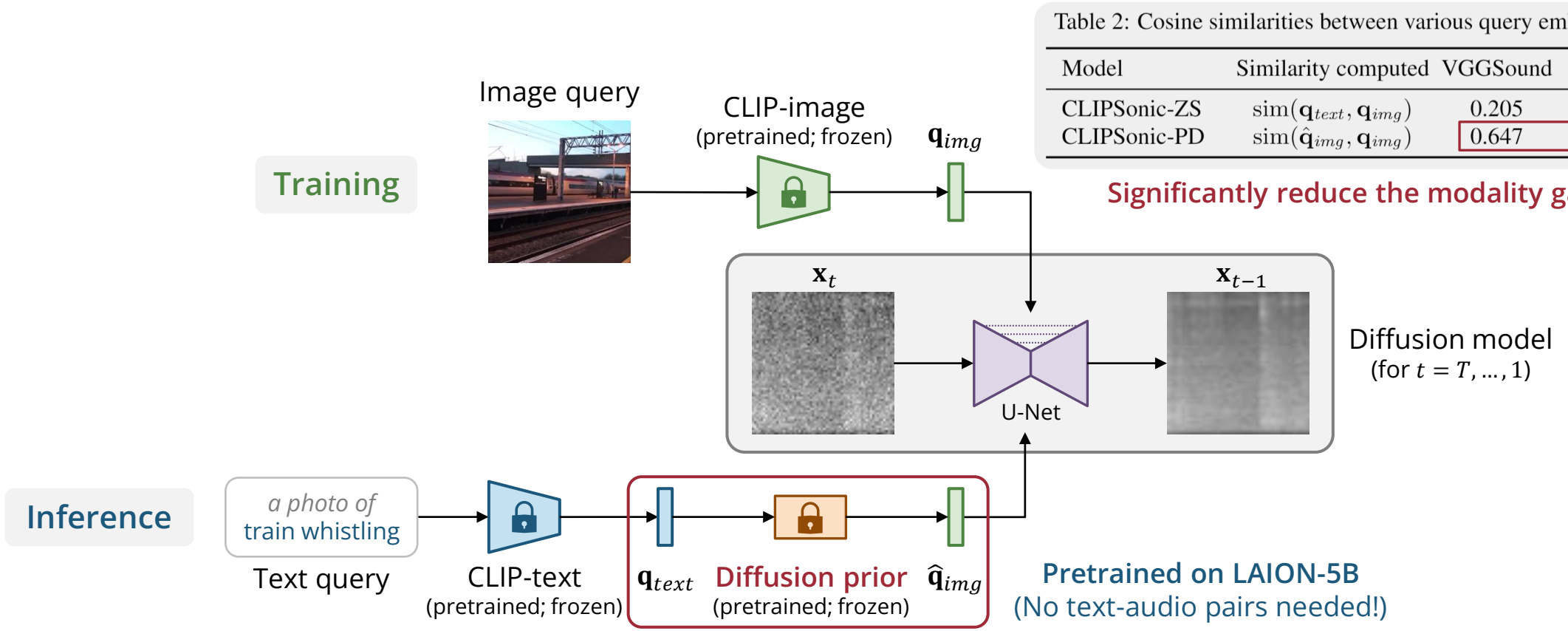


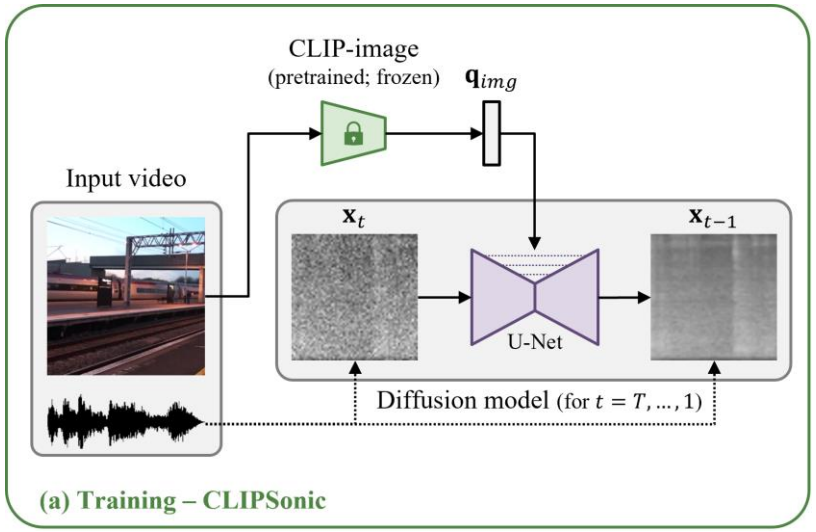
Table 2: Cosine similarities between various query embeddings.

