

Edge Storage Management Recipe with Zero-Shot Data Compression for Road Anomaly Detection

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Motivation

- Sound-based road anomaly detection with edge computer



[1] Park et al., "Frequency of Interest-based Noise Attenuation Method to Improve Anomaly Detection Performance." IEEE BigComp 2023

Motivation

- ❑ High-quality and large-scale dataset is needed to update the model
- ❑ Edge-computer has small data storage
- ❑ Data transmission costs will also be high

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[Details](#)

Background



Dry : 1.00

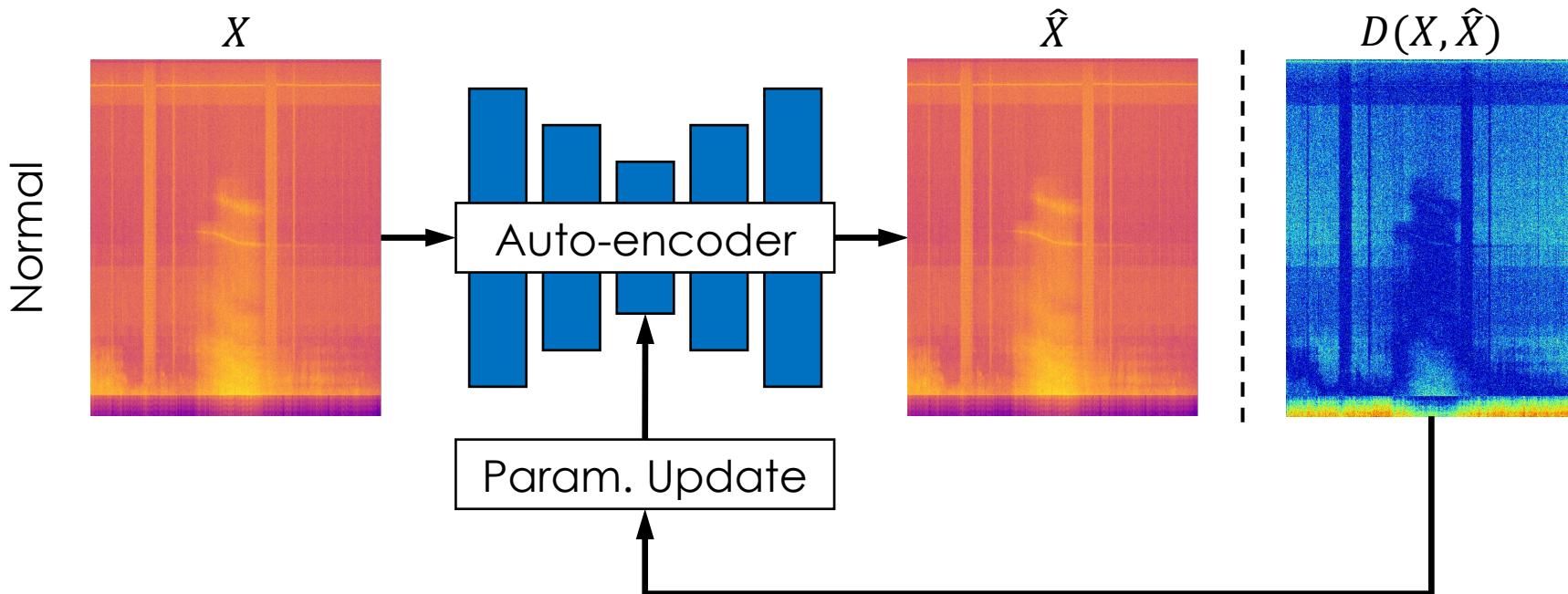


Wet : 0.30



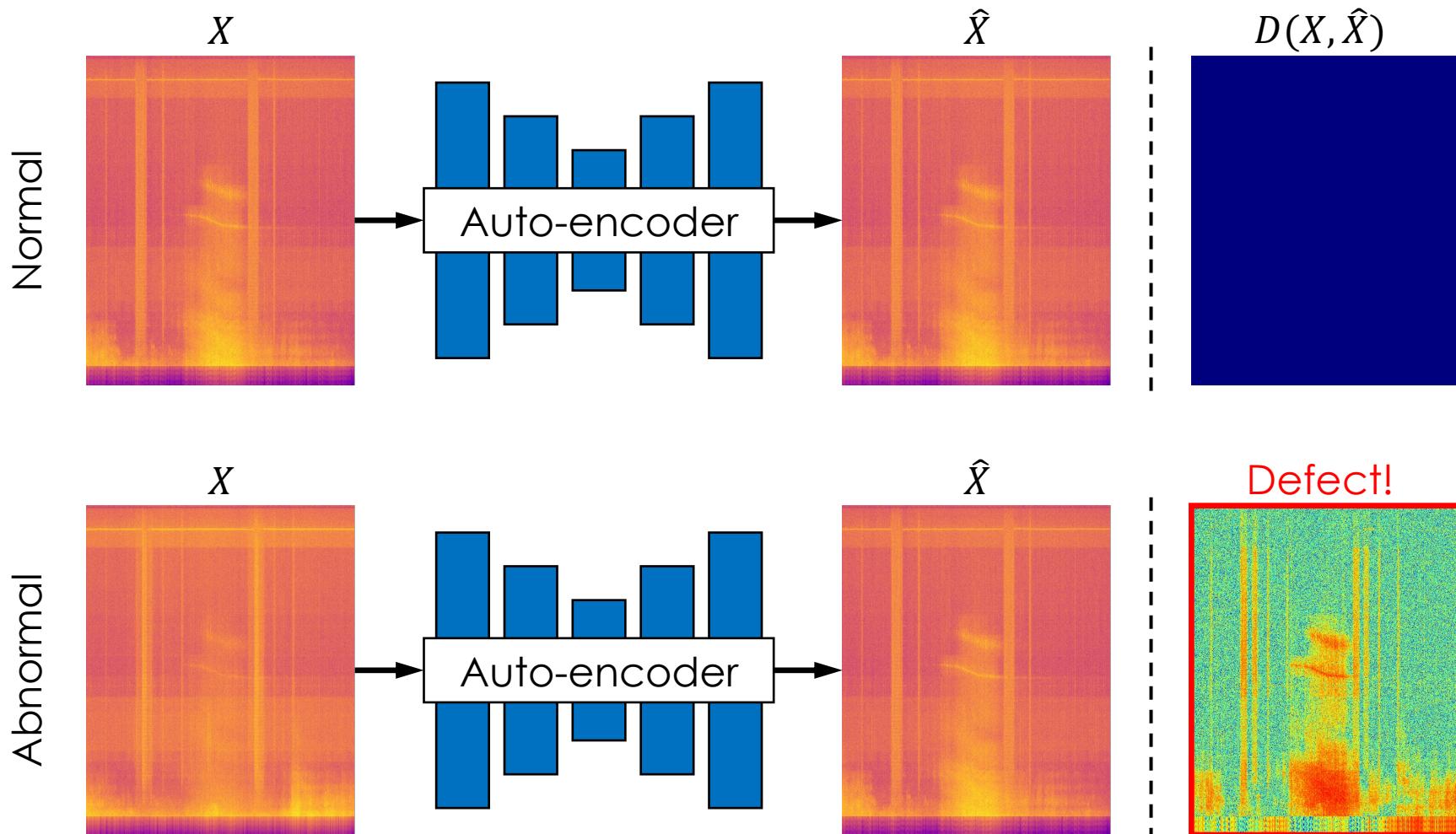
Icy : 0.14

Anomaly Detection

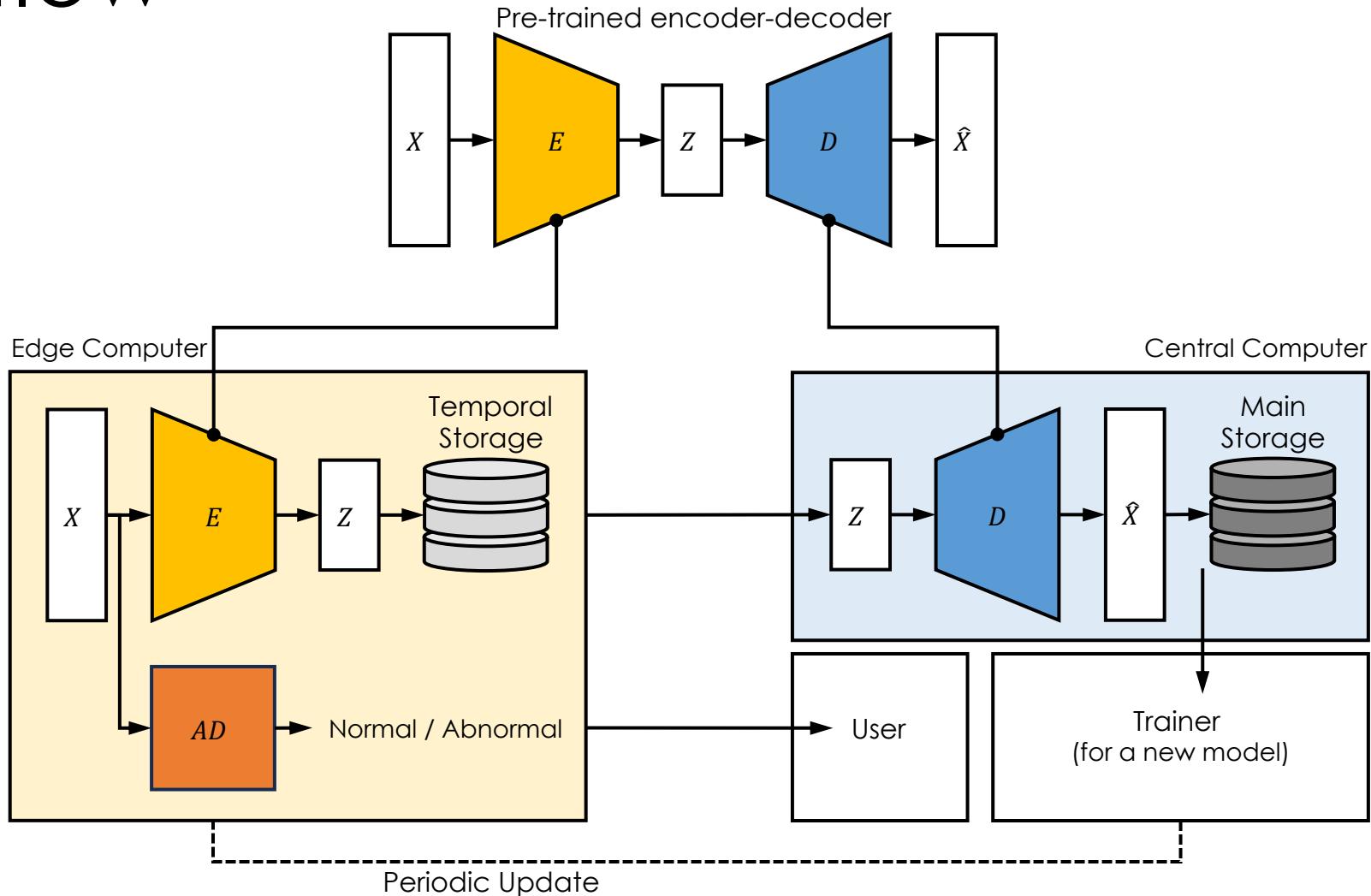


[3] Park et al., "Non-Compression Auto-Encoder for Detecting Road Surface Abnormality via Vehicle Driving Noise." IEEE ICACEH 2022

