Project Title:

Real-time Traffic Sign Detection and Classification Under Challenging Environment

1. Project Summary:

The ability to recognize and categorize traffic signs is crucial for autonomous driving and driver assistance technology(ADAS). Traditional methods often struggle to address obstructions, poor weather, and insufficient illuminations. The objective of this study is to develop a real time deep learning model that can accurately recognize and classify traffic signs, even in challenging situations.

Conventional Neural Networks(CNN's) such as YOLOv8, Efficient Net and Mobile net will be used to train the model on a range of datasets, including the LISA, Traffic sign dataset and the GTSRB (German Traffic Sign Recognition Benchmark). The final model will be optimized for edge computing devices (such as the Raspberry Pi and Jetson Nano) using Tensor RT or ONNX, ensuring low latency and high accuracy in real time applications.

1.1 Research Question:

- How can Traffic sign detection and classification based on deep learning be optimized for real-time performance under challenging environmental conditions on edge computing devices?
- How can deep learning models be optimized to achieve real-time traffic sign detection while maintaining high accuracy on low-power edge devices?
- How does quantization and pruning affect the accuracy and efficiency of traffic sign classification on edge computing devices?

1.2 Project Objectives:

- Build a deep learning model that accurately recognizes and classify traffic signs.
- By training the model under a range of conditions, including fog, rain, darkness and occlusions, you can increase its resilience.
- Utilise pruning and quantization techniques to maximise the models performance for inference in real-time.
- Use the model on edge computing devices to ensure efficient processing for real-world applications.
- Examine the systems accuracy, latency and robustness under stressful conditions.
- Integrate real world traffic sign photos from various geographical locations and lighting situations to increase the diversity of dataset.
- To increase detection accuracy, use sophisticated picture pre-processing methods including adaptive thresholding, noise reduction, and contrast enhancement.
- To improve the stability of sign identification in video streams, create a real-time object tracking system.
- To enhance model generalization, apply data augmentation strategies including rotation, random cropping, and artificial noise.
- Enhance the ability to recognise small or partially obscured traffic signs by including attention mechanisms.

1.3 Reference:

Stallkamp, J., Schlipsing, M., Salmen, J., & Igel, C. (2012). *Man vs. Computer: Benchmarking Machine Learning Algorithms for Traffic Sign Recognition.* IEEE Transactions on Neural Networks and Learning Systems.

Redmon, J., & Farhadi, A. (2018). *YOLOv3: An Incremental Improvement.* arXiv preprint arXiv:1804.02767.

Sandler, M., Howard, A., Zhu, M., Zhmoginov, A., & Chen, L. C. (2018). *MobileNetV2: Inverted Residuals and Linear Bottlenecks.* IEEE/CVF Conference on Computer Vision and Pattern Recognition.

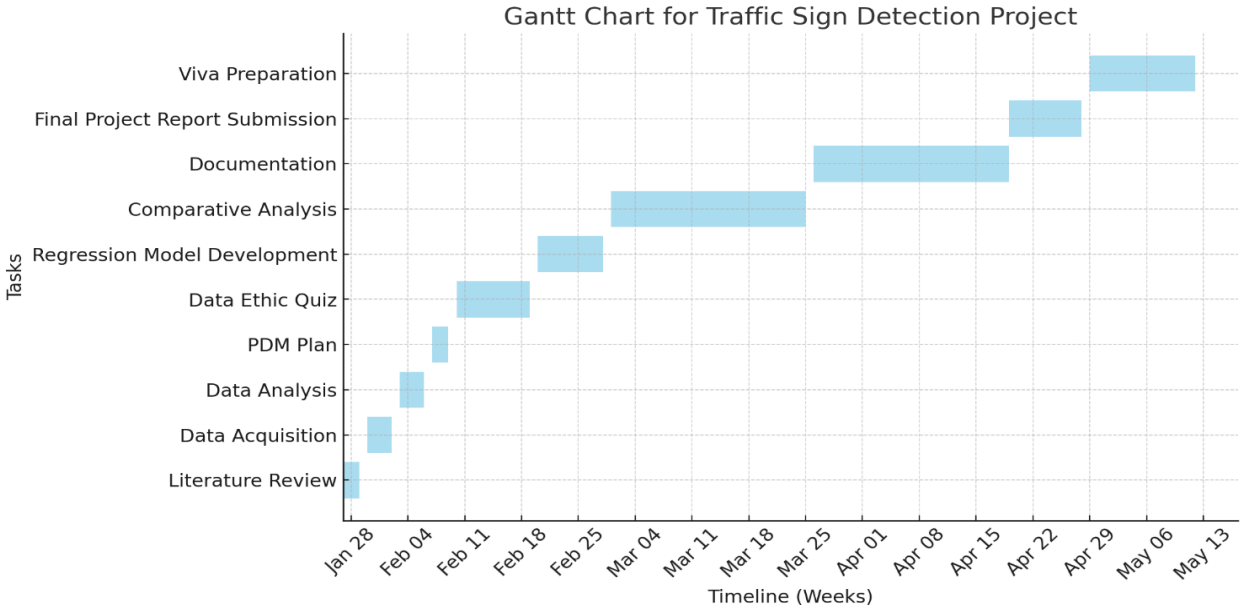
NVIDIA Developer. *TensorRT: High-Performance Deep Learning Inference Optimizer and Runtime.*

