Removing Noise from Speech with Deep Learning

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Introduction

Our task was to reduce noise from speech using deep learning.

The goal was to preserve sound quality as much as we can, while reducing the noise.

Motivation

Cool noise reducing hardware.

Figure 1: Sennheiser GSP-500

But this is hardware, and we are computer scientists, not electrical engineers.

Motivation

Noise cancelling software.

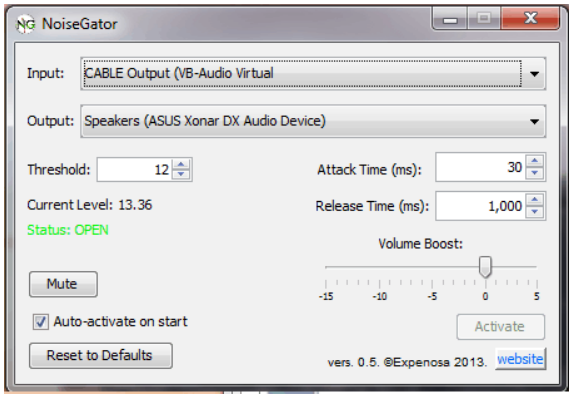

Figure 2: NoiseGator Software

If sound is above the treshold, it goes through.
Else it is cancelled.

Not flexible enough.
Deep learning could do a better job.

