Computer Vision Suggestions – 1

1. Define Computer Vision

Ans:

Computer vision is a field of computer science that works on enabling commuters to see, identify and process images in the same way the human vision does and then provide appropriate output.

Human Vision System:

Seeing --> Processing --> Intelligent Decision

Computer Vision System

Camera Image Acquisition --> Image Processing (Pre-Processing) --> Pattern Recognition & AI Algorithms (Decision Making)

Components of Computer Vision:

a. Image Capturing Device

b. Display Device for Monitoring

2. What are the applications of Computer Vision?

Ans:

Applications of Computer Vision are as follows:

- **Medical Imaging:**
  MRI Reconstruction, Automatic Pathology, Machine Aided Surgery, Cancer Detection
- **Smart Phones:**
  Photo filters including animations, QR Code Scanner Computational Photography, Face detector, OCR
- **Internet:**
  Geolocation, Image capturing, Image search, Aerial view of Map
- **Transportation:**
  Vehicle classification, Traffic flow analysis, Traffic signal detection
- **Retail:**
  Customer tracking, theft detector, people counting, waiting time analytics
- **Sports:**

Player stance tracking, ball tracking, goal-line tracking

- **Manufacturing:**
  Visual inspection of equipment, quality management

3. Write short note on Low-Level, Mid-Level and High-Level Vision.
Ans:

- **Low Level Vision**
  It focusses on discovering various information about the world that can be initially extracted from the image. The low-level image processing techniques involve extracting fundamental image primitives, like edges and corners, performing filtering and morphology

  An edge can be formed due to surface normal discontinuity or depth discontinuity, surface color discontinuity and finally illumination discontinuity.

  Edges are detected in the areas of the image where the intensity level fluctuates sharply, the more rapid the intensity change the stronger the edge.

- **Mid Level Vision**
  In contrast to low-level vision which recovers information from sensors, mid-level vision concerns how this info gets organised into what we experience as object's surfaces

  Object Recognition: To identify objects in image or video
  Motion Analysis: It is a measuring technique used in image processing for detection of any movement.

- **High Level Vision**
  Here the interpretation of the information provided by low-level vision and mid-level vision are performed.
  It is basically the stages of visual processing that transition from analyzing local image structure to analyzing structure of external world that produced those images.

4. Write short note on Digital Image Processing
Ans:

- Digital Image Processing deals with manipulation and analysis of the digital image by a digital software, usually a computer.
- Emphasizing certain pictorial information for better clarity (Human Interpretation)
- Automatic Machine Processing of the same data

The light is coming from the source and it is reflected by the object. After this, there is imaging system which is the camera. (the camera actually converts the photon into electrical signal)

So, this is the analog system we are getting. *(Analog means it is a continuous function of time)*. This analog image can be converted into digital image by sampling, that sampling is known as **Spatial Sampling.** *(i.e., sampling along the x and y directoion).*

After this quantization is done, which is quantization of intensity values. This intensity value or pixel below depends on amount of light reflected by object.

Then, image is stored in digital computer in a memory. This image can be processed in computers it can be displayed and can be stored.

5. Write short note on Spatial Resolution.

Ans:

Spatial resolution states that the clarity of an image cannot be determined by the pixel resolution. The number of pixels in an image does not matter.
Spatial resolution can be defined as the smallest discernible detail in an image.
Or in other way we can define spatial resolution as the number of independent pixels values per inch.

In short what spatial resolution refers to is that we cannot compare two different types of images to see that which one is clear or which one is not. If we have to compare the two images, to see which one is more clear or which has more spatial resolution, we have to compare two images of the same size.

Since the spatial resolution refers to clarity, so for different devices, different measure has been made to measure it.
For example

- Dots per inch: Dots per inch or DPI is usually used in monitors.
- Lines per inch: Lines per inch or LPI is usually used in laser printers.
- Pixels per inch: Pixel per inch or PPI is measure for different devices such as tablets , Mobile phones e.t.c.

