Scheme of Valuation/Answer Key

(Scheme of evaluation (marks in brackets) and answers of problems/key)

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

EIGHTH SEMESTER B. TECH DEGREE(S) EXAMINATION, OCTOBER 2023(2019 SCHEME)

Course Code: CST438

Course Name: IMAGE PROCESSING TECHNIQUE

Max. Marks: 100		Duration: 3 Hours

PART A

		Answer all questions, each carries 3 marks.	Marks
1		Image interpolation is a technique used to increase the resolution of an image by adding new pixels or data points to the low-resolution image. There are generally three methods used for image interpolation: nearest neighbor, bilinear interpolation, or bicubic interpolation. Nearest neighbor interpolation is a simple method that involves copying the value of the nearest pixel to the new pixel location. Bilinear interpolation involves taking a weighted average of the four nearest pixels to the new pixel location. Bicubic interpolation involves taking a weighted average of a larger number of pixels (usually 16) in a 4x4 grid around the new pixel location.	(3)
2		An image representation model is a mathematical model that describes an image in terms of its features or characteristics. The representation can change depending on the type of image being analyzed. For example, a representation model for a grayscale image will be different from that of a color image. Similarly, an image representation model for a medical image will be different from that of a satellite image.	(3)
3		Image transforms are used to convert an image from one domain to another. For example, an image can be transformed from the spatial domain to the frequency domain using Fourier transform. Image transforms are used for various purposes such as image compression[1], feature extraction, and image recognition.	(3)

4		The Hadamard transform is a type of Fourier-related transform that is used in signal processing and image processing. The Hadamard transform of the 2x2 image [3 2 4 3] can be computed as follows: H = [1 1 1 1; 1 -1 1 -1; 1 1 -1 -1; 1 -1 -1 1] I = [3;2;4;3], HT = H*I The result of the Hadamard transform of the image [3 2 4 3] is: HT = [12;0;-2;0]	(3)
5		Clipping and thresholding are two techniques used in image processing. Clipping is a special case of contrast stretching that is used for noise reduction when the input signal is known. It puts all grey levels below r1 to black (0) and above r2 to white (1). Thresholding is another special case of contrast stretching that is used for noise reduction. It is also used for image segmentation. Thresholding generates a binary image from a given grayscale image by separating it into two regions based on a threshold value. Pixels having intensity values less than or equal to the threshold value are set to black, while pixels having intensity values greater than the threshold value are set to white.	(3)
6		Homomorphic filtering is a frequency-domain technique that aims at a simultaneous increase in contrast and dynamic range compression. It is sometimes used for image enhancement. Homomorphic filtering can be used for improving the appearance of a grayscale image by simultaneous intensity range compression (illumination) and contrast enhancement (reflection).	(3)
7		Global thresholding determines the threshold value based on the histogram of the overall pixel intensity distribution of the image. In contrast, adaptive thresholding computes the threshold value for each fractional region of the image, so that each fractional region has a different threshold value.	(3)
8		In image processing, zero-crossing detectors are used to detect edges within an image. The zero crossing detector looks for places in the Laplacian of an image where the value of the Laplacian passes through zero - i.e., points where the Laplacian changes sign. Such points often occur at edges in images - i.e., points where the intensity of the image changes rapidly. The starting point for the zero crossing detector is an image that has been filtered using the Laplacian of	(3)

		Gaussian filter[1]. The zero crossings that result are strongly influenced by the size of the Gaussian used for the smoothing stage of this operator.	
9		Closing and Opening are morphological operations that are used to remove noise from an image1. Closing is the reverse of Opening, Dilation followed by Erosion1. It is useful in closing small holes inside the foreground objects or small black points on the object1. Opening is an erosion followed by dilation1. It is useful in removing noise from the background of an image1. For example, consider a binary image with a white object on a black background2. The opening operation erodes away the boundaries of the white object and removes small white spots inside the object2. The closing operation removes small black holes inside the object and fills in small black spots inside the object2.	(3)
10		In image processing, boundary refers to the line or location dividing two surfaces. It is also known as contour tracing. Boundary extraction is a technique that identifies the boundary pixels of a digital region. Boundary extraction can be used to extract features such as edges from an image. For example, in MATLAB, the bw boundaries function can be used to trace the boundaries of all objects in an image.	(3)
PART B			
Answer one full question from each module, each carries 14 marks.			
		Module I	
11	a)	In image processing, image formation is the process of creating an image from an object. The process involves capturing light from the object and converting it into an image. Detailed explanation with necessary diagram is included.	(8)
	b)	Arithmetic and logical operations are widely used in image processing, especially in image morphology[1]. Here are some of the arithmetic operations that can be applied to input images: - Addition: a + b - Subtracting: a – b - Image multiplication: a × b - Image division: a/b Logical operations can also be applied to input images: - AND	(6)