Existing implementations

- Autoencoder based
- GAN based
- WaveNet based

Autoencoder based

- Denoising Autoencoder

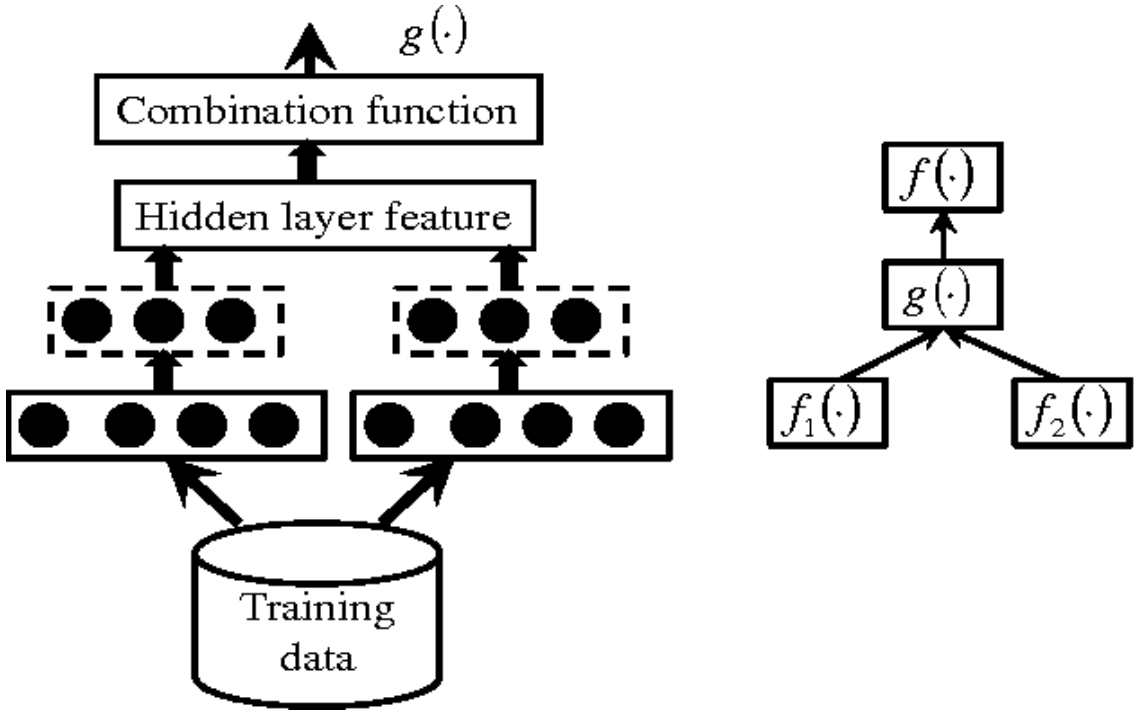

Figure 3: DAE

Autoencoder based

- Denoising Autoencoder with Multi-branched Encoders

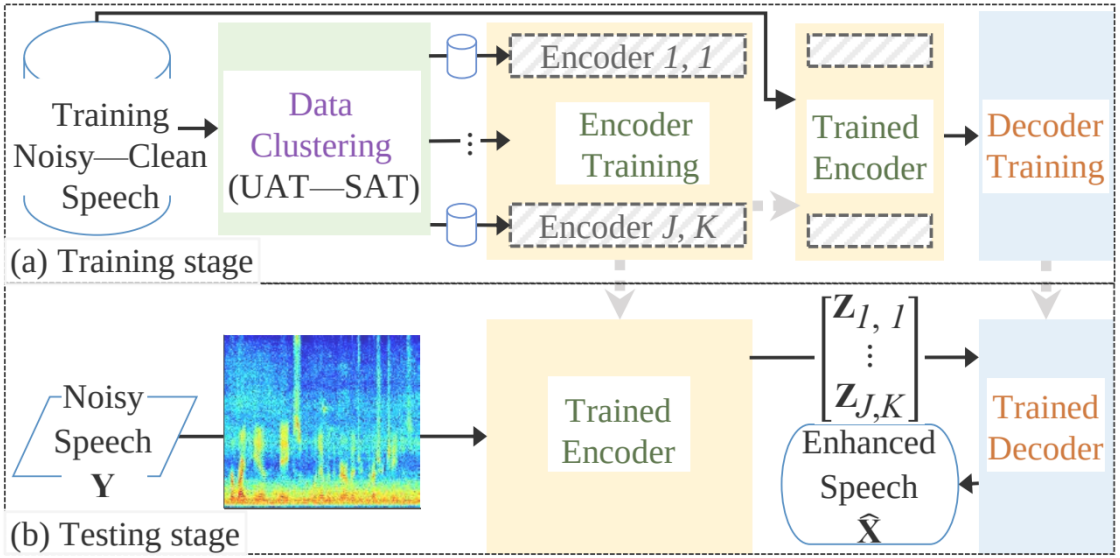

Figure 4: DAEME

GAN based

- Speech Enhancement Generative Adversarial Network

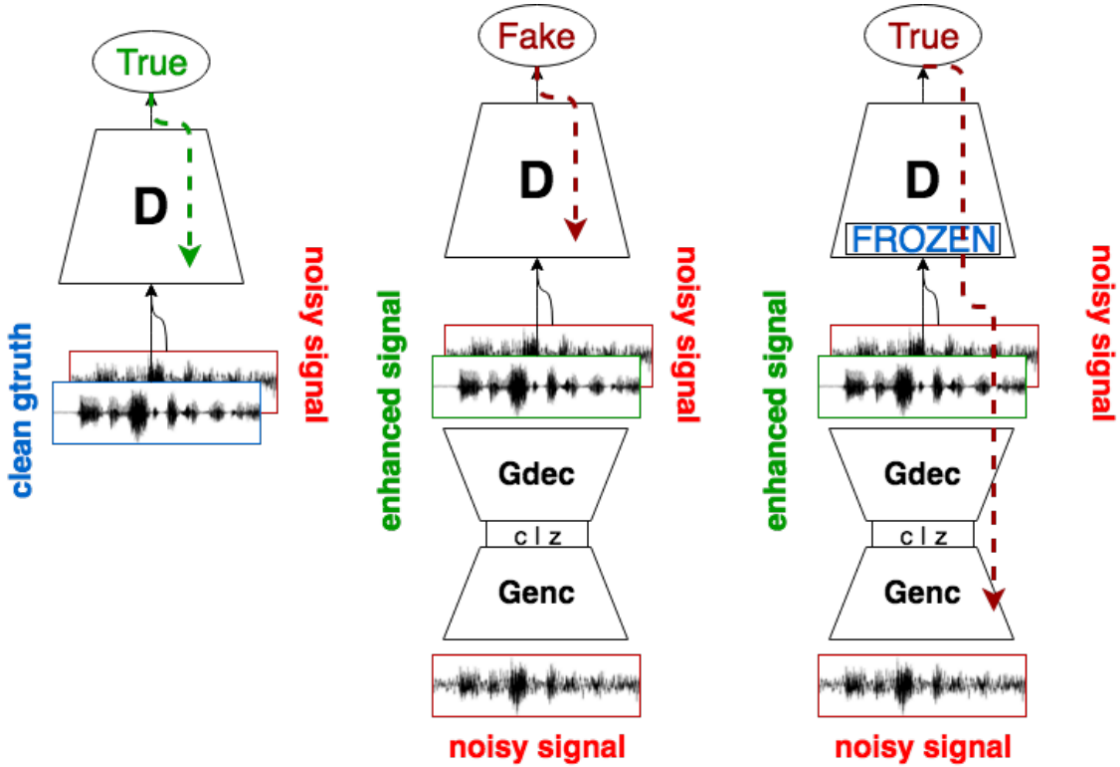

