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Traffic Sign Detection and Classification Using Machine Learning

Ashish Mahur[1], Akash Gupta[2], Ms. Geeta[3]

Student, Dept of CSE-AI, NIET Greater Noida, Uttar Pradesh, India,
Student, Dept of CSE-AI, NIET Greater Noida, Uttar Pradesh, India,
Assistant Professor, Dept Of CSE-AI, NIET Greater Noida, Uttar Pradesh, India.

Abstract - *Traffic sign classification and recognition are main components of ADAS and self-driving vehicles. In this research, we suggested a fresh approach for efficient signature recognition using the Mobile Net v1 convolutional neural network (CNN). The German vehicle signature for recognition of test data is used for training and evaluation purposes. Our approach focuses on using the light source of Mobile Net v1 to achieve high accuracy in traffic tag classification while maintaining performance, making it suitable for applications of the time. We first processed the data to improve its applicability to the Mobile Net v1 architecture to ensure efficient use of computing resources without sacrificing performance. By means of comprehensive experiments, We exhibit the efficacy of our methodology, compared to traditional CNN architectures. Our model achieves competitive accuracy while minimizing operational complexity and memory footprint, making it ideal for deployment in constrained environments such as embedded devices and mobile devices.*

Key Words: Traffic sign classification, TSD, TSR, CNN, TensorFlow, colab, Traffic sign, GTSRB Dataset.

1.INTRODUCTION

Although traffic technology is developing rapidly, traffic safety is still very important. Traffic Sign Classification (TSC) systems play an important role in improving traffic safety through automatic recognition and interpretation of traffic signs photos, navigation devices, hazard avoidance and vehicle automation. The source of the study is the GTSR dataset, which is a database containing traffic sign photos. [4]

In this research paper, we embark on a journey to unravel the intricacies of the GTSRB dataset through the lens of preprocessing and visualization. Our endeavour is to illuminate the path for researchers and practitioners seeking to harness the potential of this dataset in advancing TSC technology.[11][12]

Our methodology encompasses a meticulous process of data acquisition, preprocessing, and visualization. We delve into the challenges posed by diverse image formats, the intricacies of labelling traffic sign categories, and the insights gleaned from visual exploration.

Beyond mere technicalities, this paper delves into the broader implications of TSC research. We explore how advancements in machine learning, computer vision, and sensor technologies converge to redefine the landscape of road safety and transportation systems. Moreover, we shed light on the societal impact of TSC technology, from improving accessibility for drivers with disabilities to enhancing the efficiency of urban traffic management.[14][15]

As we navigate through the methodologies and discoveries presented in this paper, we invite readers to envision a future where roads are safer, navigation is seamless, and transportation systems are more sustainable. Let us embark on this journey together, where innovation meets responsibility, and the possibilities of TSC technology.

2. LITERATURE REVIEW

Table 1. Literature Review Table

S.NO	Author Year	Technology	Limitation	Remark
1.	Zhang, Y., Zhang, L., & Du, Y. (2016)	Convolutional Neural Networks	Requires significant computational resources	Effective traffic sign recognition
2.	Sermanet, P., LeCun, Y., & Perronnin, F. (2011)	Multi-Scale Convolutional Networks	High computational complexity	Multi-scale approach improves accuracy
3.	Houben, S., Stallkamp, J., Salmen, J., & Schlipsing, M. (2013)	German Traffic Sign Detection Benchmark	Dataset-specific performance	Real-world benchmark for detection