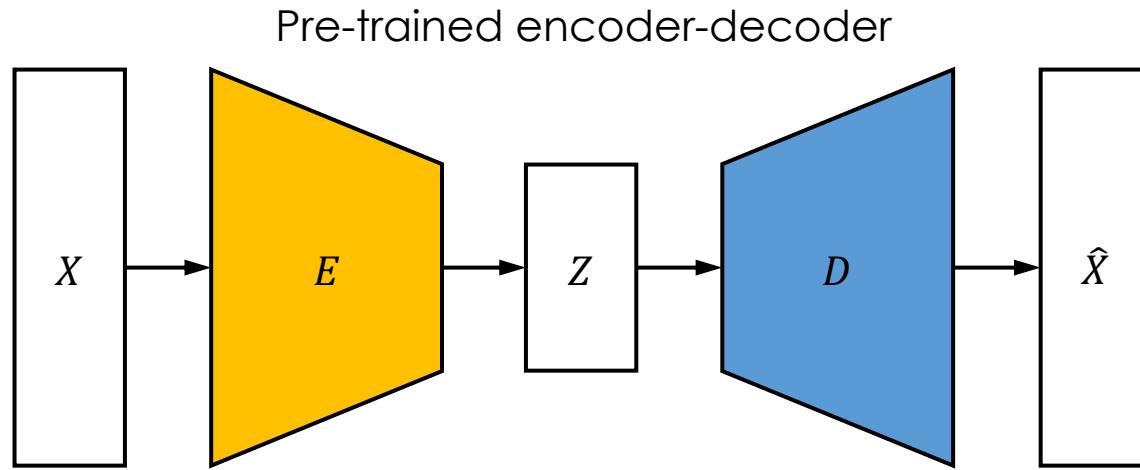
Anomaly Detection



Workflow

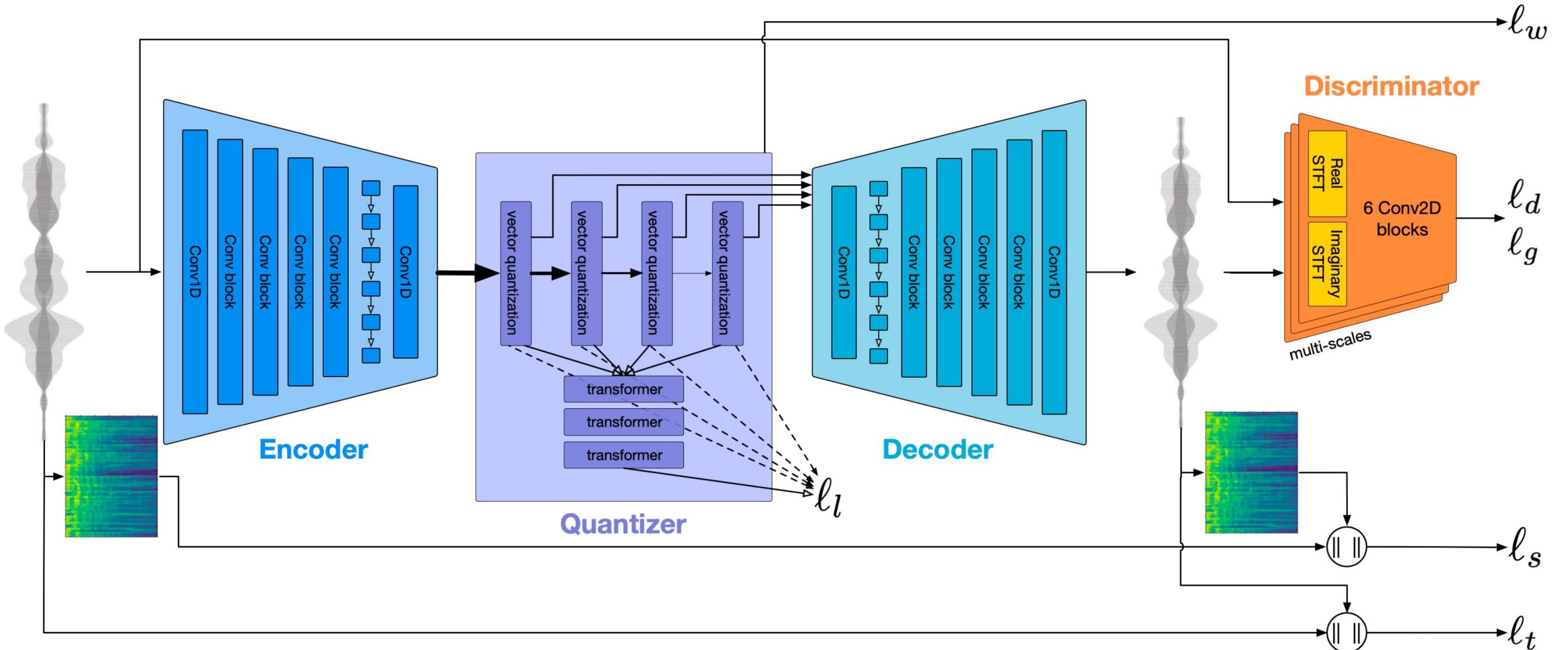


Zero-shot data compression



[4] Alexandre Défossez et al., "High fidelity neural audio compression." arXiv 2022

