**Advanced Lane Departure warning system using CNN**

**Introduction:**

Traffic accidents remain a significant issue in modern times, largely due to careless driving. Recent studies indicate that around 30% of traffic accidents result from lane deviations, with the majority being attributed to driver inattention, fatigue, and drowsiness [8]. The Lane Departure Warning System (LDWS) is designed to notify drivers when their vehicle begins to stray from its lane without signalling a turn. Most of the methods outlined in research utilize machine vision (MV) to power the LDWS. This technology can be seamlessly integrated with existing systems and adjusted as needed during the design process. It can also serve as an indicator map (IPM), offering a top-down view of the road to enhance lane detection. However, generating the IPM is a complex and time-consuming process, which can impact the system’s efficiency. So, we instead implement CNN. Additionally, the need for specific parameters and camera calibration for different vehicle models limits the system's versatility across various platforms [6].

**Literature review:**

The Lane Departure Warning System (LDWS) goes through multiple stages, beginning with pre-processing. During this stage, extraneous details in the image are reduced using filters such as the Gaussian Filter [1] and Median Filter [2]. Following this, the Region of Interest (ROI) is extracted to focus on the critical portion of the image required for precise lane detection [1].

Professor Sachin Sharma and colleagues [3] utilized the Hough transform algorithm to detect and identify lane markings. The system calculates the distance between lanes, and based on the vehicle's proximity to the lane boundaries, it determines whether the vehicle is departing from its lane. The results demonstrate that this method can accurately track lanes quickly. In this approach, a region of interest within the image is selected, and lane edges are identified using the Hough transform. The mean point of the left boundary and the midpoint of the right boundary are determined, with a line drawn from the midpoint to the Hough origin. The horizontal distance connecting these two midpoints is measured as the length.

Alvarez [4] implemented the illumination invariance technique for road detection. The proposed algorithm is effective with still images and does not rely on the road's shape. It is robust against shadows and changes in lighting conditions. Moreover, this method outperforms algorithms based on hue, saturation, and intensity (HSI). However, a key requirement for this algorithm is camera calibration, specifically the provision of intrinsic camera parameters, including the invariant direction.

Ke Mu and Jianhui Yang [5] proposed the Fast Multi-level Fuzzy Edge Detection (FMFED) technique, which efficiently detects edges using fuzzy logic. In its initial phase, FMFED enhances image quality by increasing contrast through Fast Multi-level Fuzzy Enhancement (FMFE). This process is performed twice using two image thresholds to achieve significant enhancement. The enhancement procedure is then applied in two stages based on the image's neighborhood characteristics, effectively minimizing false edges and accurately extracting very fine details.

kim and Lee [12], proposed a lane detection approach that combines Convolutional Neural Networks (CNN) with the Random Sample Consensus (RANSAC) algorithm. Initially, the algorithm detects edges in an image using a hat-shaped kernel. For simpler road scenes, lane detection can be performed using only the RANSAC algorithm. However, for more complex scenes that include obstacles like trees, fences, and intersections, detecting lanes becomes challenging due to noisy edges. To address this, the authors integrated CNN into the lane detection process both before and after applying RANSAC. During the CNN training, edge images within a region of interest are used as input data, while the target data consist of images with real white lanes drawn on a black background. The CNN structure comprises 8 layers, including 3 convolutional layers, 2 subsampling layers, and a multi-layer perceptron with 3 fully connected layers. The convolutional and subsampling layers are hierarchically organized, forming a deep learning structure. The results show that their algorithm effectively reduces noise and outperforms traditional line detection methods like RANSAC and Hough line transform. Their approach successfully detects lane markers in shadows as well as parallel, broken, and scattered markers.

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