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Learning Text-queried Sound Separation and Synthesis using Unlabeled Videos and Pretrained Language-Vision Models

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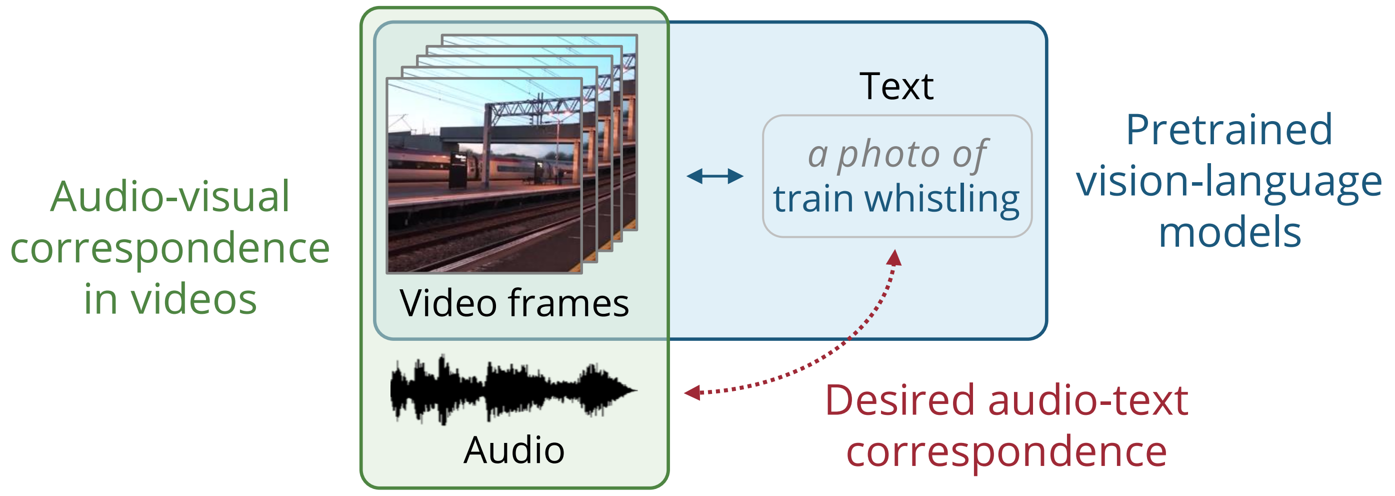
Introduction

We explore **text-audio data free training for text-queried sound separation and text-to-audio synthesis.** The proposed models learn the desired text-audio correspondence by combining

- naturally-occurring audio-visual correspondence in videos
- multimodal representation learned by contrastive language-image pretraining (CLIP)

This study offers a new direction of approaching bimodal learning for text and audio through leveraging the visual modality as a bridge.


Audio-visual correspondence in videos
Video frames
Audio
Text
a photo of train whistling
Pretrained vision-language models
Desired audio-text correspondence

