Removing Noise from Speech with Deep Learning

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Introduction

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

Preserve sound quality.

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.

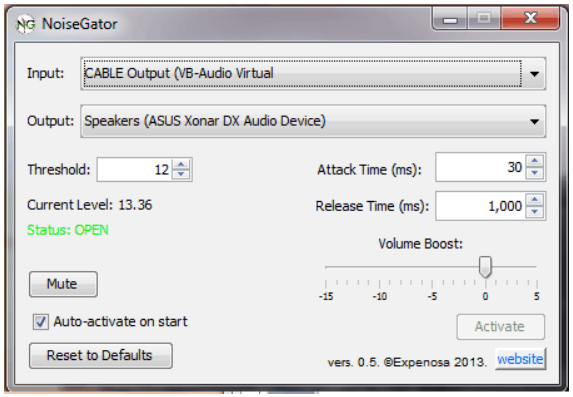

Figure 2: NoiseGator Software

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

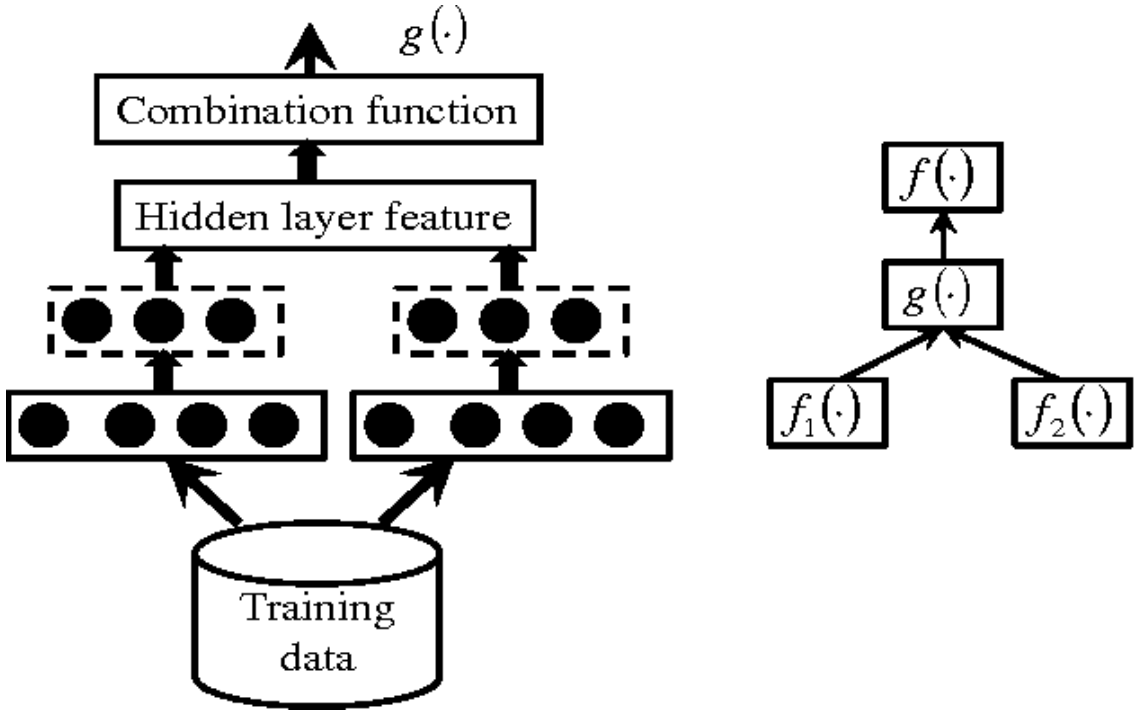

Figure 3: DAE

Autoencoder based

- Denoising Autoencoder with Multi-branched Encoders

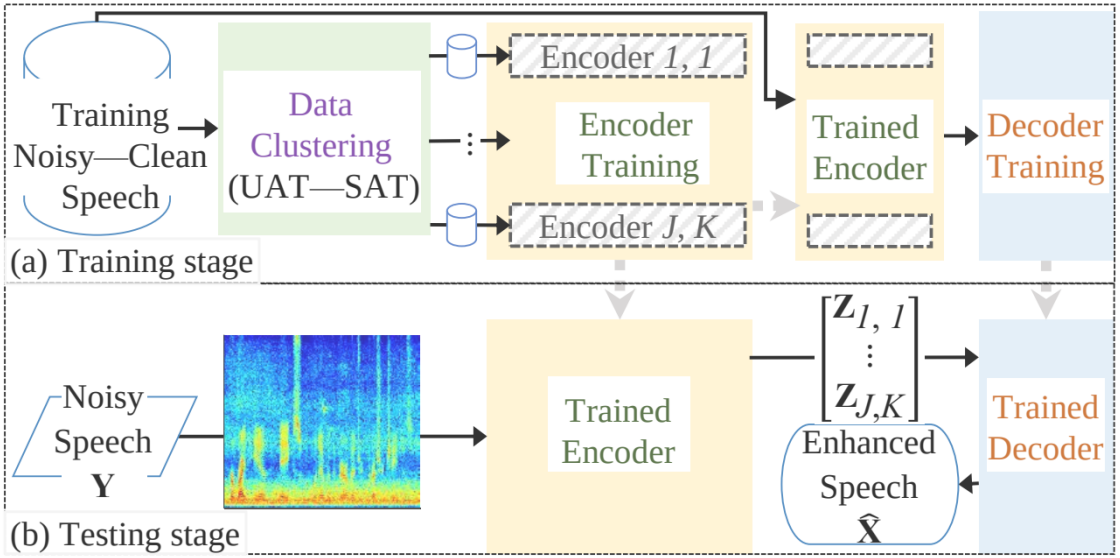

Figure 4: DAEME

GAN based

- Speech Enhancement Generative Adversarial Network

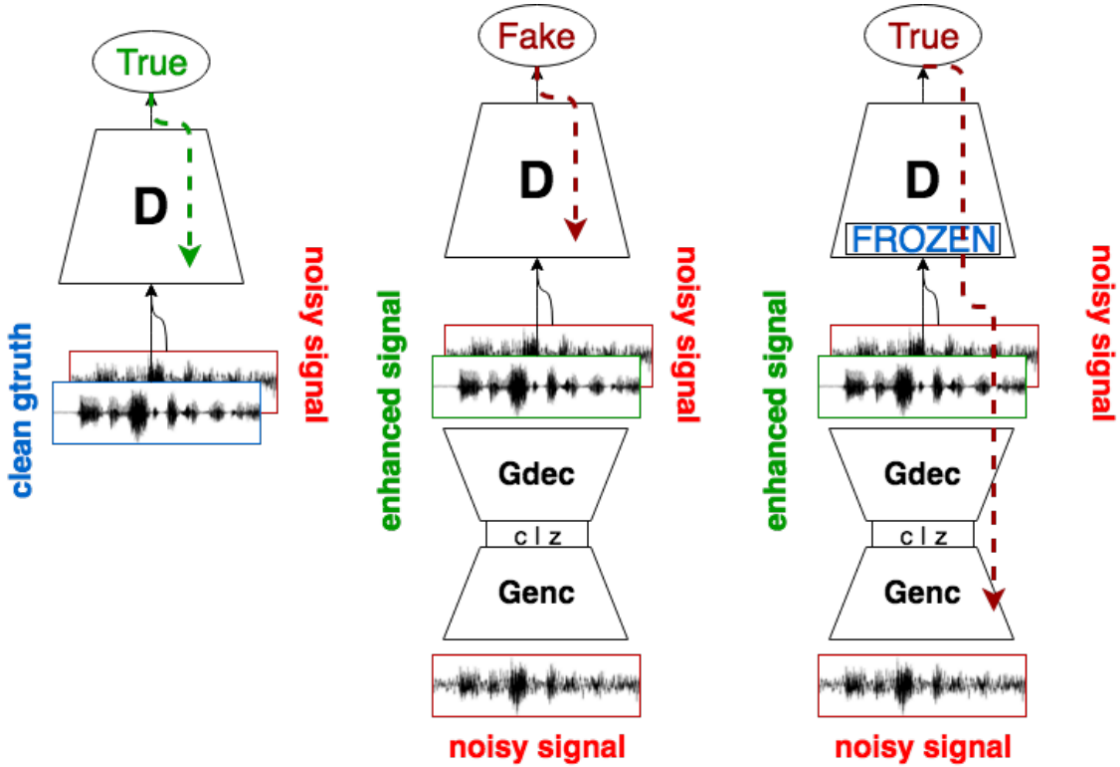

Figure 5: SEGAN

WaveNet based