6. Define Discrete Fourier Transform and Inverse Discrete Fourier Transform
Ans:

- Fourier series and Fourier transform are the mathematical tools for representing signals in frequency domain.
- It is an image processing tool which is used to decompose an image to its sine and cosine components.
- The output of transformation represents image in Fourier or Frequency domain, while input image is in spatial domain.
- It is one of the way to remove periodic noise from image.
- Image enhancement in frequency domain.

Discrete Fourier Transform is a modification of Fourier Transform so as to use it for discrete pixels to obtain a discrete frequency spectrum.

Inverse Discrete Fourier Transform is inverse of Discrete Fourier Transform which is used to obtain the original discrete pixels by combining the constituent frequencies.

7. Describe the way to remove the periodic noise from the image.

Ans:

The noise which is present in the repetitive pattern is called periodic noise. It is seen as lines in the image. The source of periodic noise is electrical reference during capturing the image.

Periodic noise after converting into the frequency domain is seen as discrete spikes in the image. To remove this type of noise we have to use notch filters in the frequency domain. After applying notch filters, some noise still remains at the corners.

Steps:

- Read the image
- Compute the Fourier Transform of the image
- Get the centred FT spectrum and display
- Spot the periodic noise pattern in the FT image
- Block the periodic noise pattern in the FT image

- Convert the image back into the spatial domain from the frequency domain.
- Compute the inverse Fourier transform of the image
- Display the image

8. What are the major filter categories?

Ans:

Image filters are used for blurring and noise reduction, sharpening and edge detection. They are mainly used for supressing high and low frequencies.

The major filter categories are as follows:

- **Low Pass Filter**
  - It is used to remove high spatial frequency noise from a digital image
  - Edges and fine textures in images contribute to high frequency content of an image when image is blurred, these edges and textures are removed.
  - It allows only low frequencies to remain intact.
  - Example: Gaussian, smoothing filters

- **High Pass Filter:**
  - It is used to make an image appear sharper.
  - Emphasize fine details in image
  - Allows high frequencies and eliminate or weakens the lower frequencies.
  - Example: Laplacian, Sharpening Mask Filters.

- **Band Pass Filter:**
  - Allows frequencies within a certain band to pass, attenuates the frequencies below to a threshold and above the threshold to pass.

- **Band Stop Filter:**
  - Attenuates signal in a range of certain frequency.
  - Allows frequency below a certain threshold and above another threshold to pass.

9. What is Edge Detection? Write steps of Edge Detection.

Ans:

Edge Detection is an image processing technique for finding the boundaries of objects within the images. It works by detecting discontinuities in brightness. Edge detection is

used for image segmentation and data extraction in areas such as image processing, computer vision and machine vision.

Edge can be defined as sudden changes in the intensity of an image. These changes happen in between boundary of object in an image.

Steps for Edge Detection:

- **Input Image**
- **Smoothing:** It involves removal of noise from image without destroying the original edges.
- **Enhancement:** Apply a filter to enhance the quality of edges in image (Sharpening).
- **Edge point detection:** Determine which edge pixels should be discarded as noise and which should be retained.
- **Edge localization:** Determine the exact location of an edge. Edge thinning and linking are usually required in this step.
- **Output Image**

10. What are the types of Edges?

Ans:

Types of Edges:

- **Step Edge:** Image intensity abruptly changes from one value to one side of the discontinuity to a different value on the opposite side

- **Line Edge:** Here one value to another value changes are done but we can get back to the return value

- **Ramp Edge:** A step edge where the intensity charge is not instantaneous but occur over a finite distance.
- **Roof Edge:** Line edge can form roof edge if the intensity changes are not immediate but occurs overs finite distance gradually for longer duration.

11. What is Canny Edge Detection?

Ans:

Canny Edge Detection is a technique to extract useful structural information from different vision objects and dramatically reuse the amount of data to be processed. It has been widely applied in computer vision systems.

12. Explain K-Means Clustering.

Ans:

K-Means Clustering is an Unsupervised Learning algorithm, which groups the unlabelled dataset into different clusters. Here K defines the number of pre-defined clusters that need to be created in the process, as if K=2, there will be two clusters, and for K=3, there will be three clusters, and so on.