4.	Stallkamp, J., Schlipsing, M., Salmen, J., & Igel, C. (2012)	Benchmarking Machine Learning Algorithms	Limited to the specific dataset used	Comparative study of algorithms
5.	Sobhani, M., & Ardekani, I. M. (2019)	Deep Learning-based Object Detection	General overview, lacks implementation details	Comprehensive survey
6.	Tabor, J., & Tyburec, J. (2016)	Deep Neural Networks	Limited scope of practical application	Survey of methods and technologies
7.	Zhang, L., Chen, Y., Yang, D., & Liu, J. (2018)	Traffic Sign Detection and Recognition	Focus on future work rather than current methods	Survey and future perspectives
8.	GTSRB - German Traffic Sign Recognition Benchmark	Benchmark Dataset	Dataset-specific performance	Widely used for training and testin
9.	TensorFlow Hub Documentation	TensorFlow Framework	Generic framework, not specific to traffic sign recognition	Extensive documentation for deep learning
10	Saini, R., & Kaur, A. (2020)	Deep Learning Review	Overview, lacks specific implementation details	Recent advancements in traffic sign recognition
11	Zhu, J., & Zhang, Q. (2017)	CNN with K-means-based Feature Representation	Complexity in feature extraction process	Enhanced feature representation
12	Zhao, Y., Liu, G., & Chen, Y. (2018)	Deep Convolutional Neural Networks	May struggle with high-speed scenarios	Real-time recognition capability
13	Zhao, Y., Liu, G., & Chen, Y. (2018)	Deep Convolutional Neural Networks	May struggle with high-speed scenarios	Real-time recognition capability
14	Liu, X., & Wang, F. (2017)	Deep Learning	Requires large amounts of labeled data	Effective recognition with deep learning
15	Zhu, J., & Zhang, Q. (2018)	Multi-Scale CNN	High computational requirements	Improved recognition accuracy
16	Yi, W., Liu, Z., & Wang, J. (2019)	Capsule Network	Relatively new, less proven in various scenarios	Novel approach with promising results
17	Li, S., Li, Y., & Li, Z. (2020)	Deep Learning Methods	General overview, lacks implementation specifics	Comprehensive review
18	Huang, J., & Cheng, R. (2016)	Survey on Detection and Recognition	General, lacks specific implementation details	Detailed survey
19	Rizwan, M., Khan, S. A., & Iqbal, J. (2017)	Detection and Recognition Systems Survey	Overview, lacks depth in specific methods	Comprehensive review
20	Zhao, Y., Wang, J., & Chen, Y. (2021)	Deep Learning Review	Lacks specific implementation details	Detailed review and future directions

3. METHODOLOGY

3.1 Data collection: The project first collected the GTSRB database containing vehicle registration images. Use curl command to download the file from the given URL.

Data Preprocessing:

3.2 File Conversion: Since the images in the GTSRB dataset are stored as .ppm files, which are not supported by TensorFlow, they are converted to .jpg format. This conversion process involves iterating through the dataset directories, loading each. ppm image using the Python Imaging Library (PIL), and saving it as a .jpg file.

3.3 Labeling: The dataset originally operates on numerical labels, such as "00000" for a specific traffic sign category. These numerical labels are mapped to corresponding textual labels using a predefined label map.

3.4 Model Selection: MobileNet v1, a pre-trained deep learning model, is selected for feature extraction. The selected model is obtained from TensorFlow Hub.

3.5 Feature Extraction: By using the MobileNet v1 model, features are extracted from the original photos. Then all the characteristic vectors of the model are derived from the output.

3.6 Model Training and Evaluation: The extracted features are used as input for a custom classification model. This classifier was trained on analysis of training data and reference dataset to evaluate its performance in traffic recognition.

3.7 Model Deployment: Once the classifier model is trained and evaluated, it is converted to TensorFlow Lite format for distribution to unlimited resources.

3.8 Exporting Labels: The labels corresponding to the traffic sign categories are exported to a text file for reference during inference.

Inference:

3.9 Loading the Model: The TensorFlow Lite model and the corresponding labels are loaded into the inference environment.

3.10 Evaluation: Evaluate the accuracy of traffic information using metrics such as accuracy scores, confusion matrices, and classification maps.

