



Speech quality evaluation of neural audio codecs

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Abstract

This paper presents speech quality results to characterize the state of the art and technological advance of recent neural audio codecs targeting low bitrates. Audio quality was evaluated in one clean speech experiment (in French). Degradation Mean Opinion Score (DMOS) results are reported and discussed for neural audio codecs (LPCNet, Lyra V2, EnCodec, AudioCraft, AudioDec, Descript Audio-Codec) – traditional codecs (Opus, EVS) are also included as performance yardsticks. We also discuss observed codec complexity to complement subjective test results.

Index Terms: speech and audio coding, subjective test, neural audio coding

1. Introduction

The development of generative audio models (e.g., WaveNet [1], SampleRNN [2], WaveRNN [3]) and autoencoders with discretized latent space (VQ-VAE in [4]) has led to a new generation of vocoders or audio codecs based on neural networks [5, 6, 7]. Significant progress has been made thanks to advanced architectures based on generative adversarial networks (GAN) [8, 9] and recent methods also consider the use of diffusion models [10]. Such neural audio codecs address various applications, including voice/video calling [11, 12], text-to-speech synthesis [13], or music generation [14, 15].

It is of great interest to assess the audio quality of this new generation of codecs and characterize the state of the art and technological advances. To the best of our knowledge, there is no comprehensive benchmarking of neural audio codec quality in the literature. Until now, limited quality assessments have been reported as part of model proposals [16, 17, 18], often relying on objective evaluations (e.g., VisQOL [19] or STOI [20]), or the MUSHRA subjective methodology [21] which limits the number of test conditions and test samples and requires experienced listeners. In this work we consider the evaluation of neural audio codecs with a test methodology (P800 DCR [22]) relying on naive subjects and allowing a more comprehensive comparison. To get performance “yardsticks”, we include “traditional” speech/audio codecs: Opus [23, 24] and EVS [25].

Subjective quality is evaluated here in terms of listening audio quality. Different input types and channel conditions should be considered, including clean and noisy speech (with different languages and noise types and levels), music and mixed content, noisy channels. In this work, we only report test results for one clean speech experiment (in French); more experiments should be conducted for a complete characterization.

This article is organized as follows. In Section 2, we present the audio codecs selected for the subjective evaluation. In Section 3, the use of DCR is justified, and relevant test plan aspects

are described. Experimental results are presented in Section 4, before concluding in Section 5.

2. Speech/audio codecs under test

2.1. Neural speech/audio codecs

For this evaluation, we selected neural codecs which have a publicly available implementation. For this reason we did not consider codecs such as SoundStream [16], MDCTNet [26], CBRC [27] or LABCCodec [28]. Codecs considered below operate at constant bitrates (CBR), either at a single bitrate or in a multi-rate fashion. We used “default” versions that sometimes are not “streamable”, i.e., they do not process one input frame at a time in a sequential manner. Note some codecs such as HiFi-Codec [29] could not be considered due to limitations in number of test conditions.

2.1.1. GAN-based autoencoders

Lyra V2 [12], EnCodec [17], AudioDec [30] and Descript Audio Codec (DAC) [18] are based on a VQ-VAE architecture [4], i.e. an autoencoder whose latent vectors are quantized. Audio sampled at a frequency f_s is converted to $f_c = \frac{f_s}{S}$ latent vectors per second, where S is the product of the convolution strides present in the encoder. Note that DAC makes use of non-causal convolution layers. Generally, the same strides are present in reverse order in the decoder to generate audio with the same sampling frequency f_s . The product of strides S also determines the frame length. The quantization technique used is the Residual Vector Quantization (RVQ) proposed in [16], inspired from multistage vector quantization [31]. It consists of a cascade of vector quantizers (VQs), allowing to choose the trade-off between quality of reconstruction and bitrate as a function of the number of quantizer stages. The bitrate of the codec is then $f_c \times N \times B$ where N is the chosen number of VQs in the RVQ and B is the number of bits per VQ. The other interest of RVQ is to enable multi-rate coding. For Lyra V2 and EnCodec we selected all available bitrates. For DAC, we only included the model at 44.1 kHz and evaluated the four bitrates studied in [18], using the value of bitrates computed as $f_c \times N \times B$. For AudioDec, we selected the “default” autoencoder models at 24 and 48 kHz described in [30], and no vocoder variant.

2.1.2. Hybrid codec: LPCNet

LPCNet [7] is based on the source-filter model, where the source (excitation) is modeled by WaveRNN [3] and the filter is represented using linear prediction coding (LPC). LPCNet is known to be a lightweight vocoder model that can run in real-time on a CPU. Many variants of LPCNet have been developed, here we only used the original LPCNet at 1.6 kbps.

Speech Quality Assessment And Evaluation

Ute Jekosch



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