Traffic Sign Recognition Using CNN and GA

Project submitted to the

SRM University – AP, Andhra Pradesh

for the partial fulfillment of the requirements to award the degree of

Bachelor of Technology

In

Computer Science and Engineering

School of Engineering and Sciences

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November 2024

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Date: November-24

I hereby affirm that the project titled *"Traffic Sign Recognition using CNN and Genetic Algorithm"* has been conducted by the following individuals under my guidance:

Dr. Ashu Abdul

I certify that the work submitted is legitimate, unique, and suitable for submission to SRM University – AP in order to complete the requirements for the School of Engineering and Sciences' Bachelor of Technology degree.

Supervisor

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Dr.Ashu Abdul
Designation, Affiliation

Acknowledgement

We sincerely thank Dr.Ashu Abdul, our project guide, for her leadership, mentoring, and steadfast support during the project. Her knowledge and perceptions have been invaluable in determining the course and results of our effort.

Additionally, we would like to thank the entire project team for their cooperation, hard work, and dedication. Our project's objectives have been met in large part because of the dedication and hard work of every team member, which has also improved and enhanced the working environment.

Our heartfelt thanks go to the esteemed faculty members of SRM AP for their invaluable guidance, support, and commitment throughout our academic journey. Their dedication to excellence, passion for teaching, and willingness to go the extra mile have had a significant impact on our education.

Lastly, we appreciate everyone who supported us directly or indirectly in successfully completing this project.

Table of Contents

Abstract

Traffic sign recognition is a critical task in autonomous driving systems, requiring accurate identification of traffic signs to ensure safety and compliance. This project combines Convolutional Neural Networks (CNNs) with Genetic Algorithms (GAs) to automatically optimize the hyperparameters of the model, ensuring improved classification performance and efficiency.

The CNN is designed to process traffic sign images and classify them into 43 categories using the German Traffic Sign Recognition Benchmark (GTSRB) dataset. The GA optimizes key hyperparameters such as the number of filters, kernel sizes, learning rate, and batch size. By using evolutionary principles such as selection, crossover, and mutation, the GA effectively navigates the hyperparameter space to maximize validation accuracy.

The resulting model achieves high accuracy on both validation and test datasets, demonstrating the effectiveness of combining CNNs with GAs for hyperparameter optimization in traffic sign recognition.

Introduction

Traffic sign recognition is an essential component of autonomous vehicles and Advanced Driver Assistance Systems (ADAS). Recognizing traffic signs accurately helps vehicles make informed decisions, improving road safety. Convolutional Neural Networks (CNNs) are widely used for image classification tasks due to their ability to extract and learn hierarchical features from images.

However, the performance of CNNs depends heavily on hyperparameters such as filter sizes, learning rate, and batch size. Manually tuning these hyperparameters is a time-consuming and inefficient process. Genetic Algorithms (GAs) offer a systematic and automated approach to optimize these hyperparameters, inspired by the principles of natural selection.

This project aims to build an efficient and accurate traffic sign recognition system using CNNs optimized with GAs, leveraging the GTSRB dataset.

Problem Statement

Traffic sign recognition involves accurately identifying and classifying traffic signs from images. The goal of this project is to develop an automated system that optimizes the hyperparameters of a CNN for traffic sign recognition using GAs.

The challenges include:

- Dealing with the variability in traffic sign appearances due to lighting, angles, and occlusions.
- Efficiently searching the large hyperparameter space to find optimal configurations.
- Ensuring the model generalizes well to unseen data.

The solution involves using GAs to automate the hyperparameter tuning process, ensuring better classification accuracy and generalization.

Methodology

1. **Dataset**:
    - GTSRB (German Traffic Sign Recognition Benchmark) dataset with 43 classes of traffic signs.
    - Dataset split into training, validation, and testing sets.
2. **Preprocessing**:
    - Images resized to 30×30×3.
    - Normalization of pixel values to the range [0, 1].
3. **Model Architecture:**
    - CNN:
        - Two convolutional layers with ReLU activations.
        - Flatten and dense layers for classification.
    - Genetic Algorithm:
        - Optimizes the number of filters, kernel size, learning rate, and batch size.
4. **Training Process:**
    - Fitness function: Validation accuracy of the CNN model.
    - Genetic Algorithm steps:
        - Selection: Tournament selection , Size = 3.
        - Crossover: Two-point crossover.
        - Mutation: Uniform integer mutation.

5. Loss Function:

- Sparse categorical cross-entropy for multi-class classification.

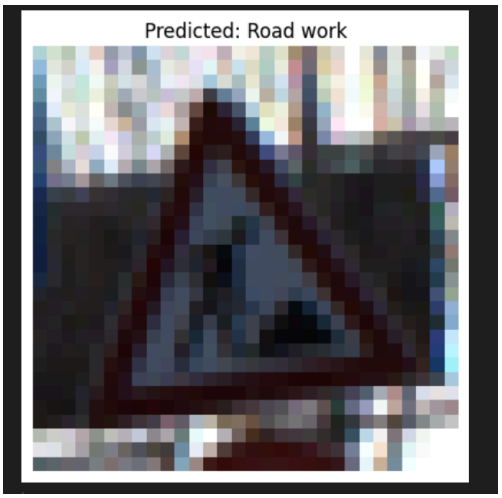
Results

- **Best Hyperparameters Found:**
  - Filters (Layer 1): 64
  - Filters (Layer 2): 128
  - Kernel Size: 3
  - Learning Rate: 0.0036743
  - Batch Size: 27
- **Performance:**
  - Validation Accuracy: 96%
  - Test Accuracy: 94%

Results :

Input:

Output:



Conclusion

The project successfully implemented a traffic sign recognition system using CNNs optimized with GAs. By automating hyperparameter tuning, the GA enhanced model performance, achieving high accuracy on unseen data. This approach demonstrates the potential of combining deep learning with evolutionary algorithms for complex optimization tasks.

Future Work

- Experiment with larger datasets like COCO or ImageNet for scalability.
- Incorporate advanced techniques such as attention mechanisms and transfer learning.
- Explore reinforcement learning to further improve classification accuracy.
- Develop real-time traffic sign recognition systems for deployment in autonomous vehicles.