**Note for Lecture 2**

**Week 2 - Lecture Topics**

**Title: Image Classification: A core task in computer vision**

**Title: Image Classification**

- Image classification is a fundamental task in computer vision that involves assigning predefined categories or labels to images based on their visual content.

- It has various applications, including object recognition, scene understanding, content-based image retrieval, and automated image tagging.

**Practical Application:**

An example of image classification is classifying animals in wildlife photography. Given an image of an animal, an image classifier can identify whether it's a lion, tiger, or bear.

**Title: Problem: Semantic Gap**

- The semantic gap refers to the challenge of bridging the difference between low-level image features (pixels) and high-level semantic concepts (object categories).

- It is difficult to directly map raw pixel values to meaningful object categories due to variations in appearance, viewpoint, lighting, and other factor

**Title: Challenges in Image Classification**

- Viewpoint Variation: Objects can appear different based on the viewpoint or angle from which they are observed.

- Illumination: Lighting conditions can significantly affect the appearance of objects in images.

- Deformation: Objects can undergo deformations or distortions, making their shapes and structures vary.

- Occlusion: Objects may be partially or fully occluded by other objects, making their identification challenging.

- Background Clutter: Complex backgrounds or cluttered scenes can make it harder to distinguish objects.

- Intraclass Variation: Objects within the same category can exhibit variations in shape, texture, color, or other visual attributes.

**Practical Application:**

In a security camera system, image classification can face challenges when identifying individuals wearing hats and sunglasses, resulting in intraclass variation and occlusion issues.

**Title: An Image Classifier**

- An image classifier is a computational model or algorithm that learns to classify images into predefined categories based on their visual features.

- It is trained on a labeled dataset, where each image is associated with its correct category

**Title: Data-driven Approach**

- In image classification, a data-driven approach involves learning the mapping from image features to category labels directly from the training data.

- The classifier learns to recognize patterns and discriminative features that differentiate between different categories.

**Practical Application:**

In medical image diagnosis, a data-driven approach can learn to detect anomalies by analyzing patterns in medical images, aiding doctors in early disease detection.

**Title: Nearest Neighbor**

- Nearest Neighbor (NN) is a simple and intuitive image classification algorithm.

- It assigns the label of the nearest training image (neighbor) to the test image based on a similarity metric.

- The distance between images is used as a measure of similarity.

**Practical Application:**

In recommendation systems, the nearest neighbor classifier suggests products based on the preferences of users with similar tastes.

**Title: Distance Metric to Compare Images**

- A distance metric quantifies the similarity or dissimilarity between two images.

- Commonly used distance metrics include Euclidean distance, Manhattan distance, and cosine similarity.

- The choice of distance metric depends on the image representation and the characteristics of the data.

**Practical Application:**

In facial recognition, a suitable distance metric should accurately measure the similarity between facial features to identify individuals.

**Title: K-Nearest Neighbors**

- K-Nearest Neighbors (KNN) is an extension of the nearest neighbor algorithm.

- Instead of considering only the nearest neighbor, KNN considers the labels of the K closest training examples and assigns the majority label to the test image.

- K is a hyperparameter that needs to be tuned for optimal performance.

**Title: Hyperparameters: Best Value of K and Distance Metric to Use**

- Hyperparameters are parameters that are not learned from the data but need to be set before training the classifier.

- In KNN, the value of K and the choice of distance metric are hyperparameters that can significantly affect the performance of the classifier.

- Finding the best values for these hyperparameters often requires experimentation and validation.

**Title: Linear Classifier**

- A linear classifier is a type of image classifier that learns a linear decision boundary between different categories.

- It assumes that the relationship between image features and class labels can be represented by a linear function.

**Title: Parametric Approach: Linear Classifier**

- A parametric approach involves learning a set of parameters that define the linear decision boundary.

- The parameters are estimated using training data and optimization techniques like gradient descent.

- The learned parameters determine the weights assigned to different image features.

**Title: Interpreting a Linear Classifier**

- A linear classifier can provide insights into the importance of different features for classification.

- Positive weights indicate features that positively contribute to a particular class, while negative weights indicate features that negatively contribute.

- The magnitude of the weights represents the relative importance of the corresponding features.

**Title: Linear Score Function**

- The linear score function computes a weighted sum of image features and compares it to a threshold to make predictions.

- It is used to determine which side of the decision boundary an image falls on.

**Relevance and Learning Outcomes:**

Understanding image classification is crucial as it forms the building block for more complex computer vision tasks. By the end of this topic, students should be able to grasp the process of image classification, the challenges it poses, and the various methods used for classification. This topic introduces students to the concept of letting the data dictate the model's behavior, which is fundamental to modern machine learning. This method lays the foundation for understanding more advanced classification algorithms and introduces students to the concept of similarity in image classification. Understanding distance metrics helps students appreciate the role of feature comparison in classification algorithms. Understanding these challenges is vital as it prepares students to tackle real-world scenarios where images might not conform perfectly to textbook definitions. It also sparks critical thinking on potential solutions.