PBL: EMBEDDED SYSTEM AUTOMATION

PROJECT : GROUP-16

**ESP32 CAM for Automatic Number Plate Recognition (ANPR)**

Abstract :

Automatic Number Plate Recognition (ANPR) technology has become a critical component in modern traffic management, law enforcement, and access control systems, facilitating real-time vehicle identification and monitoring. This project explores the deployment of ANPR using the ESP32-CAM module, a versatile and cost-effective microcontroller integrated with a camera. The ESP32-CAM is leveraged for its powerful processing capabilities and wireless communication features, enabling the capture, analysis, and transmission of vehicle license plate data. The system initiates with image acquisition, where the ESP32-CAM captures high-resolution images of vehicles in various lighting and environmental conditions. Subsequent stages involve pre-processing the captured images to enhance quality and isolate the region of interest, which contains the license plate. Techniques such as grayscale conversion, histogram equalization, and noise reduction are employed to prepare the image for accurate detection. The core of the ANPR process lies in the application of optical character recognition (OCR) algorithms. This project explores both traditional OpenCV-based methods and the integration of machine learning models trained to recognize and interpret alphanumeric characters from diverse plate styles and fonts. The recognized license plate numbers are subsequently converted into digital text format. Leveraging the ESP32-CAM’s integrated Wi-Fi capabilities, the extracted data is wirelessly transmitted to a centralized server or cloud database for storage, analysis, or real-time monitoring. The system’s low-cost hardware setup combined with its robust performance underscores its potential for wide-scale deployment in various applications such as automated toll collection, restricted area monitoring, and smart parking systems. Additionally, the project delves into optimizing processing algorithms to ensure minimal latency and high accuracy, even under challenging conditions like motion blur or low contrast. The fusion of hardware efficiency and advanced image processing techniques in this ANPR solution not only exemplifies technological ingenuity but also contributes to enhancing public safety and operational efficiency in vehicular management. This project’s findings are expected to pave the way for future innovations in embedded systems and smart city infrastructure, making advanced surveillance and automated identification more accessible and scalable.