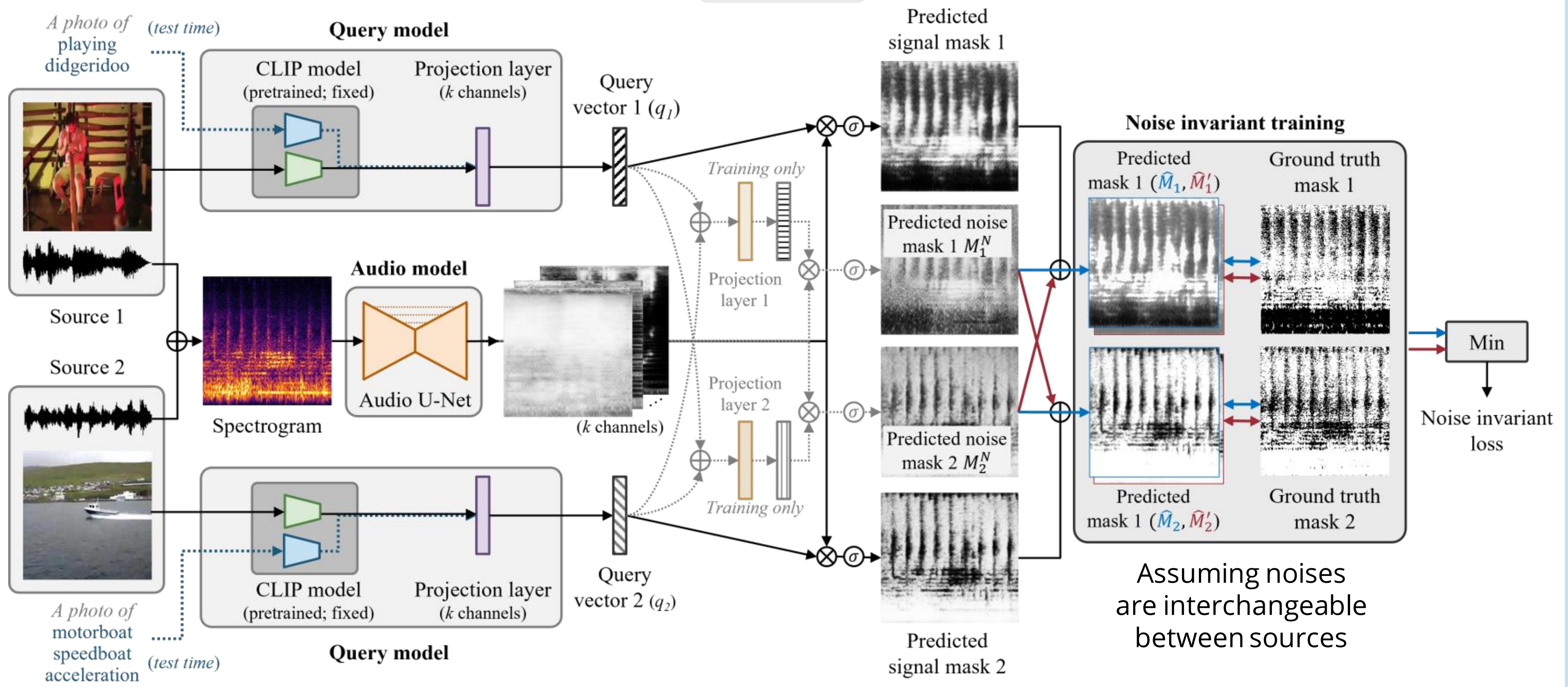
CLIPSep: Text-queried Sound Separation

ICLR 2023

Training: We mix the audio track from two videos and train the model to separate each audio source given the corresponding video frame (encoded by the pretrained CLIP-image encoder) as the query.

Inference: We take text queries as inputs by using the pretrained CLIP-text encoder to encode the text.

Model



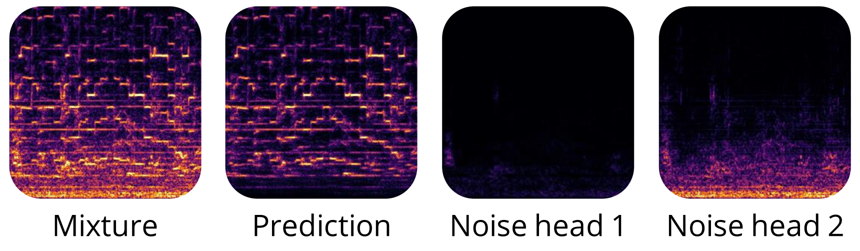
Assuming noises are interchangeable between sources

Quantitative Results

Model	Unlabeled data	MUSIC$^+$ Mean SDR	MUSIC$^+$ Median SDR	VGGSound-Clean$^+$ Mean SDR	VGGSound-Clean$^+$ Median SDR
Mixture	-	4.49 ± 1.41	2.04	-0.77 ± 1.31	-0.84
Text-queried models					
CLIPSep	✓	9.71 ± 1.21	8.73	2.76 ± 1.00	**3.95**
CLIPSep-NIT	✓	**10.27 ± 1.04**	**10.02**	**3.05 ± 0.73**	3.26
BERTSep		4.67 ± 0.44	4.41	5.09 ± 0.80	5.49
CLIPSep-Text		10.73 ± 0.99	9.93	5.49 ± 0.82	5.06
Nonqueried models					
PIT (Yu et al., 2017)	✓	**12.24 ± 1.20**	**12.53**	**5.73 ± 0.79**	**4.97**
LabelSep		-	-	5.55 ± 0.81	5.29

