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RV COLLEGE OF ENGINEERING®
(An Autonomous Institution affiliated to VTU)
V Semester B. E. Examinations March-2022
Electronics and Communication Engineering

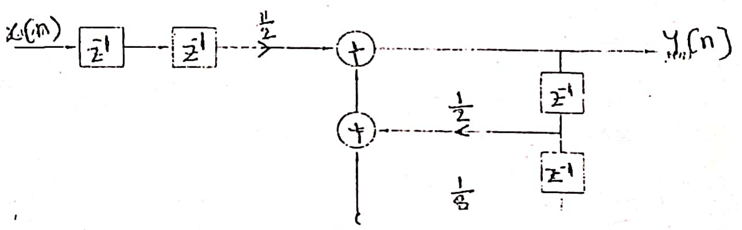
DIGITAL SIGNAL PROCESSING AND MACHINE LEARNING

Time: 03 Hours *Maximum Marks: 100*

Instructions to candidates:

1. Answer all questions from Part A. Part A questions should be answered in first three pages of the answer book only.
2. Answer FIVE full questions from Part B. In Part B question number 2, 7 and 8 are compulsory. Answer any one full question from 3 and 4 & one full question from 5 and 6.

PART-A

1	1.1	State the advantage of Direct Form II structure over Direct Form I structure.	01
	1.2	When is cascade form realization preferred in IIR filters. (1?)	01
	1.3	What are the advantages and dis advantages of Bilinear Transformation?	02
	1.4	Determine the impulse response. Classify the system as IIR or FIR. IIR  Figure 1.4	
	1.5	What is the transition width for Hamming window and rectangular window.	02
	1.6	Distinguish between bias and variance?	02
	1.7	Feature selection ________ is the process of selecting a subset of relevant features from the original set.	02
	1.8	What is the difference between stochastic gradient descent (one) (SGD) and gradient descent(GD)? (all)	01
	1.9	What is overfitting?	01
	1.10	Contrast supervised and unsupervised machine learning?	01
	1.11	Name the table that is frequently used to illustrate the performance of classification model? Confusion Matrix	01
	1.12	Why is rotation of components so important in Principle Component Analysis (PCA)?	01
	1.13	How does the SVM algorithm deal with self-learning?	01
	1.14	What is the significance of Regularization in classification?	02
	1.15	What is the preferred cross validation technique used on time series dataset? N X D 2	01
			01

$\frac{\pi}{2}$ $\frac{\pi}{6}$ $\frac{3\pi}{6} - \frac{\pi}{6} = \frac{2\pi}{6}$

PART-B

2 a Determine the system function by designing a digital band pass filter from a second order analog low pass Butterworth filter prototype using the bilinear transformation. The specifications of the digital filter are shown in figure 2a.

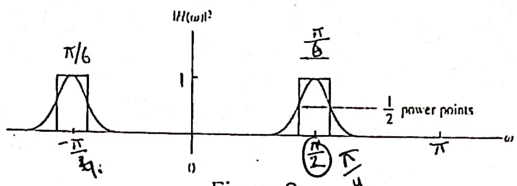


Figure 2a

The cut off frequencies (measured at the half power points for the digital filter lie at $\omega_1 = \frac{5\pi}{12}$ and $\omega_u = \frac{7\pi}{12}$. The analog proto type is given by

$$H_a(S) = \frac{1}{s^2+\sqrt{2}\, s+1}$$

~~10~~ 8

b Draw IIR Direct Form-I and II realizations for the system described by the system function

$$H(z) = \frac{10(1-\frac{1}{2}z^{-1})(1-\frac{2}{3}z^{-1})(1-2z^{-1})}{\left(1-\frac{3}{4}z^{-1}\right)\left(1-\frac{1}{8}z^{-1}\right)[1-(\frac{1}{2}+j\frac{1}{2})z^{-1}][1-(\frac{1}{2}-j\frac{1}{2})z^{-1}]}$$

$10[1-\frac{13}{6}z^{-1}+\frac{8}{3}z^{-2}+\frac{2}{3}z^{-3}]$ $2+3+3$

~~06~~ 08

3 a Given the FIR filter with the following difference equation , sketch linear phase FIR structure

