UNIVERSAL NEURAL VOCODING WITH PARALLEL WAVENET

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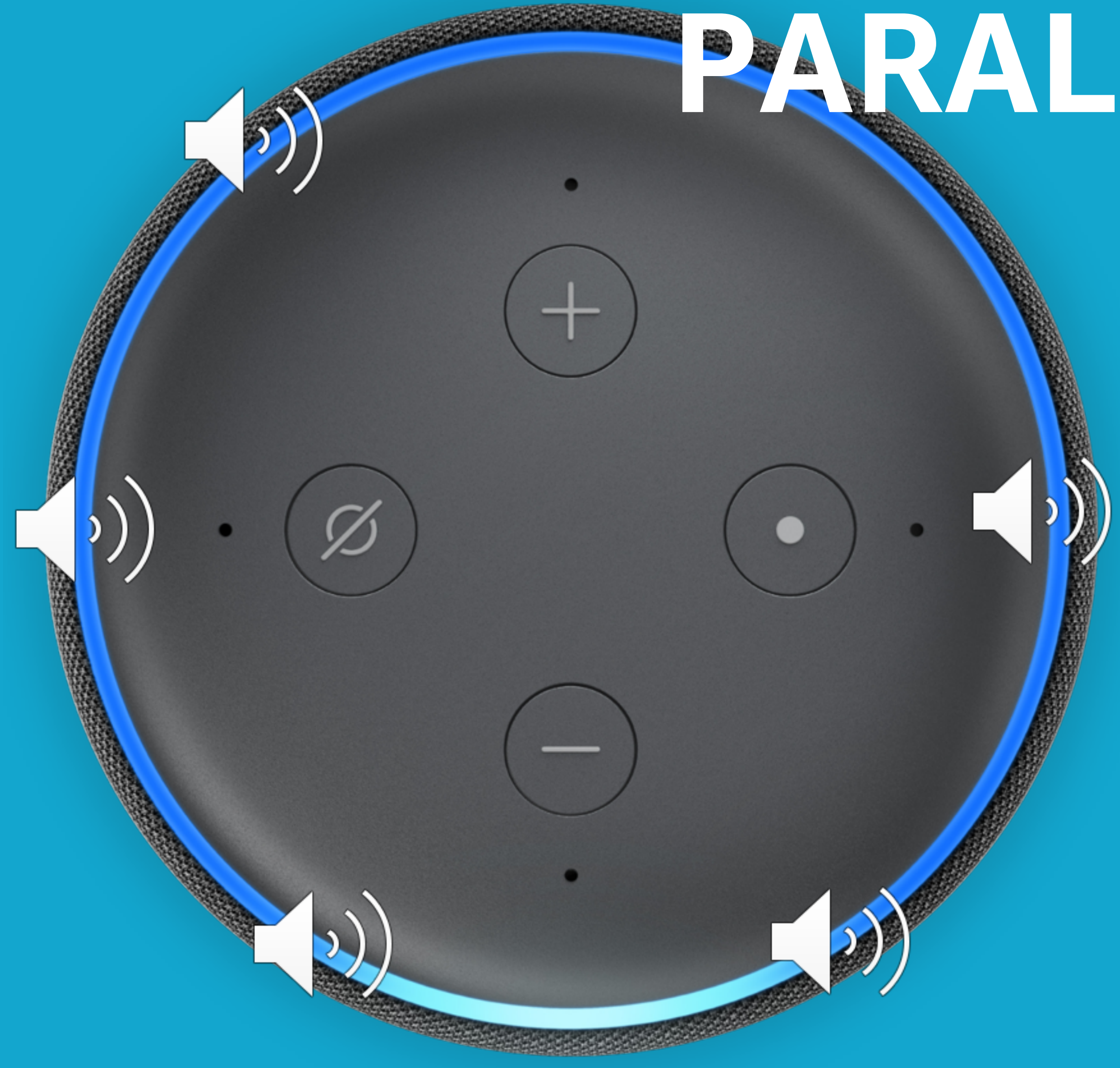

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Agenda

- Motivation
- Research question
- Architecture
  - Parallel WaveNet (PW)
  - Universal Parallel WaveNet (UPW)
- Evaluations
  - Comparison with speaker-dependent vocoders
  - Comparison with other multi-speaker vocoders
- Conclusions

Motivation

- State-of-the-art neural vocoders are capable of synthesizing natural-sounding speech.
- Most existing neural vocoders are either speaker-dependent, or have not been evaluated sufficiently to support out-of-domain voices, styles, and languages.
- Training high-quality neural vocoders requires significant computational resources and large amounts of audio data for each target speaker.
- A high-quality speaker-independent vocoder, or so-called **universal vocoder**, is key to scaling up production of TTS systems.

