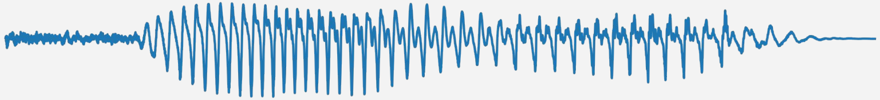
Vector Quantized Neural Networks for Acoustic Unit Discovery



Benjamin van Niekerk, Leanne Nortje, Herman Kamper

The Generative Factors of Speech

HH / Y / UW / M / ER

HUMOUR

Content:

- Discrete phonetic units.
- ≅44 phonemes in English.

Prosody:

- Rhythm
- Intonation
- Stresses

Timbre:

- Quality of a particular voice.
- Characterized by frequency spectrum.

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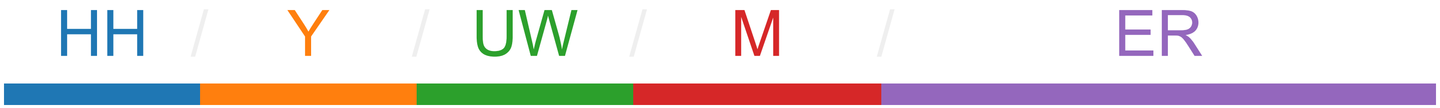

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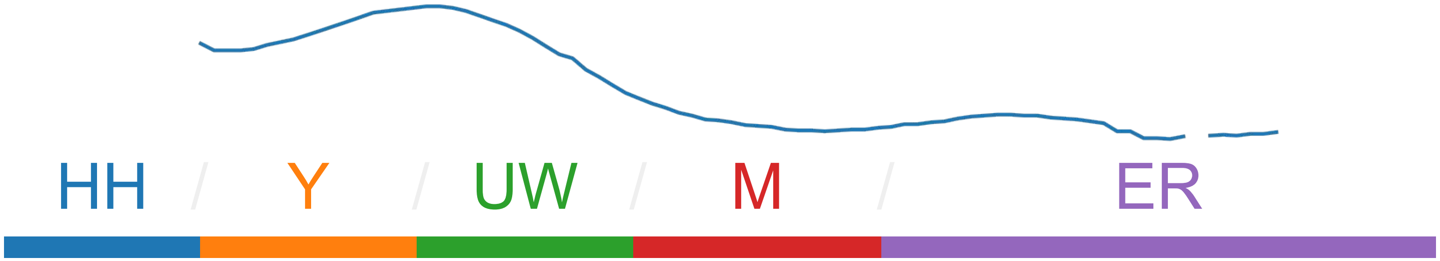

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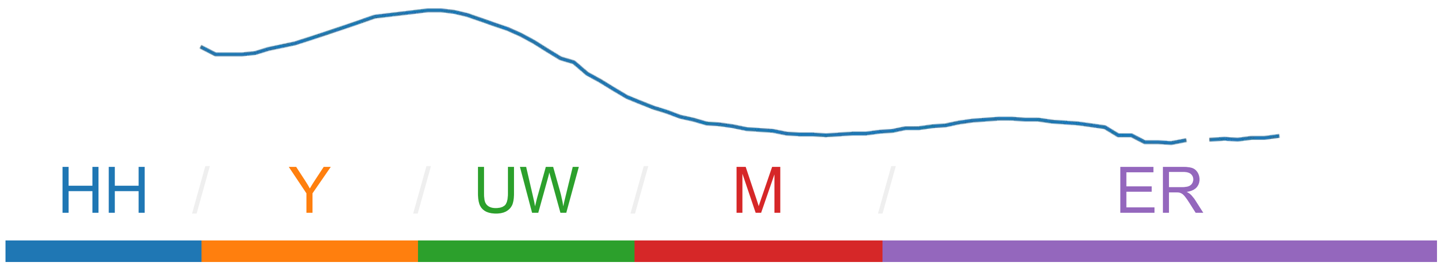

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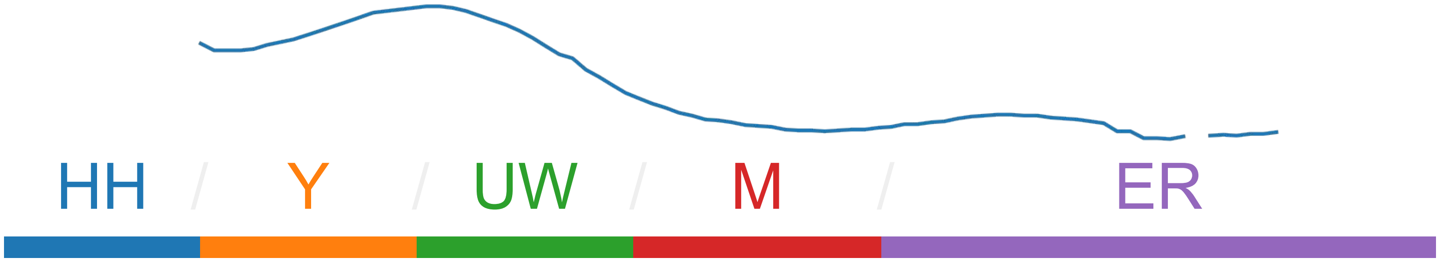

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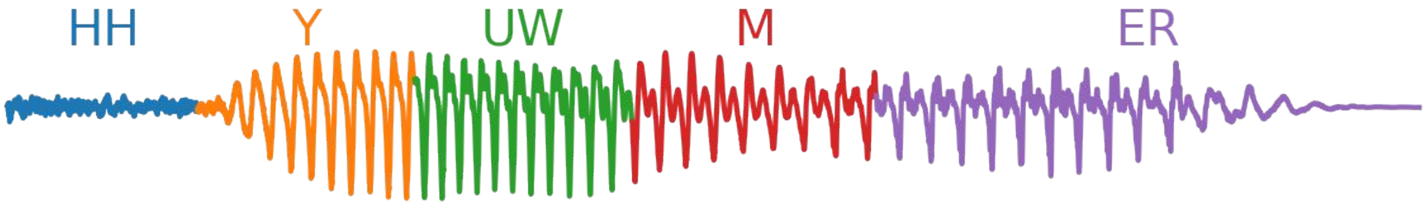

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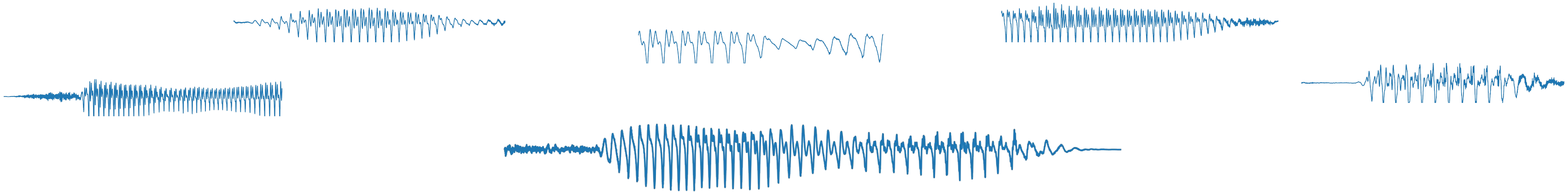

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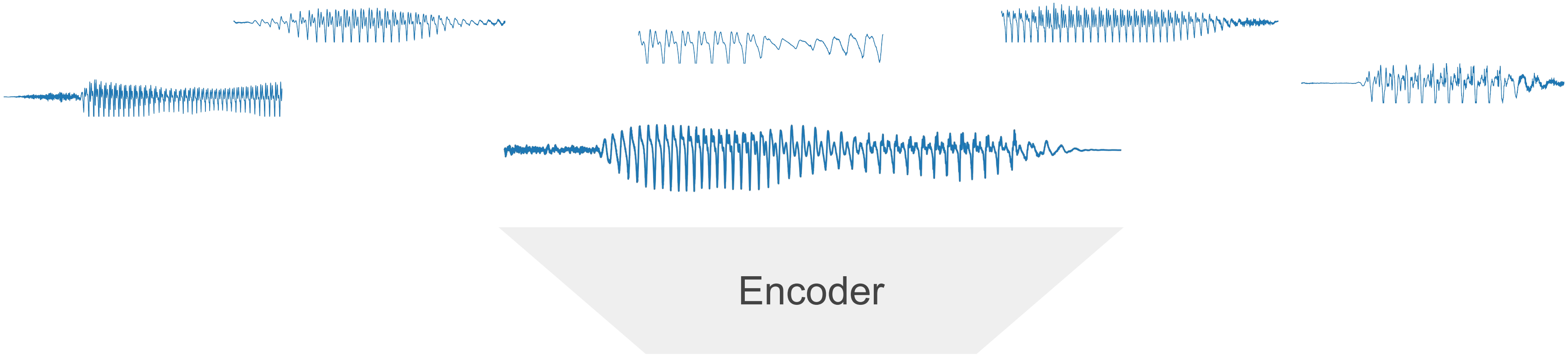

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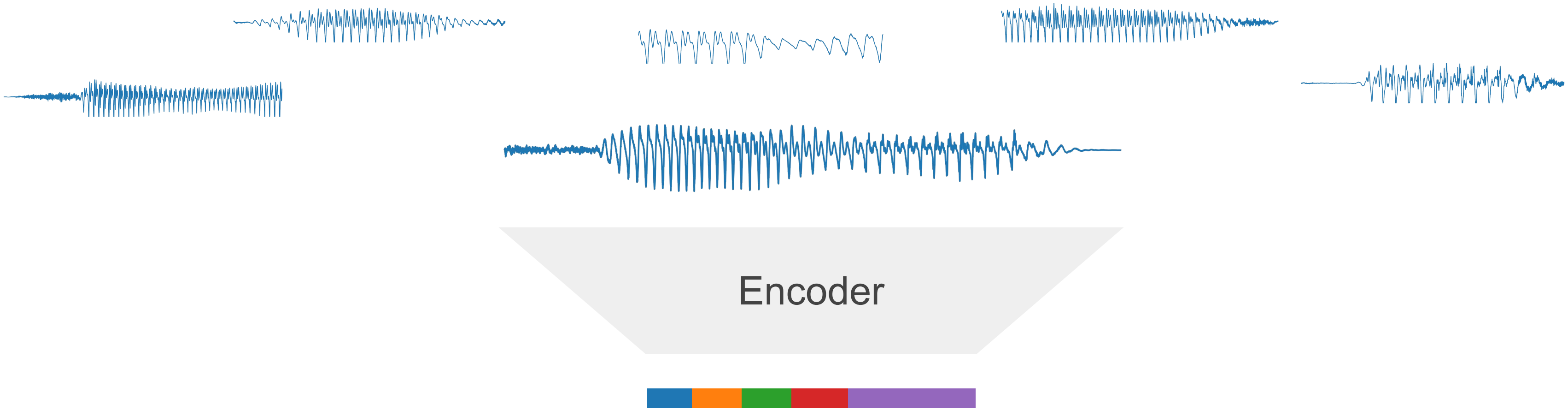

Applications

Bootstrap training of **low-resource** speech systems:

- Automatic speech recognition
- Text-to-speech
- Non-parallel voice conversion

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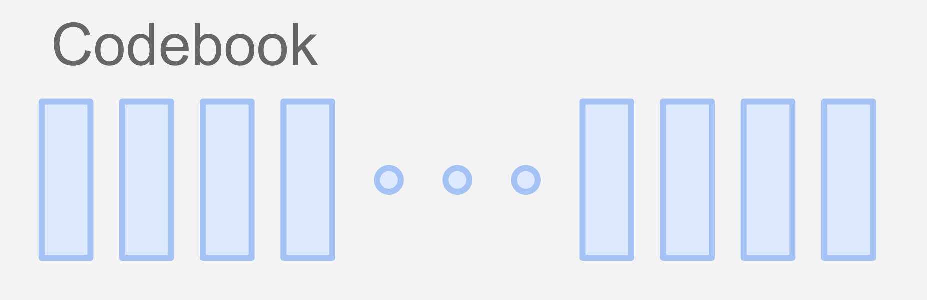
A. van den Oord, O. Vinyals, and K. Kavukcuoglu. “Neural discrete representation learning.” *Advances in Neural Information Processing Systems*. 2017.