$y(n) = x[n] + 3.5x(n-1) + 5.2x(n-2) - 3.5x(n-2) - x(n-4)$ — 06

b Design an FIR linear phase bandpass filter approximating the ideal frequency response :

$$H_d(\omega) = \begin{cases} 1, for\ |\omega| \le \frac{\pi}{6} \\ 0, for\ \frac{\pi}{6} < |\omega| < \frac{\pi}{3} \\ 1, for\ \frac{\pi}{3} < |\omega| \le \pi \end{cases}$$

with 25 filter coefficients using hamming window. — 10

$1-4.5z^{-1}+1.54z^{-2}+1.1z^{-3}+\frac{1}{2}z^{-4}$ $a_4(3)=1.1$

OR

$a_4(2)=1.54$ $a_4(1)=1.24$

4 a Determine all the FIR filters which are specificed by the lattice parameters K1=1/2 , k=0.6,k3=0.7,and k4=1/3. — 08

b Determine the coefficients {h(n)} of a linear phase FIR filter of length M=15 which has a symmetric unit sample response and a frequency response that satisfies the condition:

$$H_r = \begin{cases} 1, k = 0,1,2,3 \\ 0.4, for\ k = 4 \\ 0, for k = 5,6,7 \end{cases}$$

08

5 a For the given dataset, perform gradient descent on linear regression to minimize the error. Clearly mention the equations used. Show all the intermediate steps of calculations. Perform three iterations. Consider zero initial weight and learning rate of 0.05.

77	79.77
21	23.17
22	25.60
20	17.85
36	41.84
15	9.81
62	58.87
95	97
20	18
5	8.74

12

b What is MLE? How can it be used to predict parameters of a distribution form the dataset of the same distribution? 04

OR

6 a The coordinates of the sample distribution of three classes of balls: Blue, Green and Red are given below:
Blue balls (1.5,2)(2.5,1,5)
Green Balls (7,1)(9,1.5)
Red Balls (4,9) (5,7)
Let the coordinate of a new ball is given by (1.25,2.75) . Estimate and classify the new ball using the conditional probability log likelihood function. (Use MLE) 08

b Consider a dataset for a given day in a restaurant, the bill amount and tips received from the customer are given in the table 6b. Develop a prediction model using least square error and compute R-squared for the given data set

Table 6b

X	Y
13	17
46	46
13	10
79	77
53	50
15	13
28	31
81	73
69	74
52	52

$B_0 = 1.4$
$B_1 = .9$
$R^2 = .97$

08

7 a For the given positive labeled data points
$\{\binom{2}{2}, \binom{2}{-2}\binom{-2}{-2}, \binom{-2}{2}\}$
Add the following negative labeled data points
$\{\binom{1}{1}, \binom{1}{-1}\binom{-1}{-1}, \binom{-1}{1}\}$
Use nonlinear SVM for classification of data. Mapping function is nonlinear mapping from input space into some feature space given as

$$\varphi_1\binom{x_1}{x_2}\begin{cases}\binom{4 - x_2 + |x_1 - x_2|}{4 - x_1 + |x_1 - x_2|} & if\ \sqrt{{x_1}^2 + {x_2}^2} > 2 \\ \binom{x_1}{x_2}\ other\ wise & \end{cases}$$

10

b Predict the class of the given unknown using Naïve Bayes classifier.
Holiday=No, Weather=Not Rainy, With friends = Yes

Sl No	Holiday?	Weather	With friends	Go for Kite flying
1	Y	Rainy	Y	No
2	Y	Rainy	N	Yes
3	Y	Not Rainy	N	No
4	Y	No Rainy	N	Yes
5	Y	Not Rainy	Y	No
6	N	Not Rainy	N	No
7	N	Rainy	N	Yes
8	N	Rainy	Y	Yes
9	N	Rainy	Y	No
10	N	Rainy	Y	Yes

06

8 a The following data is given to Principal component analysis for dimensionality reduction. Determine the immediate values of the PCA algorithm. The intermediate values like covariance matrix, eigen values, eigen vectors and projection of data onto the principal components.

X1	2	5	7	6	1	8	9
X2	1	4	6	3	4	5	6

10

b Assume that we need to cluster seven observations into three clusters using K means clustering algorithm. After the first iteration clusters C1,C2 and C3 has following observations:

C1:{(2,2),(4,4),(6,6)}

C2:{(0,4)(4,0)}

C3:{(5,5)(9,9)}

What will be Manhattan distance for observation (9,9) from cluster centroid C1 in second iteration. 06