Research Question

Can we build universal non-autoregressive neural vocoder?

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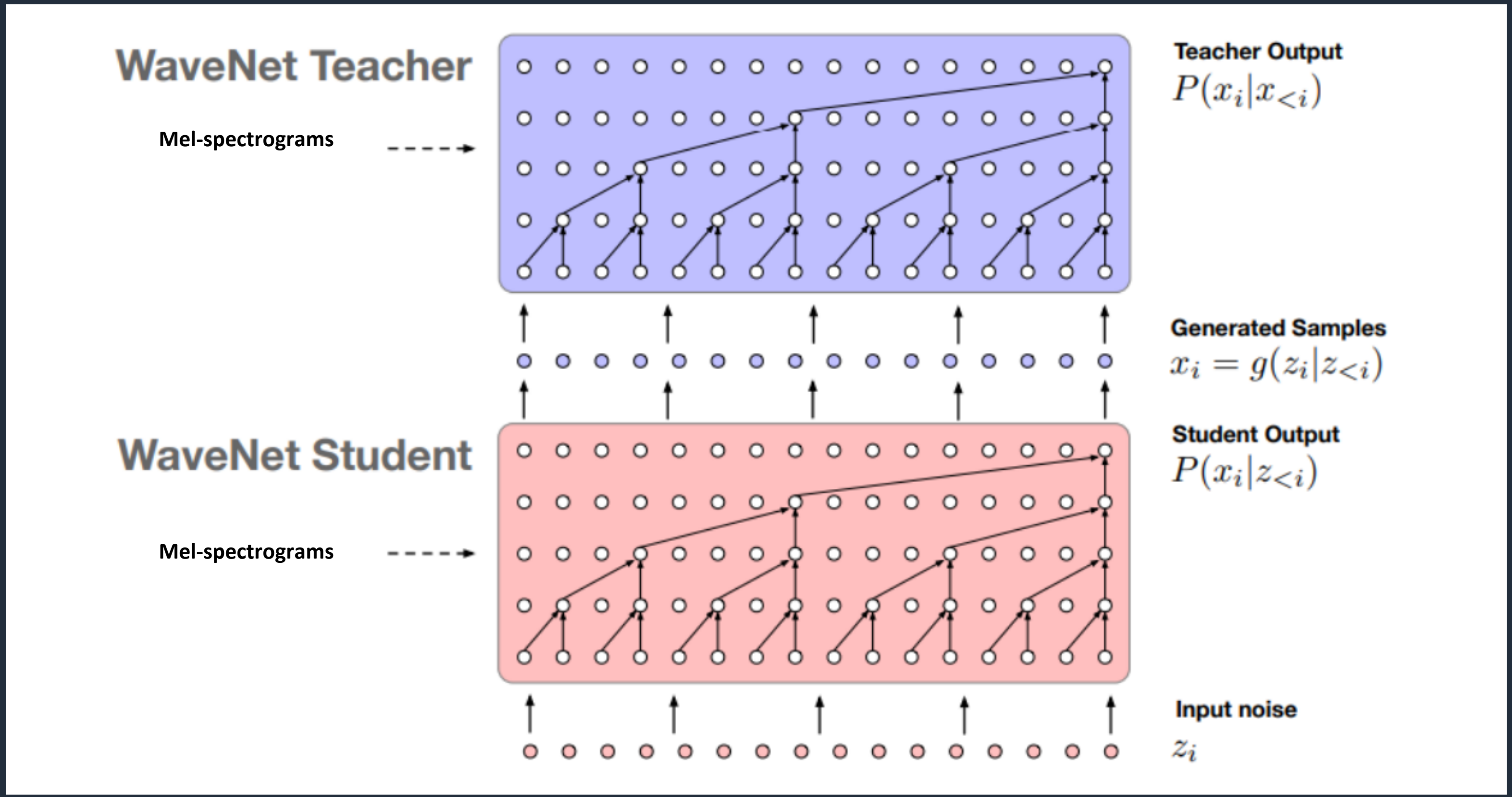
Architecture

Parallel WaveNet (PW)