Model	Similarity computed	VGGSound	MUSIC
CLIPSonic-ZS	$\text{sim}(\mathbf{q}_{text}, \mathbf{q}_{img})$	0.205	0.245
CLIPSonic-PD	$\text{sim}(\hat{\mathbf{q}}_{img}, \mathbf{q}_{img})$	0.647	0.720

Significantly reduce the modality gap

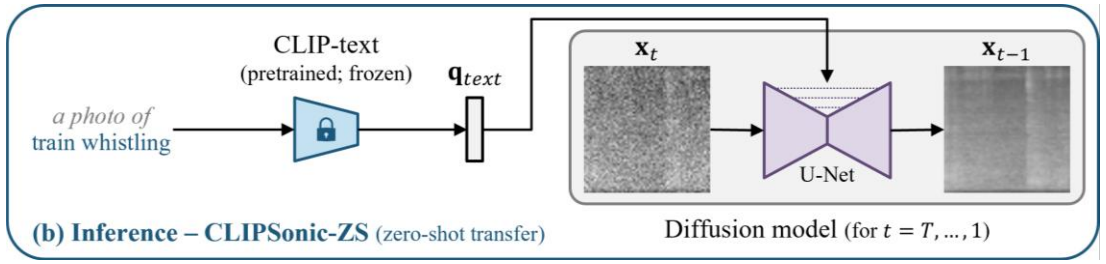
Recap

Training

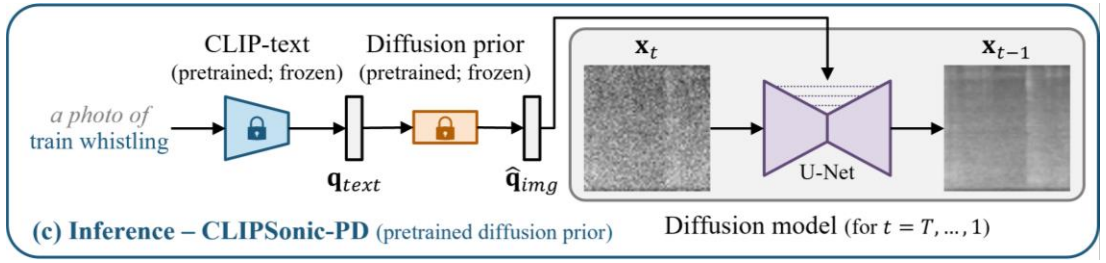


CLIPSonic-IQ
(image-queried)

