1. (a) Differentiate between human and computer vision. Mention some features used in computer vision-based object detection and recognition.

(b) Describe a computer vision system for separating two Bangladeshi common fishes, such as Rui and Katla in a fish-processing plant.

1. (a) Compare between Canny and SUSAN edge detectors.

(b) Describe the Hough transformation algorithm for detecting straight lines.

1. **(a) What is affine movement invariant? Discuss a practical computer vision application using any moment invariant.**

**Answer:**

Affine movement invariant means that a **property or a feature** of an **image or a video is not affected by affine transformations**, such as scaling, rotation, translation, or skewing. Affine transformations are linear mappings that preserve parallelism and ratios of distances between points. Affine movement invariant methods in computer vision aim to design representations and metrics that are robust to these transformations, which are often considered as nuisance factors in tasks such as object recognition, segmentation, or tracking.

One practical computer vision application that uses moment invariants is face recognition. Moment invariants are scalar values derived from the moments of an image, which are functions of the pixel intensities and their spatial coordinates. Moment invariants are designed to be invariant to certain geometric transformations, such as translation, rotation, and scaling. They can be used to capture the shape and appearance of an object in an image, such as a face. Moment invariants can be used as features for face recognition, by comparing the similarity of the moment invariants of different face images. [For example, Hu’s seven moment invariants are commonly used for this purpose](https://link.springer.com/referenceworkentry/10.1007/978-3-030-03243-2_747-1). They are based on the central moments of an image, which are invariant to translation, and can be further normalized to achieve scale and rotation invariance. [Hu’s moment invariants have been shown to be effective for face recognition under varying poses and expressions](https://link.springer.com/referenceworkentry/10.1007/978-0-387-31439-6_747). However, they also have some limitations, such as sensitivity to noise, occlusion, and illumination changes. [Therefore, other types of moment invariants, such as Zernike moments, Legendre moments, or complex moments, have been proposed to improve the performance of face recognition](https://msp.org/camcos/2010/5-1/camcos-v5-n1-p04-p.pdf).

**(b) What is optical flow constraint equation? Describe an algorithm for estimating optical flow.**

**Answer:**

Optical flow constraint equation is an equation that expresses a constraint on the components of the optical flow vector, which is the apparent motion of image objects between two consecutive frames. The equation is derived from the assumption that the pixel intensities of an object do not change between consecutive frames. The equation is given by:

where Ix​, Iy​, and It​ are the partial derivatives of the image intensity I with respect to x, y, and t, and u and v are the x and y components of the optical flow vector.

One algorithm for estimating optical flow is the Lucas-Kanade method, which is a widely used differential method developed by Bruce D. [Lucas and Takeo Kanade](https://bing.com/search?q=optical+flow+estimation+algorithm). The method assumes that the optical flow is smooth and constant in a small window around each pixel, and solves a system of linear equations to obtain the optical flow vector for each pixel. The method can be summarized as follows:

* Compute the image gradients Ix​, Iy​, and It​ for the current and previous frames using finite differences or other methods.
* For each pixel in the current frame, select a small window around it and construct a system of linear equations using the optical flow constraint equation for each pixel in the window.
* Solve the system of linear equations using the least squares method to obtain the optical flow vector for the pixel.
* Repeat the above steps for all pixels in the current frame.

The Lucas-Kanade method can handle small motions, but may fail for large motions or complex scenes. To improve the performance, the method can be combined with other techniques such as pyramids, warping, and cost volumes. [For more details and examples of optical flow estimation algorithms, you can refer to the following links](https://paperswithcode.com/task/optical-flow-estimation)

1. (a) Explain an adaptive thresholding algorithm for segmentation.

(b) Describe a window-based image disparity estimation technique in detail.

1. (a) Background subtraction is a useful technique that finds applications in computer vision. Explain an application of the background subtraction technique.

(b) Discuss a color model for face region detection based on skin color.

1. (a) What are the drawbacks of the pinhole camera in forming an image? Write down the perspective projection equation (coordinates) in forming a 2D image from a 3D object.

(b) Lighting is an inherently ill-posed problem in computer vision. Briefly describe an approach to compensate for it.

1. (a) Explain the principle of estimating SIFT and SURF features.

**(b) Mention the different noises that can affect image quality. Also briefly describe a technique for removing a particular noise.**

**Answer:**

There are various types of noise that can affect image quality. Here are some common types of image noise along with a brief description of a technique for removing each:

1. **Gaussian Noise:**
   * **Description:** Gaussian noise is a type of statistical noise that follows a Gaussian or normal distribution. It appears as random variations in pixel intensity.
   * **Noise Reduction Technique:** Gaussian smoothing or blurring is often used to reduce Gaussian noise. It involves convolving the image with a Gaussian filter to average pixel values.
2. **Salt-and-Pepper Noise:**
   * **Description:** Salt-and-pepper noise manifests as randomly occurring white and black pixels in an image, resembling grains of salt and pepper.
   * **Noise Reduction Technique:** Median filtering is effective for removing salt-and-pepper noise. It replaces each pixel value with the median value in its local neighborhood, reducing the impact of outliers.
3. **Speckle Noise:**
   * **Description:** Speckle noise is a granular noise that appears as bright and dark pixels in a random pattern. It is often found in images acquired through imaging sensors like ultrasound or radar.
   * **Noise Reduction Technique:** Anisotropic diffusion or non-local means filtering can be used to reduce speckle noise. These methods aim to preserve edges while smoothing the image.
4. **Poisson Noise:**
   * **Description:** Poisson noise is associated with low-light conditions and is characterized by the randomness in the arrival of photons when capturing images.
   * **Noise Reduction Technique:** Wiener filtering is commonly employed to reduce Poisson noise. It is a statistical method that involves the application of a frequency-domain filter.
5. **Quantization Noise:**
   * **Description:** Quantization noise arises during the digitization of continuous-tone images. It results from the limited number of bits used to represent pixel intensities.
   * **Noise Reduction Technique:** Dithering is a technique used to reduce quantization noise. It involves introducing a controlled amount of noise to mask the artifacts caused by quantization.
6. **Color Noise:**
   * **Description:** Color noise affects the color components of an image and appears as random variations in color channels.
   * **Noise Reduction Technique:** Color noise can be mitigated using techniques such as color smoothing or bilateral filtering. These methods consider both spatial and color information.
7. (a) How texture can be used for object recognition?