Zero-shot data compression

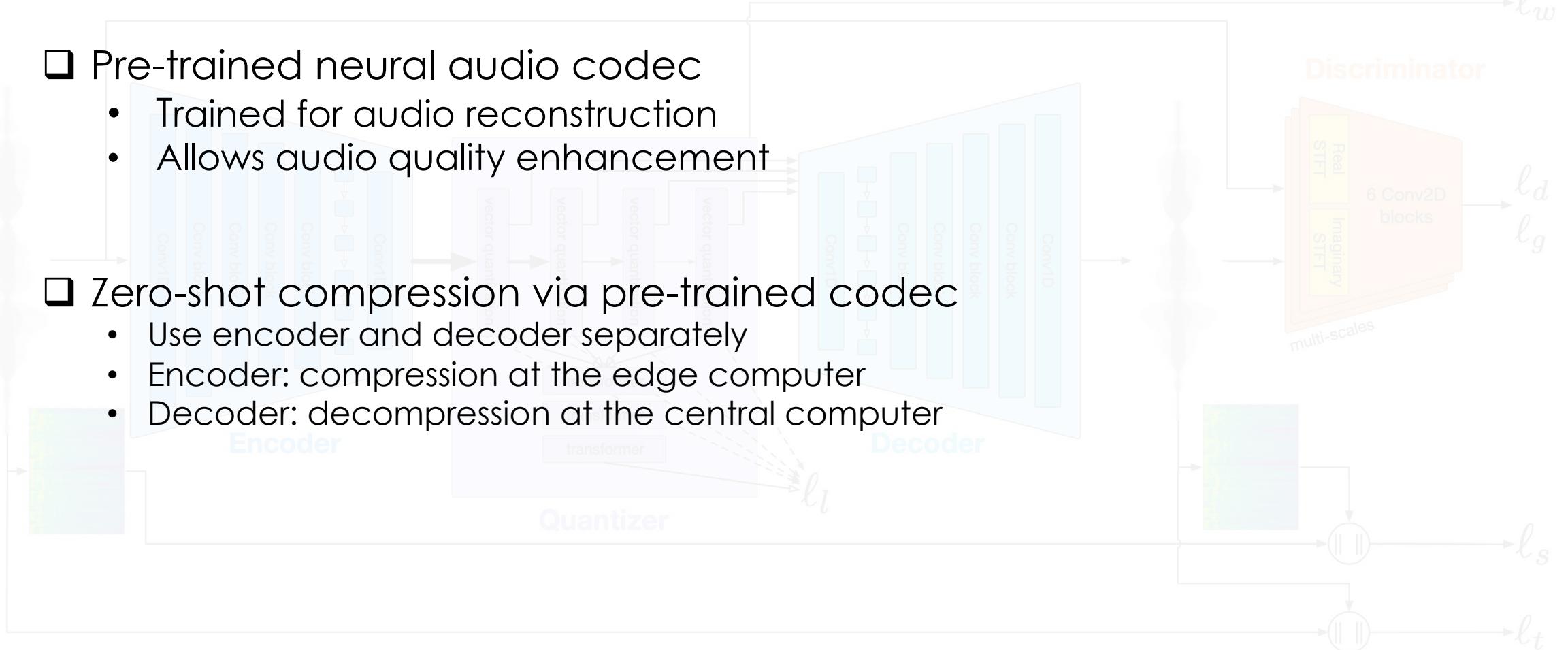


[4] Alexandre Défossez et al., "High fidelity neural audio compression." arXiv 2022

Zero-shot data compression

- Pre-trained neural audio codec
 - Trained for audio reconstruction
 - Allows audio quality enhancement

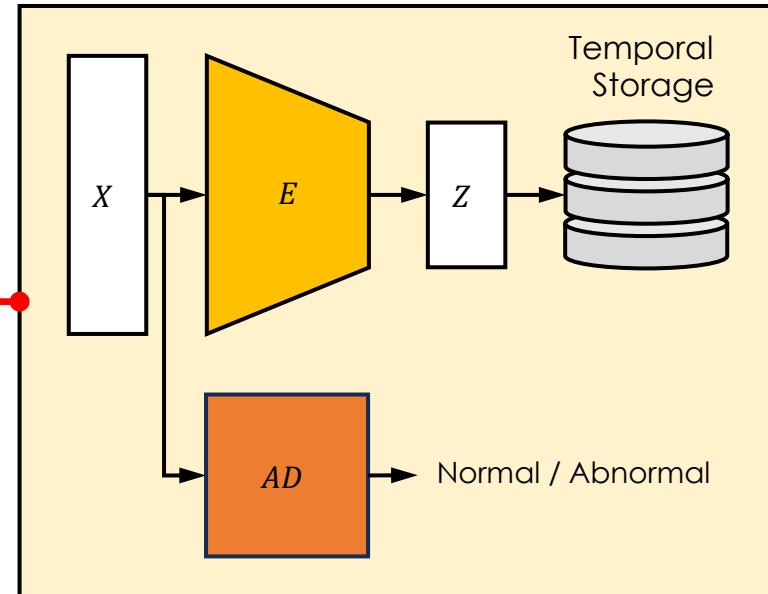