Inference

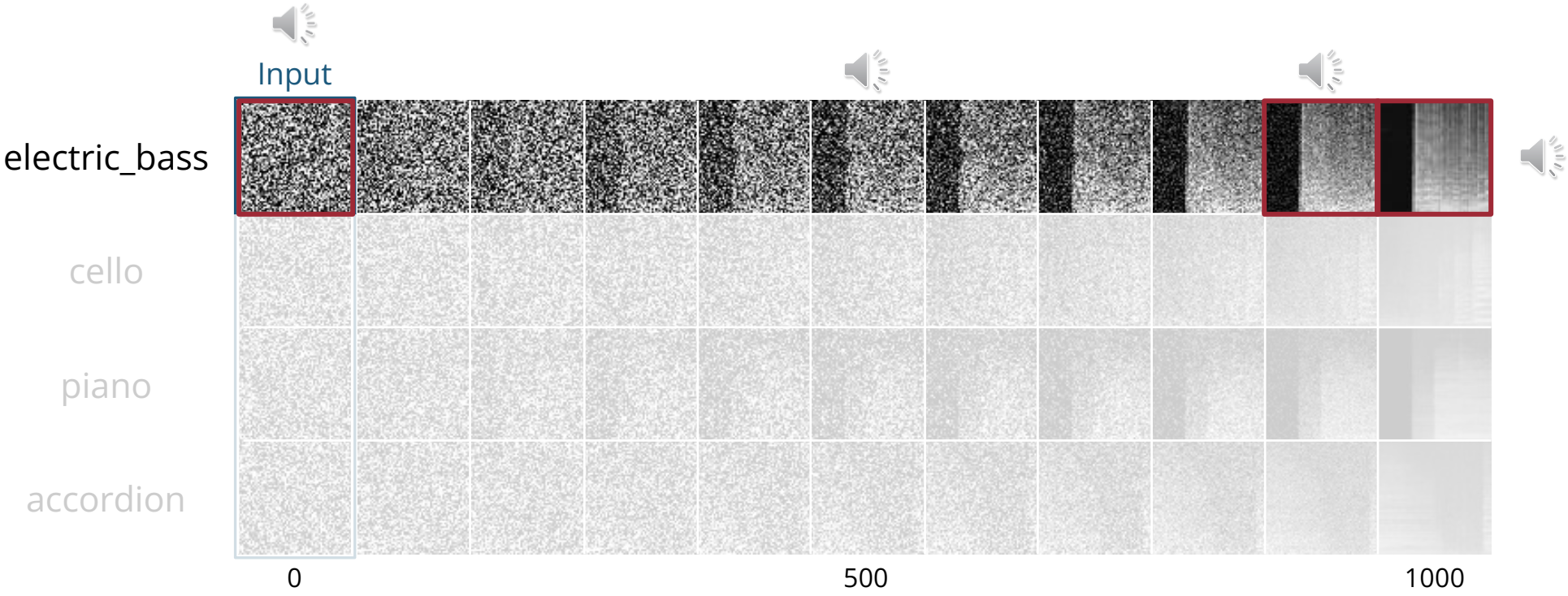


CLIPSonic-ZS
(zero-shot transfer)



CLIPSonic-PD
(pretrained diffusion prior)

CLIPSonic – Inference Examples



Data

MUSIC

(Zhao et al., 2018)


Violin


Acoustic guitar

Accordion

Music instrument playing videos

(1,055 videos, 21 instruments)

VGGSound

(Chen et al., 2020)


Hedge trimmer running


Dog bow-wow


Bird chirping, tweeting

Noisy videos with diverse sounds

(172K videos, 310 classes)

Zhao et al., "The Sound of Pixels," *ECCV*, 2018.
Chen et al., "VGGSound: A Large-Scale Audio-Visual Dataset," *ICASSP*, 2020.

Text-to-Audio Synthesis – Demo

Rapping

Sea waves

Thunder

Smoke detector beeping

Playing table tennis

Playing violin fiddle

Text-to-Audio Synthesis – Listening Test

Table 3: Listening test results for text-to-audio synthesis (MOS).

Model	VGGSound		MUSIC	
	Fidelity	Relevance	Fidelity	Relevance
CLIPSonic-ZS	2.55 ± 0.22	2.01 ± 0.27	2.98 ± 0.23	3.87 ± 0.24
CLIPSonic-PD	$\mathbf{3.04 \pm 0.20}$	2.86 ± 0.25	$\mathbf{3.67 \pm 0.18}$	3.91 ± 0.24
Ground truth	3.78 ± 0.19	3.54 ± 0.29	3.90 ± 0.17	4.34 ± 0.18

Significant performance improvement against the baseline!

Image-to-Audio Synthesis – Demo (Out-of-distribution)

Image-to-Audio Synthesis – Listening Test

Table 4: Listening test results for image-to-audio synthesis (MOS).

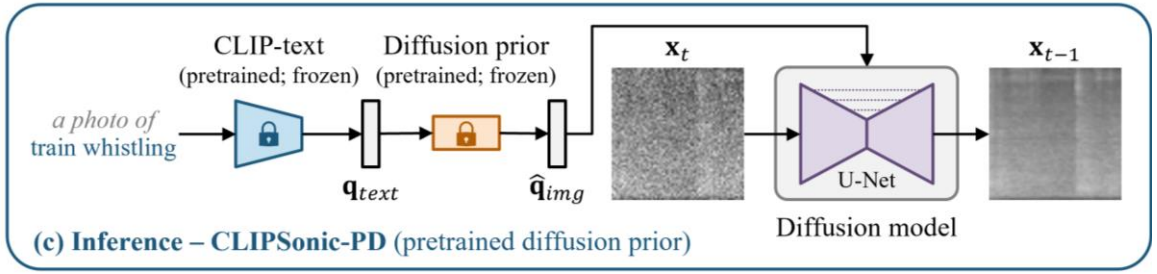
Model	Fidelity	Relevance
CLIPSonic-IQ (image-queried)	**3.29 ± 0.16**	3.80 ± 0.19
SpecVQGAN [20]	2.15 ± 0.17	2.54 ± 0.23
im2wav [21]	2.19 ± 0.15	**3.90 ± 0.22**

State-of-the-art image-to-audio performance!