- Wavenet for Speech Denoising

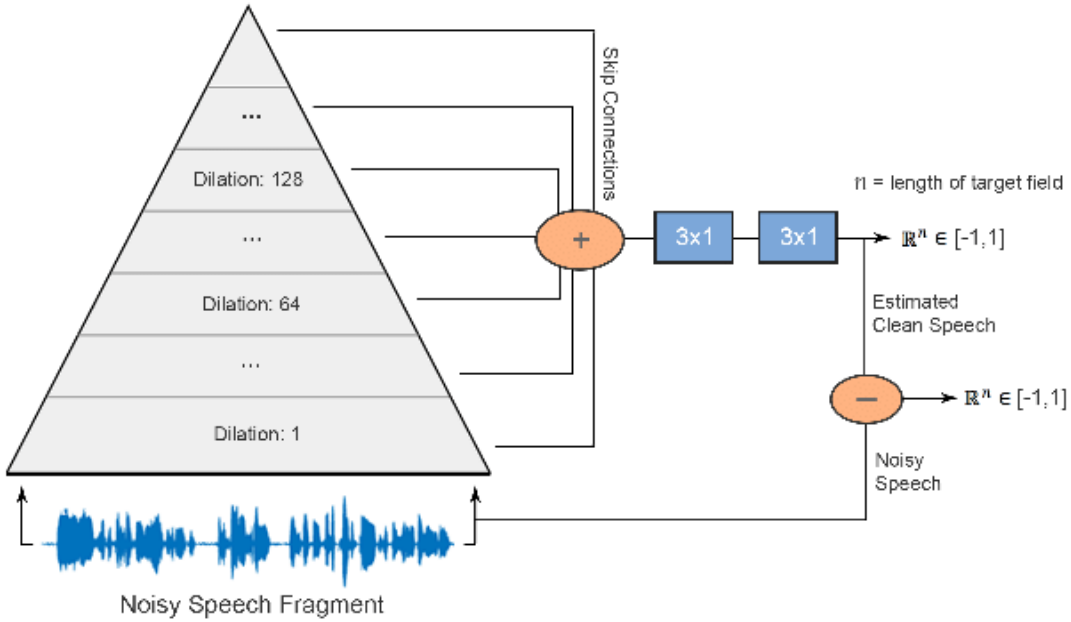

Figure 6: Speech denoising WaveNet

Training and testing data

- ~23000 samples
- 56 different voices and noise conditions

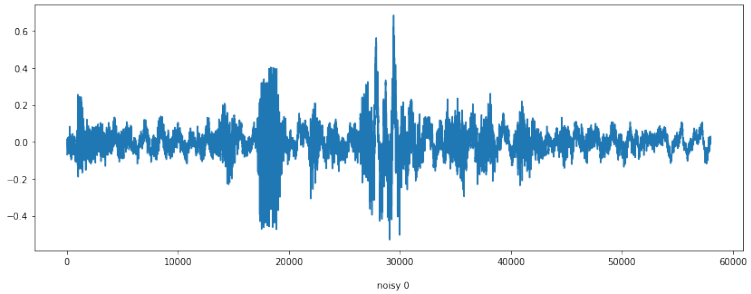

Figure 7: Noisy data

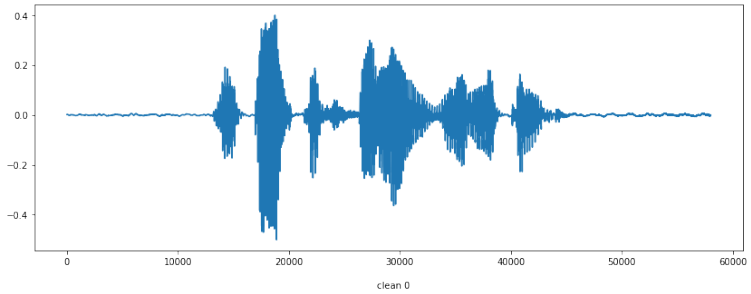

Figure 8: Clean data

Data pipeline

Training phase.

