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Improving call quality by generation of replacement packets

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ABSTRACT

Voice communications often suffer from lost packets due to, e.g., radio channel fades, network errors, etc., resulting in audio glitches and poor call quality. This disclosure describes machine learning techniques to replace lost packets. By masking audio glitches and providing continuity, the replacement packets improve call quality as perceived by call participants.

KEYWORDS

- Audio communication
- Phone call
- Bluetooth audio
- Audio glitch
- Call quality
- Lost packets
- Replacement packet
- Machine learning
- Generative model

BACKGROUND

Voice communications over, e.g., Bluetooth, WiFi, 3G, 4G, 5G, LTE, ethernet, etc., often suffer from lost packets due to, e.g., radio channel fades, network errors, etc., resulting in audio glitches and poor call quality.

DESCRIPTION

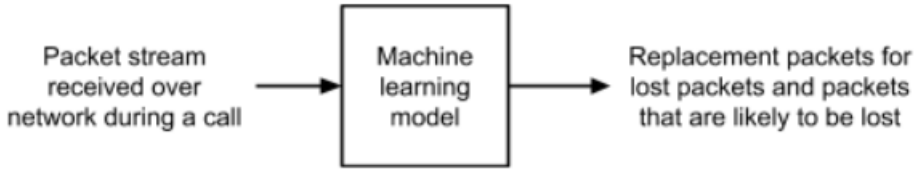

Fig. 1: Improving call quality by generation of replacement packets

Fig. 1 illustrates the use of machine learning to improve call quality by generating replacement packets for lost packets. With user permission, a trained machine learning model accepts as input a stream of packets received during a call. The machine learning model produces predictions that include replacements for one or more of packets that are lost from the input packet stream or packets that are likely to be lost. For example, the model generates a prediction of which packets are likely to be lost, e.g., based on prior packets, and can preemptively generate replacement packets. This enables high quality replacement packets to be generated in a timely manner. While Fig. 1 illustrates packet replacement, the described techniques can also take as input an audio waveform and generate one or more missing sections.

In this manner, the techniques of this disclosure can mask audio glitches and network errors by generating and using replacement data. The techniques also apply to calls placed via over-the-top (OTT) applications, e.g., messaging applications that include calling features, dedicated calling applications that enable calls over a data network, etc.

The machine learning model can include, e.g., regression learning models, generative learning models, neural networks, etc. Example types of neural networks that can be used include neural networks, long short-term memory (LSTM) neural networks, recurrent neural networks, convolutional neural networks, etc. Other machine learning models, e.g., support vector machines, random forests, boosted decision trees, etc. can also be used. For example, any

suitable type of machine learning model can be utilized to identify likely lost packets and one or more generative models may be used to generate replacement packets for such lost packets.

The machine learning model can be trained using data obtained with permission from multiple users. If an individual user provides permission, the machine learning model can be trained or personalized to that user. The techniques of this disclosure can be implemented at one or more points within the protocol stack, e.g., at the audio communications layer of the Bluetooth stack (A2DP, HFP, HSP, etc.). The techniques can be useful for any device, e.g., that receives voice communications over Bluetooth or other communications media such as WiFi, 3G, 4G, 5G, LTE, ethernet, etc. Device manufacturers and/or software developers can utilize these techniques to reduce audio glitches.

Alternatively, a lost packet can be replaced by packet(s) immediately previous to the lost packet. Although this is a simpler technique, such an approach may result in a stutter effect or in audio glitches, thus providing a less than satisfactory user experience.

CONCLUSION

This disclosure describes machine learning techniques to replace packets that are lost or dropped in a voice call. By masking audio glitches and providing continuity to the call, the techniques improve call quality.