- Transforms a sequence of input noise into audio waveforms using Inverse Autoregressive Flows
- Can synthesise samples very efficiently by fully exploiting the computational power of modern deep learning hardware
- Trained using Knowledge Distillation with WaveNet teacher



Recording

Speaker Dedicated PW

Baseline PW on multi-speaker data

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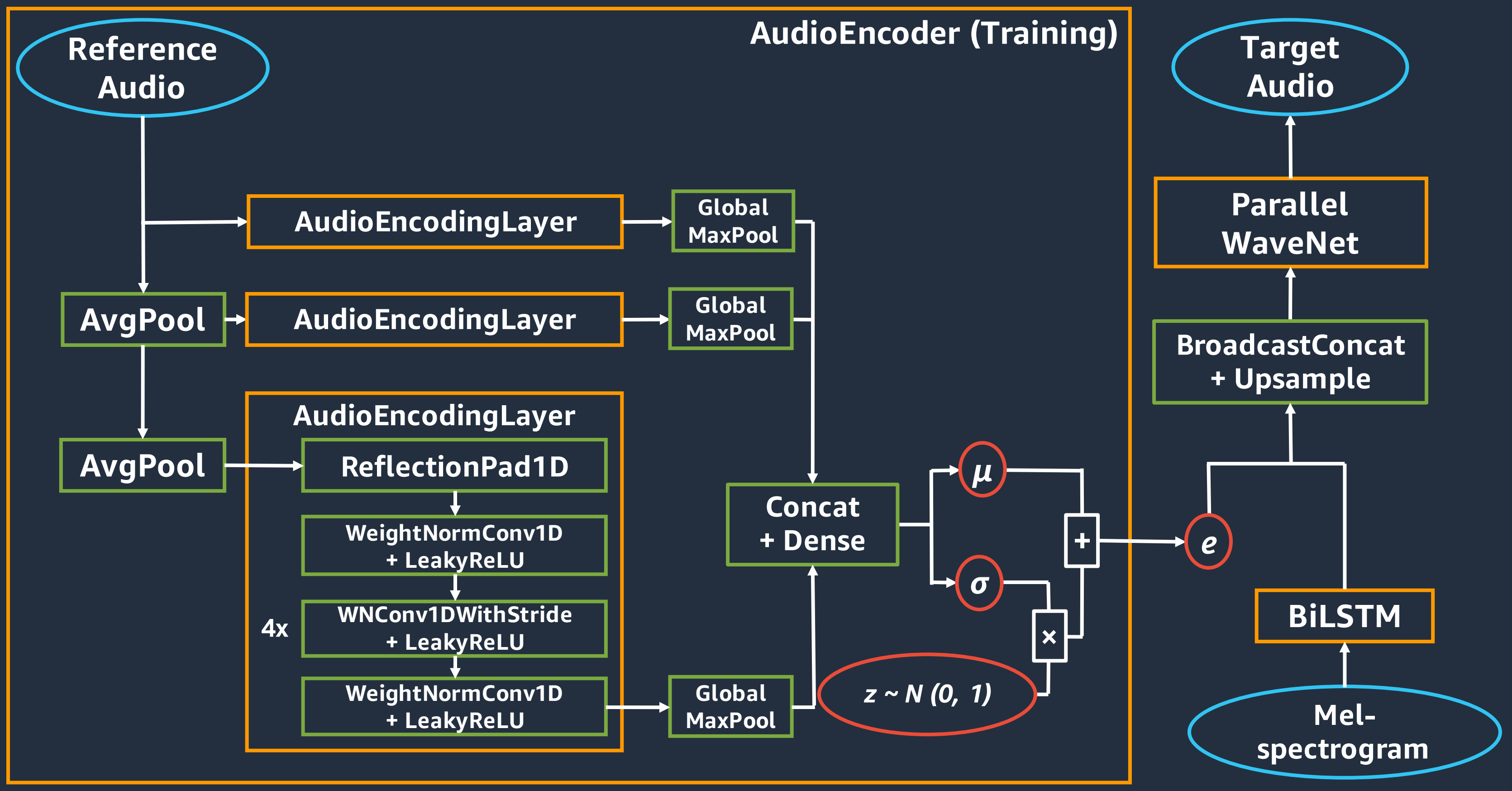
Architecture

Universal Parallel WaveNet (UPW)

- We trained a **universal neural vocoder** based on Parallel WaveNet, using a multi-speaker multi-lingual high-quality speech corpus.
- In order to train a universal vocoder, we propose an additional VAE-type conditioning network called **Audio Encoder**.



