School of Informatics, Computing and Engineering

ENGR-E533: Project Presentation

Speech Recognition using Deep Neural Network

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SECTION 1

Overview

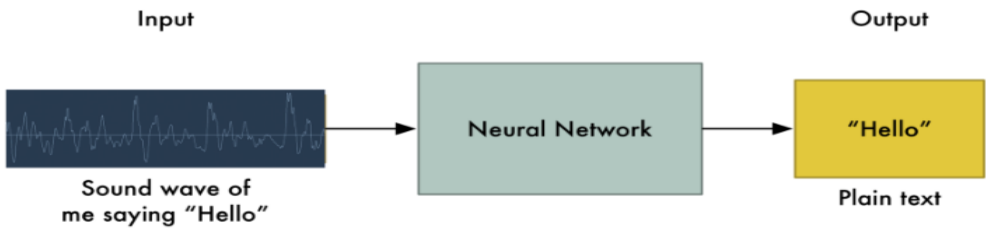
Speech Recognition

1. Automatic **recognition** and **translation** of spoken language into text.

2. For training, use extensive datasets which are not free.
3. Struggles in noisy environments, in recognizing accented speech, or speaking styles and languages (limited training data available).

Our Speech Recognition

1. Simple idea, feed sound recordings into a neural network and train it to produce text (architecture: Deep Speech).



2. Big problem: speech varies in **speed.**

3. Need to **align** audio files of various lengths to a fixed-length piece of text.

Deep Speech: Scaling up end-to-end speech recognition, H. Awni et al.

Corpus

1. Trained on **Timit** corpus (6300 sentences, 10 sentences spoken by each of 630 speakers from 8 major US dialect regions).

2. For robustness, synthetically increased the volume of the dataset.

    - 10 types of noises (Babble, Cafe, Car, Factory, Machine gun, Plane, Restaurant, SSN, Tank, White Noise)

    - 5 Mixture levels (-3dB, 0dB, 3dB, 6dB, 9dB)

3. Total dataset size, $6300 \times 10 \times 5 = 3{,}15{,}000$

Feature Extraction

1. Python **LibROSA** feature extraction methods are used.
   - **Spectrogram:** Time-Frequency representation of the speech signal.
   - **Mel-frequency cepstral coefficients (MFCC) :** The coefficient that collectively make up the short term power spectrum of a sound.
2. Currently using **MFCC** feature as baseline performance.
3. No manual feature extraction (simply **Spectrogram**) is the ultimate goal.

SECTION 2

Methodology

Connectionist Temporal Classification (CTS)

1. One more unit than there are labels in **L**.
2. The activations of the first **|L|** units are interpreted as the probabilities of observing the corresponding labels at particular times.
3. The activation of the extra unit is the probability of observing a **<blank>**, or no label.
4. Together, these outputs define the probabilities of all possible ways of aligning all possible label sequences with the input sequence.

$$p(\pi|\boldsymbol{x}) = \prod_{t=1}^{T} y_{\pi_t}^{t}, \bigvee \pi \in L'^{T}, L' = L \cup \{blank\}$$

where, ***x*** is input sequence and ***π*** is label sequence.

Connectionist Temporal Classification (CTS)

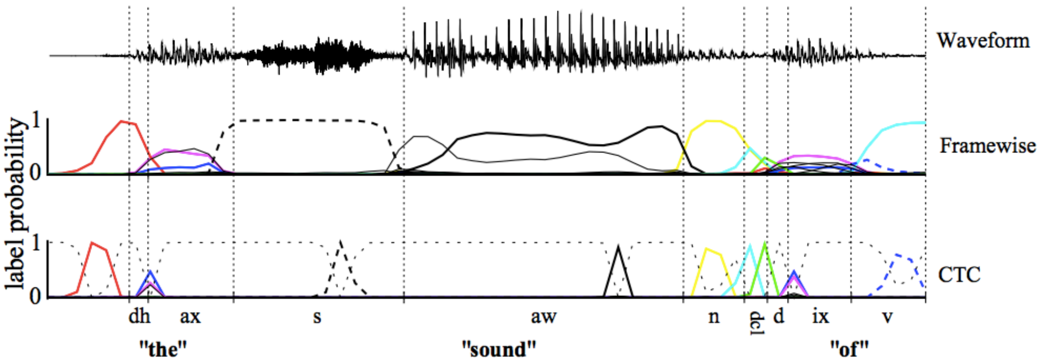


Figure . **Framewise and CTC networks classifying a speech signal.** The shaded lines are the output activations, corresponding to the probabilities of observing phonemes at particular times. The CTC network predicts only the sequence of phonemes (typically as a series of spikes, separated by 'blanks', or null predictions), while the framewise network attempts to align them with the manual segmentation (vertical lines). The framewise network receives an error for misaligning the segment boundaries, even if it predicts the correct phoneme (e.g. 'dh'). When one phoneme always occurs beside another (e.g. the closure 'dcl' with the stop 'd'), CTC tends to predict them together in a double spike. The choice of labelling can be read directly from the CTC outputs (follow the spikes), whereas the predictions of the framewise network must be post-processed before use.