Figure 5: SEGAN

WaveNet based

- Wavenet for Speech Denoising

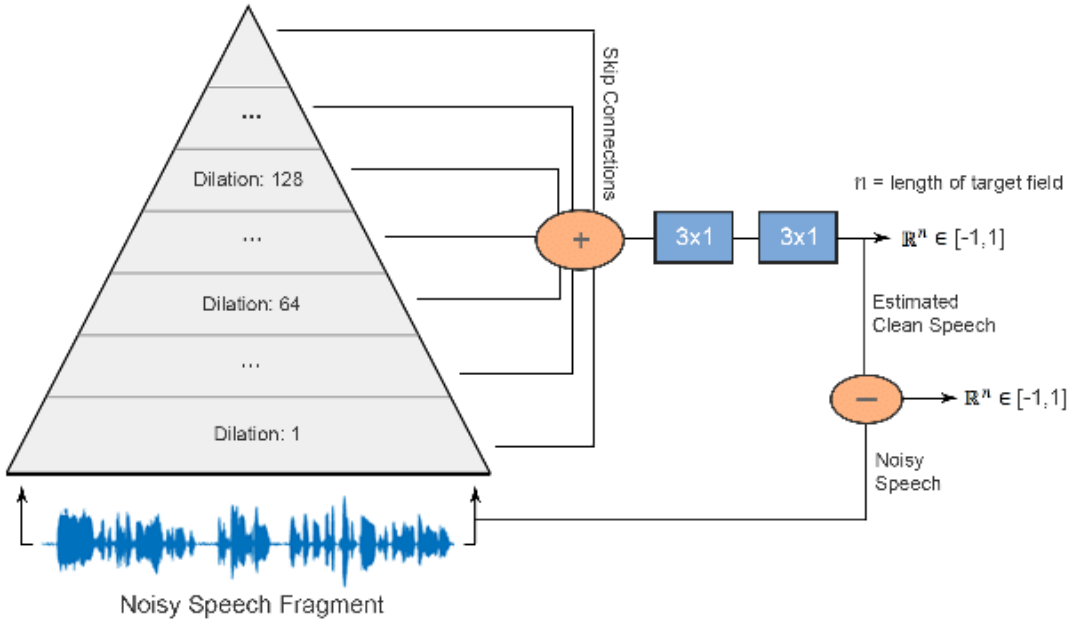

Figure 6: Speech denoising WaveNet

Training and testing data

- ~23000 samples
- 56 different voices and noise conditions

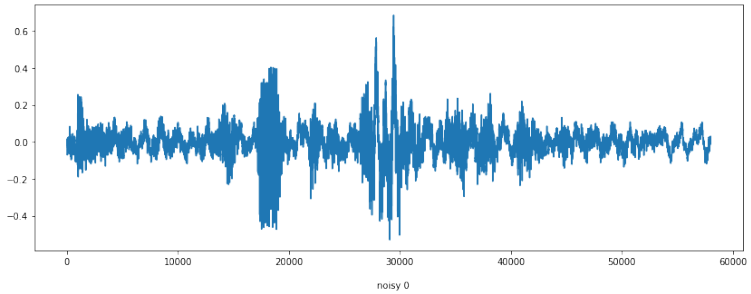

Figure 7: Noisy data

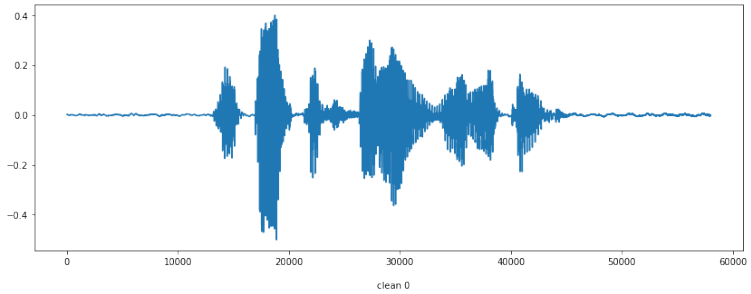

Figure 8: Clean data

Data pipeline

Training phase.