		- OR - NOT - XOR These operations can be helpful in enhancing the properties of the input images. For example, addition of two images can be done using function cv2.add(). This directly adds up image pixels in the two images. Detailed Explanation required	
		OR	
12	a)	There are many different image file formats available, each with its own advantages and disadvantages. Here are some of the most common image file formats: - JPEG (Joint Photographic Experts Group): This is a lossy compression format that is widely used for photographs and other complex images. It can be compressed to a small size without losing too much quality. - PNG (Portable Network Graphics): This is a lossless compression format that is widely used for graphics and images with transparent backgrounds. It can be compressed to a small size without losing any quality. - GIF (Graphics Interchange Format): This is a lossless compression format that is widely used for animations and simple graphics. It can be compressed to a small size without losing any quality. - BMP (Bitmap): This is an uncompressed format that is widely used for Windows-based applications. It can be compressed to a small size but loses quality when compressed. - TIFF (Tagged Image File Format): This is a lossless compression format that is widely used for high-quality images. It can be compressed to a small size without losing any quality. - PSD (Photoshop Document): This is Adobe Photoshop's native file format that supports layers and other advanced features. Detailed Explanation required	(6)
	b)	Color in images is determined by the nature of the light reflected from an object. All colors that we see in our images on the screen or in print are created by mixing three primary colors: Red, Green, and Blue. This is called the Additive color mode – RGB (stands for Red, Green, Blue) – which is the mixing of red, green,	(8)

		and blue points of light in varying proportions to produce any color on a computer, television, or mobile device screens. There are other color models as well such as CMYK (Cyan, Magenta, Yellow and Key (Black)) which is used for printing purposes. Another model is HSV (Hue, Saturation and Value) which is used for histogram equalization and converting grayscale images to RGB colour images. YIQ is another widely used color model in Television broadcasting where Y stands for luminance part and IQ stands for chrominance part. Detailed Explanation required.	
		Module II	
13	a)	The Discrete Fourier Transform (DFT) is defined as a mathematical technique that transforms a finite sequence of equally spaced samples of a function into a same-length sequence of equally spaced samples of the discrete-time Fourier transform (DTFT), which is a complex-valued function of frequency1. The DFT generally varies from 0 to 360 and there are basically N-sample DFT, where N is the number of samples. Detailed Explanation required.	(5)
	b)	A unitary matrix is a square matrix of complex numbers whose inverse is equal to its conjugate transpose.. A square matrix is unitary if either U H = U -1 (or) U H U = U U H = I, where U H is the conjugate transpose of U. To determine whether a given matrix is unitary or not, you can check if its inverse is equal to its conjugate transpose. If it is, then the matrix is unitary; otherwise, it is not. Detailed Explanation with solution required.	(9)
		OR	
14	a)	The Discrete Cosine Transform (DCT) is preferred over the Discrete Fourier Transform (DFT) in image compression because it results in less blocking artifacts due to the even-symmetric extension properties of DCT. Also, DCT uses real computations, unlike the complex computations used in DFT. This makes DCT hardware simpler as compared to that of DFT.	(5)
	b)	The inverse 2D DFT of the transform coefficients F(k,l) you provided can be computed as follows: IDFT(F(k,l)) = (1/N^2) * ΣΣ F(k,l) * exp(j*2π*(i*k/N + j*l/N)) where i = 0,1,...,N-1 and j = 0,1,...,N-1. Substituting the values of F(k,l) you provided in the above equation, we get:	(9)

		IDFT(F(k,l)) = (1/16) * [64 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0] = (1/16) * [64] = [4] Therefore, the inverse DFT of the given transform coefficients is: [4 4 4 4; 4 4 4 4; 4 4 4 4; 4 4 4 4]	
		Module III	
15	a)	(i) Bit Extraction: Bit extraction refers to generating an output image defined by y = b(x), where b(x) is a binary function of x. In other words, it involves extracting one or more bits from each pixel in an image and using them to form a new image. (ii) Intensity Level Slicing: Intensity level slicing means highlighting a specific range of intensities in an image. In other words, we segment certain gray level regions from the rest of the image. This technique is used to highlight a specific range of gray levels in a given image. (iii) Range Compression: Range compression refers to compressing the dynamic range of an image so that it can be displayed on a device with a lower dynamic range. This technique is often used when an image has a large dynamic range that cannot be displayed on a standard monitor or printer.	(9)
	b)	Obtain the padding parameters using function padded size. Obtain the Fourier transform of the image with padding. Generate a filter function, H , the same size as the image. Multiply the transformed image by the filter. Obtain the real part of the inverse FFT of G. To filter a signal in the frequency domain, first compute the DFT of the input, multiply the result by the sampled frequency response, and finally compute the inverse DFT of the product1. The DFT's length must be at least the sum of the input's and unit-sample response's duration minus one. Detailed explanation required.	(5)
		OR	
16	a)	Gaussian high-pass filter and Butterworth high-pass filter are two types of high-pass filters used in image processing for image enhancement in the frequency domain.	(8)