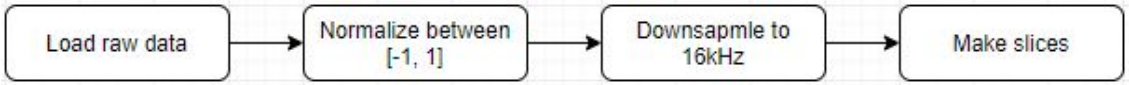

Figure 9: Training preprocessing

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

Data augmentation: Overlapping slices

Full data pipeline

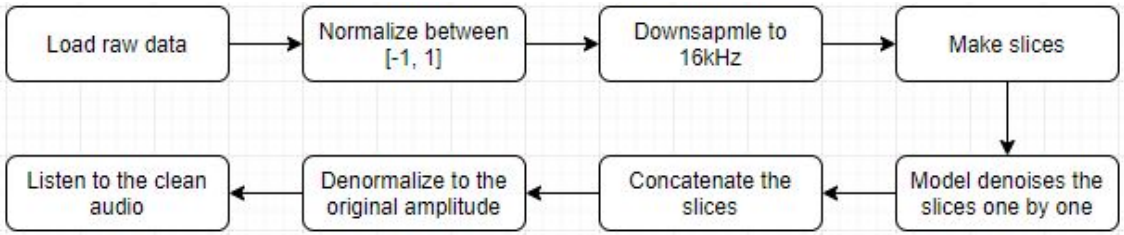

Figure 10: Full pipeline

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

Original WaveNet

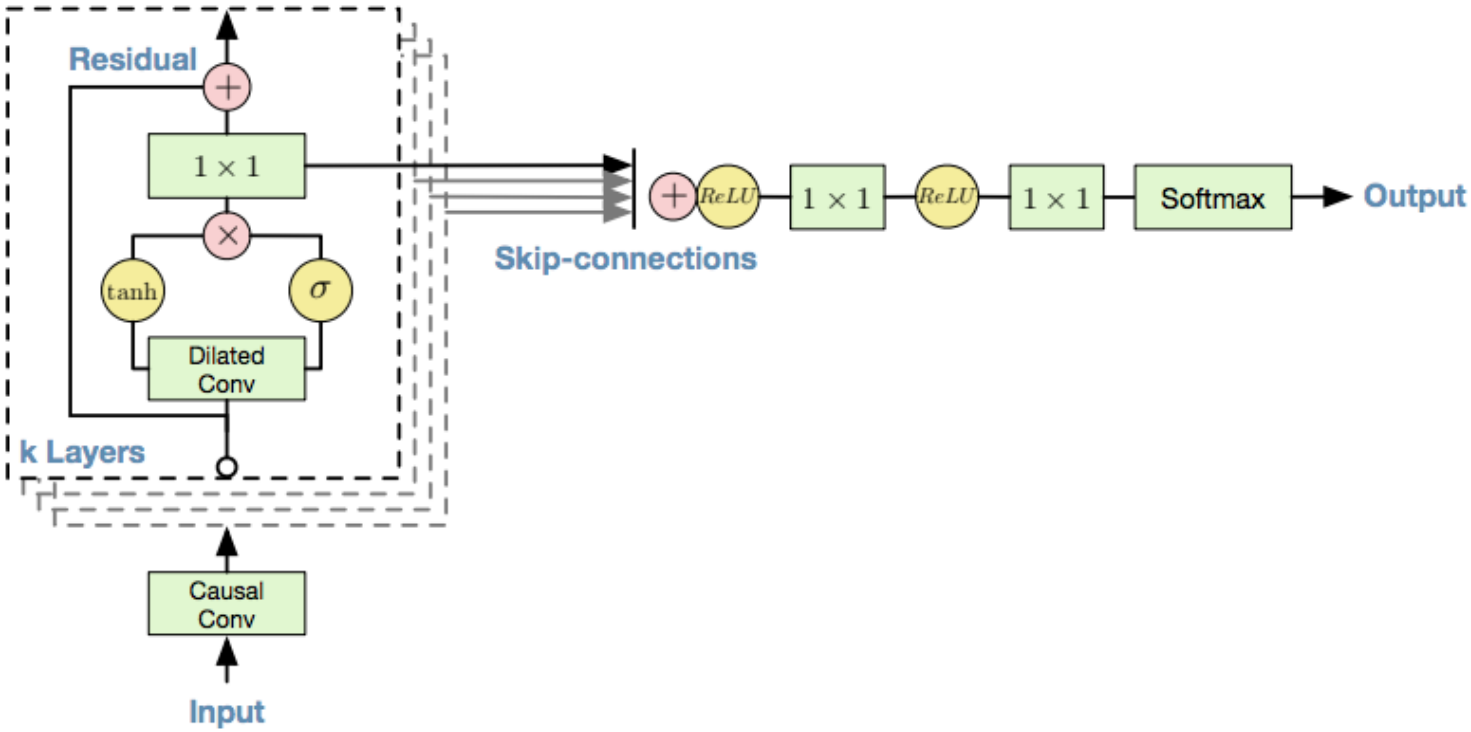

Figure 11: WaveNet

Causal convolutions, mu-law transform and softmax distribution.

