**Final Exam Preparation Notes**

**1. Image Classification and Object Localization**

**Image Classification**

* **Definition**: Assigning a single label to an entire image.
* **Key Algorithms**: Convolutional Neural Networks (CNNs), Transfer Learning (e.g., ResNet, VGG, EfficientNet).

**Object Localization**

* **Definition**: Identifying the location of objects within an image and assigning bounding boxes.
* **Techniques**:
  + Single Shot Detectors (SSD)
  + YOLO (You Only Look Once)
  + Faster R-CNN
* **Challenges**: Handling multiple objects, overlapping objects, occlusion, and scale variance.

**2. Metrics for Image Classification**

**Confusion Matrix**

|  |  |  |
| --- | --- | --- |
| **Predicted \ Actual** | **Positive** | **Negative** |
| **Positive** | TP | FP |
| **Negative** | FN | TN |

* **True Positive (TP)**: Correctly predicted positive cases.
* **False Positive (FP)**: Incorrectly predicted positive cases.
* **True Negative (TN)**: Correctly predicted negative cases.
* **False Negative (FN)**: Incorrectly predicted negative cases.

**Metrics**

* **Precision**:
* **Recall**:
* **F1-Score**:
* **Accuracy**:

**Advanced Metrics**

* **Precision-Recall (PR) Curve**: Plots precision vs. recall at various thresholds.
* **Receiver Operator Curve (ROC)**: Plots true positive rate vs. false positive rate.
* **Area Under the Curve (AUC)**: Area under the ROC curve; higher values indicate better performance.
* **F1-Score vs. Confidence Score**: Helps determine the threshold for optimal performance.

**When to Use Which Metric**

* **Precision**: When false positives are costly (e.g., spam detection).
* **Recall**: When false negatives are costly (e.g., medical diagnosis).
* **F1-Score**: When there’s a need to balance precision and recall.

**3. YOLO Object Detector and Evaluation Metrics**

**YOLO Overview**

* **Definition**: A real-time object detection algorithm that predicts bounding boxes and class probabilities simultaneously.
* **Advantages**: Fast, efficient, and suitable for real-time applications.

**Key Metrics**

* **Intersection over Union (IoU)**: Measures overlap between predicted and ground truth bounding boxes.
* **Confidence Score**: Probability that a detected object belongs to a certain class.
* **Average Precision (AP)**: Precision averaged over recall levels.
* **Mean Average Precision (mAP)**: Average of AP across all classes.
* **Anchor Boxes**: Predefined boxes used to detect objects of varying shapes and sizes.

**4. Data Imbalance and Solutions**

**Definition**

* **Data Imbalance**: When some classes have significantly fewer samples than others.

**Solutions**

1. **Oversampling**: Duplicate samples from the minority class.
2. **Undersampling**: Reduce samples from the majority class.
3. **Synthetic Data Generation**: Techniques like SMOTE to create synthetic samples.
4. **Weighted Loss Function**: Assign higher weights to minority classes during training.
5. **Data Augmentation**: Apply transformations (e.g., rotation, flipping) to increase diversity.

**5. Layers in CNNs and Fully Connected Networks**

**CNN Layers**

1. **Convolutional Layer**:
   * Extracts features using filters (kernels).
   * Produces feature maps.
2. **Pooling Layer**:
   * Reduces spatial dimensions.
   * Types: Max pooling, Average pooling.
3. **ReLU Activation**:
   * Applies non-linearity.
   * Formula: .
4. **Dropout Layer**:
   * Prevents overfitting by randomly dropping neurons during training.
5. **Batch Normalization**:
   * Normalizes inputs to a layer to improve training stability.

**Fully Connected Layers**

* Flatten feature maps into a 1D vector.
* Dense layers for classification.
* Commonly used at the end of CNNs.

**Additional Notes**

* **Study Resources**:
  + *Deep Learning* by Ian Goodfellow.
  + *Pattern Recognition and Machine Learning* by Christopher Bishop.
* **Hands-On Practice**:
  + Use TensorFlow, PyTorch, or OpenCV for practical implementation.
  + Experiment with YOLO and CNN models on datasets.