- Zero-shot compression via pre-trained codec
 - Use encoder and decoder separately
 - Encoder: compression at the edge computer
 - Decoder: decompression at the central computer



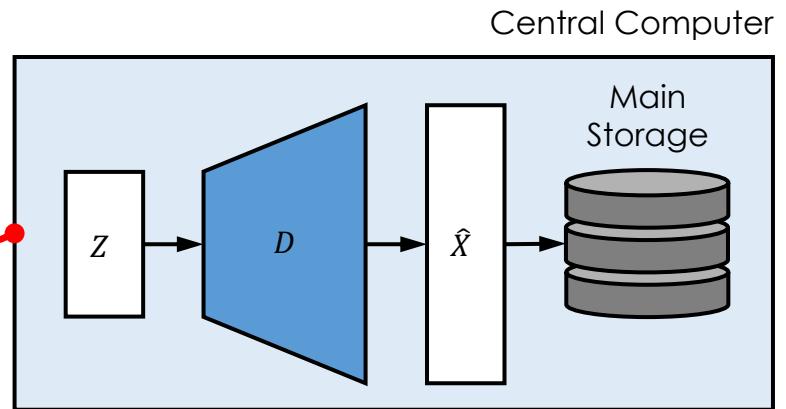
Audio compression



Edge Computer



Audio decompression



Dataset



Post-A
(Tunnel)



Post-B
(City)



Post-C
(Outer)