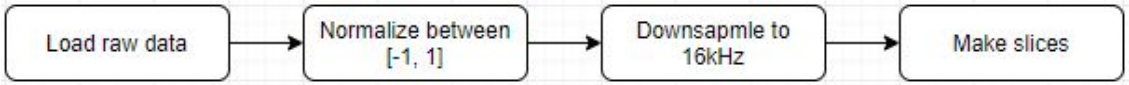

Figure 9: Training preprocessing

We do this on the noisy and clean data as well.
Input: Noisy slices
Output: Clean slices

Data augmentation: Overlapping slices

Full data pipeline

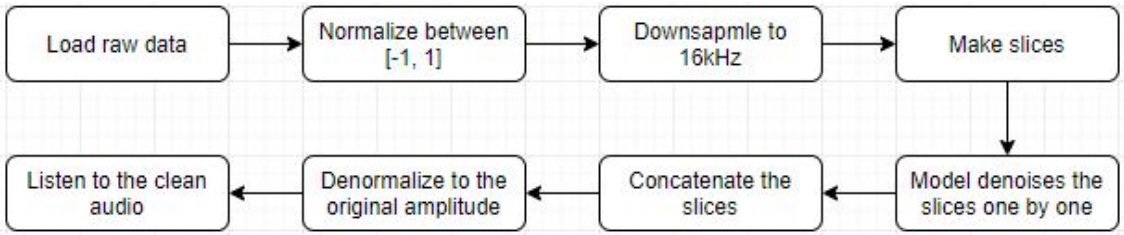

Figure 10: Inference preprocessing

Model is a black box now, it will be elaborated later.