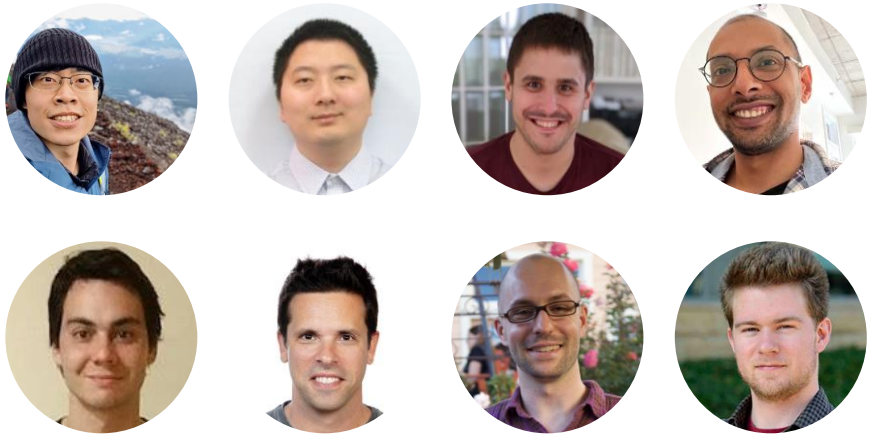
Sheffer and Adi, "I Hear Your True Colors: Image Guided Audio Generation," *ICASSP*, 2023.
Iashin and Rahtu, "Taming Visually Guided Sound Generation," *BMVC*, 2021.

Summary

- Proposed a text-to-audio synthesis model that requires *no* text-audio pairs
- Achieves strong performance in objective and subjective evaluations
- Achieves state-of-the-art performance in image-to-audio synthesis



Paper: arxiv.org/abs/2306.09635
Demo: salu133445.github.io/clipsonic



My Research

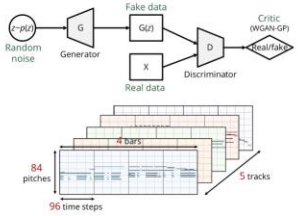
Generative AI for Music & Audio

Empowering music and audio creation with machine learning

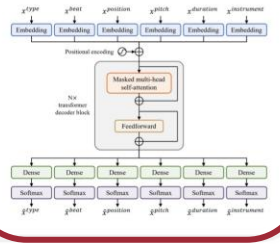
Multitrack Music Generation

Advancing deep generative models for multitrack music

MuseGAN
(AAAI 2018)



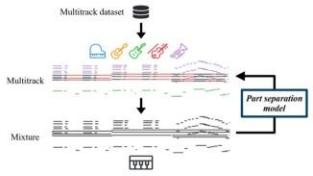
MMT
(ICASSP 2023)



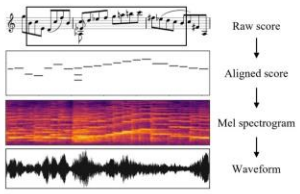
Assistive Music Creation Tools

Developing AI-augmented assistive music creation tools

Arranger
(ISMIR 2021)



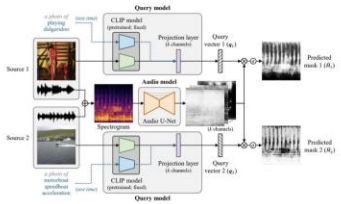
Deep Performer
(ICASSP 2022)



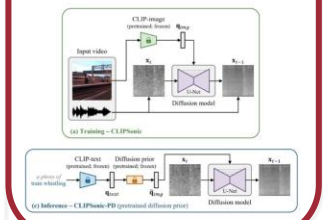
Multimodal Learning for Audio & Music

Learning sound separation and synthesis from videos

CLIPSep
(ICLR 2023)



CLIPSonic
(WASPAA 2023)

