

Deep Learning for Audio

Lecture 5

Pavel Severilov

MIPT

2024

Outline

1. Text-to-speech
2. Attention ideas in TTS
3. FastSpeech models

Outline

1. Text-to-speech
2. Attention ideas in TTS
3. FastSpeech models

Text-to-speech (TTS)

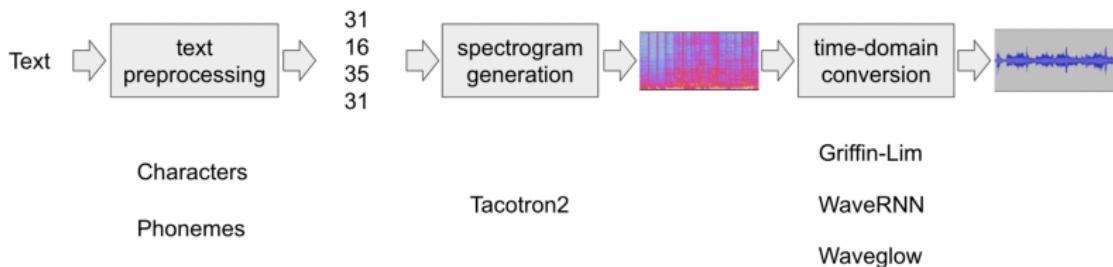


Figure: Base pipeline of Text-to-speech task

Datasets: LJSpeech, LibriTTS, CommonVoice, OpenTTS (Ru)

TTS: quality

- ▶ Quality: Subjective perception
- ▶ Overall impression, Intelligibility, Similarity, Naturalness, Pleasantness, Intonation and pauses, Emotions, Listening effort
- ▶ Mean Opinion Score (MOS): Crowdsourcing by Yandex Toloka/Amazon

$$\text{MOS} = \frac{\sum_{n=1}^N \mathcal{R}_n}{N}$$

Rating	Quality	Distortion
5	Excellent	Imperceptible
4	Good	Just perceptible, but not annoying
3	Fair	Perceptible and slightly annoying
2	Poor	Annoying, but not objectionable
1	Bad	Very annoying and objectionable

- ▶ Side-by-Side audio comparison (evaluate small improvements)

Outline

1. Text-to-speech
2. Attention ideas in TTS
3. FastSpeech models

Tacotron 2

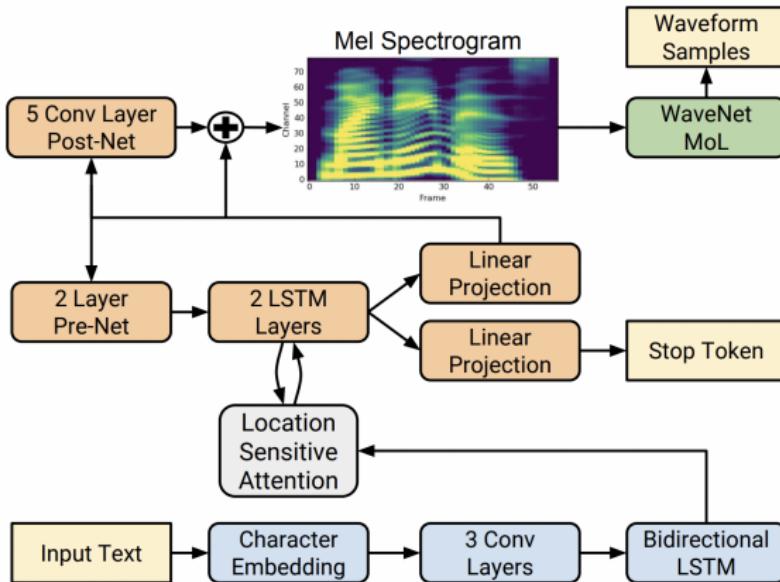
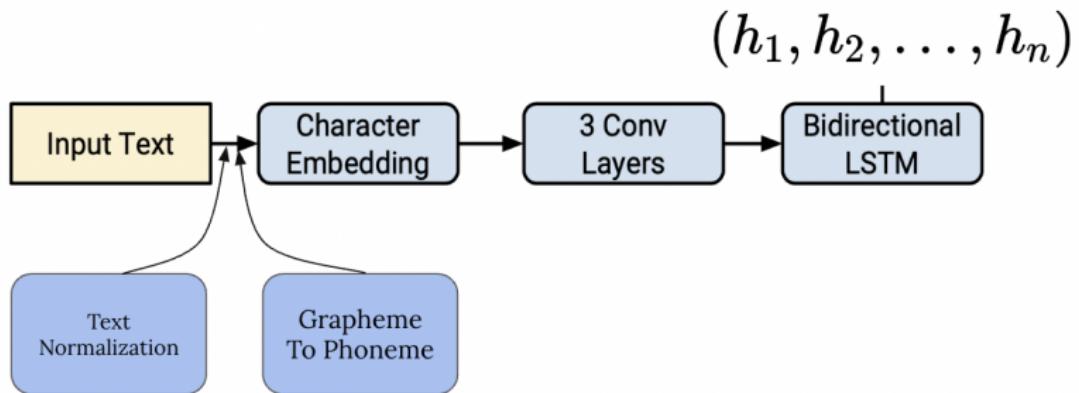