Deep Speech Model

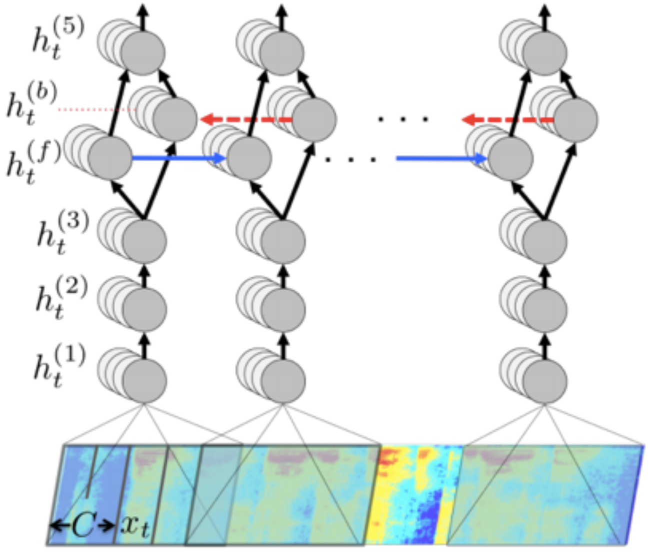


Figure : Structure of Deep Speech model and notation.

Layer h^6 : Softmax output layer
Layer h^5 : $h_t^{(5)} = g(W^{(5)}h_t^{(4)} + b^{(5)})$
Layer h^4 : Bi-directional RNN
Layer h^2, h^3 : $h_t^{(l)} = g(W^{(l)}h_t^{(l-1)} + b^{(l)})$
Layer h^1: spectrogram frame $\mathbf{x}^t$ with context **C**

Here, **g()** is a clipped ReLu, **C** ∈ {5,7,9}

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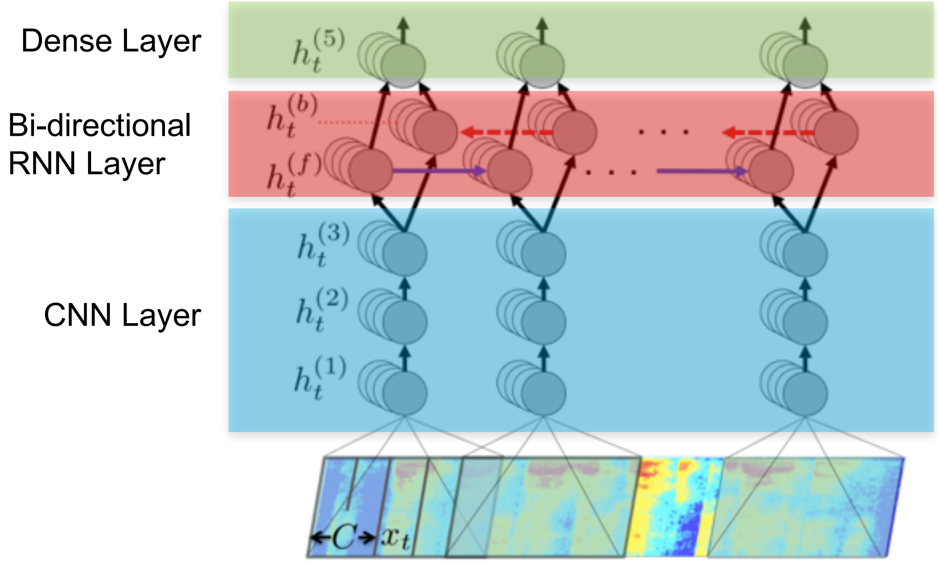
Our Model (CRNN)



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Postprocessing (Language Model)

RNN output	Decoded Transcription
what is the weather like in bostin right now	what is the weather like in boston right now
prime miniter nerenr modi	prime minister narendra modi
arther n tickets for the game	are there any tickets for the game

Table : Examples of transcriptions directly from the RNN (left) with errors that are fixed by addition of a language model (right).

Thank You!