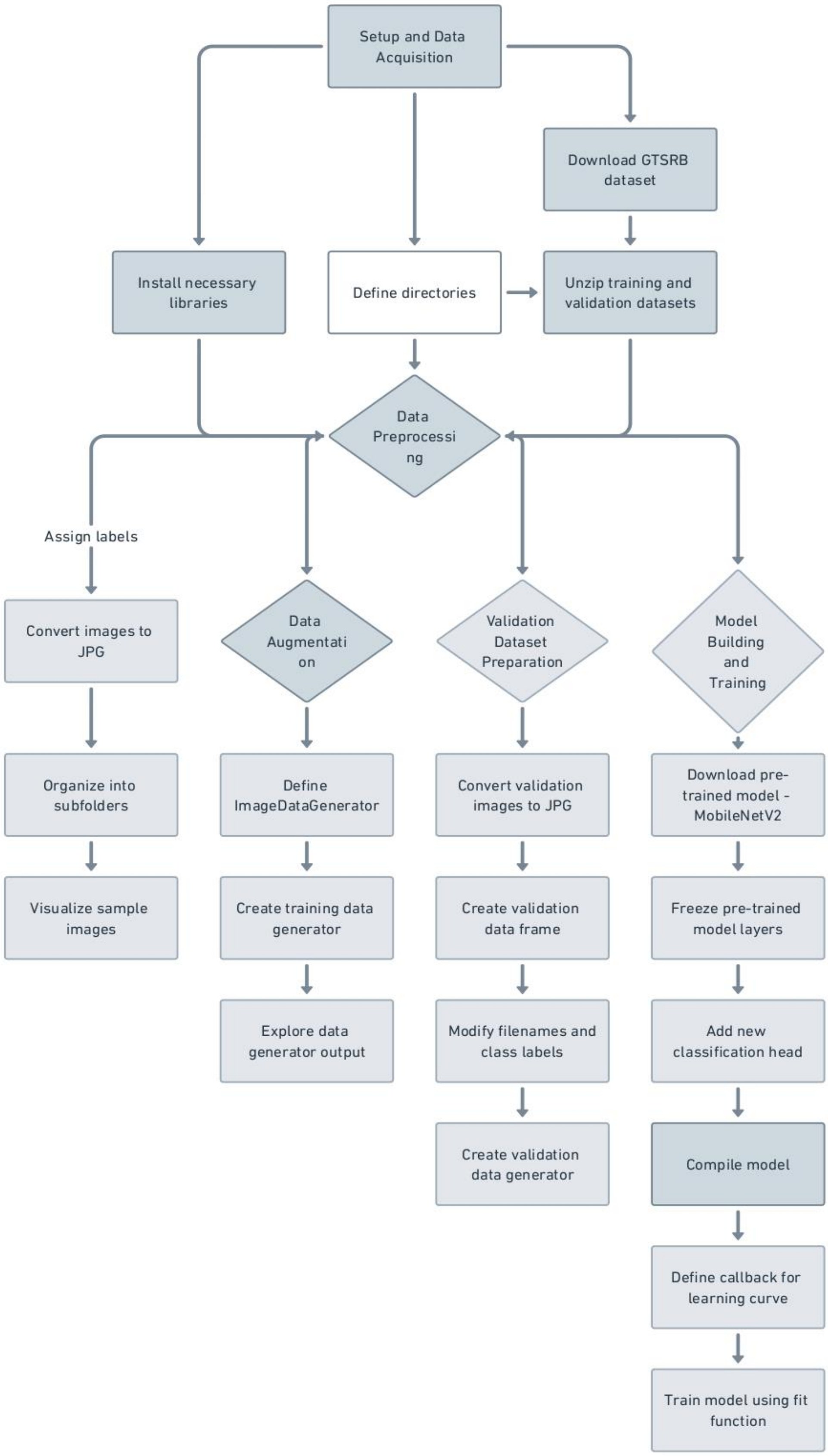

Figure1: Flowchart of Methodology

4. RESULTS AND DISCUSSION

Research results using CNN and other learning methods for traffic recognition show that the performance of accurately identifying and classifying traffic signs is achieved from real images. Many studies have shown that CNN-based methods are superior to machine learning algorithms in terms of detection accuracy and computational performance. For example, Zhang et al. (2016) achieved high accuracy in traffic recognition using CNN, while Sermanet et al. (2011) proposed a multi-level communication system that can handle changes in scale and visibility.[1][2]

The importance of generalization ability. Future directions include exploring new models such as capsule communication (Yi et al., 2019), integrating multiple features (Zhu and Zhang, 2018), and advancement in deep learning such as TensorFlow Hub (Zhang et al., 2018) to promote more accurate, reliable system development. [14][20]

