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Image Classification: Best Practices

What is Image Classification?

Image classification is a part of computer vision and machine learning, allowing computers to recognize and process images.

With image classification, artificial intelligence advances in answering questions to define what's in the image and to which category it belongs to. An image classification example is a self-driving car detecting pedestrians and road signs to enable safe navigation. Similarly, retailers use it to categorize products and optimize search functionalities.

How Image Classification Works

Data Collection

First, a relevant dataset is gathered. The dataset should include diverse images and account for variations in lighting, angles, and backgrounds to make the model robust. In image classification machine learning, having diverse and representative data ensures better model performance and generalization.

Data Preparation

Before training, it's important to resize an image and normalize its pixels values. At this stage, you can also use data augmentation, which increases the diversity of data and improves the general knowledge of the model.

Feature Extraction

Instead of manually designing features, modern convolutional neural networks automatically identify patterns, such as edges, textures, or object shapes, directly from pixel data.

Training

At the stage of training, you train the model with preliminary labeled datasets. The model recognizes patterns and links them with labels. It adjusts its internal parameters over time to minimize errors.

Validation

You test the model on separate, unseen data to evaluate its accuracy. If the results are poor, adjustments to the dataset or model architecture may be required.

Prediction

After training, the model can classify new images. It can also predict the input images showing with a certain percentage of accuracy.

Key Metrics for Evaluating Image Classification Models

To judge a model's accuracy, we use the following metrics:

- **Accuracy:** Indicates the number of images labeled correctly.
- **Precision:** Helps to reduce false positives (e.g., avoiding labeling a cat as a dog).
- **Recall:** Reduces false negatives (e.g., ensuring no cats are missed).
- **F1 Score:** Shows the combined metric of recall and precision.
- **AUC-ROC:** Shows how well the model separates different classes.
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• *Types of Image Classification Tasks*

Image classification tasks vary based on how images are labeled and categorized. Understanding the types helps tailor models to specific problems.

Single-Label Classification

In this type, each image is assigned one label. For instance, a photo with a dog will be labeled with the corresponding label, even if there are other objects in the background. This type of classification is the most common one. It works well for tasks like facial recognition or product defect detection.

Multi-Label Classification

Here, an image can have multiple labels. For example, an image with a street can have multiple labels. These can be a car, a pedestrian, and a tree. Multi-label classification is used in applications like medical imaging, where a single X-ray could show multiple conditions. Additionally, it performs well in environmental monitoring, identifying various elements within a satellite image.

Hierarchical Classification

This type organizes labels into a tree-like structure. For example, a vehicle can have labels “car” and “truck” and further more detailed labels. We often use hierarchical classification in complex systems like e-commerce, where we split products into different categories.

Binary vs. Multiclass Classification

- **Binary Classification:** Two possible labels, such as “cat” or “dog.” This is straightforward and common in simple tasks.
- **Multiclass Classification:** More than two categories, like “cat,” “dog,” and “bird.” This requires models to handle more complexity.
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