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National Institute of Technology Hamirpur
Digital image processing and pattern recognition (EC-714)

Note: All questions are compulsory and carry equal marks. Write answers of sub-parts of each question in continuation only.

Maximum time: 3 Hours

- Q1. If $x[n] = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X[k] \exp(j2\pi kn/N)$, then show that $X[k] = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} x[n] \exp(-j2\pi kn/N)$, and $\sum_{n=0}^{N-1} |x[n]|^2 = \sum_{k=0}^{N-1} |X[k]|^2$.
- Q2. Define the Dirichlet conditions for one dimensional Fourier series and Fourier transform. Define the two dimensional (2D) discrete Fourier transform and 2D discrete inverse Fourier transform for an image of size $M \times N$. Show that the 2D discrete Fourier transform can be computed by first considering 1D discrete Fourier transform along the rows and then along the columns of the image.
- Q3. Define the distributional Fourier transform and obtain the Fourier transform of the (i) polynomial $p_n(t) = a_0 + a_1 t + a_2 t^2 + \cdots + a_n t^n$, (ii) exponential $x(t) = \exp(t)$, and (iii) superexponential $x(t) = \exp(\alpha t^2)$ where $\alpha < \pi$.
- Q4. Explain the affine transformations. Write expressions for (i) Rotation, (ii) Translation, (iii) Scaling/Reflection, and (iv) Shear operation in the 2D coordinates.
- Q5. Explain the image histogram matching with the help of derivation. Suppose that the intensity value in an image have the probability density function (PDF) $p_R(r) = \frac{2r}{(L-1)^2}$ for $0 \leq r \leq L-1$ and $p_R(r) = 0$ otherwise. Find the transformation function that will produce an image whose intensity PDF is $p_Z(z) = 3z^2/(L-1)^3$ for $0 \leq z \leq L-1$ and $p_Z(z) = 0$ otherwise.
- Q6. Write analysis and synthesis equations for both one and two dimensional (1) Fourier series, (2) Fourier transform, (3) Discrete time Fourier transform, (4) Discrete Fourier transform, (5) Wavelet transform, and (6) Discrete cosine transform
- Q7. The probability density function of exponential noise is given by $p_Z(z) = a \exp(-az)$ for $z \geq 0$ and $p_Z(z) = 0$ for $z < 0$. Compute mean and variance of this density function.
- Q8. Define probability density function of white Gaussian noise, also compute its mean and variance.