Modified wavenet

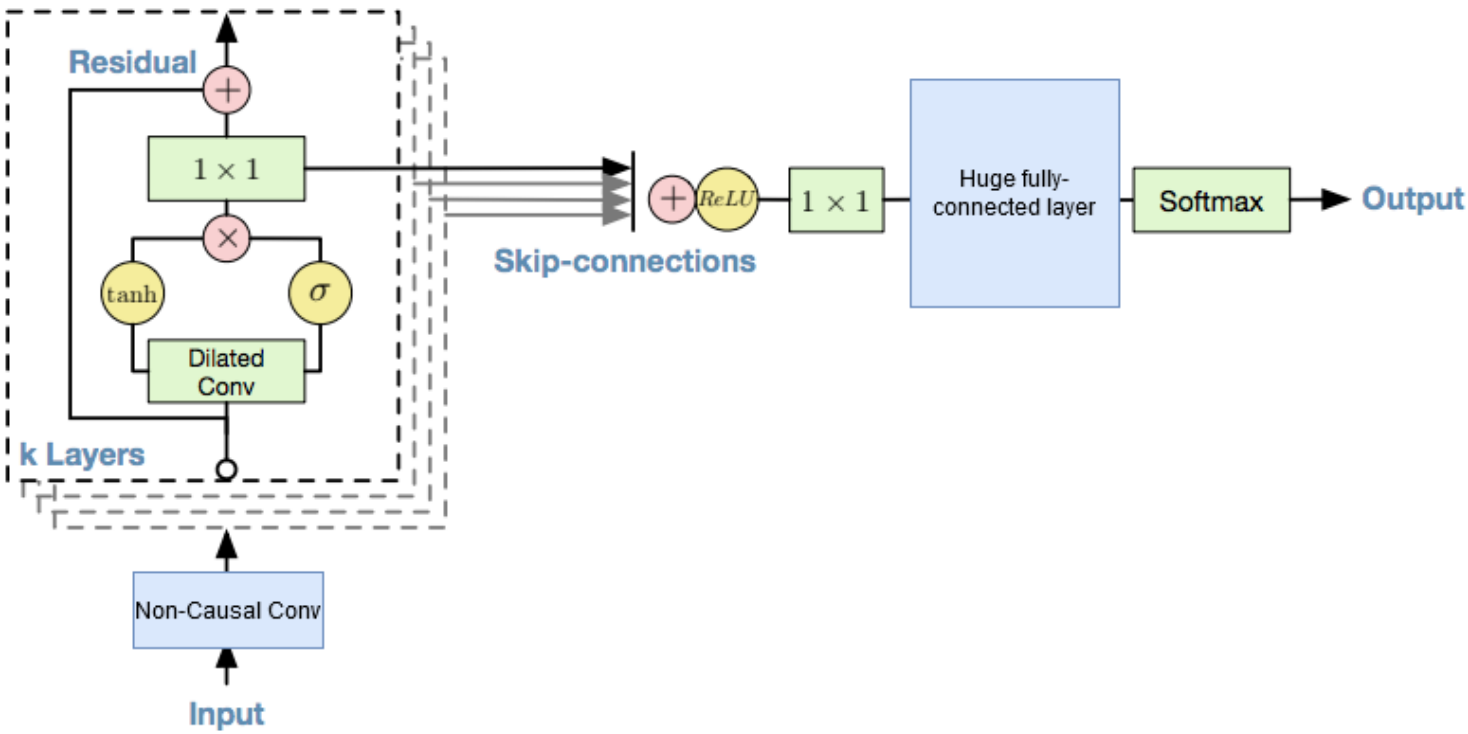

Figure 12: Modified WaveNet

Non-causal convolutions, and dense output layer.