Dataset

Post	Normal		Abnormal					
	Dry	Wet	Slush	Snow				
Tunnel	10 (384)	10 (21)	4 (7)	- -				
City	10 (804)	10 (529)	2 (11)	- -				
Outer	10 (1,153)	9 (1,032)	10 (76)	3 (5)				
Total	30 (2,341)	29 (1,582)	16 (94)	3 (5)				

↑ ↑

Audio samples Driving events
(10-minute length) (10-seconds length)

[1] Park et al., "Frequency of Interest-based Noise Attenuation Method to Improve Anomaly Detection Performance." IEEE BigComp 2023

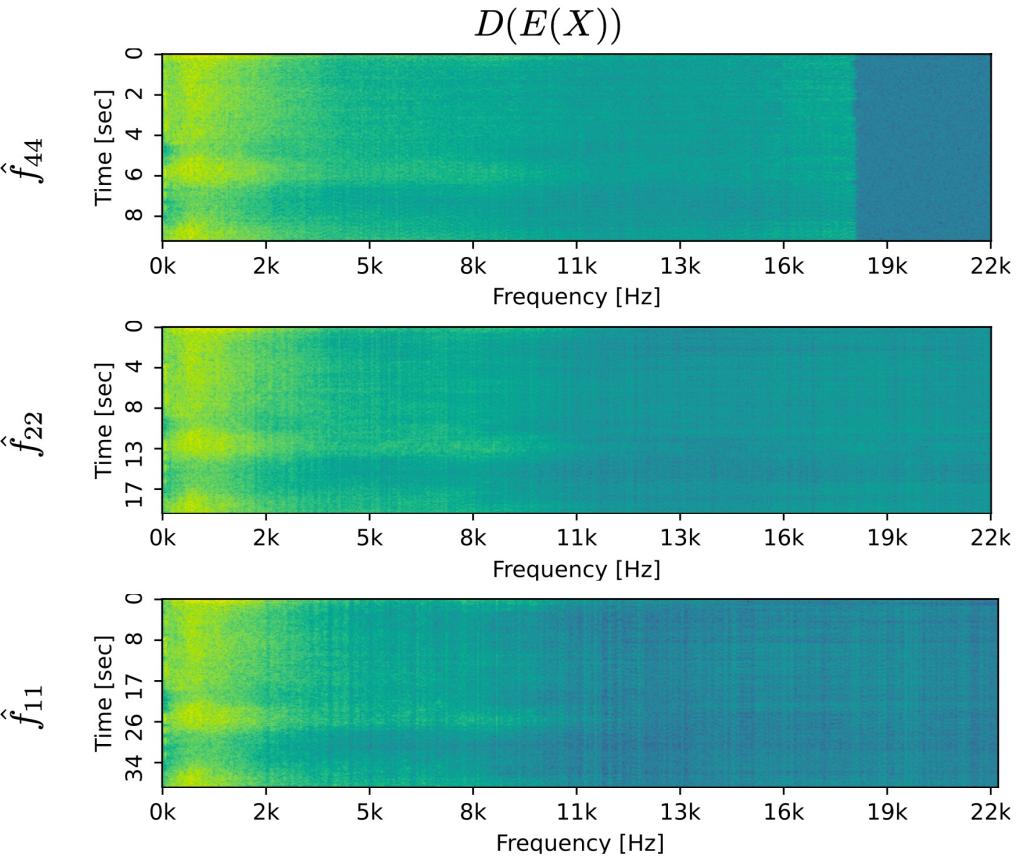
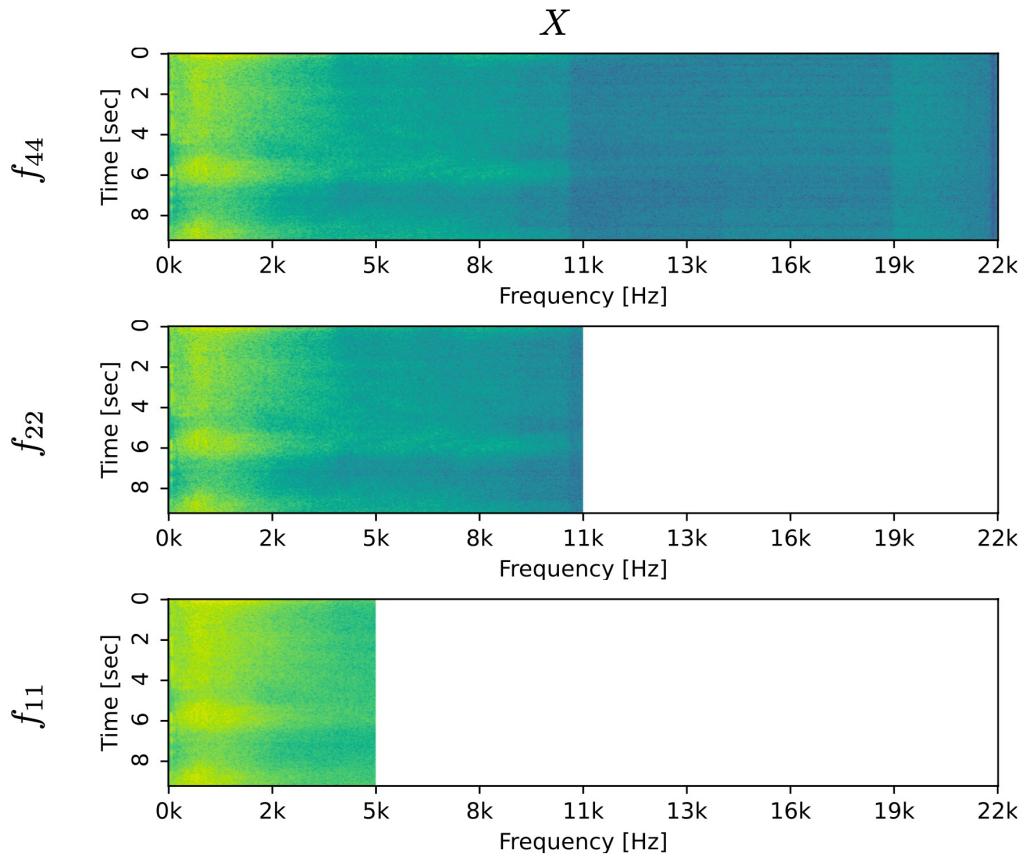
Compression effectiveness