Vector Quantization Layer



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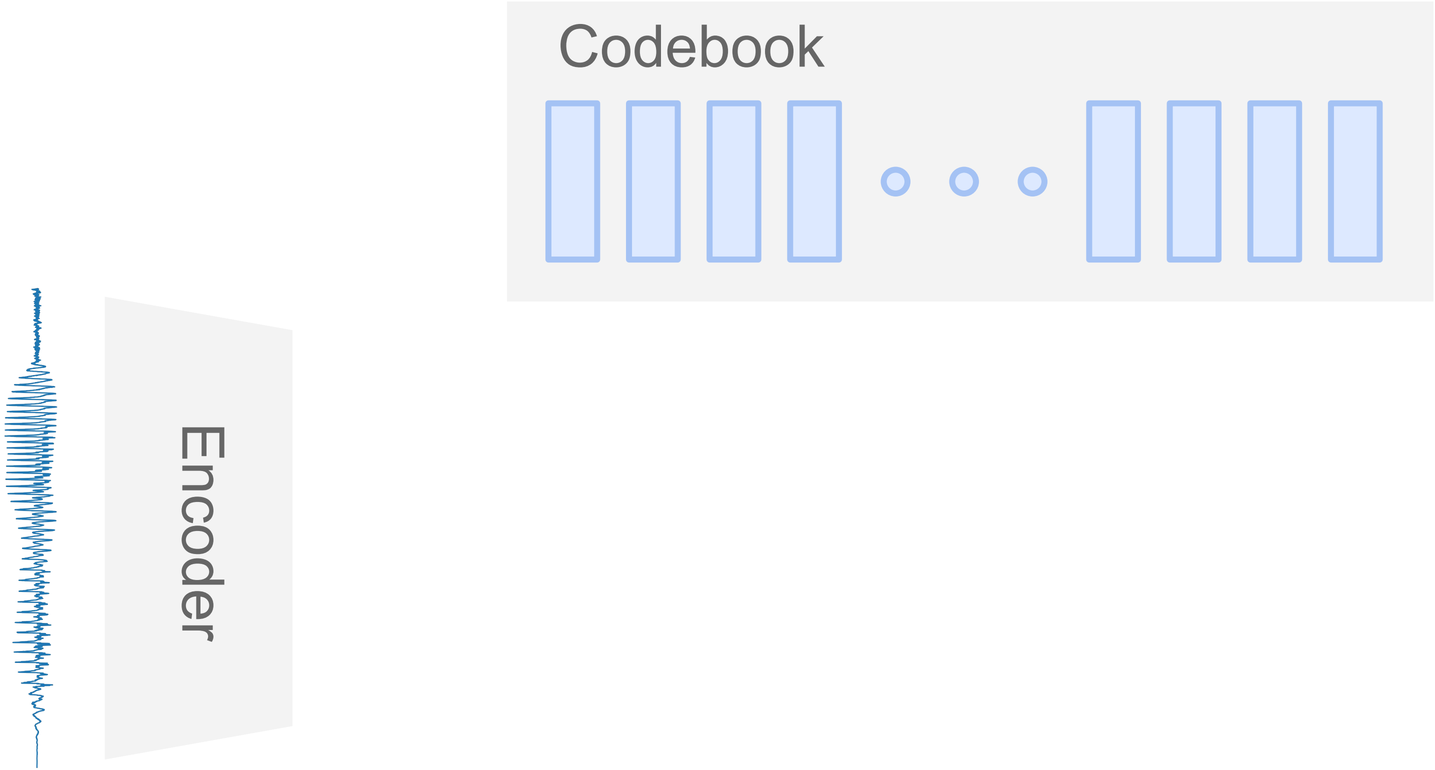

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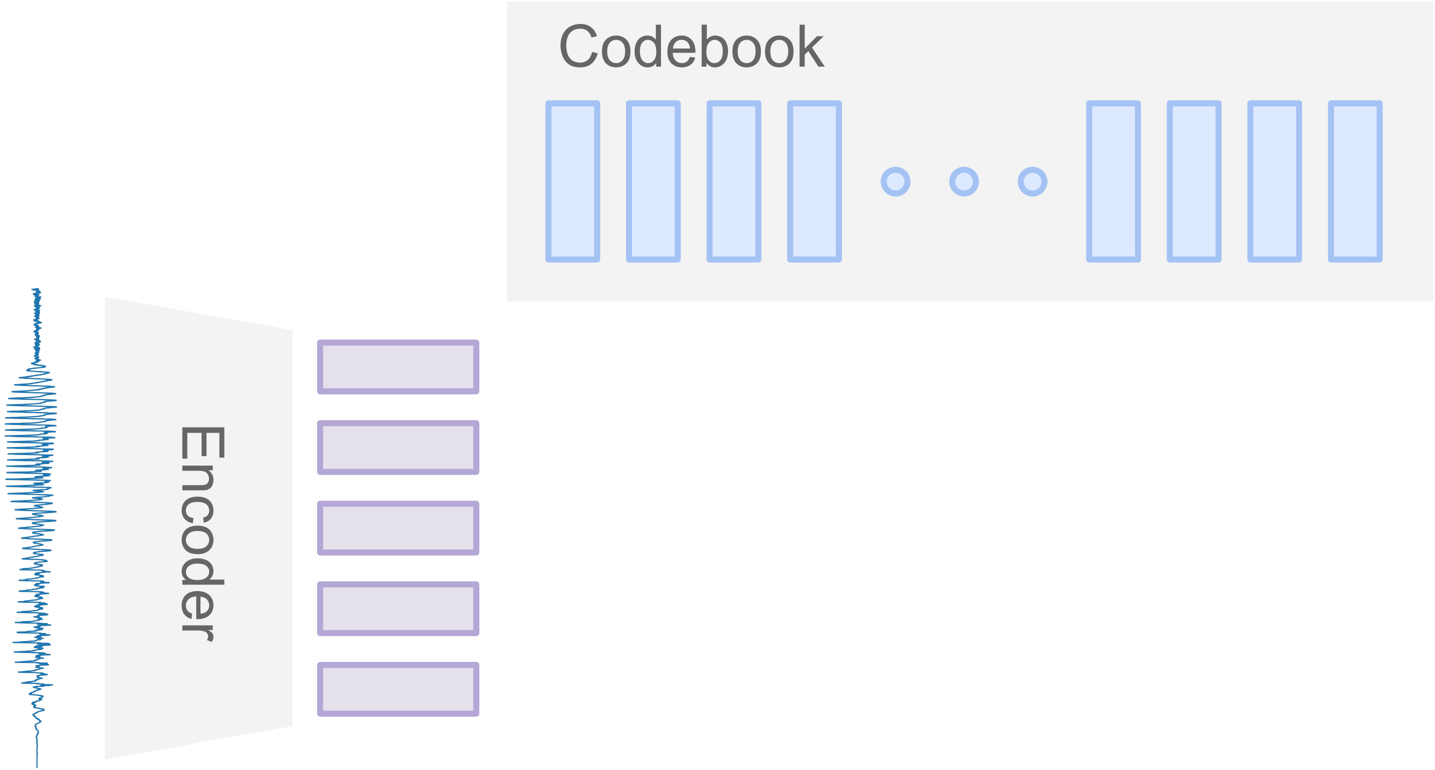

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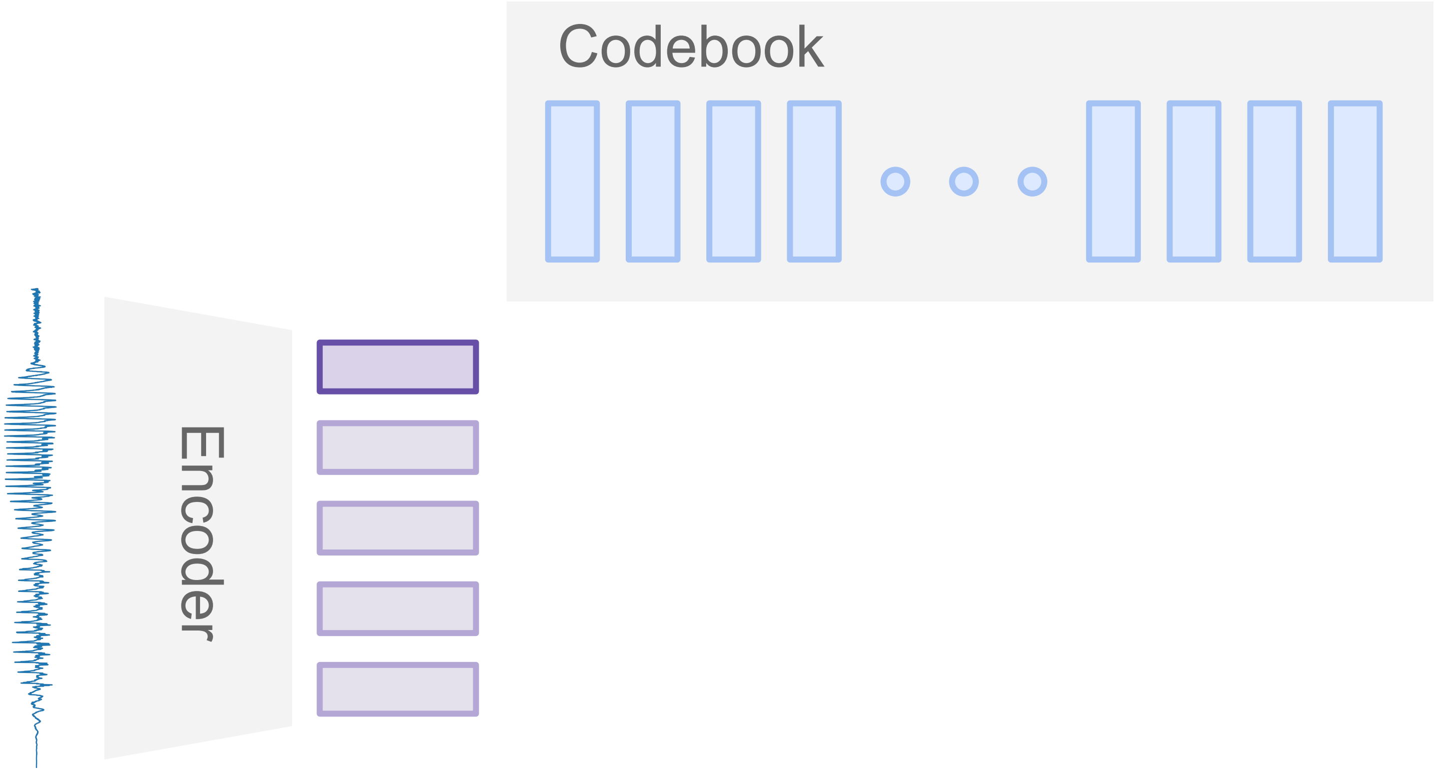

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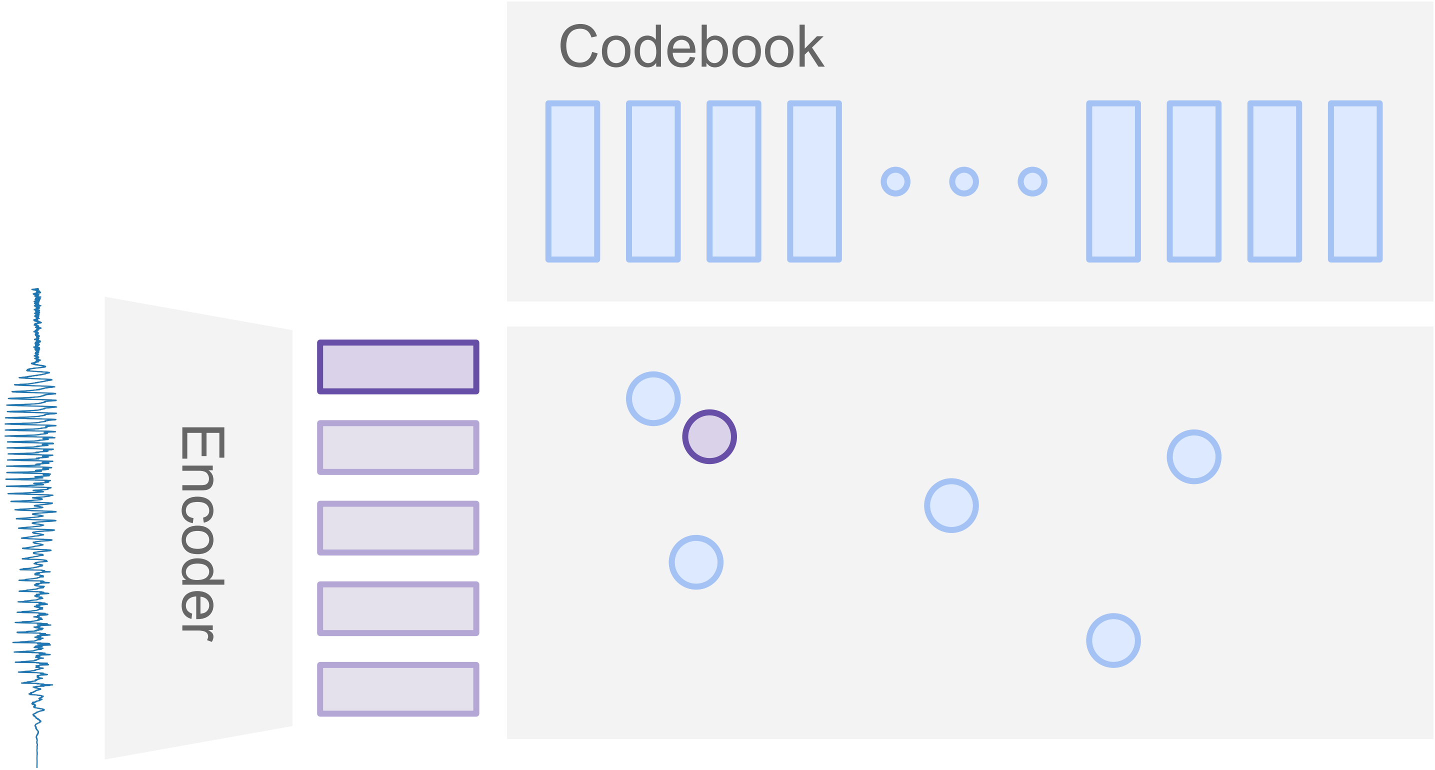

