MINOR PROJECT - I SYNOPSIS

ROAD SIGN RECOGNITION USING RASPBERRY PI

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INTRODUCTION

The Raspberry Pi is a mini, versatile and cost effective single-board computer. Despite its compact size, the RPI is fully functional and is capable of running an operating system(Preferably Raspbian OS, based on Linux or Ubuntu) as well as handling multiple tasks such as programming, web browsing, multimedia playback and much more.

It supports the deployment of lightweight machine learning models such as TensorFlow Lite. This project aims to develop an intelligent system for **object detection, recognition, and identification** using the **Raspberry Pi 3 B+** (refer Figure 1) , and **USB Camera**. The system will leverage the capabilities of computer vision and machine learning to detect objects in real time, recognize them, and identify specific characteristics based on a pre-trained model.

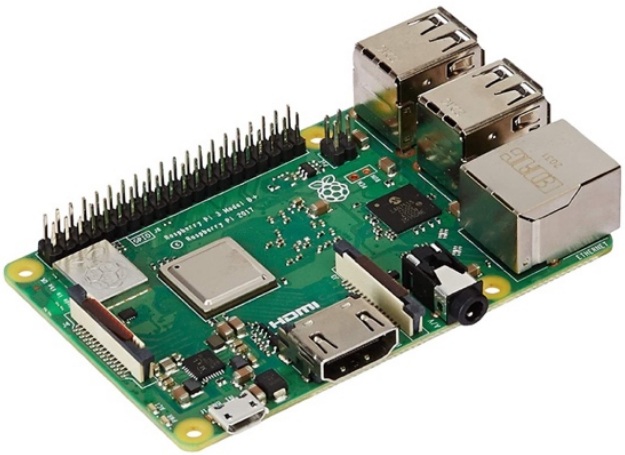

Figure 1: Raspberry Pi 3 B+ [1]

The Raspberry Pi provides an efficient platform that supports the deployment of lightweight machine learning models. Using a USB Camera, the Raspberry Pi captures live video feed at an adequate FPS (Frames Per Second) which is then processed using OpenCV module. TensorFlow Lite is used to detect and classify road signs (refer Figure 2).

The system has significant applications in daily life and aims to assist and aid in menial tasks for those who are unable to perform them with appropriate accuracy. It can be applied in all sorts of fields and industries to reduce human workload and improve quality of services. It can be used in fields such as **smart surveillance**, **assistive technology**, and **automated systems**, where real-time detection and interaction with objects is crucial for functioning.

Figure 2: Tested Road Sign Detection using TensorFlow Lite

TENTATIVE TECHNOLOGIES

1. Raspberry Pi OS: It is a light weight Linux based OS especially made for Raspberry Pi. It's user friendly GUI makes it efficient and perfect for programming, especially Python. It also supports a wide range of hardware and software applications, making it versatile. The Raspbian / Debian Bullseye version OS and Distribution System is installed.

2. TensorFlow Lite: It is a light version of TensorFlow library especially designed for light-weight devices such as the RPI. It lets us run pre-trained machine learning models for multiple applications. Here, for real-time object recognition [3].

3. OpenCV: It is widely used open-source library for computer vision. It is essential for our task of object recognition and also assists in image filtering and real-time image analysis.

4. fsWebCam : The **fswebcam** library is a command-line tool used on Raspberry Pi for capturing images from USB webcams. It allows for easy configuration of camera settings such as resolution and image quality, making it suitable for projects involving image processing and computer vision. The library is lightweight and efficient, enabling users to take snapshots quickly, which is particularly useful in applications like real-time road sign recognition systems where image capture is a crucial step.

PROBLEM FORMULATION

The necessity for efficient and accurate road sign recognition systems has become increasingly critical due to the growing emphasis on smart transportation and automation. Road signs are essential for ensuring safety and guiding vehicles and pedestrians; however, existing recognition systems frequently rely on expensive hardware and high computational power, which limits their accessibility and practicality. As automation in transportation systems rises, there is a pressing need for reliable technologies that can interpret road signs in real-time. Traditional methods of traffic sign recognition often fall short in terms of accuracy and speed, particularly in complex environments where factors like lighting variations and motion blur can significantly impact performance. Moreover, the lack of cost-effective solutions restricts the deployment of advanced recognition technologies in various applications, including education and small-scale automation projects. Addressing these challenges is crucial for enhancing road safety and improving the overall efficiency of transportation systems, highlighting the potential for innovative approaches that leverage affordable technology to deliver practical solutions in this domain.