Example Result

Query: "playing bagpipes"



Demo

Data

MUSIC

(Zhao et al., 2018)

Violin

Acoustic guitar

Accordion

Music instrument playing videos

VGGSound

(Chen et al., 2020)

Hedge trimmer running

Dog bow-wow

Bird chirping, tweeting

Noisy Videos with diverse sounds

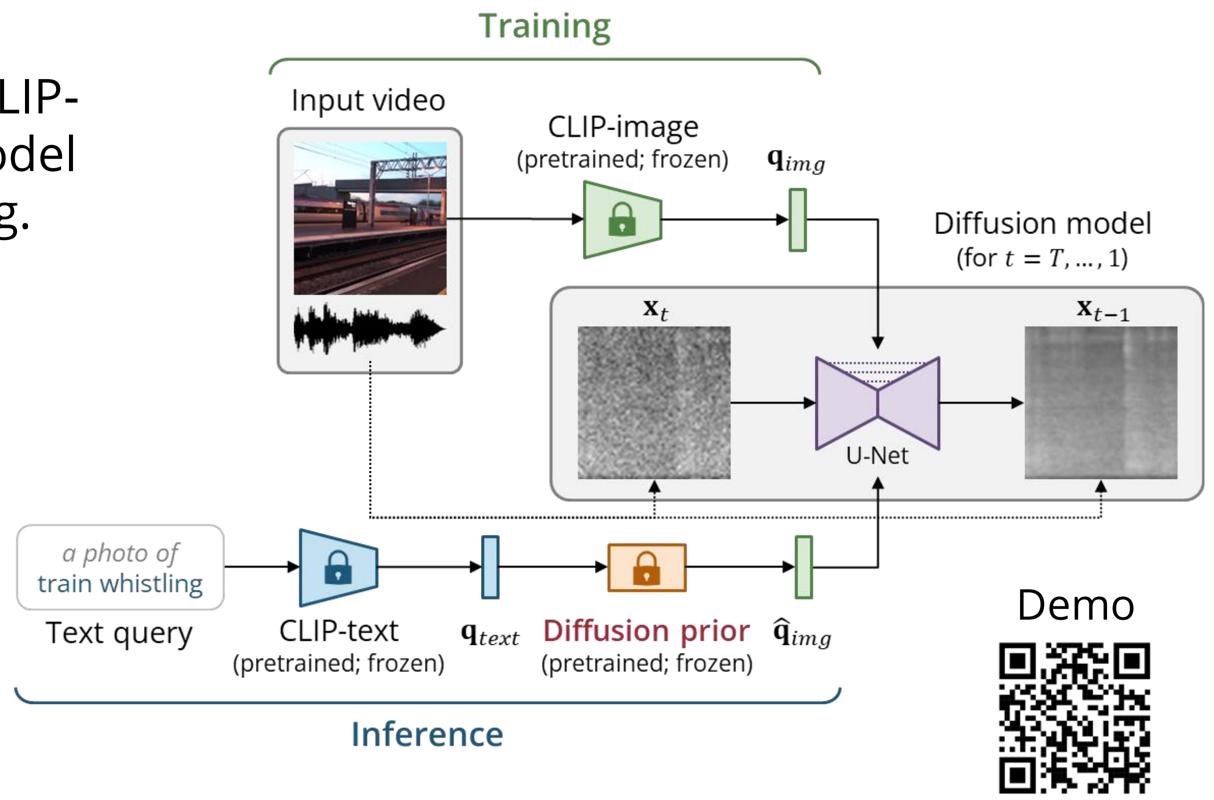
CLIPSonic: Text-to-audio Synthesis

WASPAA 2023

Training: Similarly, we train a diffusion model that generates a mel spectrogram given the corresponding video frame as the query.