2. Project Plan

2.1. Project Timeline:

TASK	DESCRIPTION	START DATE	END TIME
Literature Review	Review the literature in-depth with an emphasis on deep learning and edge computing techniques for traffic-sign recognition and categorization.	**27/01/2025**	**29/01/2025**
Data Acquisition	Gather and prepare data sets of traffic science from open images, roboflow universe and actual photos taken in various settings	**30/01/2025**	**02//02/2025**
Data Analysis	Clean data for model training, visualize data distribution, and do exploratory data analysis (EDA). Determine any trends all discrepancies.	**03/02/2025**	**06/02/2025**
PDM plan	Create a Project Development and Management(PDM) strategy that includes important milestones, risk assessment, and methodology. Send in for evaluation.	**07/02/2025**	**09/02/2025**
Data Ethic quiz	To make sure data handling and Ai model creation adhere to ethical standards and laws, take and ethics compliance quiz.	**10/02/2025**	**19/02/2025**
Regression Model Development	Use a base line regression model to classify traffic indicators initially. Adjust the hyper parameters to increase accuracy.	**20/02/2025**	**29/02/2025**
Comparative Analysis	To find the best model for real-time traffic sign detection, compare various deep learning architectures.	**01/03/2025**	**25/03/2025**
Documentation	For the final project submission record the methods, data sets, model performance and system deployment specifics.	**26/03/2025**	**19/04/2025**
Final Project Report Submission	Create a final project report and submit it with all the conclusions, assessments, and findings.	**19/02/2025**	**28/04/2025**
Viva preparation	Review the project results, polish the presentations, and prepare for any questions that may come up during the final viva.	**29/04/2025**	**12/05/2025**

2.2. Gantt Chart



3. Data Management Plan:

The German Traffic Sign Recognition Benchmark (GTSRB) and the LISA Traffic Sign Dataset are two publicly accessible sources from which the traffic sign detection dataset is sources. Images of different traffic signs taken in actual circumstances are included in these datasets.

Several image categories that depict various traffic signs are included in the collection, along with the labels that go with them for categorization. The dataset seeks to offer a thorough standard for creating reliable machine learning models for the detection and classification of traffic signs in real time.

3.1. Data Collection

The following sources provided the datasets utilized in this project:

- GTSRB Dataset: https://benchmark.ini.rub.de/gtsrb_news.html
- LISA Traffic Sign Dataset
- Augmentation of synthetic traffic signs

To replicate difficult real-world situations, more data may be gathered using data augmentation techniques including noise injection, rotation, and contrast modifications.

3.2. Metadata

The dataset consists of both **categorical** and **numerical data**:

Metadata Type	Description	Example
Categorical Variables	Traffic sign classes (stop, speed limit, pedestrian crossing)	'Stop Sign', 'Yield', 'Speed Limit 50'
Numerical Variables	Image dimensions, bounding box coordinates	(Xmin, Ymin, Xmax, Ymax)
Ordinal Variables	Occlusion severity, lighting conditions	Low, Medium, High
File Format	Images in PNG/JPEG, Annotations in CSV/JSON/XML	224x224 images, COCO format annotations
Dataset Size	Approximately 50,000 labelled images	~2GB

3.3. Data Control

The GitHub link is provided here and the regular updates will be committed in the GitHub every 2 weeks to track the changes in model development and dataset pre-processing.

https://github.com/amritharaj018/traffic-signal-detection.git

3.4. Security and Storage

Data is being stored at one drive and also the changes are being committed at the GitHub account link above.

3.5. Ethical Requirements

Only image of public traffic signs is utilized in the dataset, no personal data is included. The study respects privacy rules and complies with GDPR. The initiative complies with the ethical standards for AI-based research set forth by the University of Hertfordshire. Only publicly accessible datasets are used.