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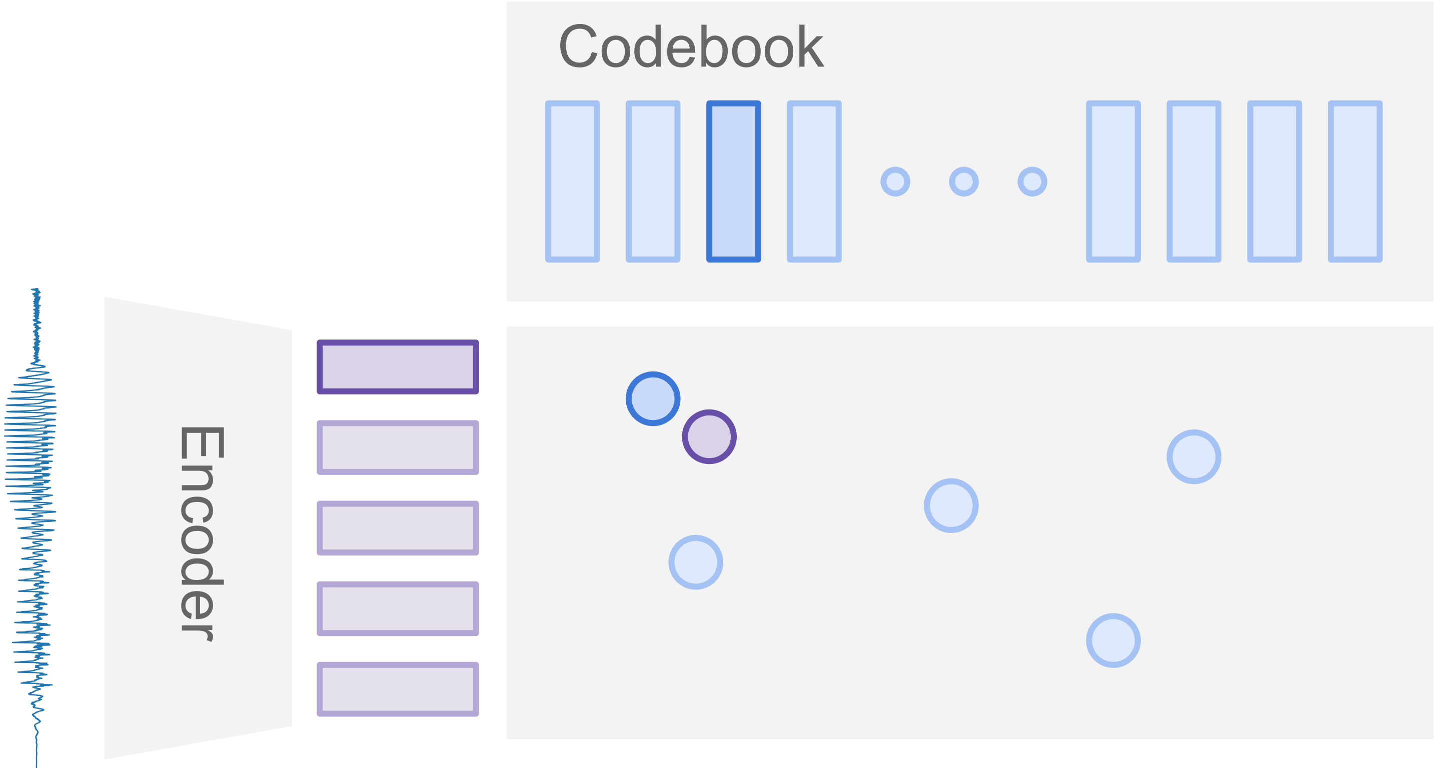

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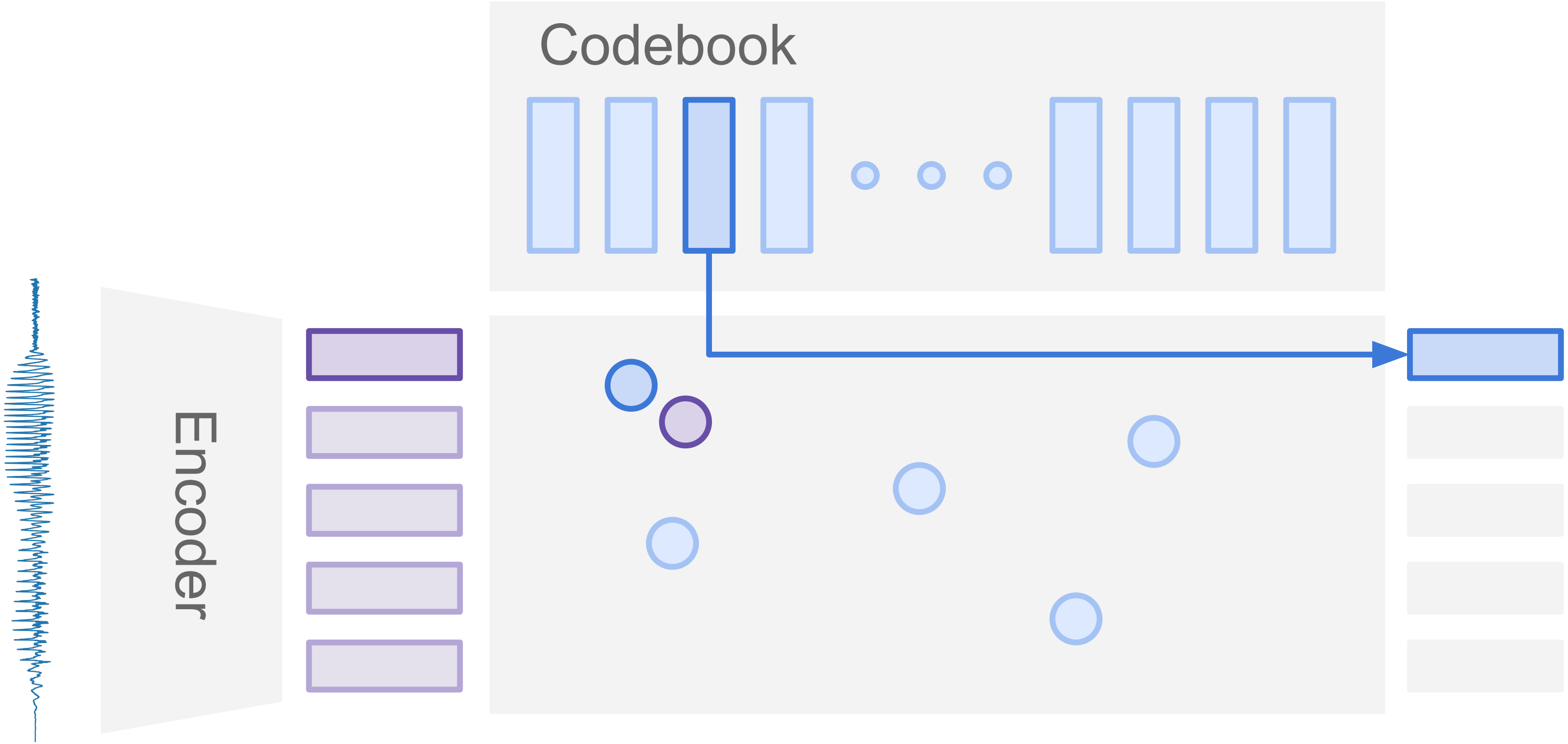

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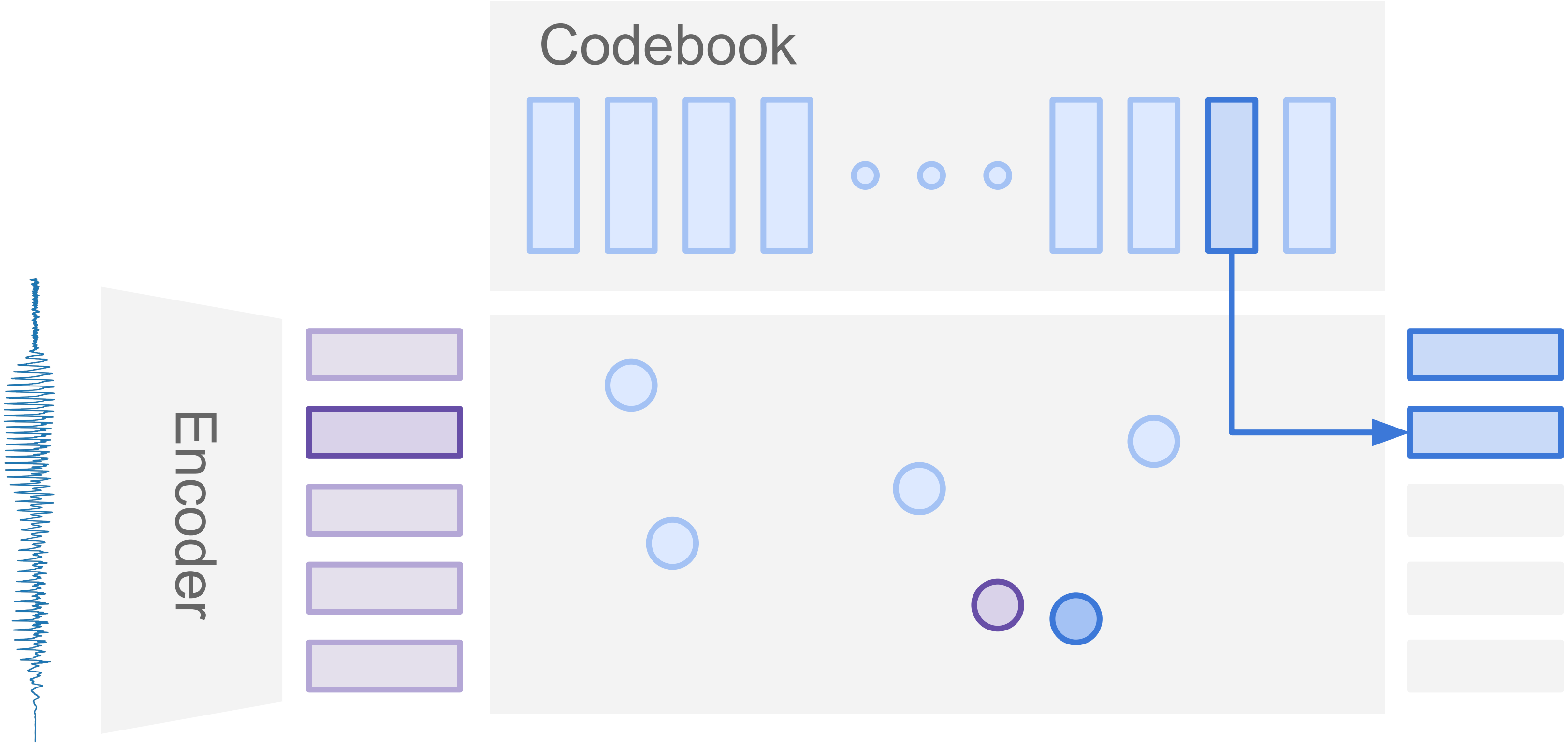

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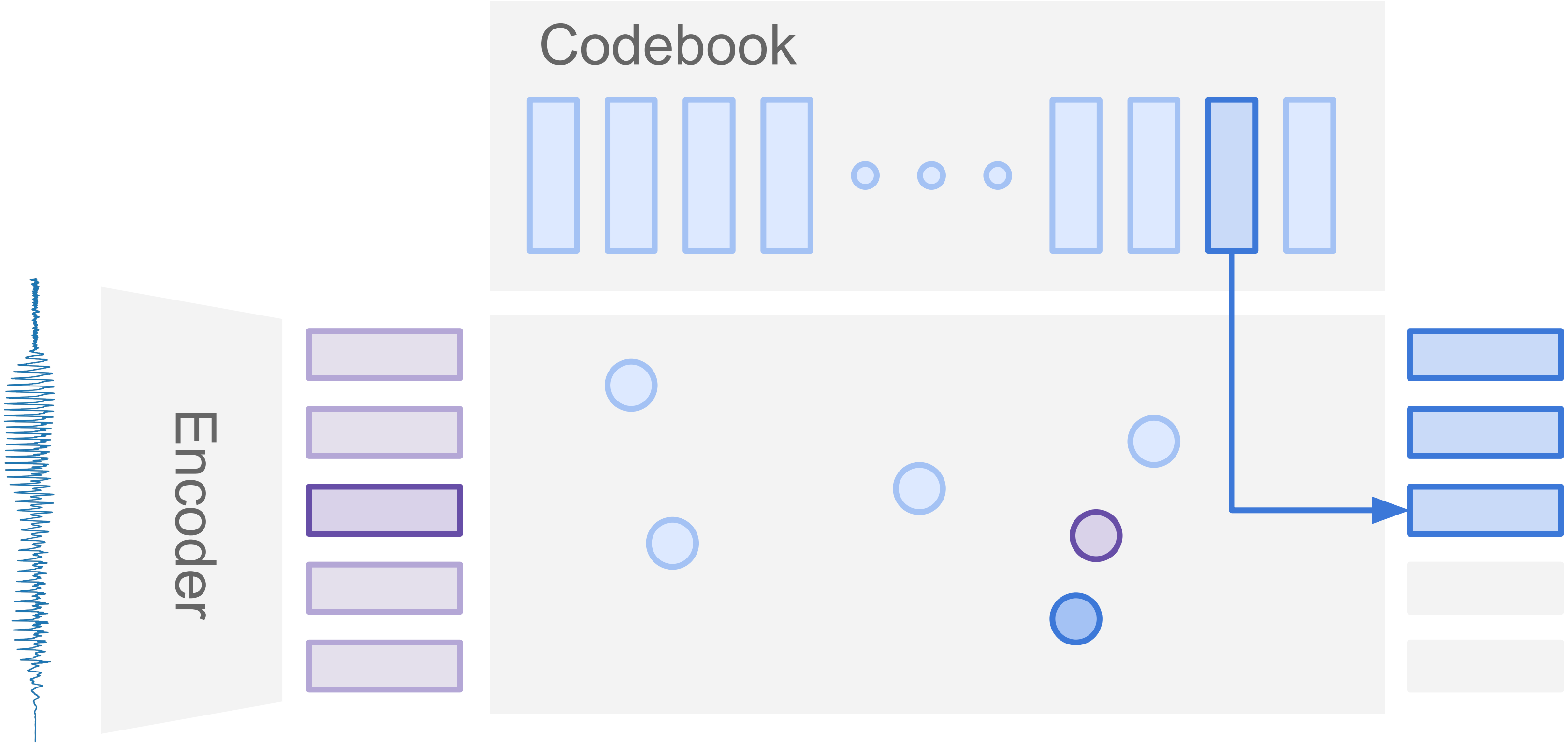
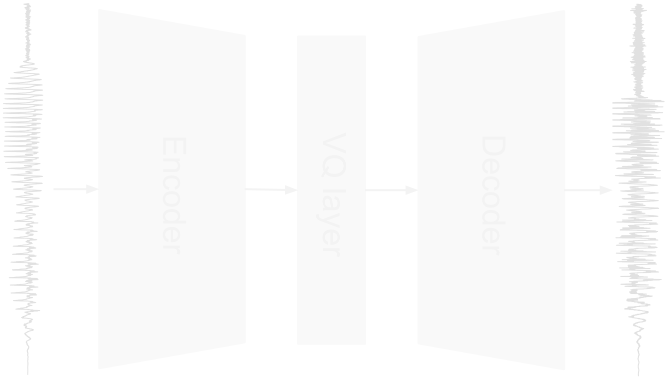