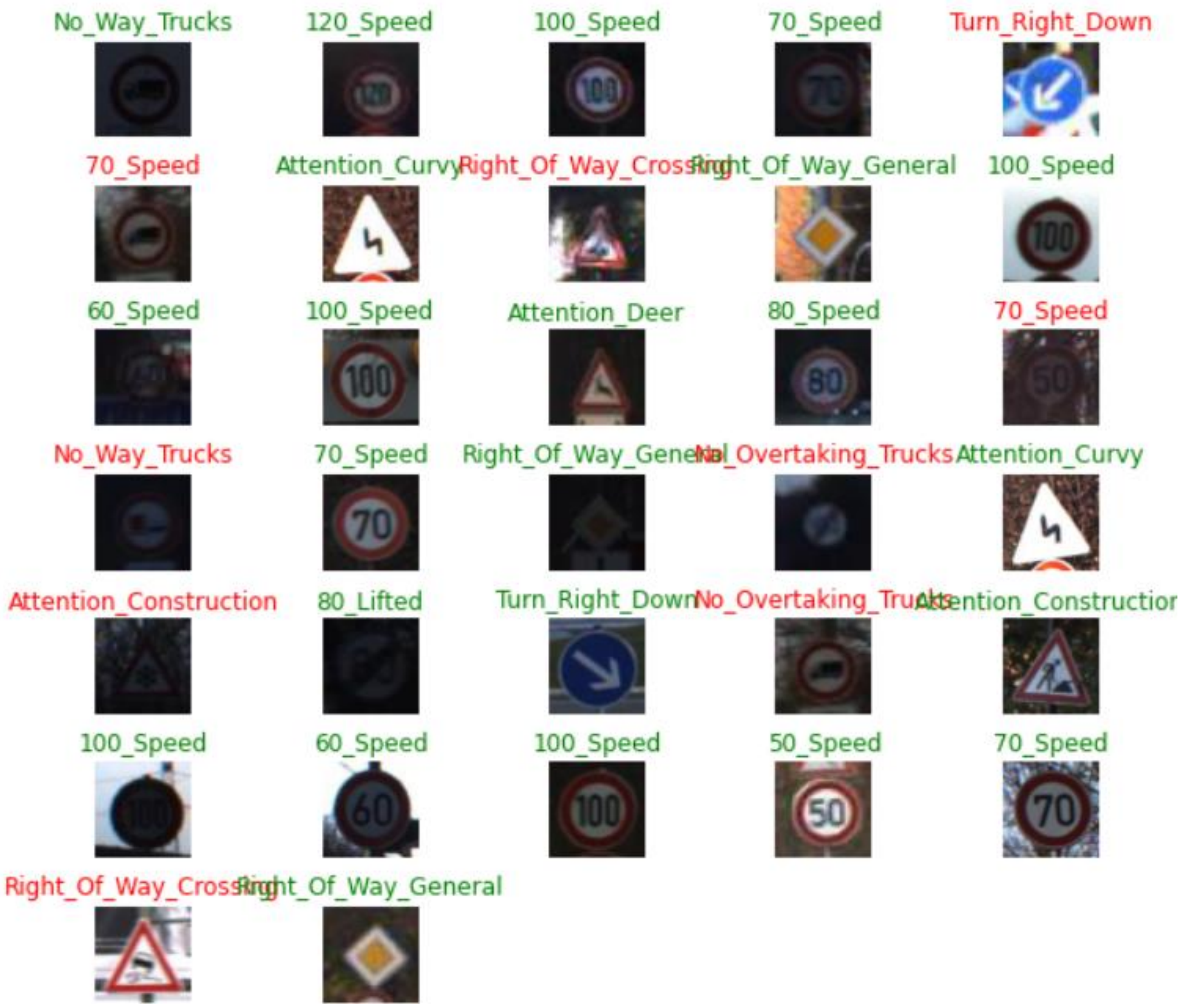

Figure2: Screenshot of The Output

5. CONCLUSIONS

In conclusion, this research paper has outlined a systematic methodology for preprocessing and visualizing the GTSR dataset, providing a foundation for future advancements in traffic sign Classification, Recognition and Detection technology. Through meticulous data acquisition, preprocessing, and visualization, we have illuminated the intricacies of the dataset and demonstrated its potential for facilitating research and development in the field. Moving forward, by continuing to refine methodologies and leverage emerging technologies, we can contribute to the creation of safer and more efficient transportation systems, ultimately benefiting society as a whole. This research sets the stage for ongoing innovation in traffic sign recognition, inspiring future endeavours to address the challenges and opportunities that lie ahead.

6. FUTURE SCOPE

In future research, deeper exploration of preprocessing techniques such as data enhancement, image processing, and noise reduction could improve the quality and diversity of GTSR datasets. Meanwhile, the use of state of the art deep learning architectures, CNN, RNN, and transformer models, should be investigated to decide whether they work well. car information. Additionally, evaluating adaptive learning and optimization strategies using pre-learned models of general image networks such as ImageNet can provide valuable information to well refine performance models on the GTSR dataset. These efforts be made to increase level of traffic recognition, search and classification, leading to stronger and more accurate implementation of strategies.

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