

SEVENTH SEMESTER B.Tech. (E & C) DEGREE END SEMESTER EXAMINATION NOV 2017 SUBJECT: DICITAL SPEECH PROCESSING (ECE 4007)

SUBJECT: DIGITAL SPEECH PROCESSING (ECE - 4007)

TIME: 3 HOURS	
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MAX. MARKS: 50

Instructions to candidates

- Answer **ALL** questions.
- Missing data may be suitably assumed.
- 1A. With necessary diagram and equations explain the wave propagation in a concatenated tube model. Also find the minimum and maximum possible values of reflection coefficient assuming that area of each section in the concatenated tube model is positive and finite.
- 1B. A speech synthesizer generates voiced speech signal whose pitch period can vary between 8ms and 2.5ms. Output of the synthesizer is sampled at 10KHz and segmented using rectangular window to get Short Time Fourier Transformation. Find the minimum length of window that is required such that all harmonics of pitch frequency are resolvable in the spectrum.
- 1C. Briefly explain the digital model of speech production with a diagram.

(5+3+2)

- 2A. i) Consider a speech signal sampled at 14.4KHz. Find the minimum rate at which Short Time Average Magnitude Function (STAMF) has to be calculated on this speech signal using a Hamming window with length of 25ms. Also find the amount of overlapping between two successive frames.
 - ii) Find the rate of STAMF calculation if segments are taken with an overlapping of 80%.
- 2B. Consider the calculation of short-time energy via the relation $E_n = \sum_{m=-\infty}^{\infty} x^2 [m]h[n-m]$.

Where $h[n] = \left[-\frac{a}{b-a}a^n + \frac{b}{b-a}b^n\right]u[n]$

Where a and b are distinct with |a| < 1 and |b| < 1. Find a difference equation representation for the computation of short-time energy using the impulse response given above.

2C. How modified Short Time Autocorrelation Function (STACF) is different from normal STACF?

(5+3+2)

3A. i) Consider a speech signal sampled at 8KHz for which discrete STFT is to be computed using a Hamming window of duration 25ms. Find the minimum total sampling rate required to get an unaliased representation.

ii) Repeat the calculation if segments are taken at 80% overlapping and DFT is computed at a resolution of 10Hz per DFT point.

iii) Assume that for the same signal discrete STFT is computed with total sampling rate as 50K/second with total number of segments per second as 400. Will this resultant spectrum be free from aliasing effects? Explain your answer.

- 3B. Consider a speech signal x(n) with DTFT $X(e^{jw})$. Let $\tilde{X}(k)$ be the DFT of x(n) obtained by sampling $X(e^{jw})$ at frequencies $w_k = \frac{2\pi k}{N}$, k = 0, 1, 2, .., N 1. If $\tilde{x}(n)$ represent the inverse DFT of $\tilde{X}(k)$, show that $\tilde{x}(n)$ is periodic with period N.
- 3C. Compare the spectrum of speech signal obtained using Hamming and Rectangular window of same length. Which one is preferred?

(5+3+2)

- 4A. Derive the expression for the minimum mean squared prediction error of a linear predictor. Hence show that the minimum prediction error consists of a fixed component and a component that depends on the predictor coefficients.
- 4B. Compare the spectrum of speech signal with spectrum of LPC prediction error signal. Explain the reason for the difference between these two.
- 4C. Find the file size of an uncompressed standard CD quality stereo audio with duration of file as 2mins 30 seconds.

(5+3+2)

5A. Consider a first order Markov Model for weather condition at Manipal. With help of state transition probabilities as in table Q.5A calculate the following.

i) Given that yesterday was Sunny, what is the probability that today is Foggy and tomorrow is Rainy?

ii) Given that yesterday was Rainy and today it is Rainy, what is the probability that day after tomorrow is Rainy?

iii) Given that today is Foggy, what is the probability that it will be Rainy two days from now and Sunny four days from now?

iv) If weather on $(N-1)^{th}$ day is Foggy, and $(N+1)^{th}$ day is Sunny, what is the most probable weather condition on N^{th} day?

- 5B. What is a Mel filter bank? Explain how MFCC feature vectors are obtained from speech signal.
- 5C. What are the different elements in an HMM?

(5+3+2)

	Tomorrows Weather			
		Sunny	Rainy	Foggy
Todays	Sunny	0.8	0.05	0.15
Weather	Rainy	0.2	0.6	0.2
	Foggy	0.2	0.3	0.5

Table Q.5A