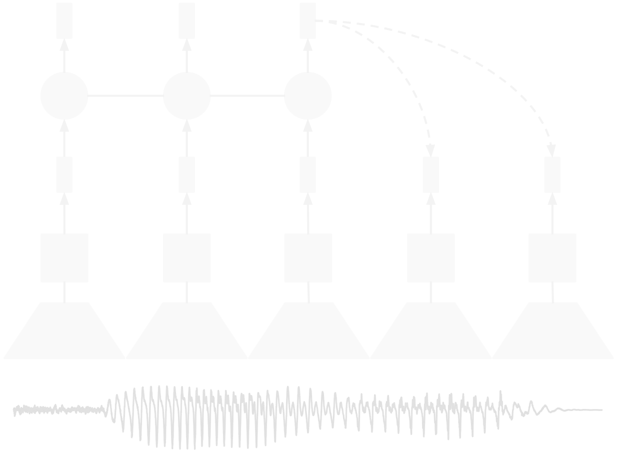
Our contribution: we propose and compare two models for acoustic unit discovery in the *ZeroSpeech 2020 Challenge*.

1. A Vector-Quantized Variational Autoencoder (VQ-VAE)



Inspired by: J. Chorowski, et al. "Unsupervised speech representation learning using wavenet autoencoders." IEEE/ACM transactions on audio, speech, and language processing. 2019.

2. A combination of Vector-Quantization and Contrastive Predictive Coding (VQ-CPC)



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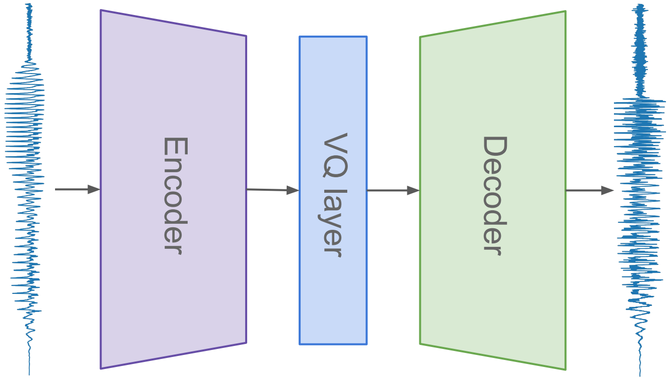

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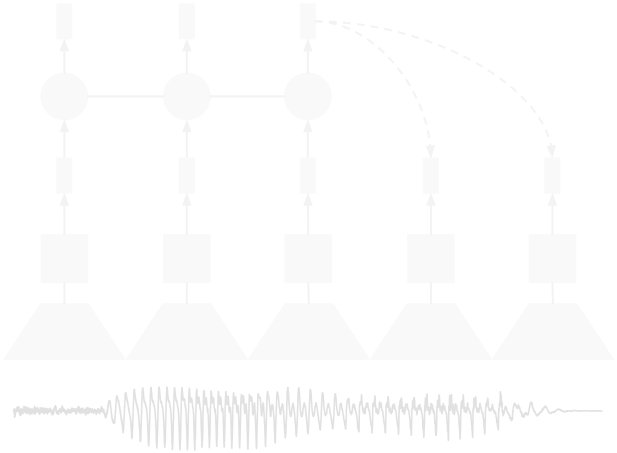

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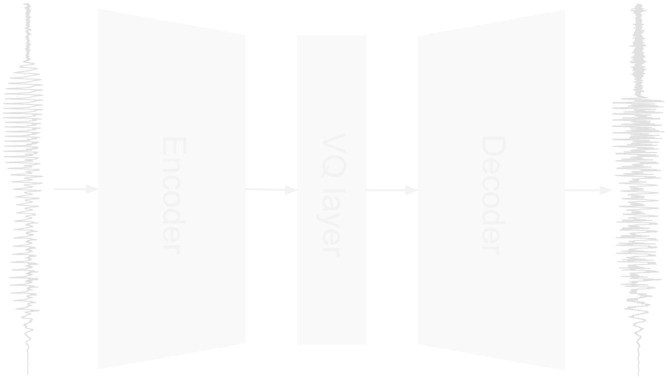

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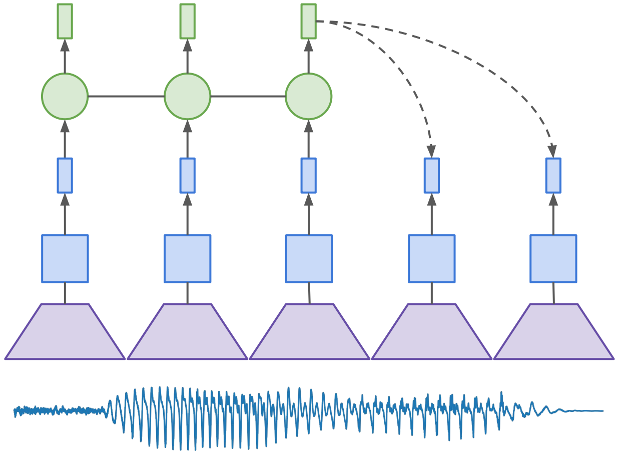

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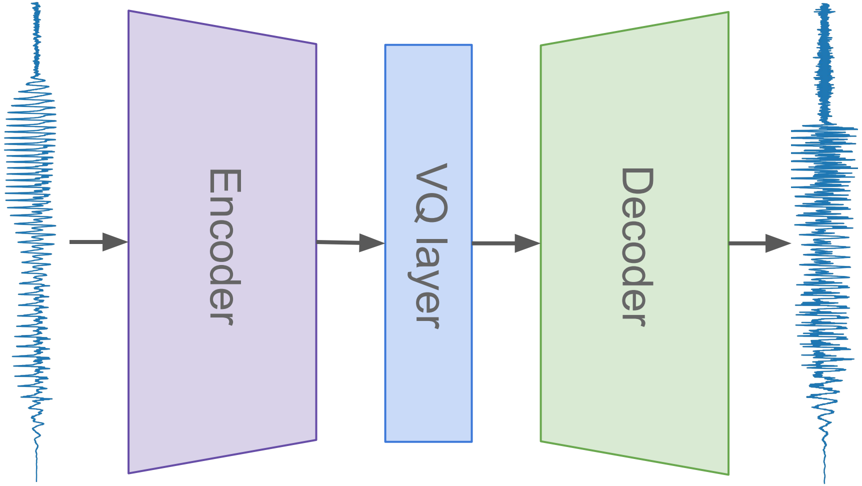
Vector-Quantized Variational Autoencoder



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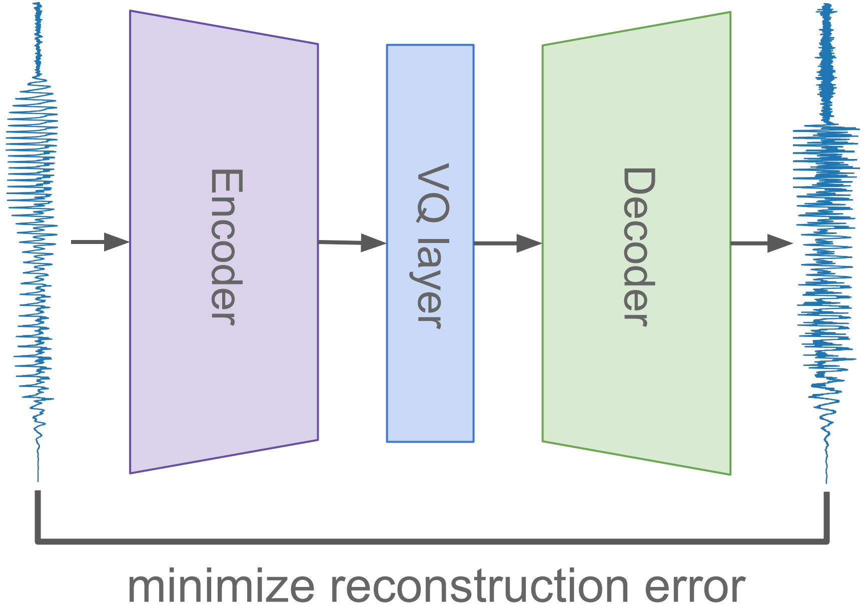

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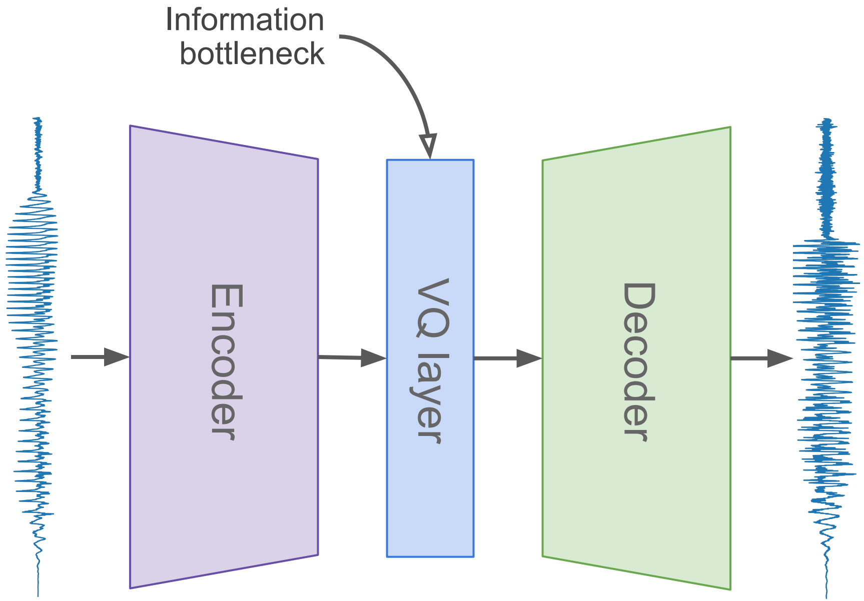
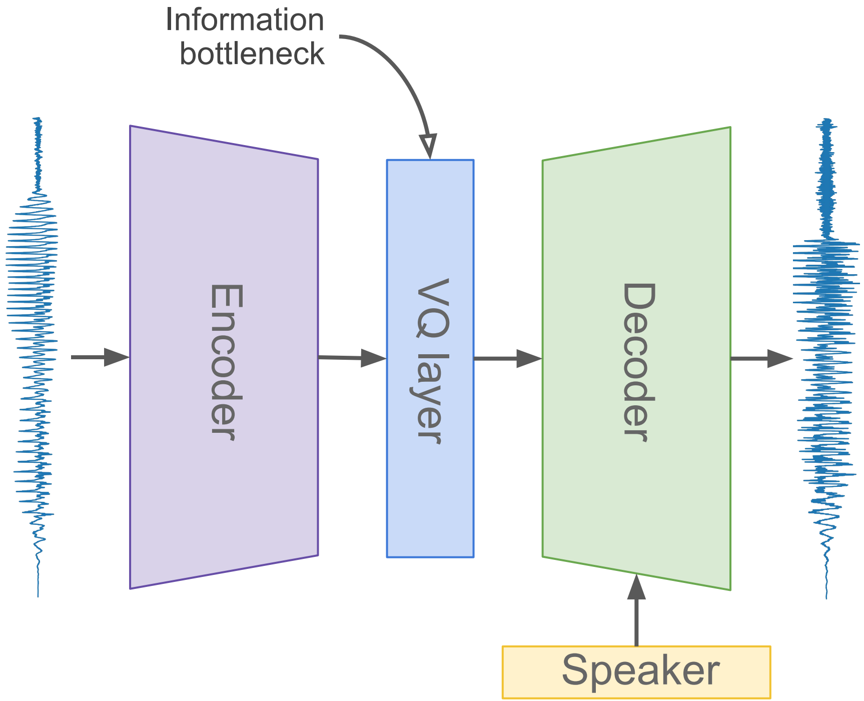