		Gaussian high-pass filter attenuates frequency components that are near to the image center (W/2, H/2). It is defined as: H(u,v) = 1 - e^(-(D(u,v)^2)/(2*D0^2)) where D(u,v) is the distance between a point (u,v) in the Fourier transform plane and the origin (W/2,H/2), and D0 is a positive constant called cutoff frequency. Butterworth high-pass filter removes low-frequency components from an image and preserves high-frequency components. It is defined as: H(u,v) = 1/(1 + (D(u,v)/D0)^(2n)) where D(u,v) is the distance between a point (u,v) in the Fourier transform plane and the origin (W/2,H/2), D0 is a positive constant called cutoff frequency, and n is an integer called order of filter.	
	b)	Spatial averaging and spatial low-pass filtering are two types of low-pass filters used in image processing for image enhancement in the spatial domain. Spatial averaging is a simple low-pass filter that replaces each pixel value with the average value of its neighbouring pixels. It is also known as a smoothing filter and is used to blur an image. Spatial low-pass filtering removes high-frequency content from an image and preserves low-frequency content. It is also used to blur an image. A low-pass averaging filter mask is used for spatial low-pass filtering.	(6)
		Module IV	
17	a)	Image restoration is a process of removing noise and other distortions from an image to improve its quality and clarity. The process involves modeling the degradation function and applying a reverse process to obtain an estimate of the original image. There are several noise probability functions used frequently in digital image processing. Here are four important ones: 1. Gaussian noise: It is a type of additive noise that follows a Gaussian distribution. It is commonly found in electronic devices and can be modeled as a zero-mean random variable with a constant variance. 2. Impulse noise: It is a type of noise that appears as white and black dots in an image. It can be modeled as a random variable that takes on only two values (a and b) with some probability.	(9)

		3. Poisson noise: It is a type of noise that occurs in images captured by photon detectors such as cameras. It can be modeled as a random variable that follows a Poisson distribution. 4. Salt-and-pepper noise: It is a type of impulse noise that appears as white and black dots in an image.	
	b)	Region-based segmentation is a technique for determining the region directly. It involves dividing the image into smaller segments that have a certain set of rules. This technique employs an algorithm that divides the image into several components with common pixel characteristics. The process looks out for chunks of segments within the image. Region growing is a simple region-based image segmentation method. It is also classified as a pixel-based image segmentation method since it involves the selection of initial seed points. The basic formulation of region growing is that it is a logical predicate defined over the points in set and is the null set. (a) means that the segmentation must be complete; that is, every pixel must be in a region.	(5)
		OR	
18	a)	Adaptive filters are important in image restoration systems because they can remove noise from images while preserving edges and details. Adaptive filters are used to remove noise from images that have been corrupted by impulse noise. Adaptive filters are used in image restoration systems because they can remove noise from images while preserving edges and details. The working of adaptive median filters is a two-step process. In the first step, it finds the median value for the kernel. In the second step, it checks whether the current pixel value is an impulse (salt and pepper noise) or not. If the pixel value is corrupted, then it changes its value with median; otherwise, it retains the value of the grayscale pixel. Detailed explanation required.	(8)
	b)	Region growing and region splitting and merging are two common techniques for segmenting images into meaningful regions based on some criteria, such as pixel intensity, color, texture, or shape. Region growing is an iterative process that starts with a seed point and adds neighboring pixels that meet certain criteria to form a region[2]. The process	(6)

		continues until no more pixels can be added[2]. The main advantage of region growing is that it can produce connected regions. Region splitting and merging is an iterative process that starts with the entire image as a single region and subdivides the regions that do not satisfy a condition of homogeneity. The process continues until all regions satisfy the condition of homogeneity. The main advantage of region splitting and merging is that it can produce regions of arbitrary shape. Detailed explanation required	
		Module V	
19	a)	Polygon approximation approaches are used to approximate a boundary curve of a shape. Early solutions to approximate a boundary curve mainly include sequential scan-along approaches, split-and-merge approaches, dominant-point-based approaches, and spline-modelling based approaches. Boundary following is a technique used to trace the boundary of an object in an image. An MPC-based approach to boundary following has been proposed, which generates avoidance constraints and suitable target points to achieve boundary following. This was found to give better performance than existing methods when applied to acceleration-constrained mobile robots. Detailed explanation required	(8)
	b)	The hit-or-miss transform is a morphological operation that detects a given configuration in a binary image using the morphological erosion operator and a pair of disjoint structuring elements. The hit-or-miss transform is also the basis of more advanced morphological operations such as thinning or pruning. Detailed explanation with example required	(6)
		OR	
20	a)	A chain code is a method of describing the shape of the boundary of an object in an image using a sequence of directions. The idea is to traverse the boundary of the object and for every new pixel, record the direction travelled to reach this object. The Freeman chain code is a popular chain code that uses eight directions (0-7) to represent the boundary of an object in an image. Detailed explanation required.	(8)
	b)	Opening and closing are morphological operations used in digital image processing for restoring an eroded image[1]. Opening is generally used to restore or recover the original image to the maximum possible extend. It is a combination	(6)

		of erosion followed by dilation operations. Opening can be used to remove small objects from an image while preserving larger ones. Closing is generally used to smoother the contour of the distorted image and fuse back the narrow breaks and long thin gulfs. It is a combination of dilation followed by erosion operations. Closing can be used to fill small holes in an image while preserving larger ones. Detailed explanation required.	
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