Regression with dense layer

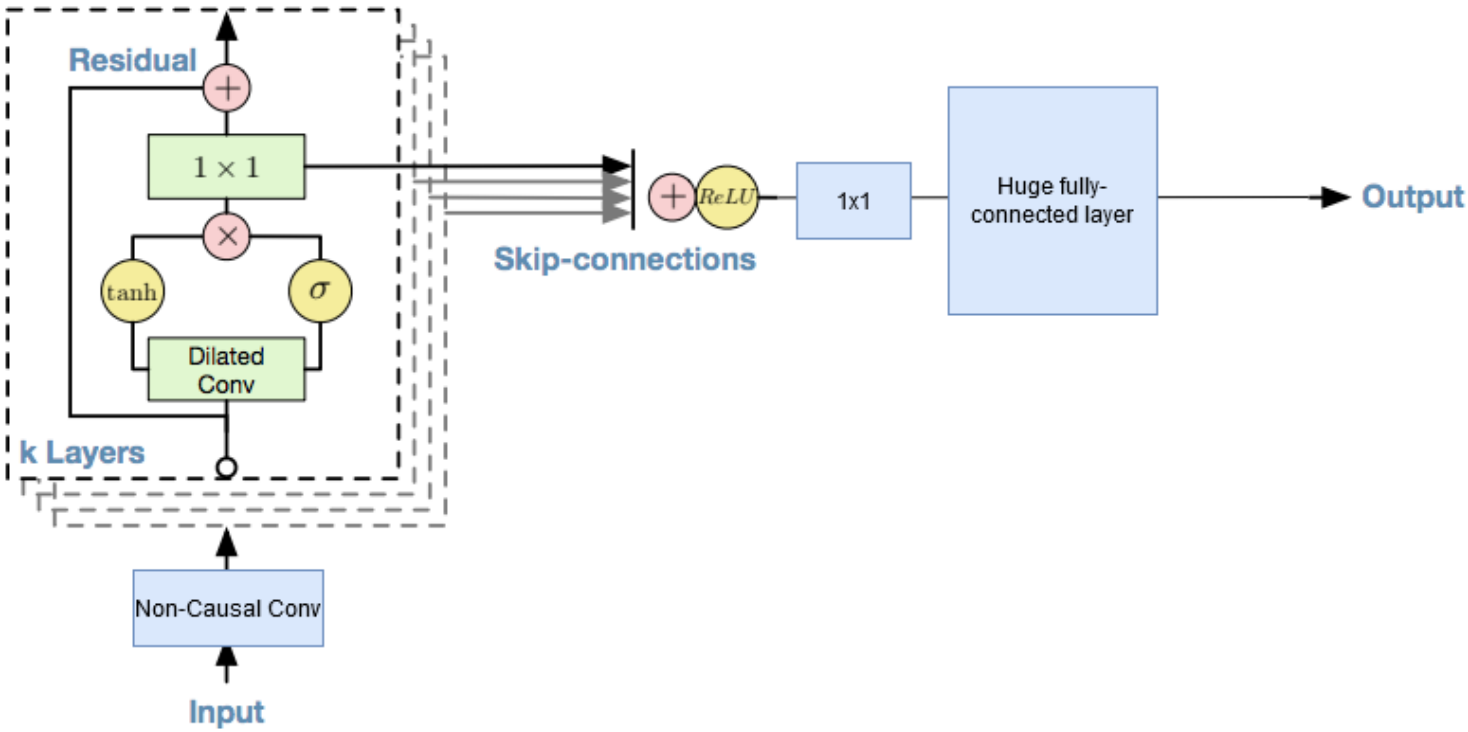

Figure 13: Regression with dense layer

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

WaveNet based autoencoder

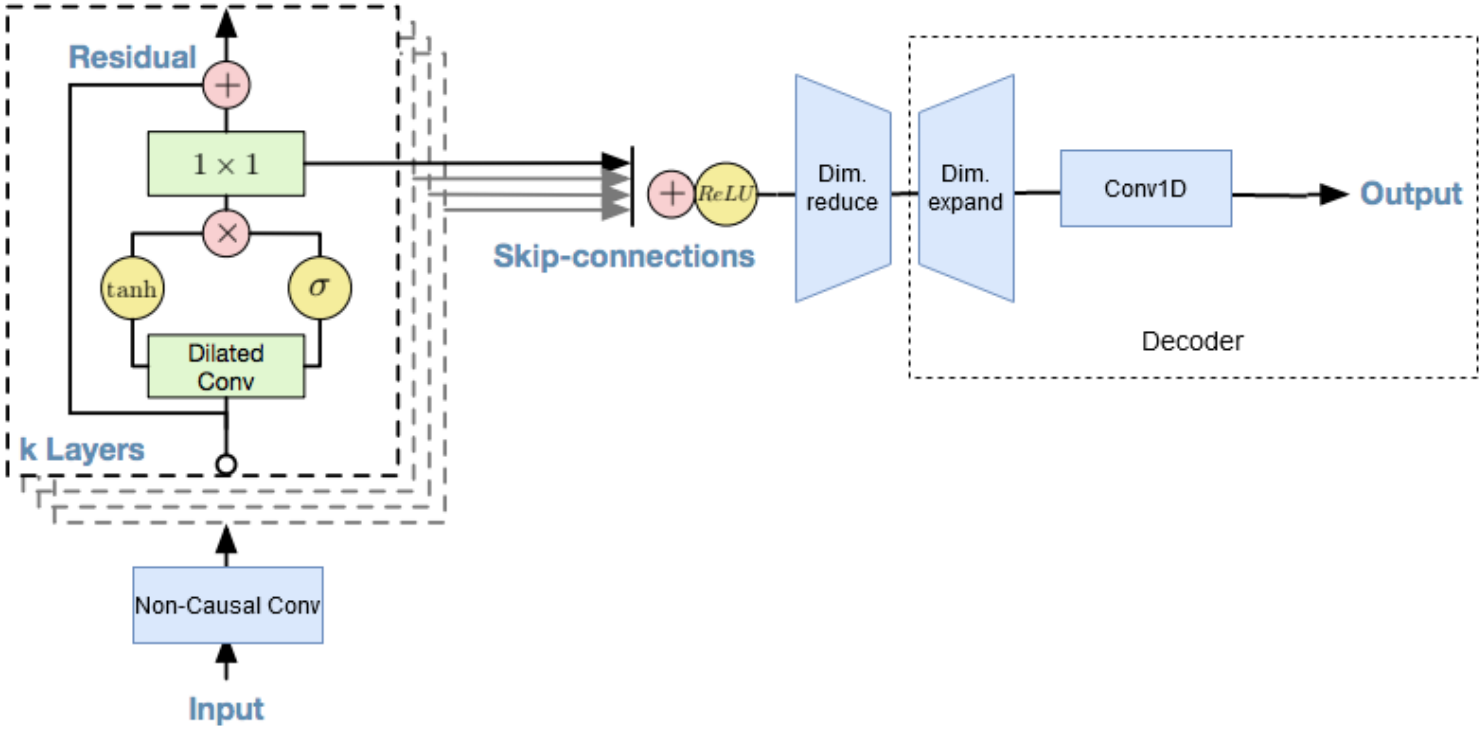