Information bottleneck

Vector-Quantized Variational Autoencoder



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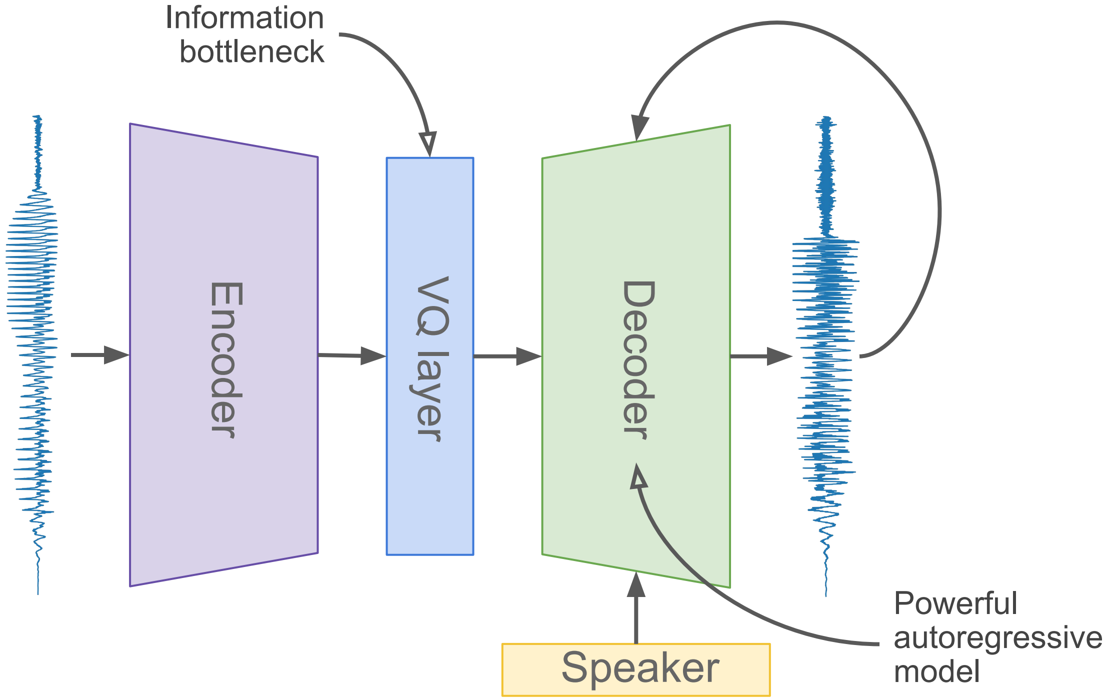
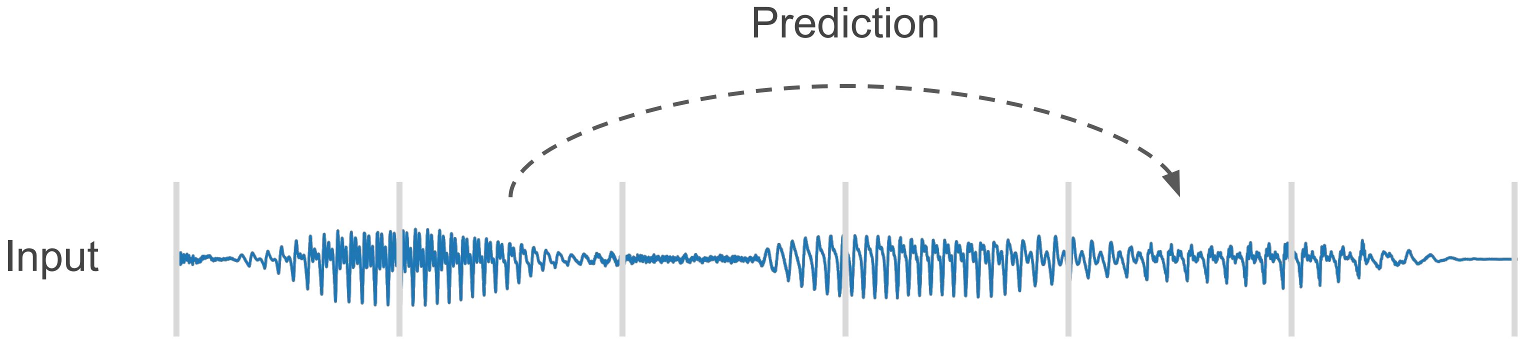


Vector-Quantized Contrastive Predictive Coding



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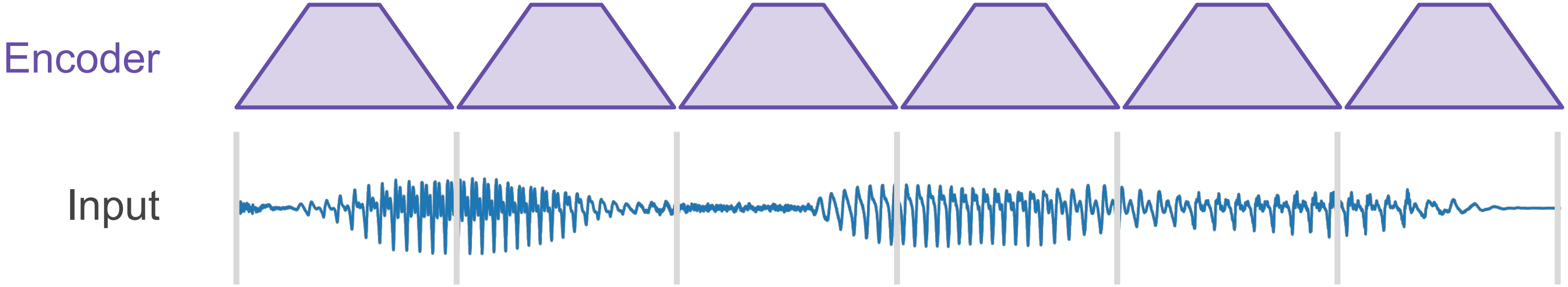

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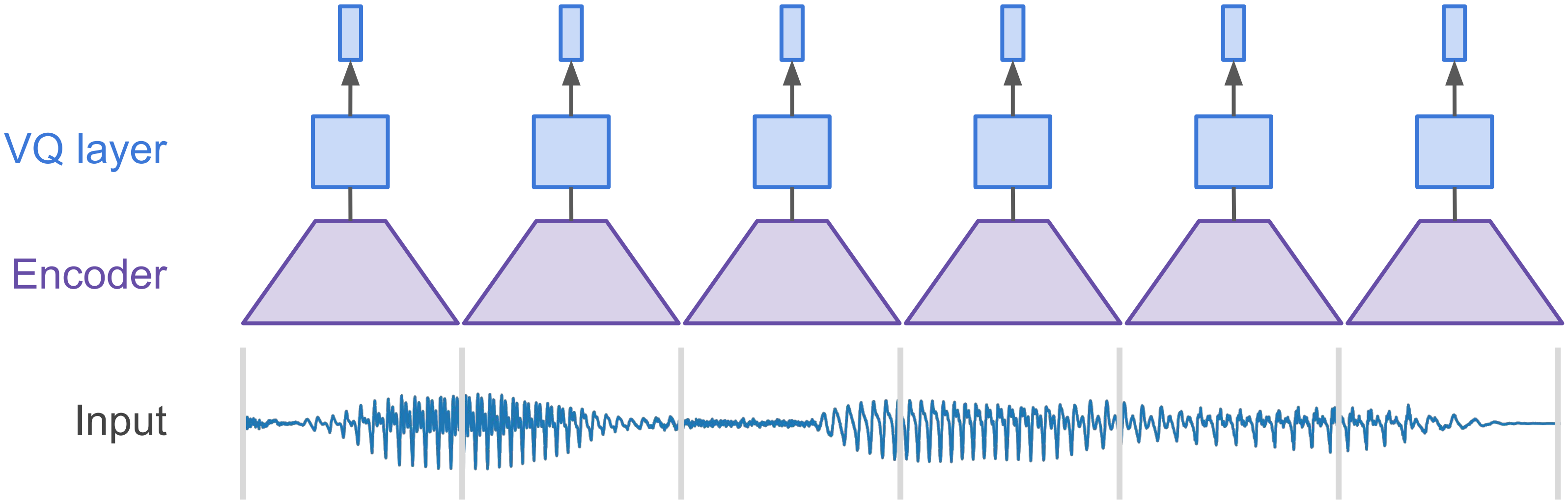

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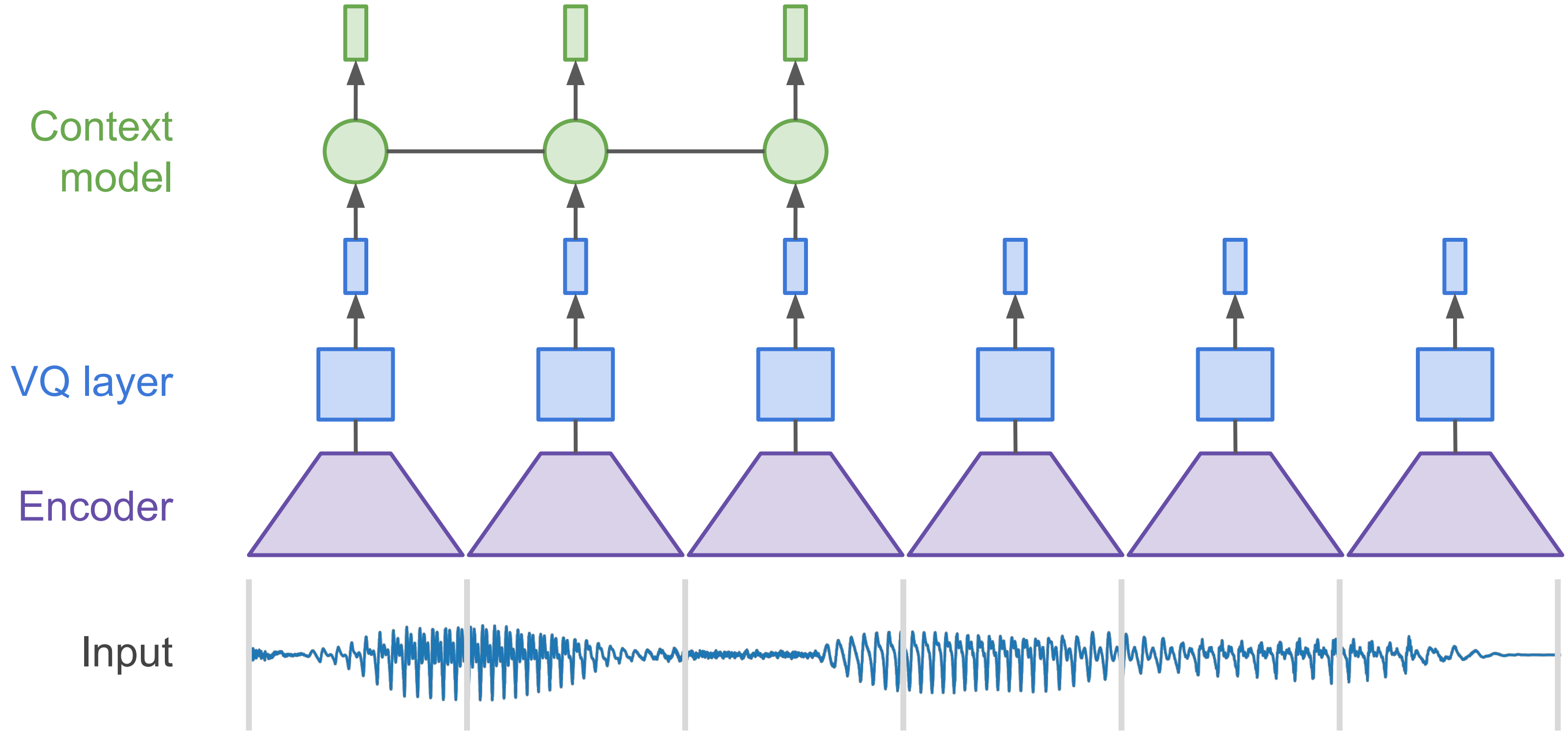