Original WaveNet

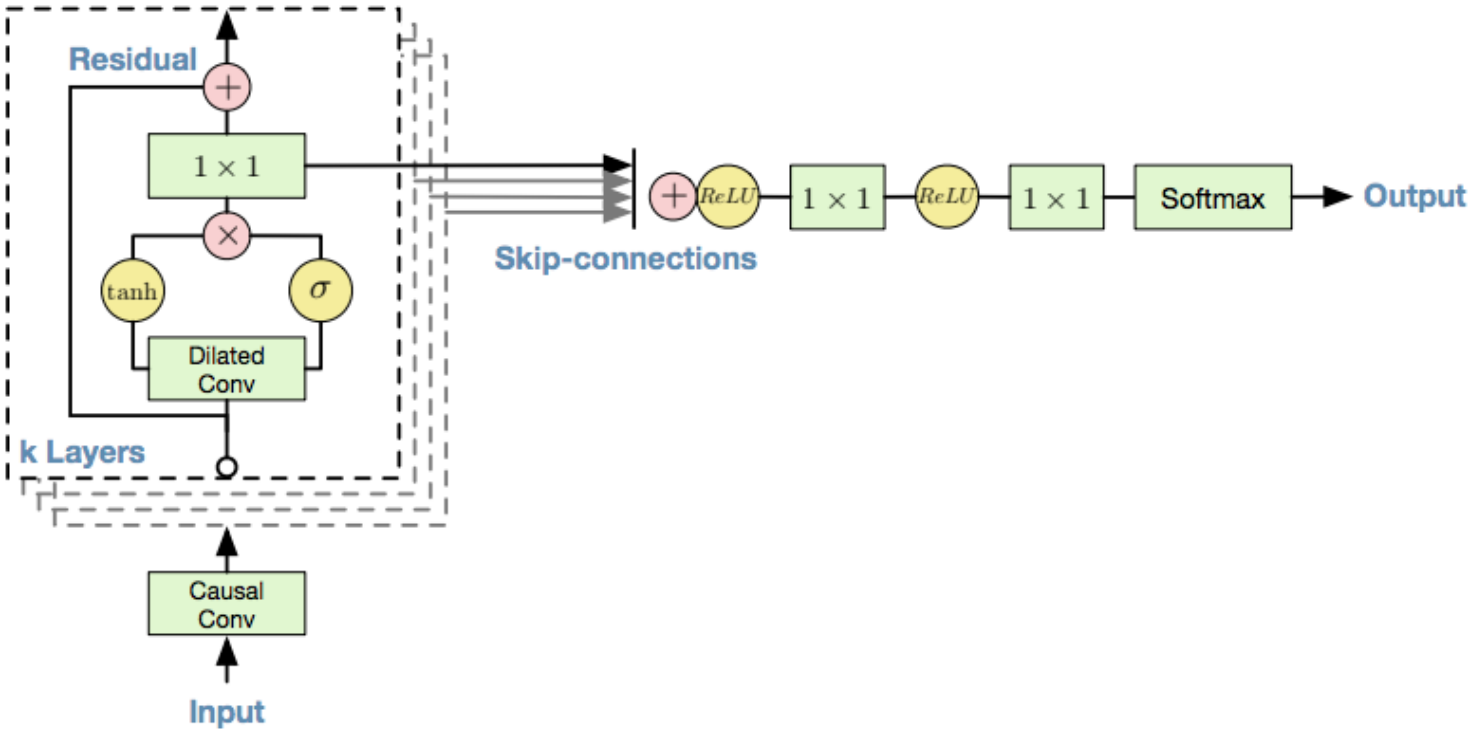

Figure 11: WaveNet

Causal convolutions, mu-law transform and softmax distribution.