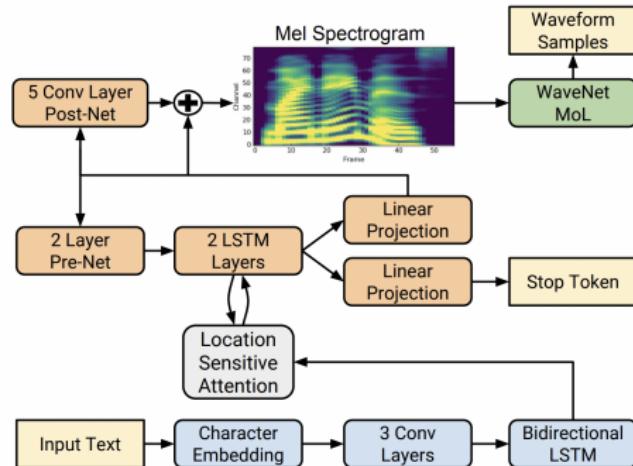
Figure: Recurrent seq-to-seq feature prediction network with attention that maps character embeddings to spectrograms, followed by a modified WaveNet to synthesize time-domain waveforms

Shen et al., Natural TTS Synthesis by Conditioning Wavenet on MEL Spectrogram Predictions, 2018 IEEE ICASSP

Tacotron 2: text Encoder



Tacotron 2



$$\mathcal{L} = \mathcal{L}_{\text{pre}} + \mathcal{L}_{\text{post}} + \text{StopToken}$$

$$\mathcal{L}_{\text{pre}} = \text{MSE}(x, \hat{x}_{\text{pre}})$$

$$\mathcal{L}_{\text{post}} = \text{MSE}(x, \hat{x}_{\text{post}})$$

$$\text{StopToken} = \text{CE}(a, \mathcal{I}[h = \text{Stop}])$$

Guided Attention

- Idea: text position n progresses nearly linearly to the time t :

$$n \sim at, \quad a \sim N/T$$

- Add loss $\mathcal{L}_{\text{att}}(A) = \mathbb{E}_{nt}[A_{nt} W_{nt}]$, where

$$W_{nt} = 1 - \exp\{-(n/N - t/T)^2/2g^2\}, \quad g = 0.2, \quad A \in \mathbb{R}^{N \times T}$$

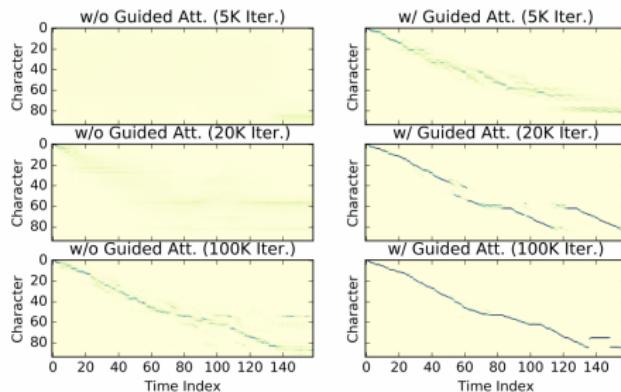


Figure: Comparison of the attention matrix A , trained with (Right) and without (Left) the guided attention loss

Monotonic Attention

$$e_{i,j} = a(s_{i-1}, h_j)$$

For $j = t_{i-1}, t_{i-1} + 1, t_{i-1} + 2, \dots$: $p_{i,j} = \sigma(e_{i,j})$

$$z_{i,j} \sim \text{Bernoulli}(p_{i,j})$$

where $a(\cdot)$ – learnable deterministic "energy function", $\sigma(\cdot)$ – logistic sigmoid function

