1 Explain the basic components of a digital image and how it is represented in a computer. State the differences between grayscale and color images

A digital image consists of **pixels** (picture elements), each representing a color or intensity. It is represented in a computer as a grid of these pixels, where each pixel is stored as numerical data (such as RGB or grayscale values).

- **Grayscale Image**: Each pixel has a single value representing intensity (from black to white).
- **Color Image**: Each pixel has multiple values, typically for **Red, Green, and Blue (RGB)** channels, combining to represent a wide range of colors.

2 Define Convolutional Neural Networks (CNNs) and discuss their role in image processing.Describe the key advantages of using CNNs over traditional neural networks for image-related tasks

Convolutional Neural Networks (CNNs) are a type of deep neural network designed for processing grid-like data, such as images. They use convolutional layers to automatically learn spatial hierarchies and extract features like edges, textures, and shapes from images.

Role in Image Processing: CNNs are used for tasks like image classification, object detection, and image segmentation by learning relevant features directly from raw image data.

Advantages over Traditional Neural Networks:

1. **Automatic Feature Extraction**: CNNs learn features automatically, reducing the need for manual feature engineering.
2. **Parameter Sharing**: The same weights are used across different parts of the image, making CNNs more efficient.
3. **Translation Invariance**: CNNs can recognize objects regardless of their position in the image.

3 Define convolutional layers and their purpose in a CNN. Discuss the concept of filters and how they are applied during the convolution operation. Explain the use of padding and strides in convolutional layers and their impact on the output size

Convolutional Layers: These layers apply convolution operations to input data (like images) to extract features by detecting patterns such as edges, textures, and shapes.

Filters: Filters (also called kernels) are small matrices that slide over the input image to perform convolution. Each filter detects specific features (e.g., edges, corners).

Padding: Padding involves adding extra pixels around the input image to preserve the original image size after convolution. It prevents the reduction of image dimensions and ensures features at the edges are not ignored.

Strides: Strides determine the step size with which the filter moves over the image. Larger strides result in smaller output dimensions as the filter skips more pixels during convolution.

Impact on Output Size:

- **Padding** keeps the image size unchanged.

- **Strides** and **filter size** influence the output dimensions. Larger strides or filters reduce the output size.

4 Describe the purpose of pooling layers in CNNs. Compare max pooling and average pooling operation

Purpose of Pooling Layers: Pooling layers reduce the spatial dimensions of the image, which helps decrease computational cost, control overfitting, and retain important features.

Max Pooling: Takes the maximum value from a patch of the input. It captures the most prominent features, making it more suitable for image recognition tasks.

Average Pooling: Takes the average value from a patch of the input. It provides a smoother output and is less sensitive to noise than max pooling.

Comparison:

- **Max Pooling** retains more distinct features, often leading to better performance in tasks like classification.
- **Average Pooling** provides a more generalized representation and can be better in tasks requiring smoother outputs.