Inference: We take text queries as inputs by using the pretrained CLIP-text encoder to encode the text and a pretrained diffusion prior model to generate a CLIP-image embedding from the CLIP-text embedding.

Model

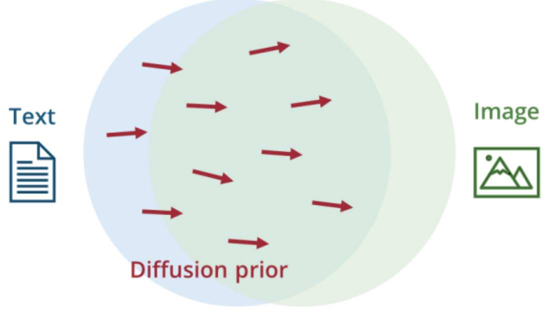

Training
Input video
CLIP-image (pretrained; frozen)
$\mathbf{q}_{img}$
Diffusion model (for $t = T, \dots, 1$)
$\mathbf{x}_t$
$\mathbf{x}_{t-1}$
U-Net
a photo of train whistling
Text query
CLIP-text (pretrained; frozen)
$\mathbf{q}_{text}$
Diffusion prior (pretrained; frozen)
$\hat{\mathbf{q}}_{img}$
Inference

Demo

Text-to-audio Synthesis Results

Model	VGGSound Fidelity	VGGSound Relevance	MUSIC Fidelity	MUSIC Relevance
CLIPSonic-ZS	2.55 ± 0.22	2.01 ± 0.27	2.98 ± 0.23	3.87 ± 0.24
CLIPSonic-PD	**3.04 ± 0.20**	2.86 ± 0.25	**3.67 ± 0.18**	3.91 ± 0.24
CLIPSonic-SD	2.96 ± 0.21	**3.49 ± 0.28**	3.36 ± 0.20	**4.07 ± 0.22**
Ground truth	3.78 ± 0.19	3.54 ± 0.29	3.90 ± 0.17	4.34 ± 0.18

Diffusion Prior



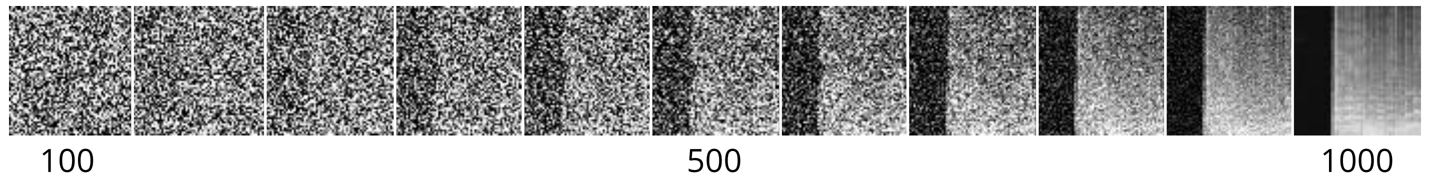
The diffusion prior model is trained to map the CLIP-text embedding space to the CLIP-image embedding space

Image-to-audio Synthesis Results

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**

Example Result

Query: "electric bass"



Work done during internships at Sony and Dolby. Joint work with Taylor Berg-Kirkpatrick, Julian McAuley (UC San Diego), Naoya Takahashi, Yuki Mitsufuji (Sony), Xiaoyu Liu, Jordi Pons, Gautam Bhattacharya, Santiago Pascual and Joan Serrà (Dolby).

[1] Hao-Wen Dong, Naoya Takahashi, Yuki Mitsufuji, Julian McAuley, and Taylor Berg-Kirkpatrick, "CLIPSep: Learning Text-queried Sound Separation with Noisy Unlabeled Videos," *ICLR*, 2023.

[2] Hao-Wen Dong, Xiaoyu Liu, Jordi Pons, Gautam Bhattacharya, Santiago Pascual, Joan Serrà, Taylor Berg-Kirkpatrick, and Julian McAuley, "CLIPSonic: Text-to-Audio Synthesis with Unlabeled Videos and Pretrained Language-Vision Models," *WASPAA*, 2023.