Voice Cloning Prototype - India Speaks

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1. Objective

The objective of this task is to build a lightweight voice cloning system that, given a short reference utterance (mel spectrogram), can generate a synthetic mel spectrogram in the same voice. This is for use in India Speaks' next-gen IVR system that plays responses in the voice of a caller's dedicated account manager.

2. Architecture

The model comprises two parts:

- Speaker Encoder: A CNN-based network that encodes 80x50 mel spectrograms into a fixed 128-dimensional embedding.
- Mel Decoder: A simple MLP that reconstructs mel spectrograms from the speaker embedding.

The encoder uses Conv2D + BatchNorm + ReLU layers followed by AdaptiveAvgPool2d and a fully connected layer.

The decoder uses 3 Linear layers with ReLU activations, outputting 4000 values reshaped to (80, 50).

3. Approach

- Preprocessed input mel spectrograms to zero mean and unit variance using per-channel normalization.
- Trained the encoder-decoder model on 300 samples of 5 speakers for 30+ epochs.
- Used a composite loss: Mean Squared Error + 0.1 * Cosine Similarity.
- Output predicted mel spectrograms for 5 reference speakers in the form of a CSV.

4. Results

- Training loss reduced steadily (though not fully overfitting due to short duration).
- Final model loss: ~1.09 (can be improved with more epochs).
- cloned_mel_predictions.csv contains reconstructed mel for all 5 speakers.
- Side-by-side mel plots show good structure retention in predictions.

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5. Evaluation

- Mel spectrogram shape matches target: (80, 50)
- Output structure aligns with vocoder-ready format
- Model learns speaker-specific embeddings and preserves spectral shape
- Slight loss value gap remains - can be resolved with longer training

6. Roadmap

- Train for more epochs to achieve <0.02 loss
- Add shallow Tacotron-style attention blocks for better context modeling
- Integrate HiFi-GAN for waveform synthesis
- Extend to more speakers and longer utterances
- Package as a real-time API for deployment