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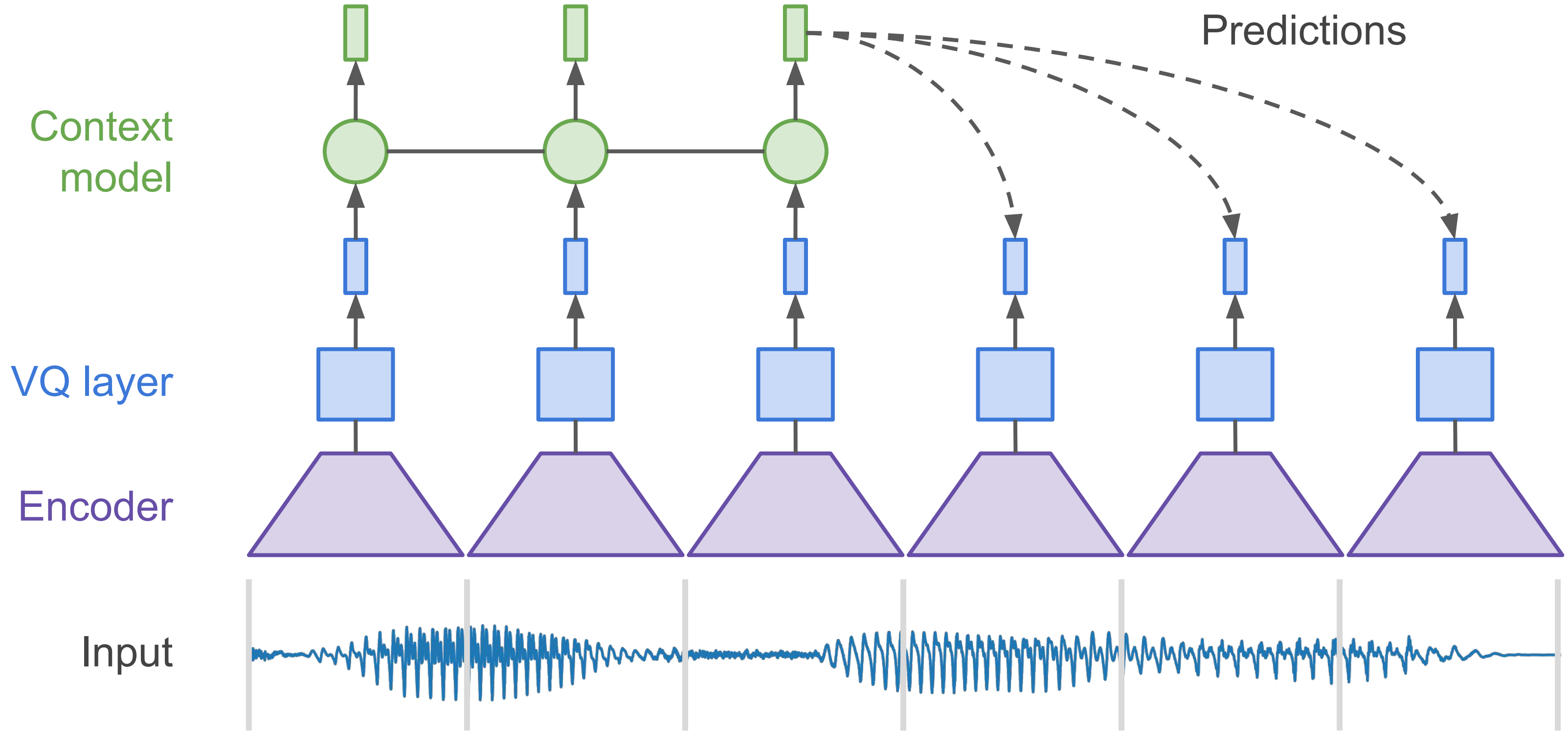

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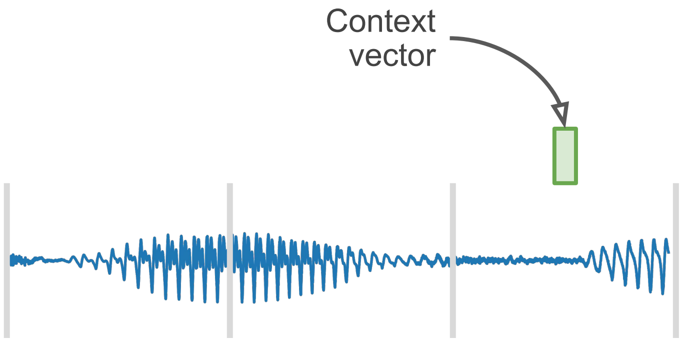

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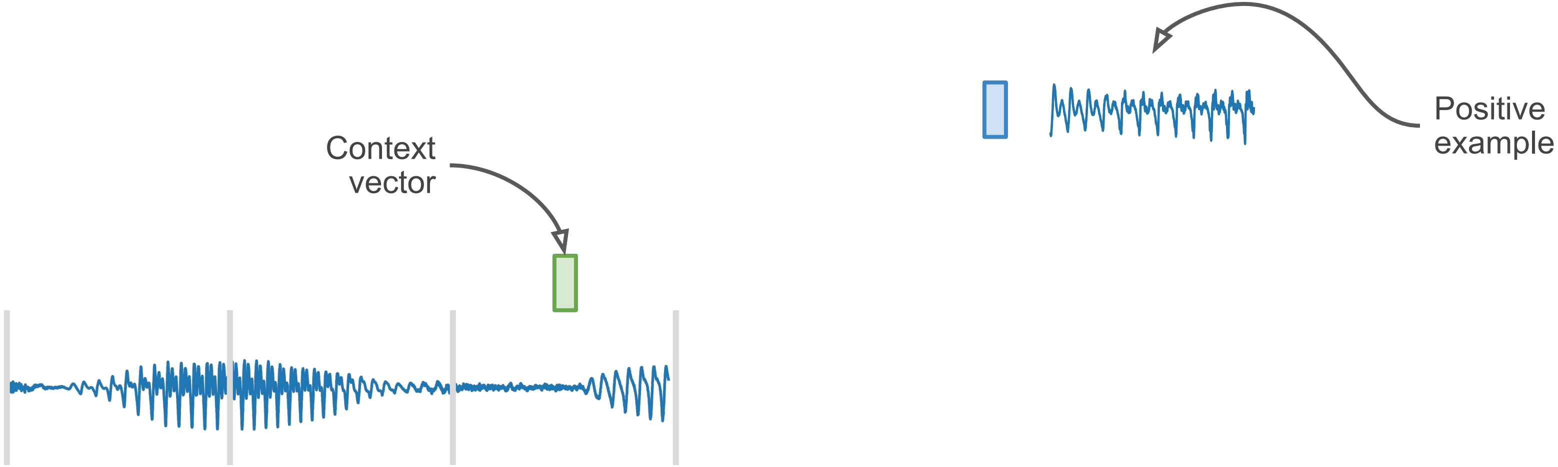
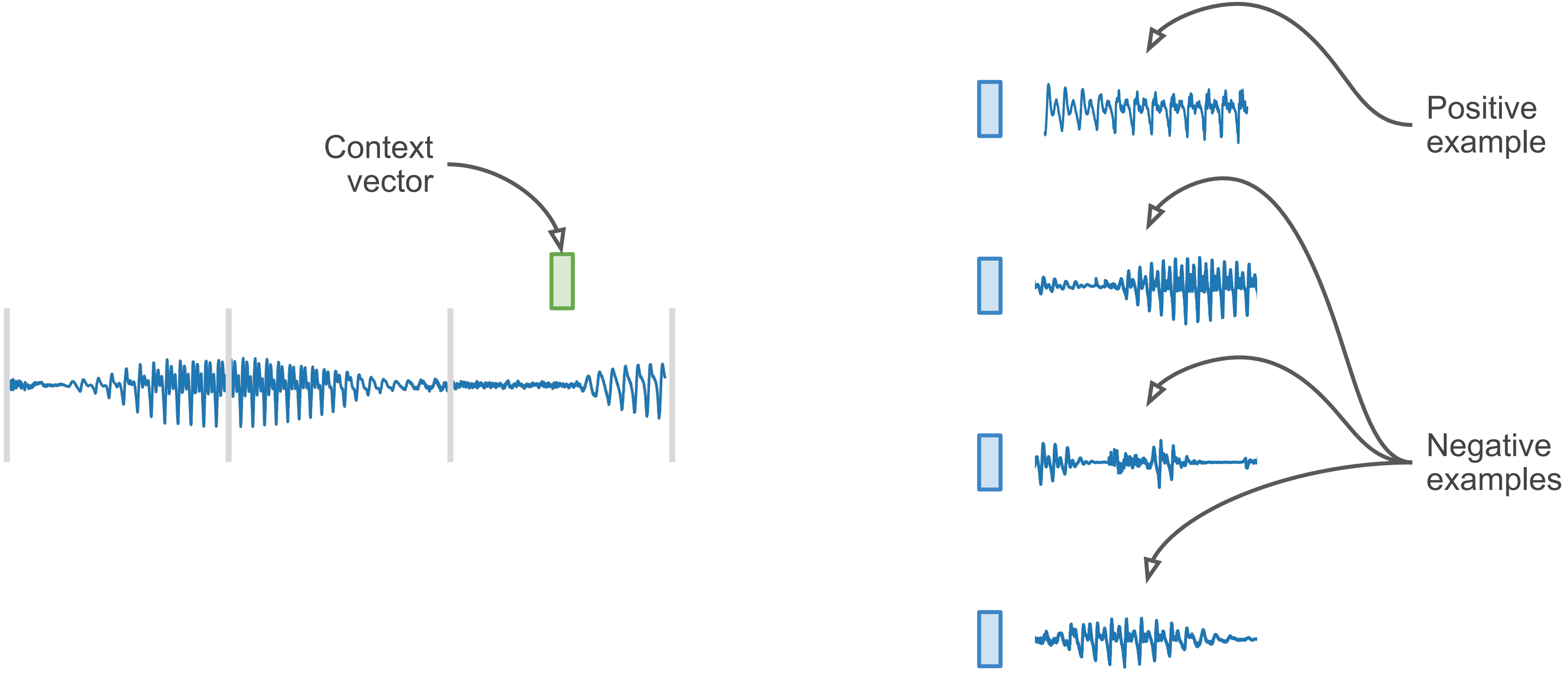


Context vector

Positive example

Vector-Quantized Contrastive Predictive Coding



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Negative examples

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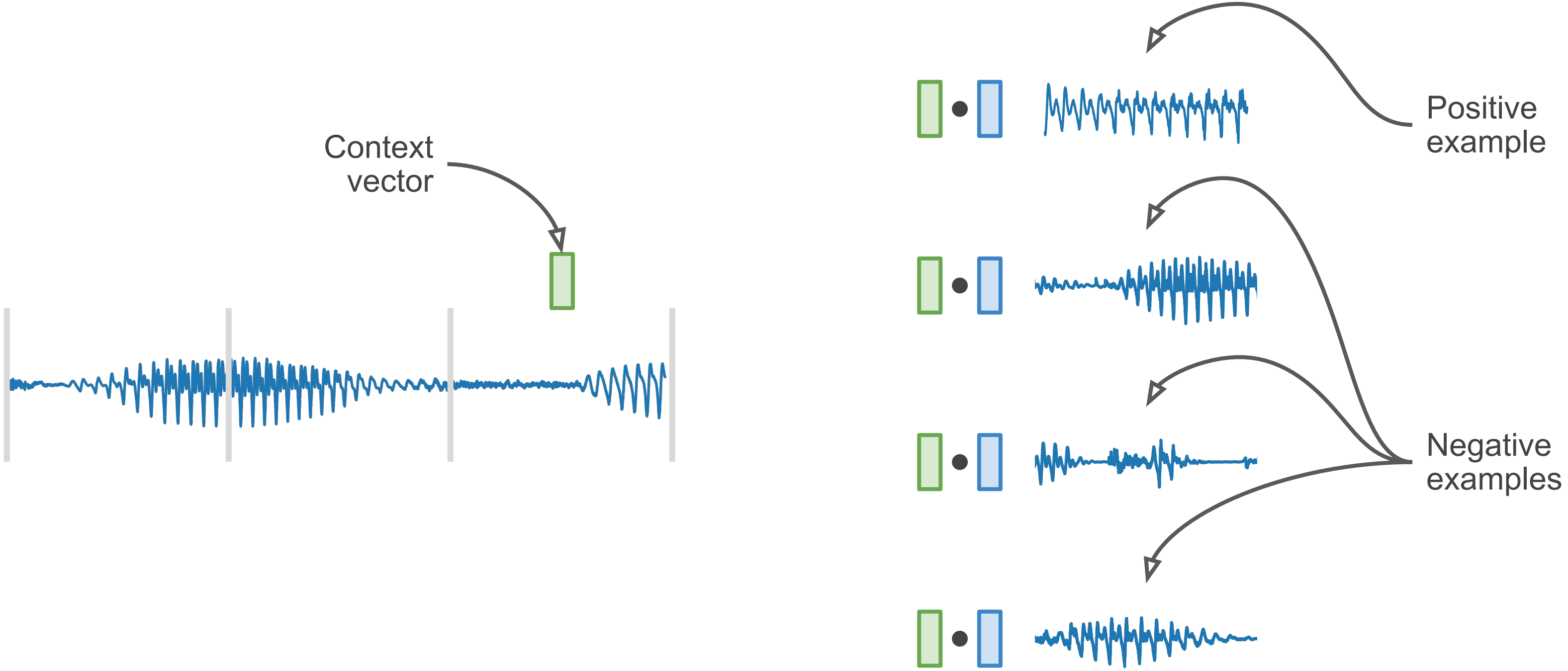