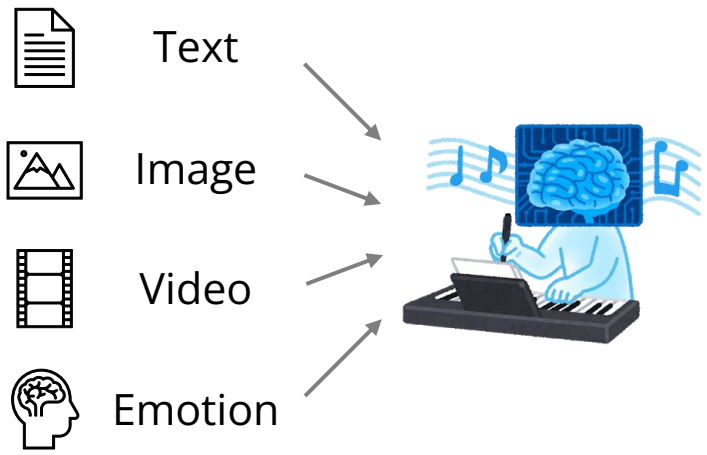


Future Directions

Future Directions

Multimodal

Multimodal generative AI with music and audio



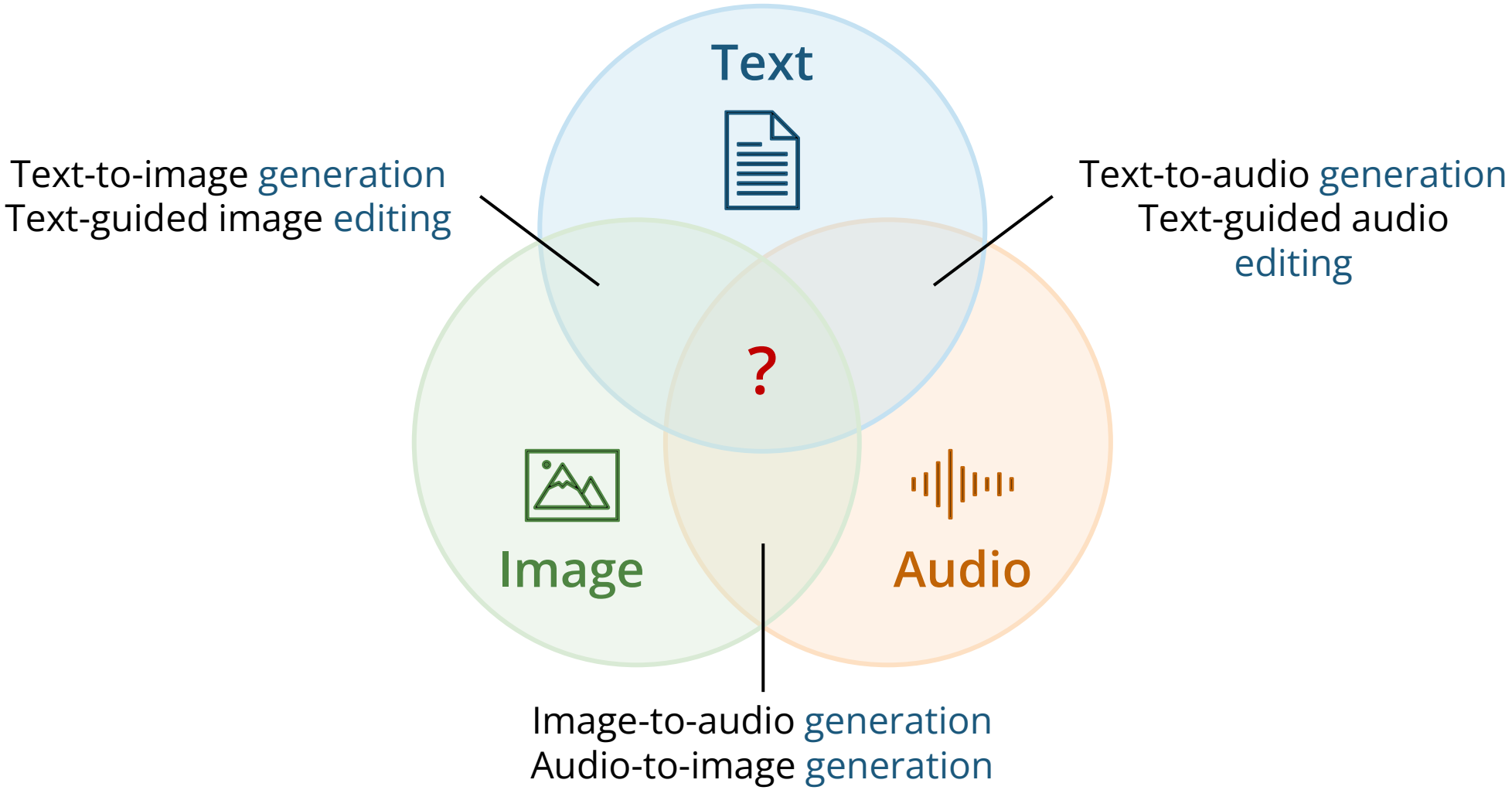
Interactive

Interactive AI tools for music and audio production

Human-inspired

Human-like machine leaning algorithms for music

Multimodal Generative AI



Multimodal Generative AI for Ads

Video **Runway Gen-2**

Music **MusicGen**

進捗共有チャンネル, "Runway Gen-2 Sample / Tiger Whiskey," *YouTube*, July 9, 2023.
Kaoru Naito, *Twitter*, https://twitter.com/ka0ru_1620/status/1678313226453520385, July 10, 2023.

Multimodal Generative AI for News

Generate an audio in Science Fiction theme: Mars News reporting that Humans send light-speed probe to Alpha Centauri.
Start with news anchor, followed by a reporter interviewing a chief engineer from an organization that built this probe, founded by United Earth and Mars Government, and end with the news anchor again.

Script	**GPT-4**
Music	**MusicGen**
Narration	**Bark**
Sound effects	**AudioLDM**

Liu et al., "WavJourney: Compositional Audio Creation with Large Language Models," *arXiv preprint arXiv:2307.14335*, 2023.

