Speech Processing Lab Assignment-3

Experiment: Phoneme Segmentation and Voicing Analysis in Speech

Objective-1: To identify, segment, and visualize different phoneme classes in a recorded speech signal and to analyze voiced and unvoiced regions using waveform-level inspection.

Record the sentence: ***"She judged the blue pen, put it on the table, and quietly whispered yes."***

Using the procedures implemented in Lab-2, perform the following steps:
1. Load and preprocess the recorded speech signal.
2. Automatically segment the speech into phoneme-level units (similar to previous lab).
3. Plot the time-domain waveform corresponding to each extracted phoneme.
4. For every phoneme segment:
   - ✓ Identify its phoneme category
     (vowel, plosive, fricative, affricate, semivowel, diphthong, or whisper segment).
   - ✓ Label the phoneme accordingly.
5. Select and extract:
   - ✓ One voiced phoneme segment
   - ✓ One unvoiced phoneme segment
6. Compare the waveform characteristics of the voiced and unvoiced segments and explain the observed differences based on:
   - ✓ Periodicity
   - ✓ Amplitude patterns
   - ✓ Presence or absence of noise-like structure

Objective-2: To analyze fricative and approximant speech sounds and infer airflow turbulence characteristics.

Record the sentence: ***"She sees you."***

Perform the following:
   i. Record the given sentence at a sampling rate of 16 kHz, mono WAV format. Load the recorded speech signal.
   ii. Identify regions corresponding to fricatives and approximants.
   iii. Use the segmentation approach implemented in the previous lab to automatically extract phoneme-level segments.
   iv. Isolate segments corresponding to fricatives (/s/, /ʃ/, /z/) and approximants (/j/).
   v. Plot the waveform of each extracted fricative and approximant segment.
   vi. Observe qualitative differences in waveform smoothness, amplitude continuity, presence of noise-like fluctuations.
   vii. Based on waveform observations, infer conceptually whether the airflow is turbulent (associated with higher effective Reynolds number) or Smooth/laminar (associated with lower effective Reynolds number).
   viii. Compare fricatives and approximants in terms of waveform irregularity, periodicity, energy variation. Relate the observations to articulatory constriction differences.

Expected Outcome

- ✓ Students should demonstrate an understanding of how different phoneme classes and voicing characteristics are reflected in the speech waveform, without using frequency-domain analysis.
- ✓ Students should be able to distinguish fricatives and approximants based on acoustic evidence of turbulence and explain how these differences correspond to high and low Reynolds number flow regimes in speech production.