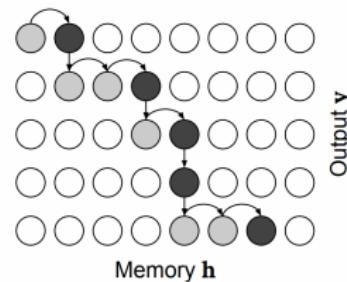
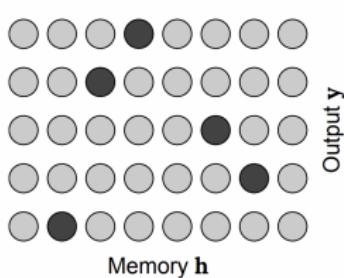


Figure: Left: schematic of the stochastic process underlying softmax-based attention decoders. Right: monotonic stochastic decoding process.

Global Style Token (GST)

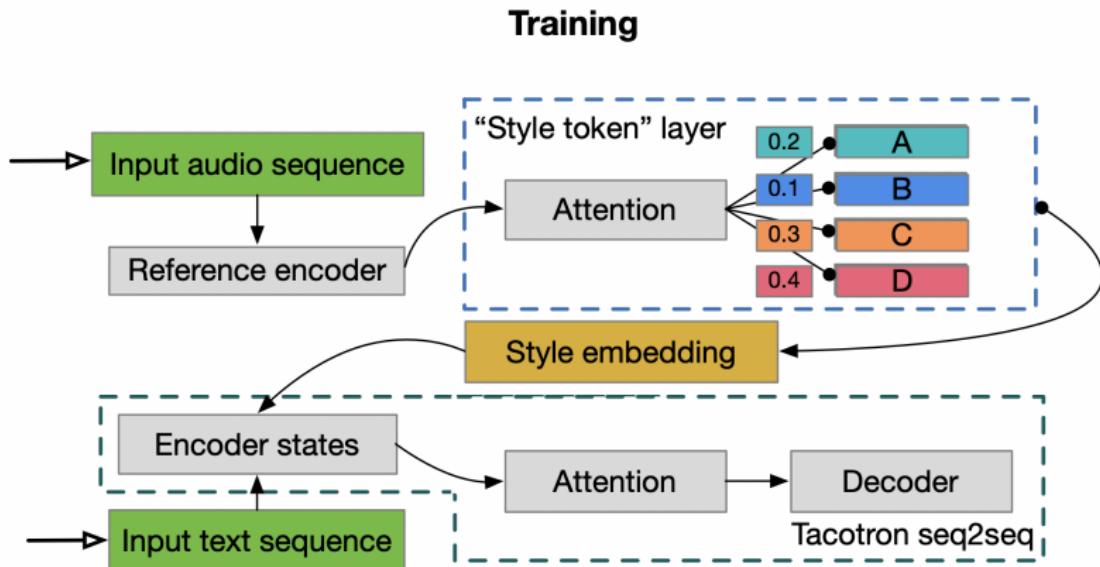


Figure: Log-mel spectrogram of the training target is fed to the reference encoder followed by a style token layer. The resulting style embedding is used to condition the Tacotron text encoder states

Global Style Token (GST)

