Lane Detection and Vehicle Detection using Neural Network

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ABSTRACT: *In the context of Advanced Driver Assistance Systems, increasing safety and reducing road accidents are of the great concern. Among the complex and challenging tasks of future road vehicles are lane detection and its boundaries detection. In this paper, we introduce an approach to detect the information about lane and vehicle for the driver assistance system. Annually, around 2- 3% of the world's gross domestic product is spent on the medical costs, property damage, and other costs associated with automotive accidents. The number of deaths on the world's roads remains unacceptably high, with an estimated 1.35 million people dying each year. To lessen these damages resulting from the road traffic accidents in order to save more lives, the reasons and factors should be analyzed and summarized. Moreover, the combination of lane detection and vehicle detection is able to support the driver assistance system, or the lane change assistant system, and also to improve the reliability of the results.*

Keywords: Color Thresholding, Region of Interest, Gaussian blur, Sliding Window, Hough Transformation, Lane Curvature

1. INTRODUCTION

In this paper we are introducing a synergistic approach to integrated lane and vehicle tracking for the driver assistance. Image processing plays a very important role in various real time applications ranging from imaging to pattern and object recognition for different purposes. A real-time system has been developed that analyzes all the color videos taken from a front video camera in a car driving on a highway. It uses a combination of color, edge, information of motion to recognize and track the road boundaries, lane markings and all the other vehicles present on the road. Cars are recognized by matching templates that are taken and then cropped from the input data online and also at times by detecting highway's scene features and then evaluating how they are related to each other.

Moreover, vehicle detection can be developed by tracking and following a preceding car, also at the same time by increase the efficient use of driving space. In consequence, an effective visual scanning of frontal road conditions is most importantly required for vehicle detection system as to identify the position of vehicles which are ahead.

The lane detection system comes from the lane markers in a complex environment and also is used to estimate the vehicle's position and trajectory relative to the lane. At the same time, lane detection also plays an important role in the lane warning system. The lane detection task can be mainly divided into two stages: edge detection (canny edge detection) and line detection.

2. LANE DETECTION PIPE LINE:

1. Convert original image to gray scale.
2. Darkened the gray scale image (this help in reducing contrast from discolored regions of road)
3. Convert original image to HLS color space.
4. Isolate yellow from HLS to get yellow mask. (for yellow lane markings)
5. Isolate white from HLS to get white mask. (for white lane markings)
6. Bit-wise OR yellow and white masks to get common mask.
7. Bit-wise AND mask with darkened image.
8. Apply slight Gaussian Blur.
9. Define Region of Interest. And by this it helps in weeding out all unwanted edges detected by canny edge detector.