(b) Explain three widely used distance metrics used in the field of computer vision. Also, define the following image-quality evaluation matrices: MSE, SSIM, and FSIM.

Question 2020

1. (a) Differentiate between human and computer vision. Mention some features used in computer vision-based object detection and recognition.

(b) Describe a computer vision system for separating two Bangladeshi common fishes, such as Rui and Katla in a fish-processing plant.

1. (a) What are the basic differences of SUSAN technique compared to conventional edge detectors.

(b) Describe the Hough transformation algorithm for detecting straight lines.

1. (a) What is affine movement invariant? Discuss a practical computer vision application using any moment invariant.

(b) Define optical flow? Describe an algorithm for estimating optical flow.

1. (a) Explain an adaptive thresholding algorithm for segmentation.

(b) What do you mean by stereo disparity? Describe a window-based disparity estimation technique.

1. (a) What are the drawbacks of the pinhole camera in forming an image? Write down the perspective projection equation (coordinates) in forming a 2D image from a 3D object.

(b) Lighting is an inherently ill-posed problem in computer vision. Briefly describe an approach to compensate for it.

1. (a) What is skeletonization? List out two principle morphological operations.

(b) Explain with example (any two): i) Discrete Haar transform ii) Principle components transform (PCT) iii) Discrete wavelet transform (DWT) iv) Discrete fourier transform (DFT).

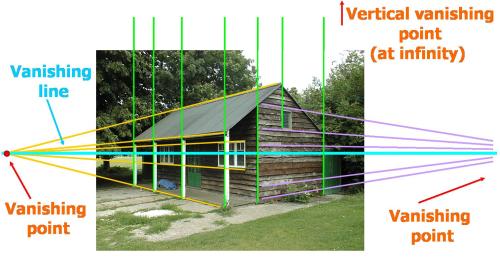
1. **(a) Define vanishing point and vanishing line.**

**Answer:**

[A vanishing point is a point on the image plane of a perspective rendering where the two-dimensional perspective projections of mutually parallel lines in three-dimensional space appear to converge](https://en.wikipedia.org/wiki/Vanishing_point). **For example**, if you look at a straight road that goes far away, the sides of the road will seem to meet at a point on the horizon. [That point is the vanishing point of the road](https://doncorgi.com/blog/vanishing-point-in-art/).

[A vanishing line is a line on the image plane of a perspective rendering where the two-dimensional perspective projections of mutually parallel planes in three-dimensional space appear to intersect](https://cse.iitd.ac.in/~suban/vision/geometry/node47.html). **For example**, if you look at a building that has many windows on the same wall, the edges of the windows will seem to align on a line on the horizon. [That line is the vanishing line of the wall](https://www.liveabout.com/vanishing-point-drawing-definition-1123080).

[Vanishing points and vanishing lines are important concepts in the science and art of perspective, as they help to create realistic and consistent representations of three-dimensional objects and scenes on a two-dimensional surface](https://en.wikipedia.org/wiki/Vanishing_point).



**(b) Describe an algorithm that computers the K-Means-partition on a point set.**

**Answer:**

The K-Means algorithm is a popular method for clustering a set of points into a given number of groups, called clusters. The algorithm works as follows:

1. Choose **k** random points from the set as the initial cluster centers.
2. Assign each point to the closest cluster center, using some distance measure (such as Euclidean distance).
3. Re-compute the cluster centers as the mean of the points assigned to them.
4. Repeat steps 2 and 3 until the cluster centers do not change significantly or a maximum number of iterations is reached.

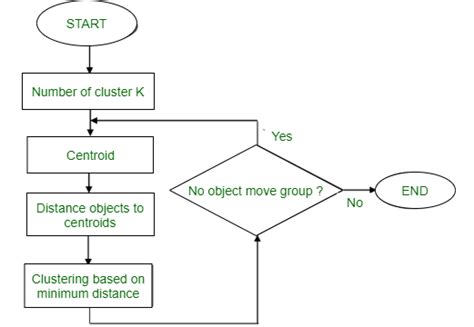
The algorithm tries to minimize the sum of squared distances between each point and its cluster center, also known as the **within-cluster sum of squares (WCSS)**. However, the algorithm does not guarantee to find the optimal solution, as it depends on the initial choice of cluster centers. Therefore, it is common to run the algorithm multiple times with different random initializations and choose the best result.

**(c) Which properties define a single K-Means-partition?**

**Answer:**

A single K-Means-partition is defined by the following properties:

* It is a subset of the data that contains some of the objects.
* It has a center (mean) that represents the average of the objects in the partition.
* It minimizes the variance (or distance) between the objects and the center within the partition.
* It maximizes the variance (or distance) between the objects and the centers of other partitions.



1. (a) How texture can be used for object recognition?

(b) Explain three widely used distance metrics used in the field of computer vision