The project aims to create an efficient, cost-effective road sign recognition system that operates in real-time using a Raspberry Pi. Current solutions often rely on high-end hardware and complex algorithms, making them impractical for widespread use, particularly in resource-constrained environments. This project seeks to bridge the gap by leveraging affordable technology while ensuring accurate detection and classification of road signs under varying conditions.

The need for real-time processing in environments that require fast and accurate object recognition is critical, particularly in fields like automation, robotics, and smart surveillance. Many existing systems either struggle to perform effectively on resource-constrained hardware or are too expensive for small-scale applications. Utilizing a platform like Raspberry Pi provides an excellent opportunity to analyse and enhance the performance of machine learning models in such constrained contexts, enabling the development of practical applications for road sign recognition that can improve safety and efficiency in transportation systems.

OBJECTIVE

The primary objective of this project is to develop a real-time object detection system that utilizes machine learning models, specifically TensorFlow Lite and OpenCV, to efficiently process and recognize road signs. The system aims to achieve the following specific goals:

1. **Real-Time Detection and Classification:** Implement algorithms that enable the detection and classification of road signs from live video feeds captured by a USB camera. This involves matching detected objects with pre-trained datasets to identify them accurately by their names or characteristics.

2. **Initial Focus on Road Signs:** The project will initially concentrate on recognizing Road Signs, sending triggers based on the identified colours and shapes.

3. **Optimization of System Performance:** Strive for a balance between processing speed and accuracy, ensuring that the system operates smoothly on the limited computational resources available in the Raspberry Pi. This includes refining pre-trained models to enhance usability without requiring high-power hardware.

4. **Comprehensive Testing and Validation:** Conduct thorough testing and validation of the system in various environments to ensure reliability and scalability for potential real-world applications. This encompasses evaluating performance under different lighting conditions and scenarios.

By addressing these objectives, the project aims to create a practical solution that not only meets current needs but also lays the groundwork for future advancements in road sign recognition technology.

WORKING

Phase 1: Project Planning and Data Collection: Gather and prepare a dataset of road signs for model training.

Tasks:

- Identify hardware and software requirements (e.g., Raspberry Pi model, camera specifications, libraries like TensorFlow Lite and OpenCV).

- Collect images of various road signs from public datasets or create a custom dataset.

Phase 2: Pre-Processing and Model Development: Create a machine learning model for road sign recognition.

Tasks:

- Apply data augmentation techniques to address class imbalances (e.g., rotation, flipping).
- Preprocess images (resize, normalize) to ensure uniform input for the model.
- Design a Convolutional Neural Network (CNN) architecture suitable for the task. Train the model using TensorFlow on a powerful hardware setup (Google Colab).
- Validate model performance using metrics like accuracy and loss.

Phase 3: Model Optimization: Optimize the trained model for deployment on Raspberry Pi.

Tasks:

- Convert the trained model to TensorFlow Lite format for lightweight deployment.
- Implement quantization techniques to reduce model size and improve inference speed.
- Test the optimized model on sample images to ensure functionality.

Phase 4: System Integration: Integrate all components into a cohesive system.

Tasks:

- Set up Raspberry Pi with necessary libraries (OpenCV, TensorFlow Lite).
- Develop a Python script to capture live video feed from the USB camera.
- Implement real-time detection algorithms to process video frames and identify road signs.

Phase 5: Testing and Validation: Evaluate system performance in real-world scenarios.

Tasks:

- Conduct field tests under varying environmental conditions (different lighting, weather).
- Collect feedback on detection accuracy and response time.
- Fine-tune parameters based on testing results to improve system reliability.

Future Enhancements: The system will be designed to scale, allowing for the inclusion of more advanced traffic sign recognition and other features such as pedestrian detection.

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