Controllable Generative AI

Large language models
(GPT-4)

Pretrained generative audio models
(MusicGen, AudioLDM, Bark)

Instructions → Audio Script → Audio

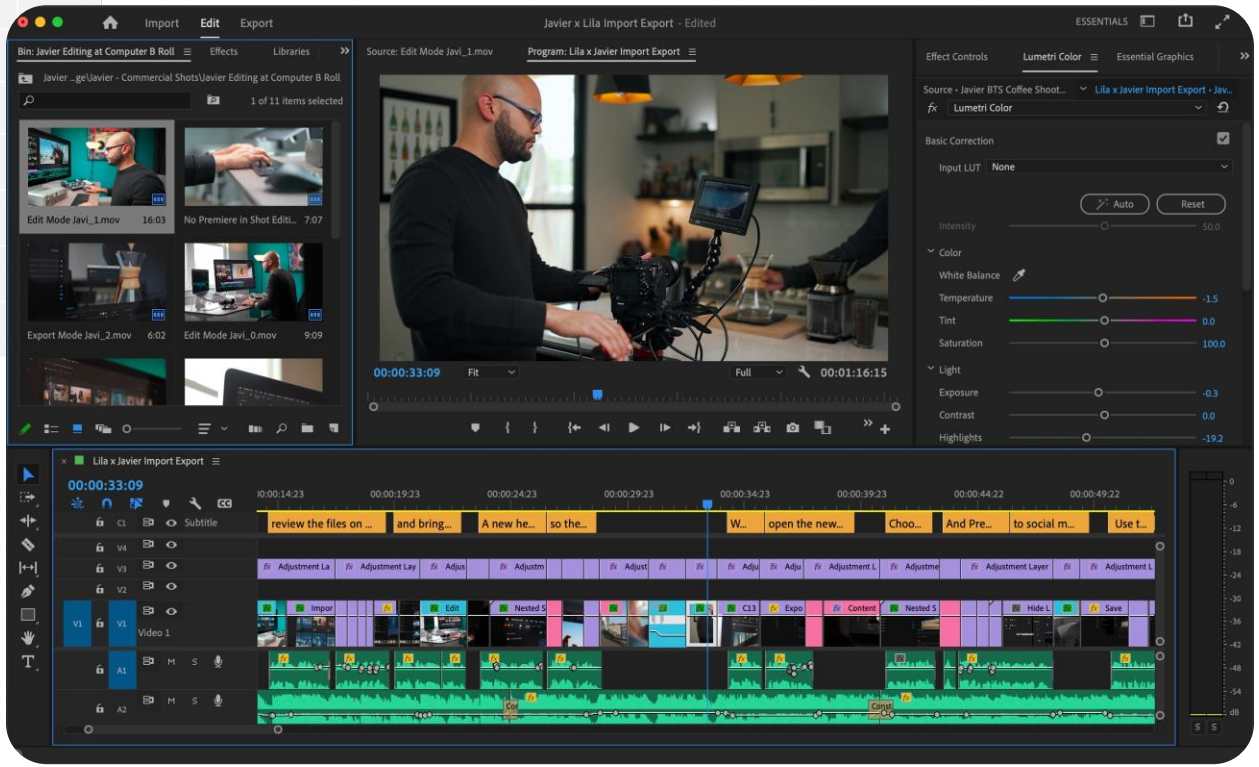
Audio Type	Layout	ID	Character	Volume	Action	Content Description	Duration
Music	Background	1	N/A	-30	Begin	Dramatic orchestral news theme.	Auto
Speech	Foreground	N/A	Host	-15	N/A	Welcome to Mars News ...	Auto
Music	Background	1	N/A	N/A	End	N/A	Auto
Speech	Foreground	N/A	Host	-15	N/A	Now let's connect with our on-site reporter ...	Auto
Sound effect	Foreground	N/A	N/A	-35	N/A	Transition swoosh.	1
Sound effect	Background	2	N/A	-30	Begin	Background noise of busy engineering office.	Auto
Speech	Foreground	N/A	Reporter	-15	N/A	We're here at the headquarters of …	Auto
Speech	Foreground	N/A	Director	-15	N/A	Thank you, so it's a fantastic …	Auto
Speech	Foreground	N/A	Reporter	-15	N/A	This is truly an impressive feat …	Auto

Interactable intermediate outputs

Liu et al., "WavJourney: Compositional Audio Creation with Large Language Models," *arXiv preprint arXiv:2307.14335*, 2023.