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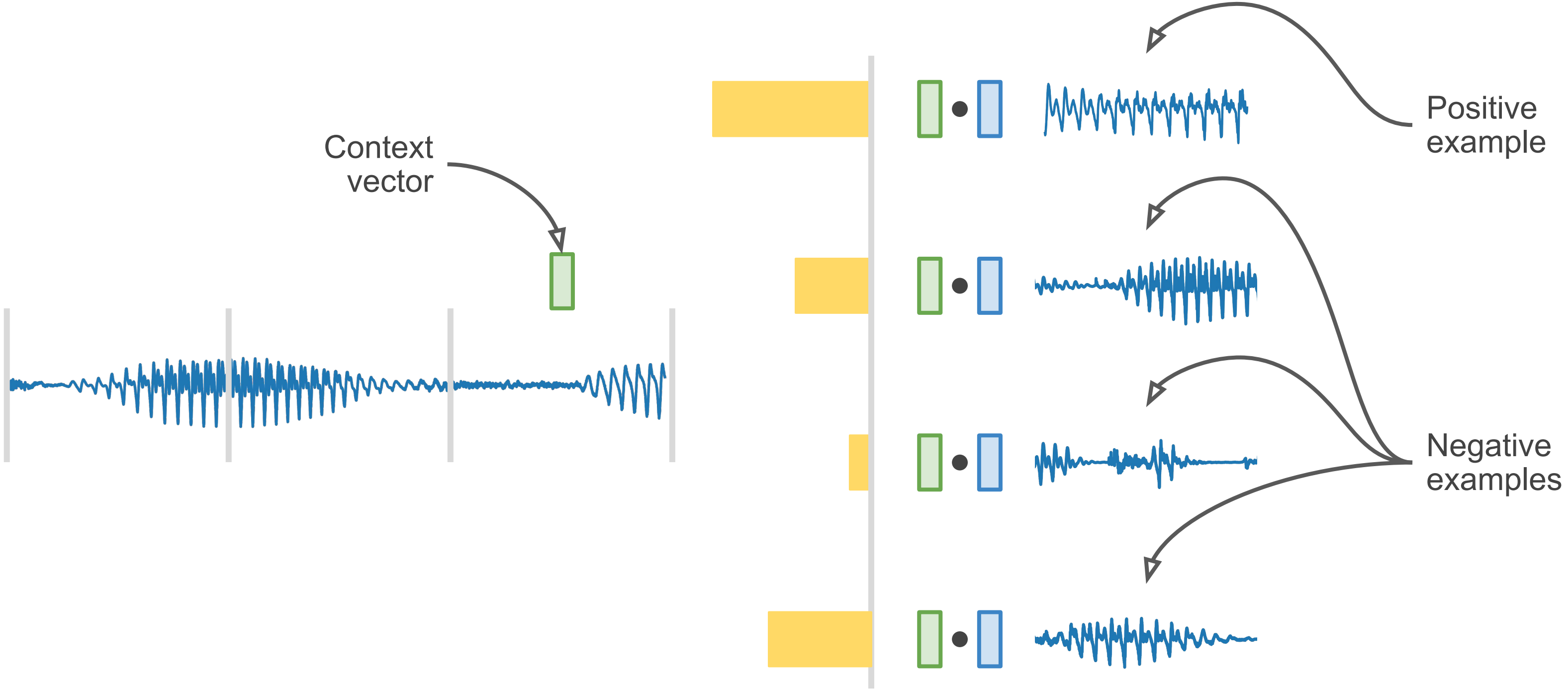
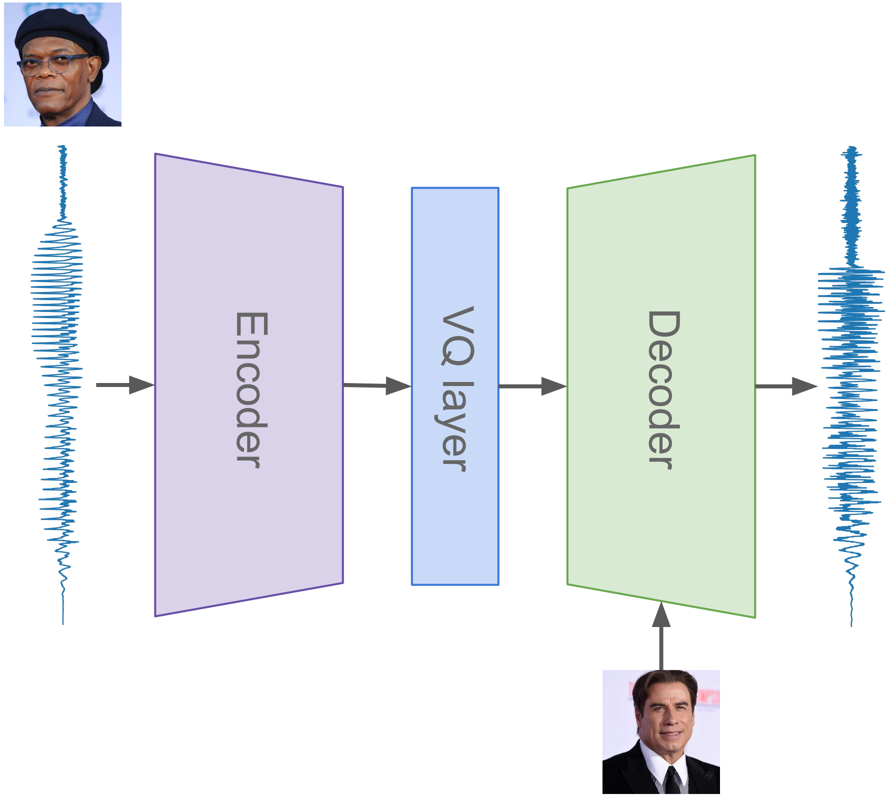


Evaluation - Voice Conversion



Evaluation Metrics:

- Speaker similarity (1-5 scale).
- Intelligibility (character error rate).
- Mean opinion score (1-5 scale).

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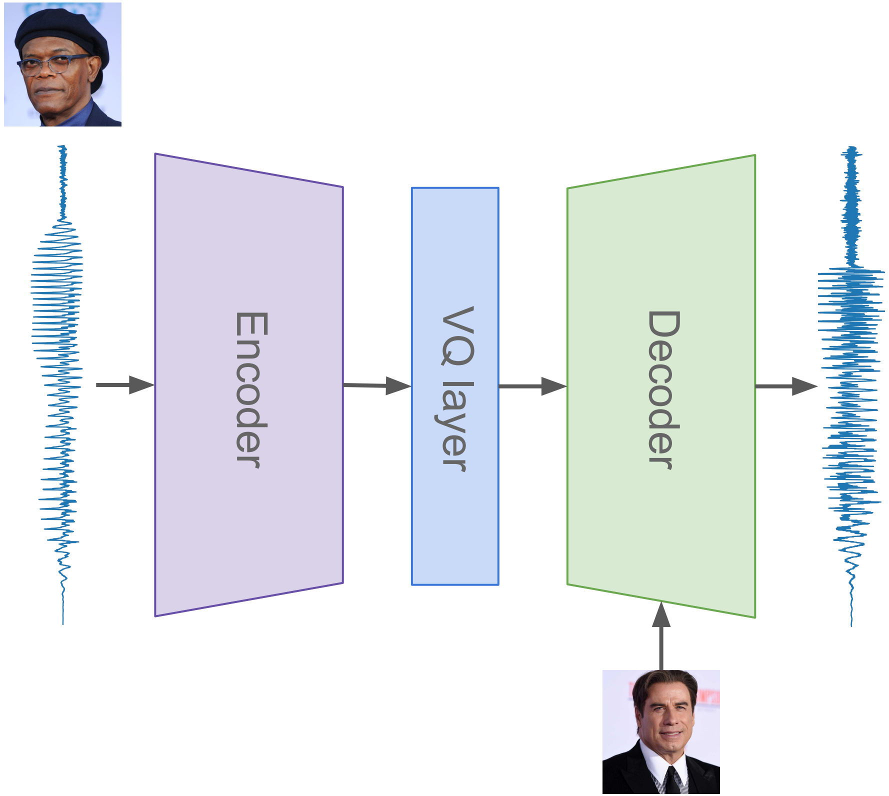

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Evaluation - Voice Conversion

Source	Converted	Target	Other Conversion
🔊	🔊	🔊	🔊
🔊	🔊	🔊	🔊

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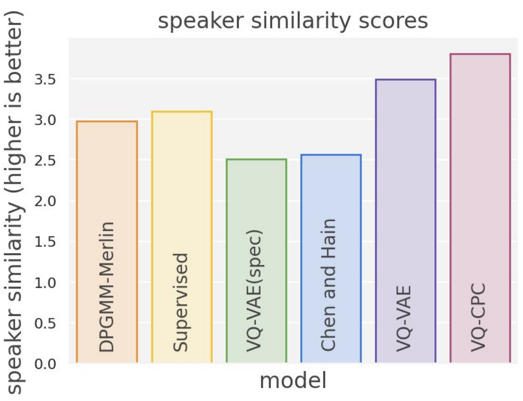

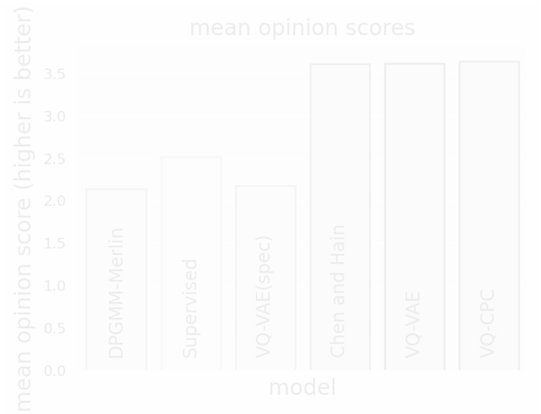

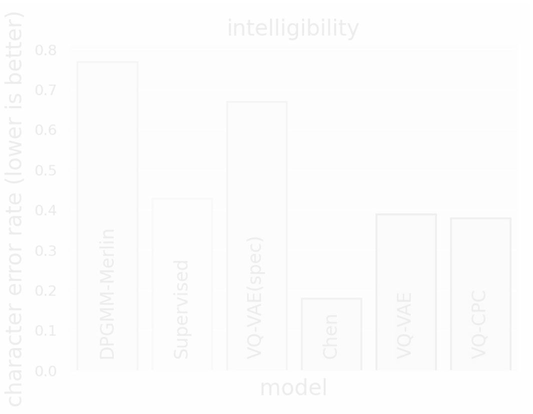

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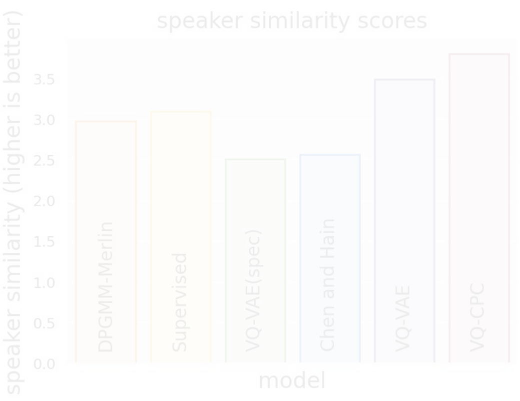

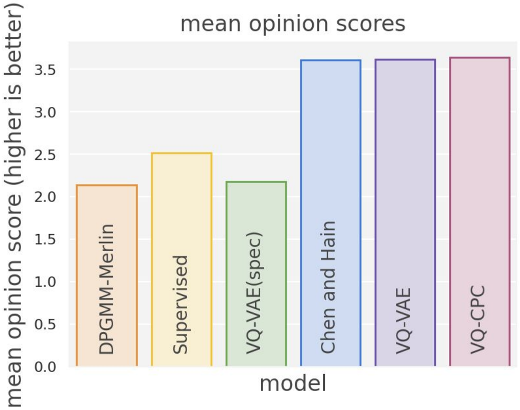

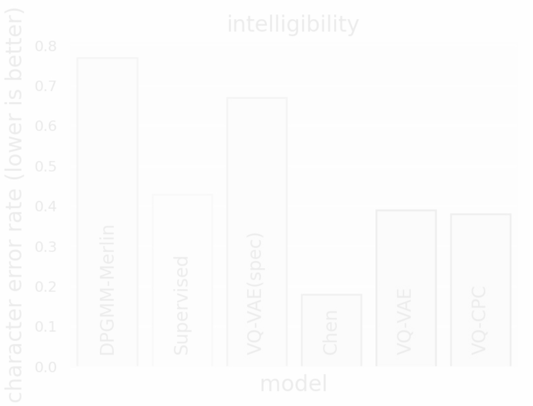

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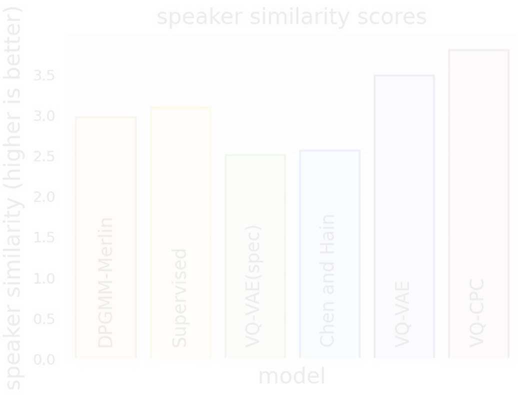
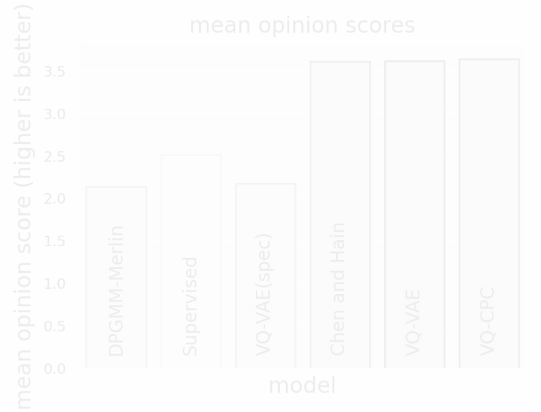
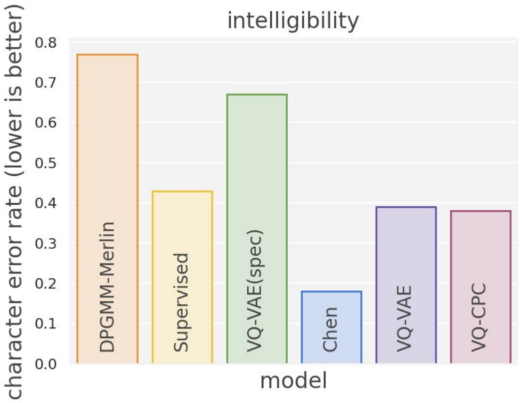
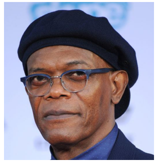




