**Identifying Road Objects for Self-Driving Cars Using Convolutional Neural Networks**

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**Overview**

This project explores how convolutional neural networks (CNNs) can be used to identify common road objects in images for self-driving cars. The dataset included five classes—**cars, trucks, pedestrians, bicyclists, and lights**—with strong class imbalance (cars heavily overrepresented).

The work demonstrates preprocessing raw images, building multiple CNN models, and testing different regularization strategies to address overfitting. The best model achieved **83.32% validation accuracy**, showing proof of concept but also highlighting the need for further refinement for real-world deployment.

**Data**

* **Source:** [Kaggle dataset](https://www.kaggle.com/datasets/alincijov/self-driving-cars?resource=downloadLinks)
* **Classes & counts:**
  + Cars: 101,312
  + Trucks: 6,313
  + Pedestrians: 10,637
  + Bicyclists: 1,442
  + Lights: 12,700
* Bounding box annotations were used to crop individual objects from larger images.
* Images were resized to **32×32 pixels** for model training.

**Methods**

**Preprocessing**

* Cropped sub-images of individual objects into class-specific folders.
* Split into training and validation sets.
* Applied class weighting to address dataset imbalance.

**CNN Architecture**

* 4 CNN models, each with:
  + **3 convolutional layers (3×3 kernels)**
  + **2 max-pooling layers (2×2)**
  + **1 flatten layer**
  + **2 dense layers (512 ReLU, 5 softmax)**
* Regularization techniques tested:
  + **Early stopping**
  + **L2 (ridge) regularization** with multiple lambda values
  + **Dropout** (0.2–0.4 rates)

**Results**

* **Unregularized CNN:** ~50% accuracy, severe overfitting.
* **Early stopping:** ~81% accuracy, more stable training.
* **Early stopping + L2:** **83.32% accuracy (best model)**, most stable validation performance.
* **Early stopping + dropout:** ~77% accuracy, fluctuating performance.

**Discussion & Takeaways**

* All three regularization methods outperformed the baseline model.
* Early stopping + L2 worked best, showing stable convergence and highest accuracy.
* Class imbalance likely still limited performance—data augmentation could help.
* At **83.32%**, accuracy is promising but insufficient for self-driving safety requirements.
* Future directions:
  + Larger, higher-quality images
  + Augmentation for minority classes
  + Multi-object detection and bounding box prediction

**Key Learning**

* CNNs can effectively extract features from road images.
* Regularization is critical to prevent overfitting.
* Achieving near-perfect accuracy is essential for safety-critical applications like autonomous driving.