Figure 14: Wavenet based autoencoder

Autoencoder surrounded by WaveNets

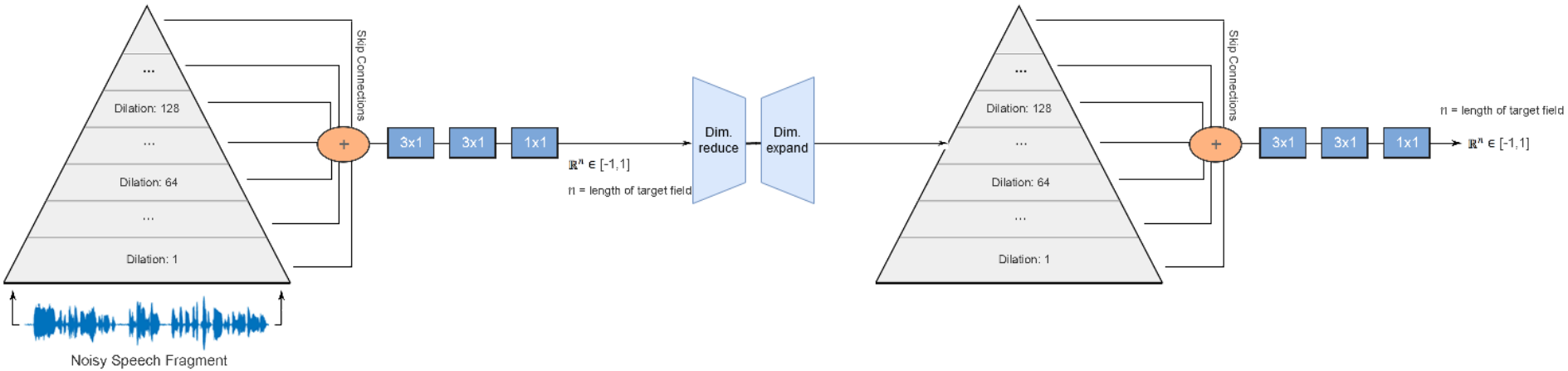

Figure 15: WaveNet + autoencoder

Regression with convolutional layers