10. Retrieve Hough lines.

11. Consolidate and extrapolate the Hough lines and draw them on original image.

3. BLOCK DIAGRAM

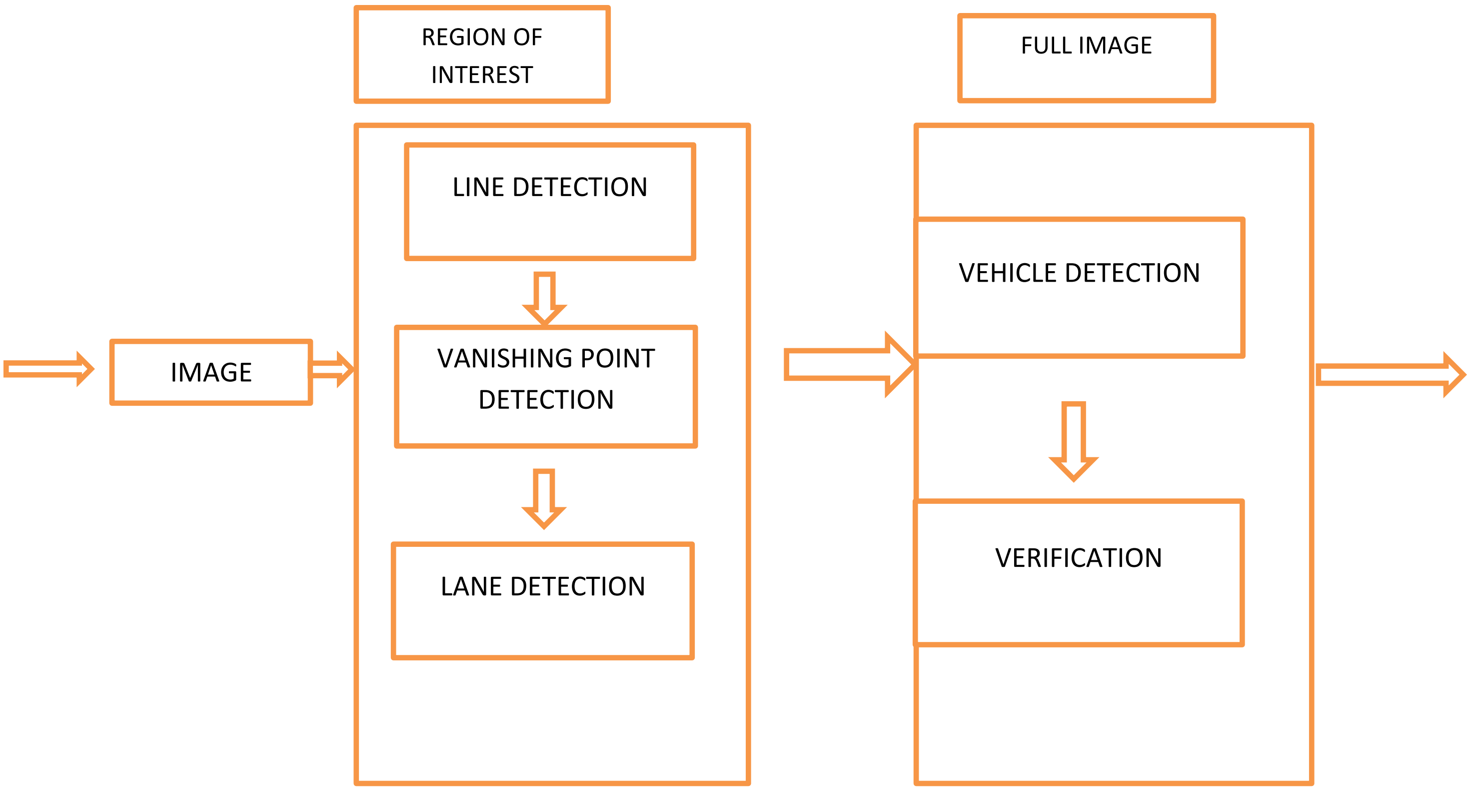

Chart 1. Pipeline of Lane and Vehicle detection.

4. LANE DETECTION INVOLVES FOLLOWING STEPS

1. Read the input signal and decode it into frames.
2. Reducing of noise by applying filter.
3. Color Thresholding.
4. Gaussian blur
5. Conversion of an image to Gray scale.
6. Detecting the edges.
7. Finding coordinates of road lane.
8. Fit the coordinates into the canny image.
9. Edge detection is done.

4.1 Capturing and Decoding of video file

The image is being captured using Video Capture object and after it has been captured the every video frame is decoded (i.e. converting it into a sequence of multiple images).

4.2 Reduce noise

Noise has ability to create false edges, therefore before going to further steps, it's imperative to perform image smoothening and removing unnecessary elements. Gaussian filter is specifically used to perform this process.

4.3 Color Thresholding

Color and edge threshold is generally used for better result while detecting the lines, and making easier to find the polynomial which best describes our left and right lanes.

The first step that is used is to explore the color spaces that one should adopt to increase the chances in detecting the lanes and later facilitating the task of the gradient threshold. At this current stage, we come across with various choices that have both pros and cons. Our main motive and goal here is to find the right thresholds on a given color channel to highlight yellow and white lines of the lane.

What we observe while working on the RGB component is that the blue channel is worst at identifying yellow lines, whereas the red channel seems to give the best results. Similarly when we discuss the HLS and HSV what we observe is that the hue channel produces an extremely noisy output, whereas the saturation channel of HLS gives the strong and better results; better than HSV's saturation channel. But if we discuss HSV's value, this particular channel gives a very clear gray scale image, especially on the yellow line, and it is way much better than HLS' lightness channel.