Modified wavenet

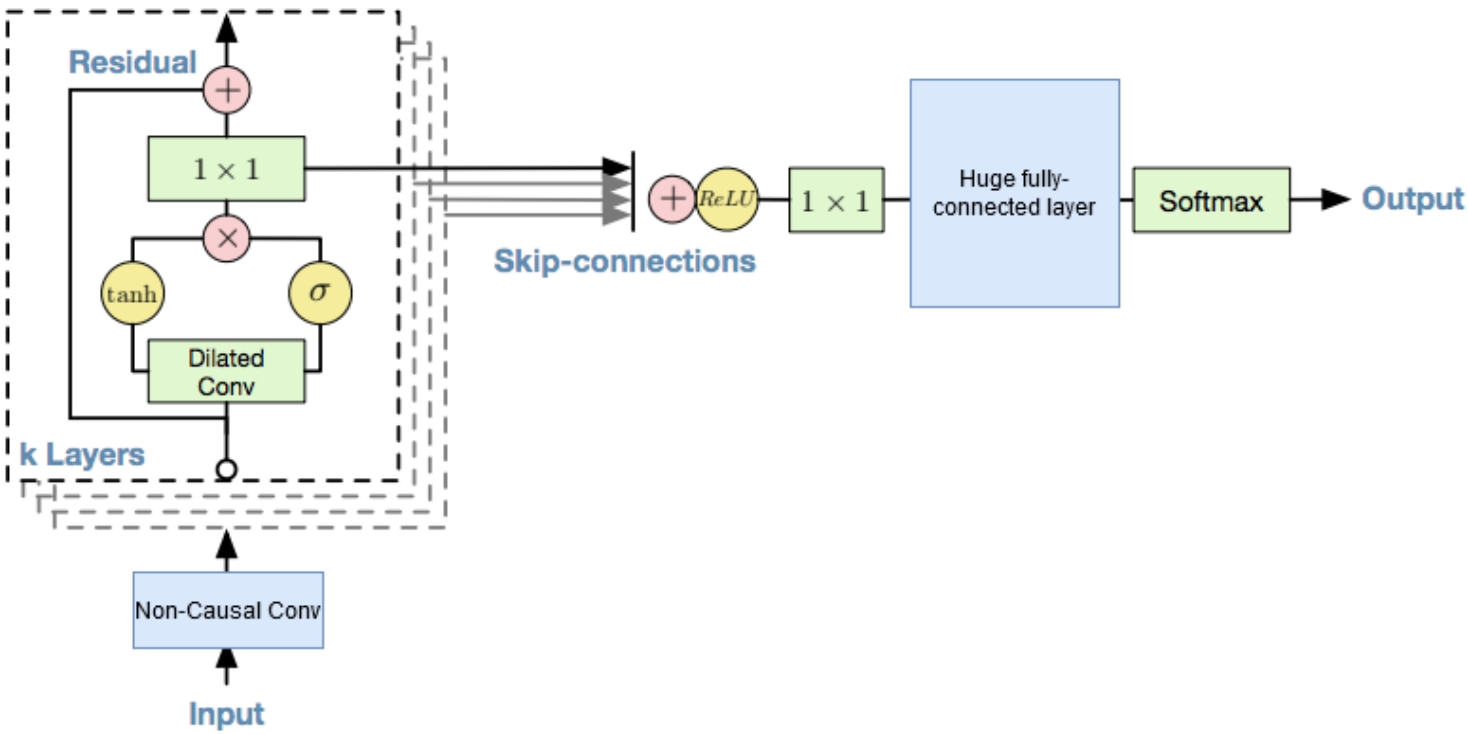

Figure 12: Modified WaveNet

Non-causal convolutions, and dense output layer.

Regression with dense layer

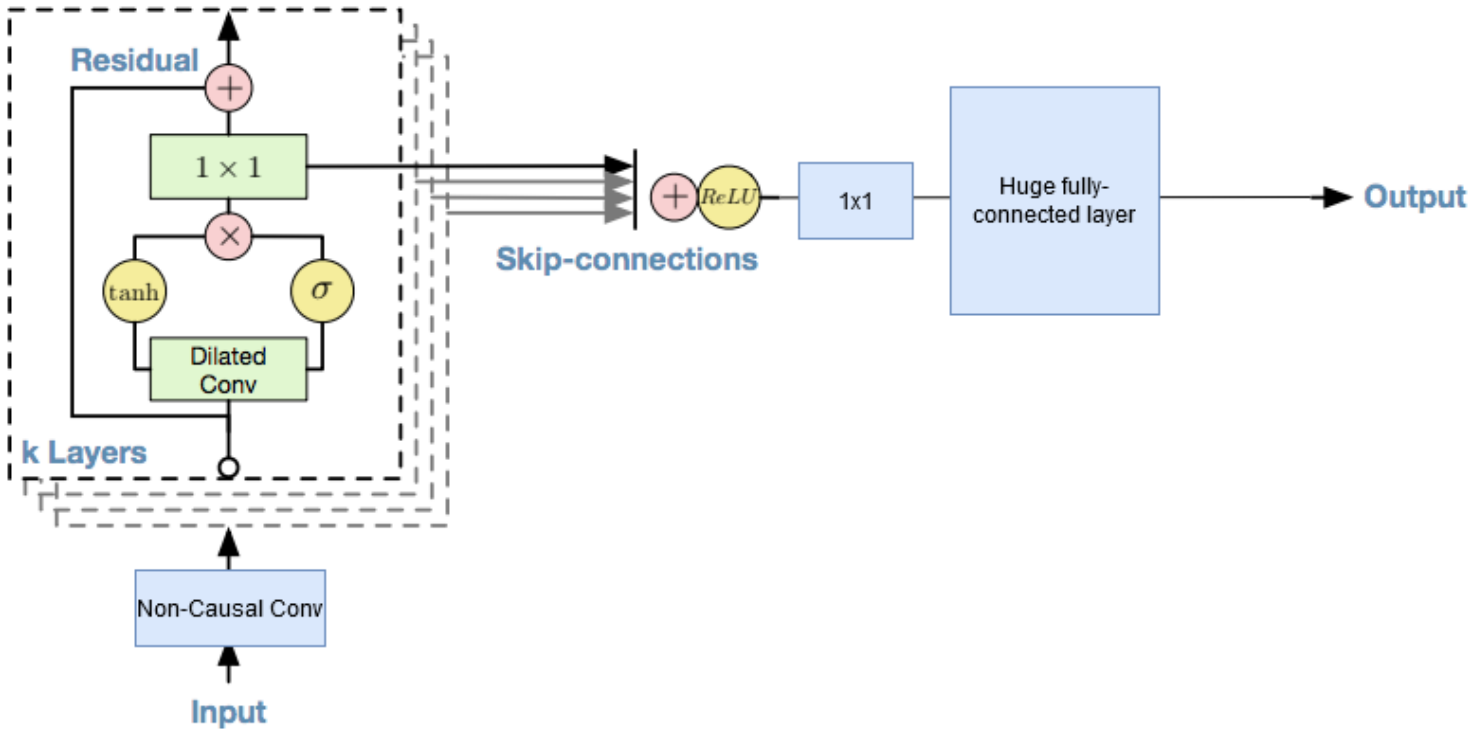

Figure 13: Regression with dense layer

WaveNet with non-causal convolutions, regression, and flatten + dense output layers