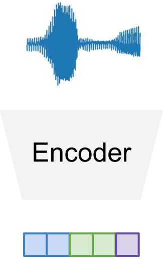


Evaluation - ABX Score

Triphone A:



beg



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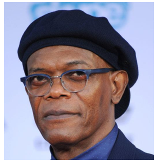

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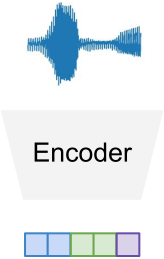
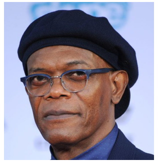
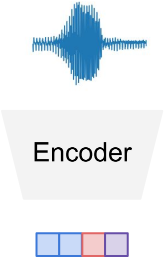


Triphone B:



bag



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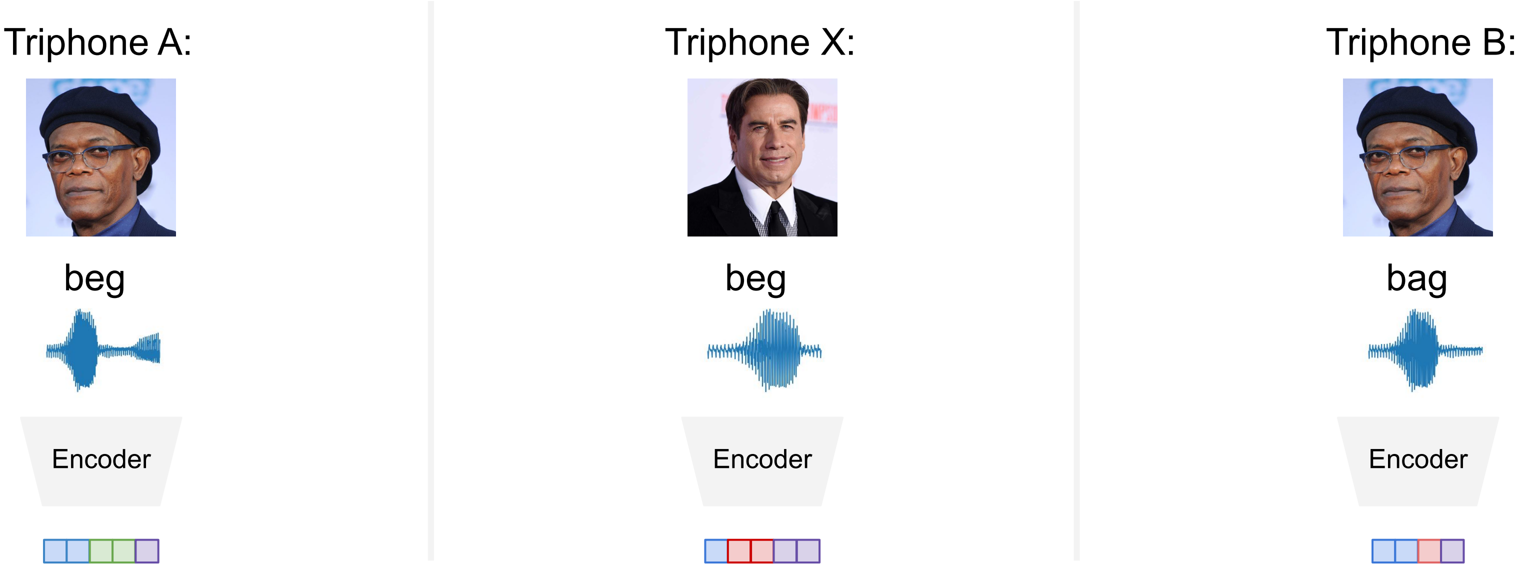


Triphone A:

beg

Encoder

Triphone X:

beg

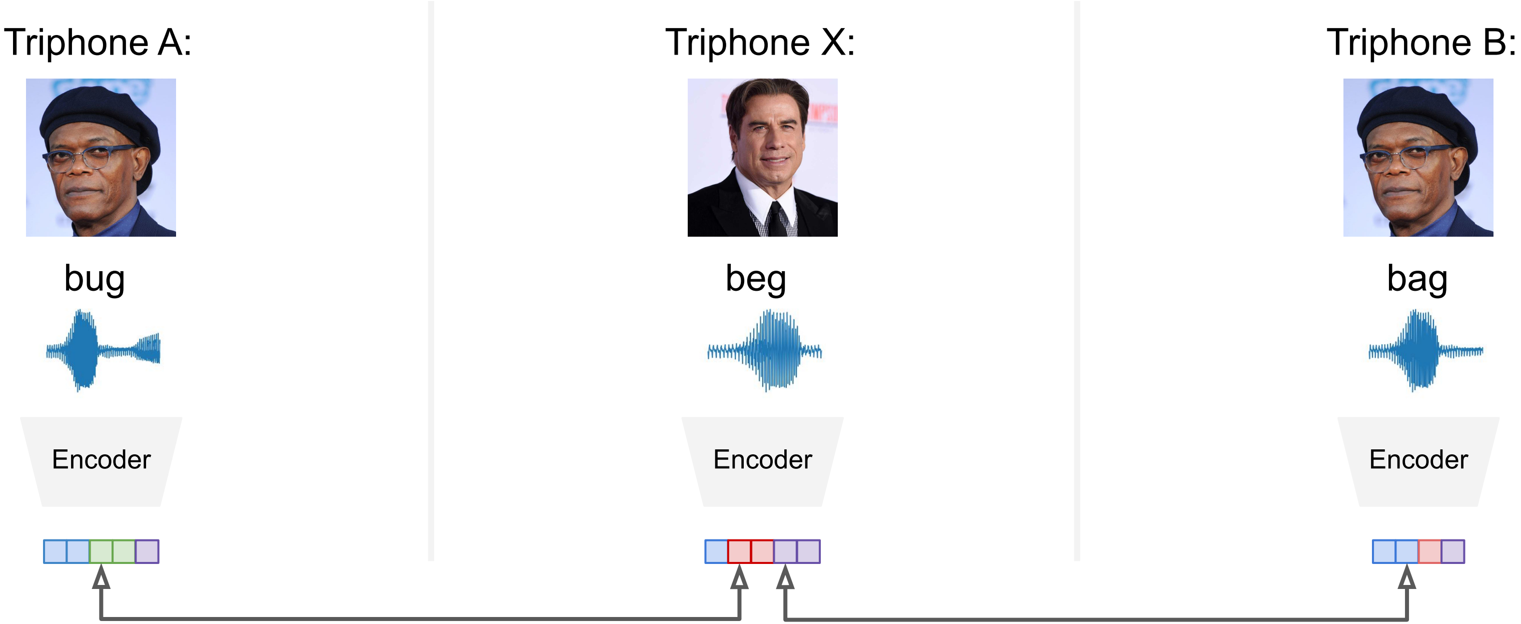
Encoder

Triphone B:

bag

Encoder

Evaluation - ABX Score



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bug

Encoder

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beg

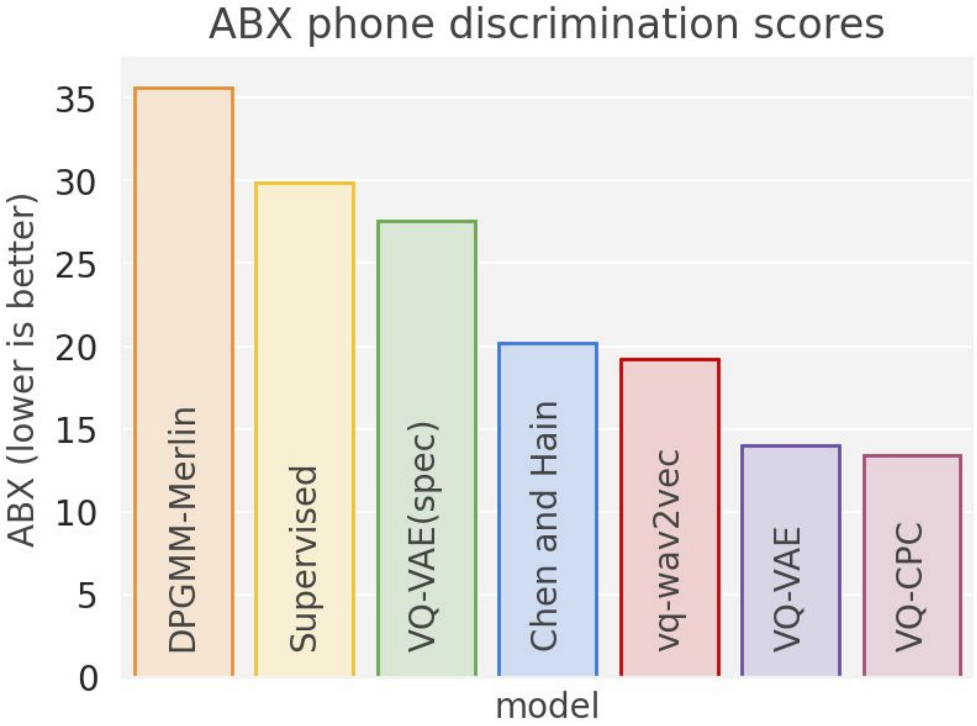
Encoder

Triphone B:

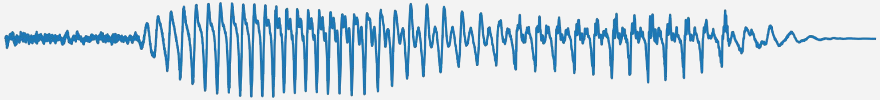
bag

Encoder

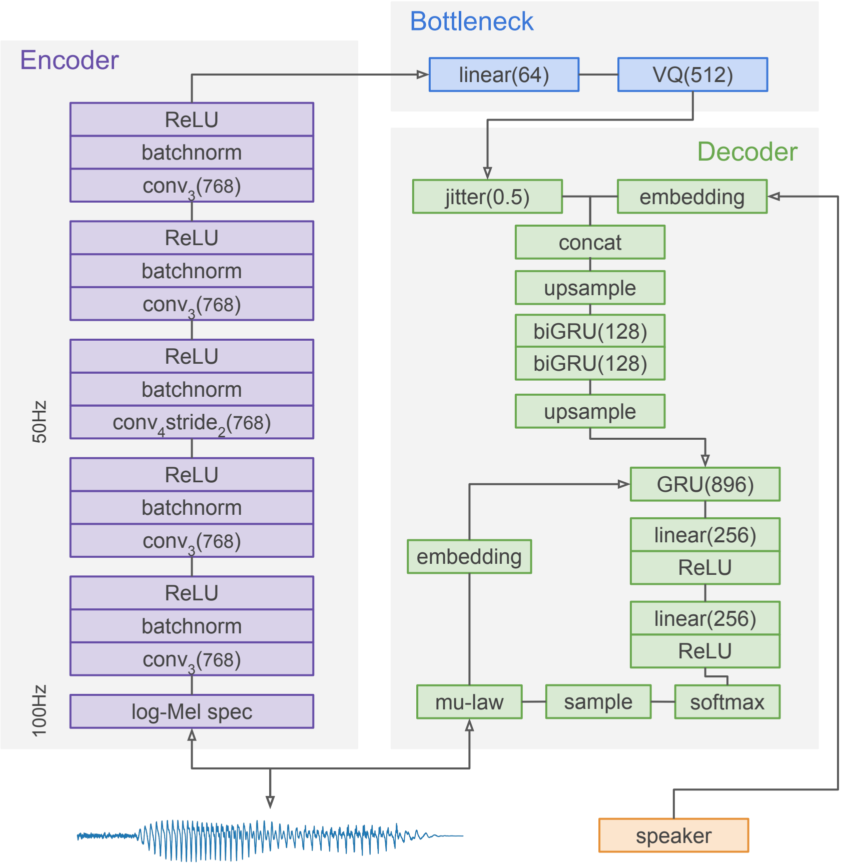
Evaluation - ABX Score



Questions?



Vector Quantized Variational Autoencoder


Encoder
ReLU
batchnorm
$conv_3(768)$
ReLU
batchnorm
$conv_3(768)$
ReLU
batchnorm
$conv_4stride_2(768)$
ReLU
batchnorm
$conv_3(768)$
ReLU
batchnorm
$conv_3(768)$
log-Mel spec
50Hz
100Hz
Bottleneck
linear(64)
VQ(512)
Decoder
jitter(0.5)
embedding
concat
upsample
biGRU(128)
biGRU(128)
upsample
GRU(896)
embedding
linear(256)
ReLU
linear(256)
ReLU
mu-law
sample
softmax
speaker