Lastly, since LAB's A channel is not doing a great job in identifying the yellow color, while whereas it's B channel which is strong at identifying the yellow line. But to identify both yellow and white lines, it is lightness channel which shines and helps in pretty good manner.

4.4 Gaussian blur

Gaussian smoothing also referred as Gaussian blur, it is a pre-processing step which is used to reduce the noise from image or to smooth the image. This pre-processing step is generally used to remove many detected edges and only keep the most prominent edges from the image. This step is added as gradients in next steps are sensitive to noise.

4.5 Gray scale conversion

The video frames obtained are mostly in RGB format, RGB is converted to gray scale because processing of image channel is faster than processing a three different channel colored images.

4.6 Region of Interest

The region of interest for the car's camera in lane detection is only the two lanes immediately in its field of view and not anything extra. The extraneous pixels present in the photo can be considered by making a polygon region of interest and rest removing all other pixels that are absent in the polygon. Even after applying Canny Edge Detection, there are many edges that are detected but those are not lanes, so a polygon shaped region of interest defines area in that image.

The ROI is defined as an area close to the lane border. The full image of it is used to detect vehicles. Basically, there are two phases:

- The lane detection;
- The vehicles detection present, based on the detected lanes.

4.7 Finding Lane Area

- **Sliding Windows**
  This method is basically used to apply the convolution, which maximizes the number of hot pixels in each window. This method is taken care assuming that the camera is mounted at center, the window template which is captured via camera is slid across the image from left to right and any overlapping values are summed together, creating the convolved signal. The peak of the convolved signal is where the highest overlap of pixels is obtained and thus it is the most likely to be position for the lane marker.

  Since the starting x position of pixels is known to us so a sliding window search is an attempt to "capture" the pixel coordinates of our lane lines. After that, via numpy's polyfit what we do is simply compute a second degree polynomial, to find the coefficients of the curves that best fit the left and right lane lines.

In the first stage, the filter do is the Text detection where an image that is captured is looked and try to find the regions of text that is appeared in the image. Text detection is an not so usual problem when it comes in computer vision. Depending on the length of the text we're trying to find, these rectangles can have different aspect.
What we can do to improve the algorithm is by saving the previously computed coefficients for the frame *t-1* and then attempt to find our lane pixels from those coefficients. However, when we couldn't get the enough lane line pixels i.e. less than 85% of total nonzero pixels, we revert back to sliding windows search to improve our chances of fitting better curves around our lane.

- **Lane Curvature**
  The measurements are generally taken where the lane lines are estimated how much the road is curving, along with the vehicle position with respect to the center of the lane. We also compute the lane curvature by calculating the radius of the smallest circle that could be a tangent to our lane lines, on a straight lane the radius of the road will be really high. We have to proper define the appropriate pixel height to lane length and pixel width to lane width ratios from the pixel space to real world units i.e. meter.

  We can also compute the car's distance from the center of the lane by taking the average of the starting coordinates of the left and right lines of the lane, then subtracting the middle point as an offset and multiplying it with lane's pixel to the real world width ratio.

Warp the detected lane area and boundaries back onto the original image and then display the numerical estimation of lane curvature w.r.to vehicle position.

Textual information about lane curvature and vehicle's center position is also added to it. The fit that are obtained from the rectified image has been warped back onto the original image and it is plotted to identify the lane boundaries. On addition to it, the big image is overlay with small images of our lane detection algorithm to give a better exposure and information of what is going on *frame by frame*.

4.8 Hough Line Transform

The Hough transform is a technique that is used in image analysis and digital image processing. The purpose of this technique is basically, to find all the imperfect instances of objects within a certain class of technique that has been pre decided.

The Hough Line Transform is a mechanism in lane detection and vehicle detection in which it is used to detect straight lines. Basically, the Probabilistic Hough Line Transform is used here, which gives output as the extremes of the detected lines that has been passed in it. Hough transform is a very useful tool as it identifies the lines and shape of an object. Canny edge detector which defines edges of an object, Hough transform is used to fill pixels between edges to produce the required and appropriate shape of an object.