WaveNet based autoencoder

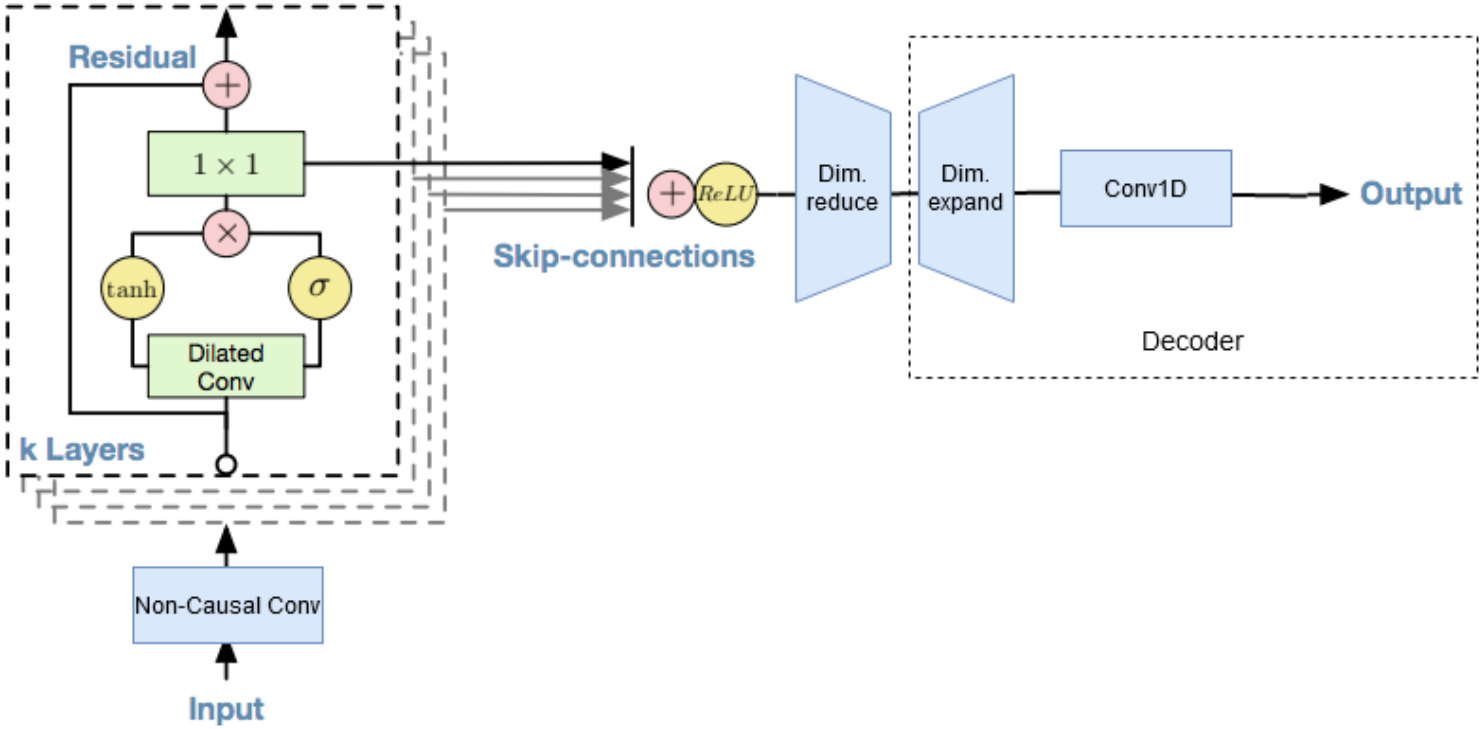

Figure 14: Wavenet based autoencoder

Regression with convolutional layers

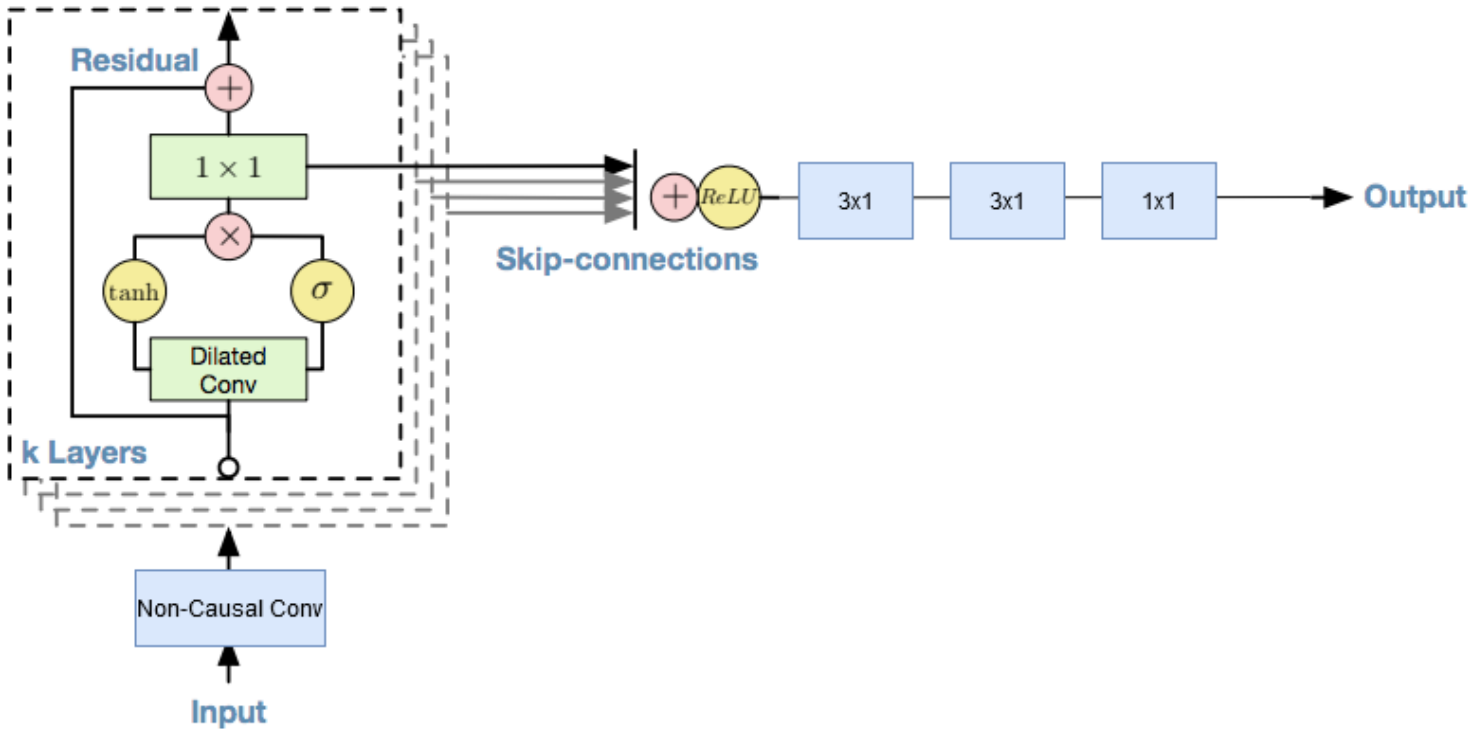

Figure 15: Wavenet based autoencoder

WaveNet with non-causal convolutions, regression, and extra one dimensional convolutional layers on the output.

Training

- Google Cloud Platform
- Clean & Noisy slice generator
- MAE loss
- SGD optimizer
- ReduceLROnPlateau

Demo

Thank you for your attention

Sources:

- Aaron van den Oord, Sander Dieleman, Heiga Zen, Karen Simonyan, Oriol Vinyals, AlexGraves, Nal Kalchbrenner, Andrew Senior, and Koray Kavukcuoglu. “WaveNet: A GenerativeModel for Raw Audio”. In: (2016) arXiv:1609.03499
- Dario Rethage, Jordi Pons, and Xavier Serra. “A Wavenet for Speech Denoising”. In: (2018) arXiv:1706.07162