

CS 753 Project

Speech to Sign-Language(with emotions) for the Hearing-Impaired

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Problem Statement

Given a speech utterance from a speaker who is trying to convey a message to a person who is hearing-impaired and/or voiceless, then speech has to be converted in a form that the other person can understand, i.e. in a sign language.

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- Most of the literature in the field of ASL and Speech are based on the conversion of sign-to-speech.
- But the converse model that completes the cycle of sign-to-speech, i.e. speech-to-sign, is mostly unexplored.
- In this project, we explore the speech-to-sign paradigm Deep Learning ASR models.
- This project could be used as a conversation model for the speech and/or hearing-impaired to interact with people who don't have knowledge of sign-language.

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Subtasks

- Speech to text conversion (ASR)
- Speech to emotion recognition
- Text to Sign Language Conversion (Future Work)

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Task1: Speech to Text

- The speech2text problem is one of the most classical problems in ASR.
- It started from a statistical modelling problem with separate model components like the acoustic model, language model and the pronunciation model.
- On the advent of the era of Deep Learning, this changed to an End-to-End modelling paradigm.
- It started with Tandem and Hybrid networks, with the present state-of-the-art(SOTA) model being the Conformer-based model.

Task1: Speech to Text

- Dataset: LIBRISPEECH¹
- We initially wanted to train our own Speech2Text network using a CTC-Beam Search based CNN-LSTM model.
- But due to constraint in resources could not train the model.(code is present but only able to run 30 epochs over 4days)
- So, we reverted to the ESPNet Toolkit².
- From this toolkit we used the model [here](#)
- It uses a conformer based architecture for the acoustic model and a transformer based architecture for the language model.
- We have used the pre-trained models for both.
- The metrics claimed by the model on test-clean are:

| Metric | Sub | Del | Ins | Err |
|--------|-----|-----|-----|-----|
| WER | 2.1 | 0.2 | 0.3 | 2.6 |
| CER | 1.2 | 0.8 | 0.7 | 2.7 |

¹Panayotov et al. 2015.

²Guo et al. 2020.

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Short Description of ESPNet Architecture

The Conformer-based model architecture³ is as follows:

- The input speech signal is converted into a sequence of 80 dimensional log-mel filterbank features with/without 3-dimensional pitch features.
- Then, passed through a Conformer-based encoder.
- The output of the above block is passed through a Transformer-based decoder.
- The encoder-decoder model was trained using joint-CTC-attention training and decoding.
- Followed by a token/word-level language model (transformer based) via shallow fusion.

³Guo et al. 2020.

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Emotion Recognition

- **Motivation:**

Often the emotion carried out by an utterance cannot be properly conveyed using sign-language.

- **Dataset:** RAVDESS⁴

- **Data Pre-processing:**

- ▶ Convert the input speech signal into 128-dimensional Mel-Spectrogram

- **Model:**

- ▶ The model used is a CNN-based model with a softmax layer.
- ▶ The model is trained on Cross-Entropy Loss based.
- ▶ Model Accuracy:

⁴Livingstone and Russo 2018.

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Text to Speech Conversion

- We thought of building a speech to sign-language tool, by first converting the speech to text and for every word map to american sign-language (ASL) representation.
- ****Disclaimer: We could not implement the text ot sign language part.**
- We came across several datasets that converted the letters to ASL hand-images, but that was not what we intended.
- There were other Unity and Blender based Avatar models, but that were not truly capable of direct text to ASL conversion, because of limited datasets.
- We got an architecture that treated this problem as a **GAN-based model**, but we could not implement it due constraints.
- The Workflow was as follows:
 - ▶ Translate text to ASL glossary using Transformer model.
 - ▶ Align the ASL Glossary to poses using OpenPose.
 - ▶ Interpolate the poses generated using a Fully-Connected neural network (FCN).
 - ▶ Generate avatar images for each pose using pix2pix GAN and compile as a video.

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Web Tool for the pipeline

- We created a toolkit using the `streamlit` module of python where we can record a 10sec audio and can detect text and emotion.

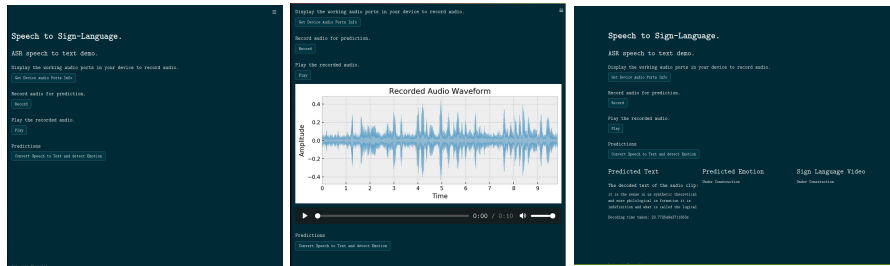


Figure: The Tool Overview

Figure: Play the Audio

Figure: Audio Decoding

The accuracy of the toolkit depends on the accuracy of the models in general and we hope to integrate the text to ASL feature in future.

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References



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Steven R. Livingstone and Frank A. Russo. “The Ryerson Audio-Visual Database of Emotional Speech and Song (RAVDESS): A dynamic, multimodal set of facial and vocal expressions in North American English”. In: *PLOS ONE* 13.5 (May 2018), pp. 1–35. DOI: [10.1371/journal.pone.0196391](https://doi.org/10.1371/journal.pone.0196391). URL: <https://doi.org/10.1371/journal.pone.0196391>.



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