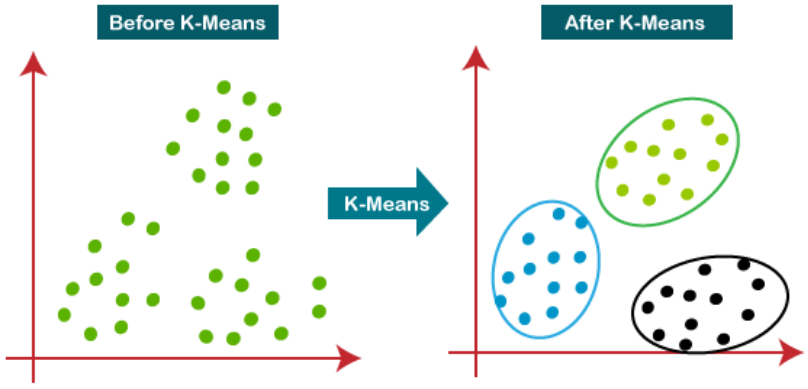
It allows us to cluster the data into different groups and a convenient way to discover the categories of groups in the unlabelled dataset on its own without the need for any training.

It is a centroid-based algorithm, where each cluster is associated with a centroid. The main aim of this algorithm is to minimize the sum of distances between the data point and their corresponding clusters.

The algorithm takes the unlabelled dataset as input, divides the dataset into k-number of clusters, and repeats the process until it does not find the best clusters. The value of k should be predetermined in this algorithm.

<u>The k-means clustering algorithm mainly performs two tasks:</u>

- Determines the best value for K center points or centroids by an iterative process.
- Assigns each data point to its closest k-center. Those data points which are near to the particular k-center, create a cluster



<u>Applications:</u>

- Diagnostic System

- Search Engines
- Wireless Sensor Networks
- Document Clustering
- Image Segmentation
- Image Compression

Steps Involved:

1. Select number K to decide number of clusters.
2. Select random K points or centroids
3. Calculate the distance between each data point and each cluster center. (Euclidean Distance)
4. Assign each data point to their closest centroid, which will form predefined clusters.
5. Recompute the center of newly formed clusters. (The center of a cluster is computed by taking of all data points contained in that cluster.)
6. Repeat the steps from 3-5 until any of the following criteria is met.
    - Center of newly formed cluster didn't change.
    - Data points remain same in cluster
    - Maximum number of iterations are reached

Advantages:

- It is relatively efficient with time complexity – O(nkt)
  where n = no of instances
  k = no of clusters
  t = no of iterations
- It often terminates at local optimum.

Disadvantages:

- It can't handle noisy data and outliers.
- It requires to specify k in advance.
- It isn't suitable to identify clusters with non-convex shapes.

13. Explain KNN Algorithm.

Ans:

K-Nearest Neighbour is one of the simplest Machine Learning algorithms based on Supervised Learning technique.

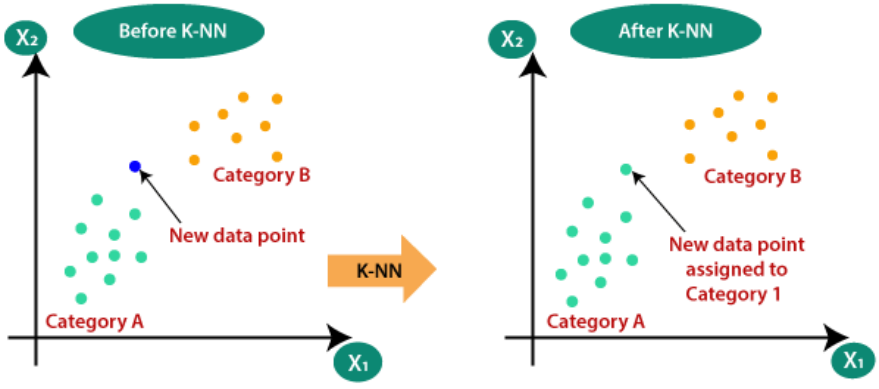
K-NN algorithm assumes the similarity between the new case/data and available cases and put the new case into the category that is most similar to the available categories.