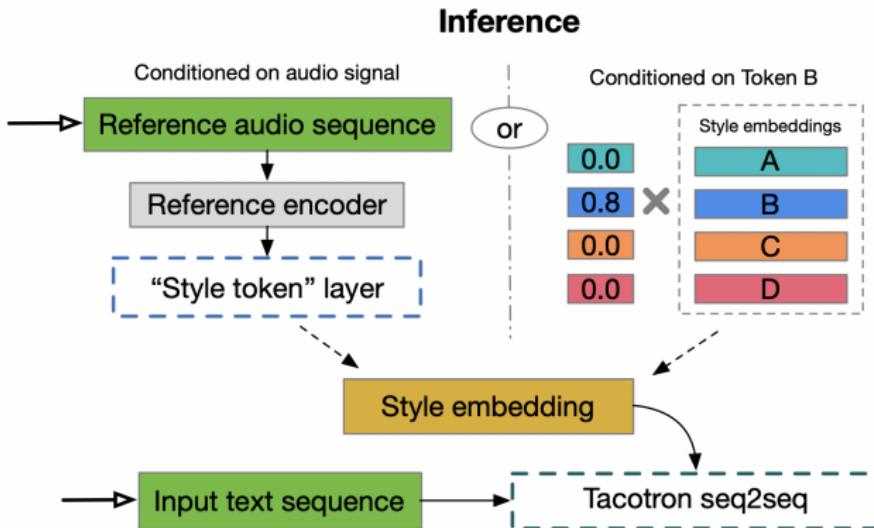
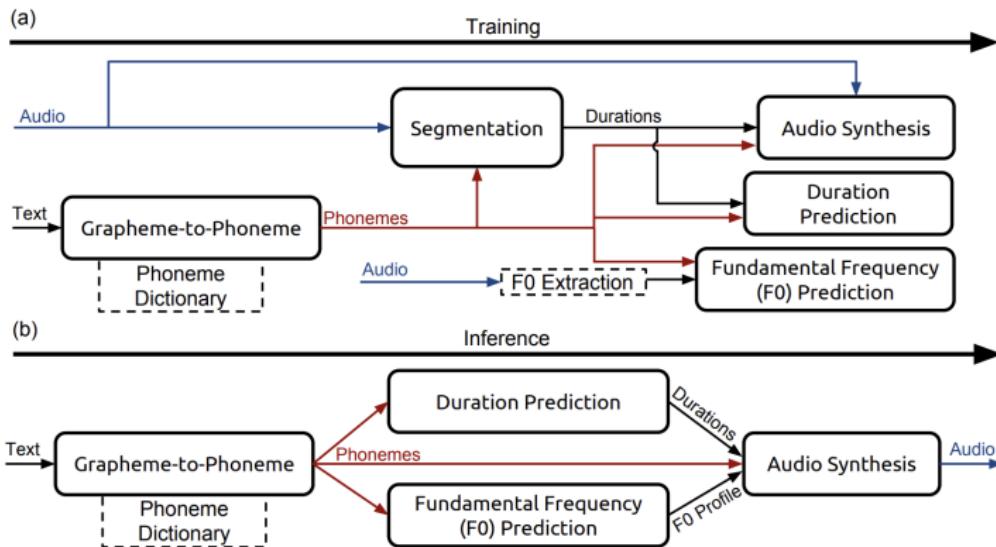


Figure: Inference: can feed an arbitrary reference signal to synthesize text with its speaking style. Alternatively, can remove the reference encoder and directly control synthesis using the learned interpretable tokens.

Outline

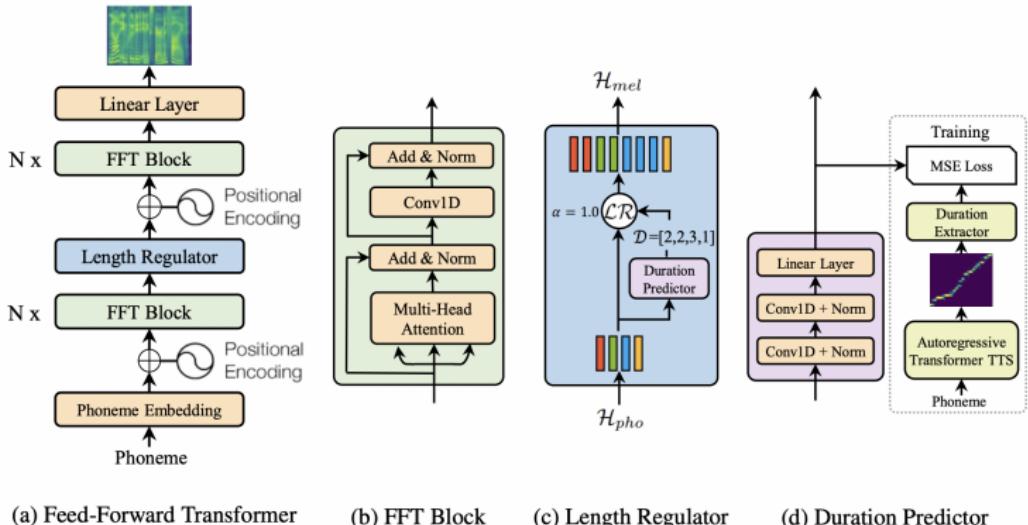
1. Text-to-speech
2. Attention ideas in TTS
3. FastSpeech models

DeepVoice



- ▶ Grapheme-to-phoneme model – for words not present in a phoneme dictionary
- ▶ Segmentation model identifies where in the audio each phoneme begins and ends