Controllable Generative AI

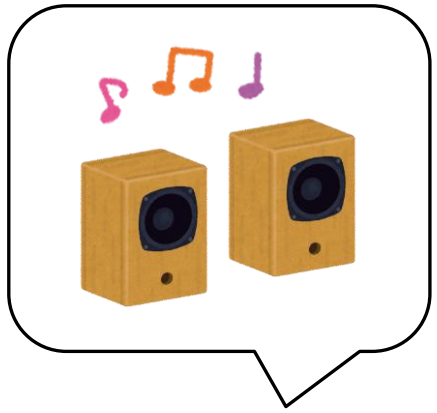
Audio Type	Layout	ID	Character	Volume	Action	Content Description	Duration
Music	Background	1	N/A	-30	Begin	Dramatic orchestral news theme.	Auto
Speech	Foreground	N/A	Host	-15	N/A	Welcome to Mars News ...	Auto
Music	Background	1	N/A	N/A	End	N/A	
Speech	Foreground	N/A	Host	-15	N/A	Now let's connect with our on-site reporter ...	
Sound effect	Foreground	N/A	N/A	-35	N/A	Transition swoosh.	
Sound effect	Background	2	N/A	-30	Begin	Background noise of busy engineering office.	
Speech	Foreground	N/A	Reporter	-15	N/A	We're here at the headquarters of …	
Speech	Foreground	N/A	Director	-15	N/A	Thank you, so it's a fantastic …	
Speech	Foreground	N/A	Reporter	-15	N/A	This is truly an impressive feat …	



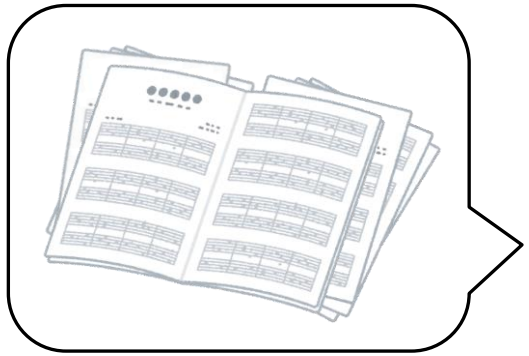
Integration into professional creative workflow