K-NN algorithm stores all the available data and classifies a new data point based on the similarity. This means when new data appears then it can be easily classified into a well suite category by using K- NN algorithm.
K-NN algorithm can be used for Regression as well as for Classification but mostly it is used for the Classification problems.

K-NN is a **non-parametric algorithm**, which means it does not make any assumption on underlying data.
It is also called a **lazy learner algorithm** because it does not learn from the training set immediately instead it stores the dataset and at the time of classification, it performs an action on the dataset.

KNN algorithm at the training phase just stores the dataset and when it gets new data, then it classifies that data into a category that is much similar to the new data.

Example: Suppose, we have an image of a creature that looks similar to cat and dog, but we want to know either it is a cat or dog. So, for this identification, we can use the KNN algorithm, as it works on a similarity measure. Our KNN model will find the similar features of the new data set to the cats and dogs images and based on the most similar features it will put it in either cat or dog category.



Applications:

- Banking System: to predict whether an individual is fit for loan approval

- Calculating Credit Ratings: to find an individual's credit rating by comparing with the persons having same traits.
- Handwriting Detection
- Speech Recognition

Advantages:

- Simple and easy to understand and implement
- Versatile as it can be used for classification as well as regression
- Has relatively high accuracy
- Very useful for non-linear data because there is no assumption about data in this algorithm.

Disadvantages:

- Prediction is slow in case of big N
- Doesn't work well with large dataset as the cost of calculating distance between the new point and each existing point is huge, which degrades performance.
- It is a bit expensive algorithm because it stores all the training data.

14. When do we use KNN?

Ans:

- Dataset is labelled
- Data is noise free
- Dataset is small, as KNN is a lazy algorithm

15. Difference between K-Means Clustering and KNN Algorithm.

Ans:

K-Means	**KNN**
It is an unsupervised learning algorithm	It is a supervised learning algorithm.
It is a clustering algorithm	It is a classification algorithm.
K represents number of centroids	K represents number of closest neighbours to look at
Centroids are not necessarily data points	Centroid is the point X to be classified
Uses distance from data points to K-centroids to cluster data into k-groups	Calculates k nearest data point from data point X. Uses these points to determine which class X belongs to
Updates centroid on each pass by calculations over all data in a class	Data point to be classified remains the same

Must iterate over data until center point doesn't move	Only requires k distance caluclations.

16. What are the Limitations of K-Means Clustering Algorithm?

Ans:

Disadvantages of K-Means Clustering are as follows:

- Being dependent on initial values
- Clustering data of varying sizes and density
- Clustering outliers
- Scaling with number of dimensions

17. Difference between Euclidean Distance and Manhattan Distance

Euclidean Distance: is calculated as the square root of the sum of the squared differences between a new point (x) and an existing point (y).

- The Euclidean Distance is the "ordinary" distance between two points in Euclidean space.
- The Euclidean distance between points p and q is the length of the line segment connecting them.

Manhattan Distance: is the distance between real vectors using the sum of their absolute difference.

- It is the sum of the lengths of the projections of the line segment between the points onto the coordinate axes.

18. What is Clustering? Give examples of clustering to solve real life problems.

Ans:

Clustering is the task of dividing the population or data points into a number of groups such that data points in the same groups are more similar to other data points in the same group and dissimilar to the data points in other groups. It is basically a collection of objects on the basis of similarity and dissimilarity between them, it is an unsupervised learning method.

K-Means Clustering Algorithm is an example of Clustering algorithm.

Applications of Clustering in different fields:

- **Marketing:** It can be used to characterize and discover segments for marketing purposes

- **Biology:** It can be used for classification among different species of plants and animals
- **Libraries:** It is used in clustering different books on the basis of topics and information
- **Insurance:** It is used to acknowledge the customers, their policies and identifying the frauds.

19. What is Supervised, Unsupervised, Semi-Supervised and Reinforcement Learning?
Ans:

- **Supervised Learning:**
  In Supervised machine learning, the machine mainly focuses on regression and classification types of problems.
  We know the correct output and relationship with input and output in this phase.
  It deals with labelled datasets and algorithms.
  In supervised learning, the machine gets the last calculated data on the machine, also be called **"target data"**. It includes the data and the result.
  The models are stored in the machines to make the prediction.