FastSpeech

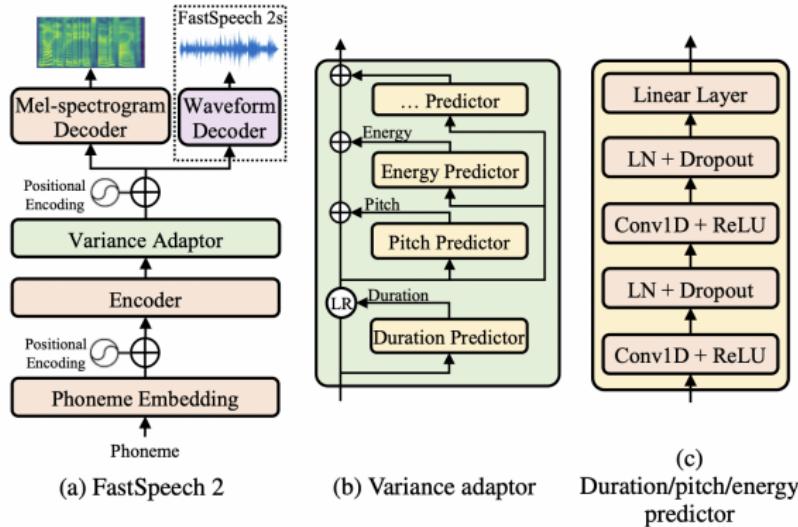


- ▶ Use of feed-forward Transformer (FFT) blocks
- ▶ Extract attention alignments from an encoder-decoder based teacher model for phoneme duration prediction

FastSpeech vs Tacotron

	Tacotron	Fastspeech
Inference speed	Slow	Fast
Synthesized speech is robust?	No, some words are skipped or repeated	Yes
Controllability (voice speed or prosody control)	Lack	Adjust voice speed smoothly

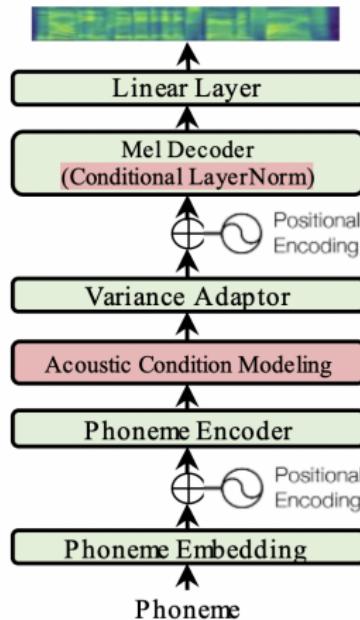
FastSpeech 2



- ▶ Directly training the model with ground-truth target instead of the simplified output from teacher
- ▶ more information of speech used as conditional inputs:
duration, pitch (emotions), energy (volume and prosody)

Ren, Yi et al. FastSpeech 2: Fast and High-Quality End-to-End Text to Speech, Arxiv preprint, 2021

AdaSpeech



- ▶ Adopted FastSpeech 2
- ▶ Add acoustic condition modeling

Chen et al., AdaSpeech: Adaptive Text to Speech for Custom Voice, Arxiv preprint, 2021

AdaSpeech: acoustic condition modeling

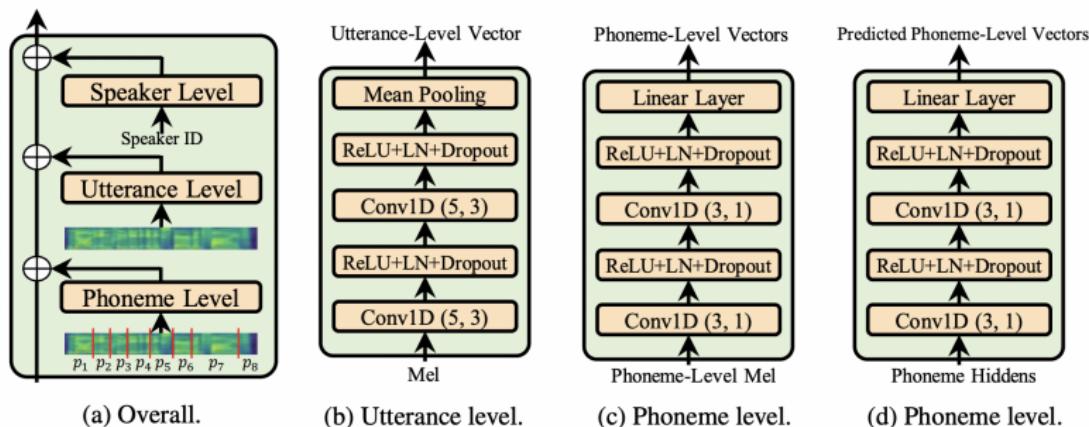


Figure: Adding acoustic conditions such as speaker timbre, prosody and recording environments into model