The diagram illustrates the compression process. It starts with 'Original Audio' at the top, which branches into two paths: 'Down-sampling' leading to 'Lo-Fi', and 'Neural codec [4]' leading to 'ASR'. The 'ASR' path is highlighted with a red box and a red arrow pointing to it.

Source	Hi-Fi	Lo-Fi	ASR
Frequency	f_{44} [15]	f_{22}	f_{11}
File size	173 KiB	87 KiB	44 KiB
$\text{Ratio}_{size} \downarrow$	1.000	0.503	0.029

[4] Alexandre Défossez et al., "High fidelity neural audio compression." arXiv 2022

Compression effectiveness



Anomaly detection

	Original Audio	Down-sampling	Neural codec [4]	
Source	Hi-Fi	Lo-Fi	ASR	
Frequency	f_{44} [15]	f_{22}	f_{11}	f_{44}
Tunnel	0.963	0.961	0.957	0.967
City	0.871	0.752	0.794	0.831
Outer	1.000	0.841	0.818	0.847
Merge	0.915	0.803	0.791	0.812
Average	0.937	0.839	0.840	0.864
Ratio $AUROC \uparrow$	1.000	0.895	0.896	0.922

Conclusion

- ❑ Zero-shot audio compression
 - Pre-trained codec also allows encoding and decoding on unseen driving sound
 - Capable of storing 34.6× more audio samples
- ❑ Cost-effective method for anomaly detection system operation
 - Reduce data transmission cost
 - Minimize performance reduction of the anomaly detection model
- ❑ Audio compression model by road type
 - Best-performing codec for each anomaly detection post
 - Eliminate performance degradation due to information loss

More informations



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