  <u>There are two major processes:</u>
  - Classification
  - Regression

  <u>Example:</u>
  - A real-world example of classification includes classifying spam emails apart from others and move them to a separate folder.

  - Regression is used to predict and forecast weather conditions. Simply put, the temperature estimates for the next day or week may be predicted using various dependent variables such as humidity, area's elevation, amount of solar energy received and proximity to large water bodies.

- **Unsupervised Learning:**
  The unsupervised machine learning is totally opposite to supervised machine learning.
  In this type of learning, the results are unknown and to be defined. It uses unlabelled data for machine learning. We have no idea which types of results are expected.

In this model, the machine observes the algorithms and finds the structure of data. It has less computational complexity and uses real-time analysis of data through this model.
The results are very reliable when compared to supervised learning. For example, we present images of fruits to this model; this model makes clusters and separates them on the basis of a given pattern and relationships.

There are two types:

- Clustering
- Dimensionality Reduction

The two common uses of unsupervised learning are:

- **Clustering:** This technique is for grouping the unlabeled data based on their similarities or differences. One of the popular clustering algorithm is K-Means Clustering where it sets aside the data points into different groups and K represents the number of groups. A common example for the use case of K-means clustering is grouping books into different genres based on their summary.

- **Dimensionality reduction:** This refers to representing the same data using lesser dimensions i.e., rows and columns while maintaining its integrity. This is usually used while removing noisy data from an image to improve its quality.

Example:

- K-means clustering is used to group books into different genres based on their summary. If the summary contains the words "night", "haunted" and "ghost" , then the book is most likely to be of the horror genre.
- Clustering is used in recommender systems to group users with similar interests together in order to recommend similar content.

- **Semi-Supervised Learning:**
  Semi-supervised machine learning is also known as hybrid learning and it lies between supervised and unsupervised learning. This model has the combination of labelled and unlabelled data. The data has fewer shares of labelled data and more shares of unlabelled data in this learning.
  The labelled-data is very cheap in contrary to the unlabelled data. The procedure is that the algorithm firstly uses unsupervised learning algorithms to cluster the labelled data and then uses the supervised learning algorithm.

Examples:

- An ideal example for the use case of semi-supervised learning is a text document classifier. Since it is nearly impossible to find a large amount of text documents that are labeled, using semi-supervised learning, the model can learn from a small amount of labeled text documents while still classifying a larger amount of unknown text documents.

- **Reinforcement Learning:**
  There are no training data sets. The machine has a special software. It works as an agent with the environment to get feedback.
  The environment means there are no training data sets. The work of an agent is to achieve the target and get the required feedback.

  An example of a reinforcement learning problem is playing game. In which an agent has
  a set of goals to get high score and feedback in terms of punishment and rewards while playing.

20. Write short note on Principal Component Analysis (PCA)
Ans:
Principal Component Analysis (PCA) is one of the most popular linear dimension reduction algorithms. It is a projection-based method that transforms the data by projecting it onto a set of orthogonal(perpendicular) axes.

PCA works on a condition that while the data in a higher-dimensional space is mapped to data in a lower dimension space, the variance or spread of the data in the lower dimensional space should be maximum.

PCA is an unsupervised statistical technique used to examine the interrelations among a set of variables. It is also known as a general factor analysis where regression determines a line of best fit.

- PCA Transforms the variables into a new set of variables called as **Principal Components**
- These principal components are linear combination of original variables and are orthogonal.
- The first principal component accounts for most of the positive variation of original data.

- The second principal component does it best to capture the variance in the data.
- There can be only two principal components for a two-dimensional data set

21. What is a centroid point in K-means? Does centroid initialization affect K-means altogether?

Ans:

A centroid is the imaginary or real location representing the center of the cluster. Every data point is allocated to each of the clusters through reducing the in-cluster sum of squares.

Yes, the final results of the k-means algorithm depend on the centroid initialization as poor initialization can cause the algorithm to get stuck into an inferior local minimum.

