

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRONICS & COMMUNICATION (SIGNAL PROCESSING & COMMUNICATION) (41)

BIOMEDICAL SIGNAL PROCESSING

SUBJECT CODE: 2724107

SEMESTER: II

Type of course: Application of Signal Processing in Biomedical Field

Prerequisite: Signal and Systems, Digital Signal Processing

Rationale: The course aims at providing the students with the knowledge and methodology for extracting useful information from a biomedical signal, interpret the results and validate the descriptors obtained in the light of knowledge of the biological system involved, produce innovation within the scope of the improvement of physiological knowledge; implement basic and advanced signal processing and pattern classification techniques on different biomedical signals like ECG, EEG, EMG.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks		Practical Marks				
			ESE (E)	PA (M)	ESE (V)		PA (I)			
						ESE	OEP	PA	RP	
3	2#	0	4	70	30	30	0	10	10	150

Content:

Sr. No.	Content	Total Hrs	% weightage
1	Introduction to Biomedical Signals: Nature and types of Biomedical Signals- action potential, electrocardiogram (ECG), electroencephalogram (EEG), electromyogram (EMG), electrogastrogram (EGG), electrooculogram (EOG), electroretinogram (ERG); Objectives of Biomedical Signal Analysis	04	12
2	Filtering Techniques for Biomedical Signals: Types of digital filters, The z-plane and pole-zero plots, The rubber membrane concept; FIR filters- Smoothing filters, derivative filters, Notch filters, Window design; IIR filters, Integer filters, Adaptive filters, Signal averaging	06	14
3	The Cardiovascular system and ECG Signal Processing: Electrical activity of heart, ECG leads and recording system, Heart rhythms, Heartbeat morphologies, Noise and artifacts in ECG; ECG Signal Processing- baseline wander removal, powerline interference removal, QRS detection- differentiation and template matching techniques, Pan-Tompkins algorithm; P and T wave detection, first and second heart sound detection	10	23
4	The Nervous system and EEG Signal Processing: The nervous	10	23

	system, EEG rhythms and waveforms, EEG recording techniques, EEG applications- epilepsy, sleep disorders, brain-computer interface (BCI); EEG Signal Processing- artifacts in EEG, artifact cancellation using reference signals, Non-parametric spectral analysis; The auto-regressive (AR) and auto-regressive moving average (ARMA) models		
5	Advanced Biomedical Signal Processing Techniques: Multi-resolution analysis (MRA) and Wavelets, Principal component analysis (PCA), Independent component analysis (ICA), Pattern classification- Supervised and Unsupervised classification, Neural networks, Support vector machines, Hidden-Markov models	12	28

Reference Books:

1. Biomedical Instrumentation and Measurements Lesli Cromwell, F J Weibell, Erich Pfeiffer PHI
2. Biomedical Digital Signal Processing Willis J Tompkins PHI
3. Biomedical Signal Analysis Rangraj M. Rangayyan John Wiley & Sons
4. Bioelectrical Signal Processing in Cardiac and Neurological Applications Leif Sornmo and Pablo Laguna Elsevier Academic Press

Course Outcome:

After learning the course the students should be able to:

1. To understand human physiological system and generation and acquisition of various biomedical signals.
2. To understand basic and advanced digital filtering and signal processing techniques for biomedical signals
3. The student will be able to model biomedical systems.
4. To implement advanced signal processing and pattern classification techniques for biomedical signals

Tutorials:

- 1 Filter the noisy ECG signal using different filters realized through MATLAB or suitable software
2. Develop a MATLAB program to perform synchronized averaging.
3. Develop different methods for selecting QRS complex from the ECG signal.
4. Develop an algorithm to remove power line interference from ECG signal
4. Select QRS complex from the ECG signal for use as the template and use a suitable threshold on the cross-correlation function for beat detection
5. Design an adaptive/ Wiener filter to remove the artifacts in the ECG signal
6. Implement PCA algorithm on ECG signal
7. Compute the PSD, kurtosis, skewness of the EEG signal
8. Implement ICA algorithm on EEG signal to identify various EEG rhythms

List of Software/learning website:

MATLAB/www.physionet.org

Review Presentation (RP): The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be

generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website