Human-inspired Machine Learning for Music & Audio

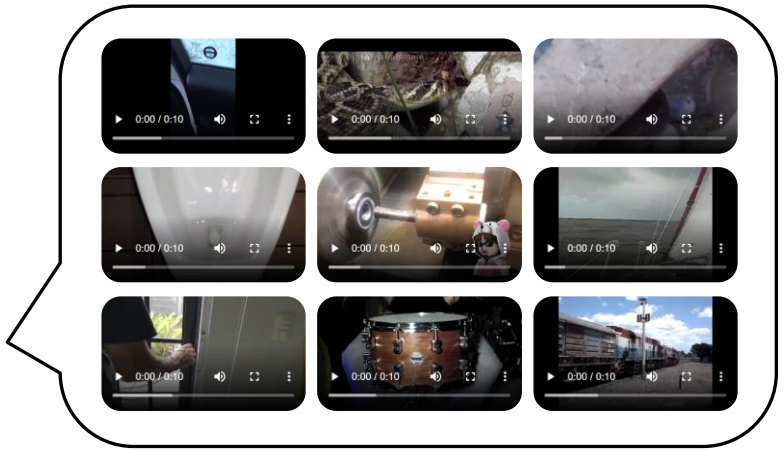
Learning from listening



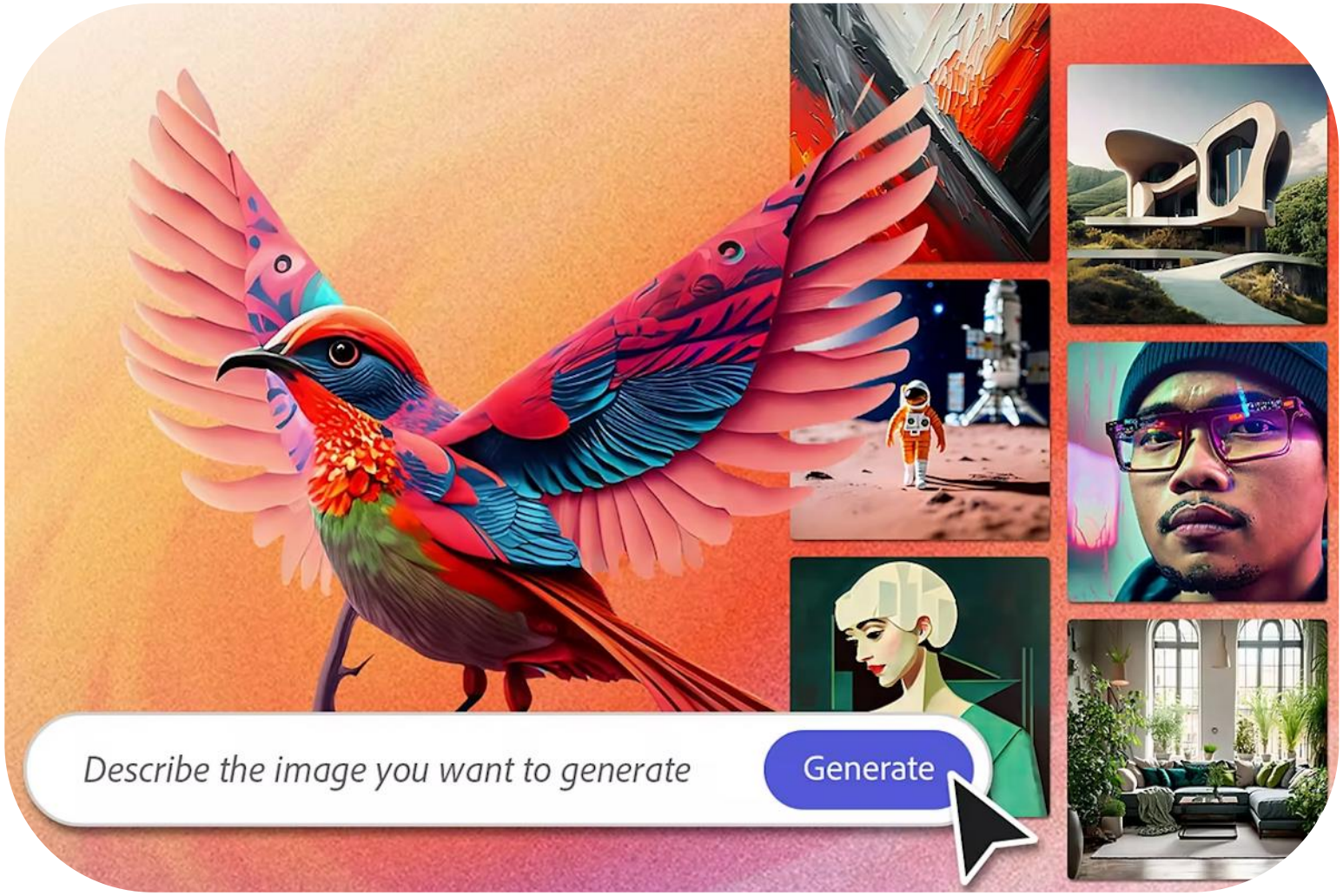
Learning from reading



Learning from watching



Licensing Example – Adobe Firefly



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Acknowledgements

UC San Diego
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Dolby
SONY
amazon
MINISTRY OF EDUCATION 教育部
erc

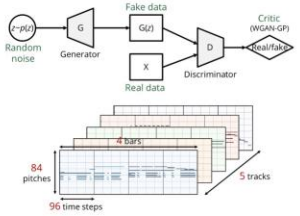
Thank you!

Generative AI for Music & Audio

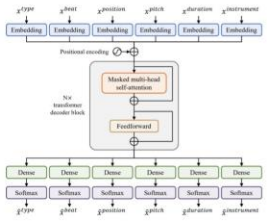
Multitrack Music Generation

Advancing deep generative models for multitrack music

MuseGAN
(AAAI 2018)



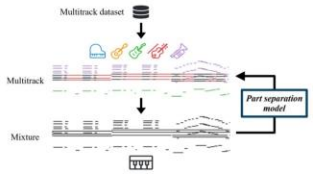
MMT
(ICASSP 2023)



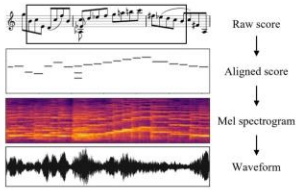
Assistive Music Creation Tools

Developing AI-augmented assistive music creation tools

Arranger
(ISMIR 2021)



Deep Performer
(ICASSP 2022)



Multimodal Learning for Audio & Music

Learning sound separation and synthesis from videos

CLIPSep
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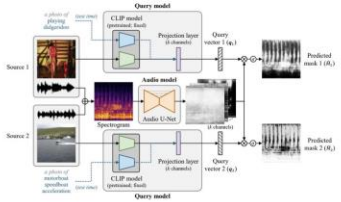

CLIPSonic
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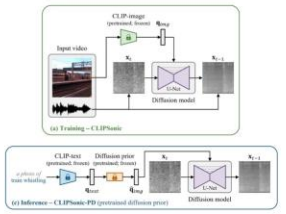

Contact: salu.hwdong@gmail.com