22. Explain Neural Network

Ans:

A neural network is a series of algorithms that endeavours to recognize underlying relationships in a set of data through a process that mimics the way the human brain operates. In this sense, neural networks refer to systems of neurons, either organics or artificial in nature.

Neural networks can adapt to changing input; so the network generates the best possible result without needing to redesign the output criteria.

A neural network works similarly to the human brain's neural network. A "neuron" in a neural network is a mathematical function that collects and classifies information according to a specific architecture. The network bears a strong resemblance to statistical methods such as curve fitting and regression analysis.

A neural network contains layers of interconnected nodes. Each node is a known as perceptron and is similar to a multiple linear regression

23. What is Activation Function?

Ans:

The activation function defines the output of a neuron / node given an input or set of input (output of multiple neurons). It's the mimic of the stimulation of a biological neuron.

The output of the activation function to the next layer (in shallow neural network: input layer and output layer, and in deep network to the next hidden layer) is called forward propagation (information propagation). It's considered as a non linearity transformation of a neural network.

24. Why KNN is not a parametric algorithm?

Ans:

KNN is a non-parametric and lazy learning algorithm. Non-parametric means there is no assumption for underlying data distribution. In other words, the model structure determined from the dataset. This will be very helpful in practice where most of the real-world datasets do not follow mathematical theoretical assumptions.

KNN is one of the most simple and traditional non-parametric techniques to classify samples. Given an input vector, KNN calculates the approximate distances between the vectors and then assign the points which are not yet labeled to the class of its K-nearest neighbors.

The lazy algorithm means it does not need any training data points for model generation. All training data used in the testing phase. This makes training faster and the testing phase slower and costlier. The costly testing phase means time and memory. In the worst case, KNN needs more time to scan all data points, and scanning all data points will require more memory for storing training data.

25. Difference between Artificial Neural Network (ANN) and Biological Neural Network (BNN)?

Ans:

S.No.	ANN	BNN
1.	It is short for Artificial Neural Network.	It is short for Biological Neural Network.
2.	Processing speed is fast as compared to Biological Neural Network.	They are slow in processing information.
3.	Allocation for Storage to a new process is strictly irreplaceable as the old location is saved for the previous process.	Allocation for storage to a new process is easy as it is added just by adjusting the interconnection strengths.
4.	Processes operate in sequential mode.	The process can operate in massive parallel operations.
5.	If any information gets corrupted in the memory it cannot be	Information is distributed into the network throughout into sub-nodes,

	retrieved.	even if it gets corrupted it can be retrieved.
6.	The activities are continuously monitored by a control unit.	There is no control unit to monitor the information being processed into the network.

26. What are the challenges associated with K-means clustering?

Ans:

k-means doesn't perform well if the clusters have varying sizes, different densities, or non-spherical shapes. Has to be run for a certain amount of iteration or it would produce a suboptimal result. Computationally expensive as distance is to be calculated from each centroid to all data points.

27. Difference between Supervised, Semi-Supervised and Unsupervised Learning.

Ans:

Supervised Learning	**Semi-Supervised Learning**	**Unsupervised Learning**
Input data is labelled	A large amount of input data is unlabelled while a small amount is labelled.	Input data is unlabelled
Used for prediction and classification models	It is used when labelling the whole dataset is expensive	Used for extracting information from large amounts of data
It takes direct feedback of the output	It is a weak type of supervision	It does not have a feedback mechanism
These models predict the output		These models find underlying patterns in data
It can be used in cases where w known the input and their respective outputs		We can use these models where we only know the input data and do not have the knowledge of the corresponding output.

28. Describe advantages of Artificial Neural Network (ANN). How is ANN useful in making machine intelligent.

Ans:

<u>Advantages of Artificial Neural Network (ANN):</u>

- Storing information on the entire network

- Ability to work with incomplete knowledge
- Having fault tolerance
- Having a distributed memory
- Ability to make machine learning
- Parallel processing capability

The ANN makes a decision by observing its environment. If the observation is negative, the network adjusts its weights to be able to make a different required decision the next time.