R/K/TY

Reg. No: 24BMT0014

VIT Vellore Institute of Technology

Final Assessment Test – November 2025

Course: BHST202L - Signal Processing for Healthcare Application

Class NBR(s): 0963

Slot: A2+TA2

Time: Three Hours

Max. Marks: 100

KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE

DON'T WRITE ANYTHING ON THE QUESTION PAPER

COs	CO Statements
CO1	Demonstrate knowledge of advanced signal processing techniques and their applications in healthcare.
CO2	Apply digital signal processing methods for analyzing physiological signals such as ECG, EEG, EMG, and PPG.
CO3	Utilize wavelet transforms, PCA, and ICA for biomedical signal preprocessing and feature extraction.
CO4	Implement AI and deep learning techniques for biomedical signal classification and predictive healthcare diagnostics.
CO5	Develop real-time signal processing pipelines for healthcare monitoring and wearable medica[l] devices.
CO6	Evaluate emerging trends in nonlinear signal processing and compressed sensing for biomedi[cal] applications.
CO7	Understand regulatory, cybersecurity, and ethical considerations in biomedical signal process[ing] and AI-based healthcare solutions.

BL – Blooms Taxonomy Level (1 – Remember, 2 – Understand, 3 – Apply, 4 – Analyse, 5 – Evaluate, 6 – Create)

Answer ALL Questions

(10 X 10 = 100 Marks)

1.	*Critically discuss four major applications of signal processing in modern healthcare and how these techniques enhance patient outcomes.*	CO1	B
2.	*Compare the characteristic waveforms, typical frequency ranges and primary clinical uses of ECG, EEG, EMG and PPG signals.*	CO1	B
3.	*Compare time-domain and frequency-domain denoising techniques-such as moving average filtering versus wavelet thresholding-in terms of complexity, signal distortion, and computational cost.*	CO2	B
.	Apply the sampling theorem to determine the minimum sampling rate needed to digitize a 0.5-150 Hz EEG signal without aliasing, and explain the consequences of sampling below this rate.	CO2	BL
.	Discuss the concept and applications of Short-Time Fourier Transform (STFT) in the analysis of non-stationary biomedical signals. Provide examples of how this is used in real-world healthcare scenarios.	CO3	BL4
.	Describe the role of wavelet-based ECG signal denoising. How does wavelet transform help in improving the accuracy of cardiovascular diagnostics?	CO4	BL3

7.(a)	Design 1–40 Hz band-pass at Fs = 500 Hz with 1-Hz transitions using pop_eegfiltnew (Hamming, linear phase). Use $N \approx 3.3 \cdot Fs/\Delta f$. i) Orders for HP (cut-in 1 Hz, Δf = 1 Hz) and LP (cut-out 40 Hz, Δf = 1 Hz). ii) Total group delay (samples and ms) if cascaded HP → LP. iii) For 2-s epochs, how many samples should you trim from each end post-filter to avoid edge effects?	CO5	BL5
	OR		
7.(b)	You record 8 channels over C3/C4 region for left vs right MI. Compute CSP and keep m = 4 filters (2 per class). Trial features are log-variance per projected signal. i) Feature vector length per trial? ii) Class means μ_L = [1.9, 2.3, 1.4, 2.1], μ_R = [1.2, 1.5, 1.0, 1.3]; shared SD per dim σ = 0.5. Compute LDA weights $w\_i = (\mu\_L,i - \mu\_R,i)/\sigma^2$ (equal priors, diagonal Σ). iii) For test x = [1.6, 1.9, 1.2, 1.8], compute $w^T x$ and bias $b = -\frac{1}{2} w^T(\mu\_L + \mu\_R)$. Decide class from sign($w^T x + b$).	CO5	BL5
8.	You record surface EMG at Fs = 2,000 Hz for 60 s. You compute moving-window RMS with a 50 ms window and 25 ms hop after full-wave rectification. a) Samples per window and per hop? b) How many RMS frames over 60 s? c) If an RMS frame sums squared samples to $\Sigma x^2 = 0.018$ with N samples in the window, what is the RMS value?	CO6	BL3
9.	Peak MVC (Maximum Voluntary Contraction) RMS for a muscle is 0.120 V (averaged over the best 500 ms). During a task, the windowed RMS is 0.036 V. a) Compute %MVC. b) If the electrode gain was mis-set by +10% (MVC should have been 0.109 V), what is the corrected %MVC?	CO6	BL3
10.(a)	Analyze the regulatory standards and compliance requirements in biomedical signal applications. How do these regulations impact the development and deployment of signal processing technologies in healthcare?	CO7	BL3
	OR		
10.(b)	Evaluate the challenges in implementing real-time signal processing for wearable healthcare devices. What are the technical and practical challenges that need to be addressed for effective deployment in healthcare settings?	CO7	BL3

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