Note: At inference time, we use e = 0 to replace the output of AudioEncoder.

Recording

Speaker Dedicated PW

Baseline PW on multi-speaker data

Proposed Universal PW

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Evaluations

Comparison with speaker-dependent vocoders

Test set statistics

Test set	Recording quality	# Voices (seen / unseen)	# Styles (seen / unseen)	# Lang. (seen / unseen)	# Utt. (**all unseen**)	Vocoder systems
Internal	Very high	24 (21/3)	16 (12/4)	13 (13/0)	3,124	UPW, SDPW

UPW (ours): Universal Parallel WaveNet

SDPW: Speaker-dependent Parallel WaveNet

Evaluations

Comparison with speaker-dependent vocoders

MUSHRA results per voice

MUSHRA	Recording	SDPW	UPW	UPW Relative	P-value
All internal	69.68	57.92	**58.70**	84.24%	**0.000**
British Eng. / F / Adult	71.64	65.69	**67.67**	94.45%	**0.000**
Aus. Eng. / M / Adult	73.52	**68.37**	68.32	92.93%	1.000
Spanish / F / Adult	69.06	60.27	**61.17**	88.58%	0.668
Indian Eng. / F / Adult	77.19	62.22	**66.95**	86.74%	**0.000**
*US Eng. / M / Senior	70.40	57.65	**60.12**	85.40%	0.201
*US Eng. / M / Child	62.31	51.26	**51.99**	83.43%	1.000
US Eng. / M / Adult	68.58	52.63	**55.46**	80.87%	0.105
French / F / Senior	72.53	54.82	**56.35**	77.69%	**0.002**
US Spanish / F / Adult	73.71	48.07	**48.37**	65.62%	1.000

Speaker Dedicated PW

Proposed Universal PW

Evaluations

Comparison with speaker-dependent vocoders

MUSHRA results per style

MUSHRA	Recording	SDPW	UPW	UPW Relative	P-value
All Internal	69.68	57.92	**58.70**	84.24%	**0.000**
Emotional	71.59	60.74	**61.40**	85.76%	0.462
Neutral	69.13	58.53	**58.73**	84.95%	0.500
Conversational	58.65	43.54	**47.61**	81.18%	**0.002**
Long-form reading	68.60	**56.69**	55.46	80.85%	0.814
News briefing	75.24	56.29	**59.86**	79.55%	**0.000**
Singing	71.94	49.96	**56.87**	79.06%	**0.000**

Speaker Dedicated PW

Proposed Universal PW

Evaluations

Comparison with other multi-speaker vocoders

Test set statistics

Test set	Recording quality	# Voices (seen / unseen)	# Styles (seen / unseen)	# Lang. (seen / unseen)	# Utt. (**all unseen**)	Vocoder systems
Internal	Very high	19 (15/4)	2 (1/1)	14 (14/0)	1,700	UPW, UWRNN, PWGAN, WGlow
LibriTTS clean	High	30 (0/30)	1 (1/0)	1 (1/0)	300	
LibriTTS other	Medium	30 (0/30)	1 (1/0)	1 (1/0)	300	
Common Voice	Low	300 (0/300)	1 (1/0)	15 (14/1)	300	

UWRNN: Universal WaveRNN

PWGAN: Parallel WaveGAN

WGlow: WaveGlow

Evaluations

Comparison with other multi-speaker vocoders

- MUSHRA results

MUSHRA	Recording	PWGAN	WGlow	UWRNN	UPW	UPW Relative	P-value
Internal	66.81	56.02	50.09	61.83	**63.35**	94.82%	**0.000**
LibriTTS clean	70.42	67.40	66.72	68.30	**69.56**	98.77%	**0.000**
LibriTTS other	68.91	65.04	64.15	63.83	**67.28**	97.64%	**0.000**
Common Voice	64.84	57.84	**58.67**	54.87	58.07	89.56%	0.015

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Conclusions

- Universal neural vocoder based on Parallel WaveNet with additional conditioning network called Audio Encoder.
- Trained on multi-speaker multi-lingual speech dataset.
- Capable of synthesising a wide range of voices, styles, and languages, and particularly suitable for scaling up production of real-time TTS
- Based on large-scale evaluation, our universal vocoder outperforms speaker-dependent vocoders overall even for unseen speakers.
- Extensive studies benchmarking several existing neural vocoder architectures in terms of naturalness and universality

Thank you for joining!

We would love to answer any questions. Feel free to contact us at

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