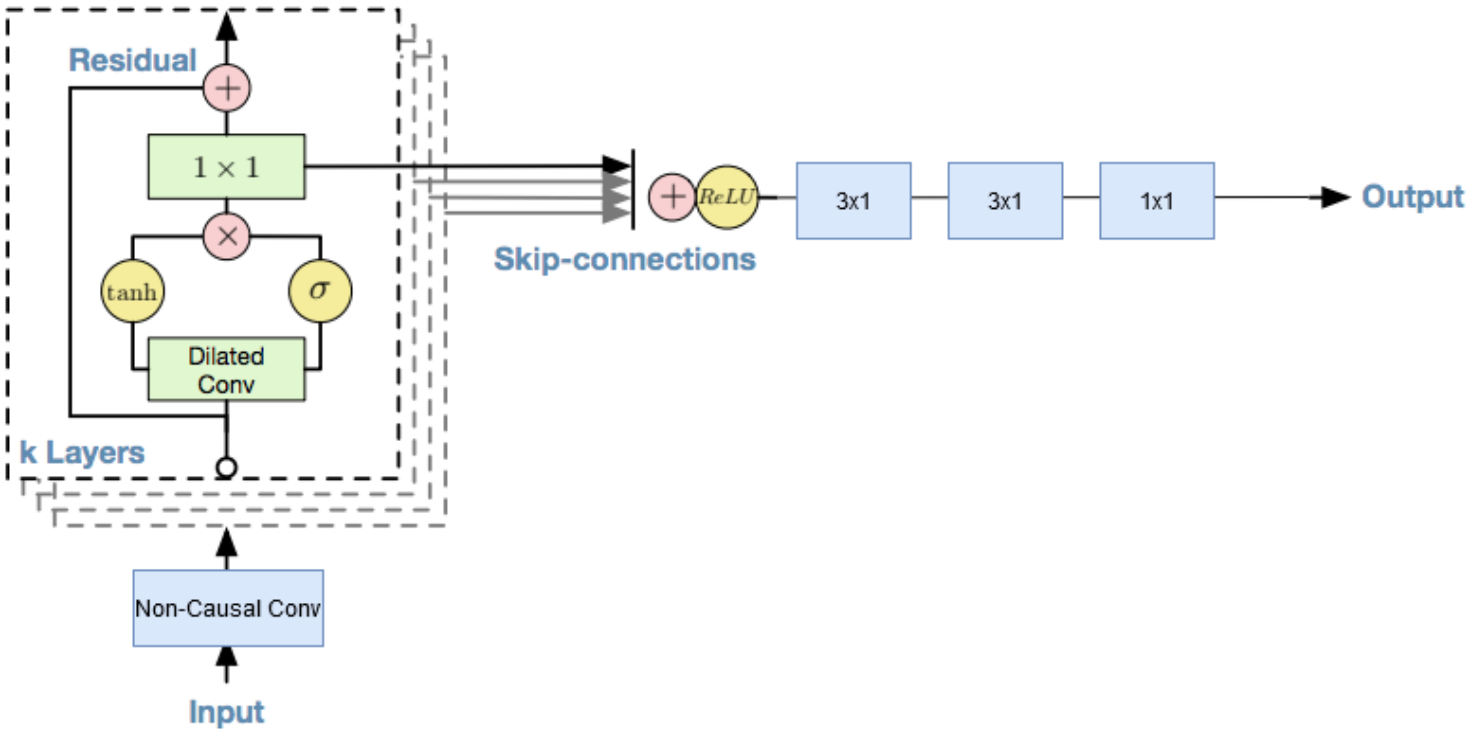

Figure 16: WaveNet + regression

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

Separately, in an .ipynb

Summary

Success, but...

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