5. CAMERA CALIBERATION

Camera calibration is the process or proper estimate or mechanism by which estimation of intrinsic and/or extrinsic parameters is done. Intrinsic parameters deal with the camera's internal characteristics which include its focal length, skew, distortion, and image center. Extrinsic parameter gives information about its position and orientation in the outer world.

Camera Models

Two camera models are supported by:

- Pinhole with radial and tangential distortion for the regular lenses.
- Universal Omni (fish eye lenses).

6. VEHICLE TRACKING APPROACHES

The object and image tracking in video processing is really an important step to track the moving objects in visual-based surveillance systems and also it represents a challenging task for researchers.

To track the physical appearance or body of moving objects such as the vehicles and identify it in dynamic scene, it has to locate the position of vehicle, estimate the motion of these objects and follow their movements between two of consecutive frames in the video frame.

Several vehicle tracking methods that have been illustrated and proposed for different issues consists of:

1. Region-Based Tracking Methods

2. Contour Tracking Methods

3. 3D Model-Based Tracking Methods

4. Feature-Based Tracking Methods

5. Color and Pattern-Based Methods

6.1 Region-Based Tracking Methods

Under these methods, the region which comes under this are the moving objects are tracked and used for tracking the vehicles. The algorithm is that the regions are segmented from the subtracting process between the input frame image taken by camera and prior stored background image also termed as reference image.

The proposed scheme that is being demonstrated in the work features the ratio and density to classify vehicles, also, geometric traits are used to eliminate the false regions and for more accurate segmentation to make this process possible the shades elimination algorithm is used.

6.2 Contour Tracking Methods

These methods depend on the boundaries of vehicle in tracking vehicle process. A novel real time traffic supervision approach has been approached which employs optical movement and uncalibrated camera parameter knowledge to detect a position of vehicle.

The techniques that are used in this approach are: color contour based matching and gradient based matching, and the results obtained are satisfactory when it tested for tracking, foreground object detection, vehicle recognition and vehicle speed assessment methods.

Kalman filter is used by the proposed work, background differencing methods and morphological operations for recognition vehicle's and extraction contour.

Kalman filtering is one of the most common and important estimation algorithms that has been demonstrating its usefulness in various applications as it provides the estimates of some unknown variables based on accurate and certain measurements observed over time. It has relatively simple form and require very small computational power. Also, the Kalman Filter provides the prediction of the future system state based on the past estimations.

What this filter does is that it cyclically overrides the mean and the variance of the result. The filter will always be confident on where it is, as long as the readings which are obtained do not deviate too much from the predicted value or reference value.

6.3 3D Model-Based Tracking Methods

Under this subsystem of vehicles detection process a 3D solid cuboid is formed with up to six vertices, and then this cuboid is used to fit any different types and sizes of vehicle images by changing the vertices for the best fit of vehicles. Therefore in vehicle detection, tracking and segmentation can be achieved efficiently due to changes in the prototype width, region proportion and height with consideration to previous saved or reference images. A unified multi-vehicle categorization and tracking system for various sort of vehicles such as motorcycle, cars, light trucks and heavy trucks on highway and windy road video sequences has been highly recommended. Here it is discussed, a vehicle anisotropic distance measurement achieved through the 3D geometric shape of vehicles.

6.4 Feature-Based Tracking Methods

The proposed framework showed under this subsystem is a good performance for vehicle classification in surveillance videos despite of few significant challenges such as limited image size and quality.

A line-based shade method is the linearity feature technique which is proposed and uses lines groups to remove all the undesirable shades. Finally, this feature based tracking method represents an automatic vehicle tracking and classification also traffic observation system.

During the image series the automatic unique visual-based expressway surveillance approach is used for segmenting and tracking vehicles.

6.5 Color and Pattern-Based Tracking Methods

Under this subsystem of color and pattern based tracking a color image series of traffic supervision views technique is used by this. It has been proven by the practical experiments that this system is proven to work under several weather situations, also it is insensitive to lighting.

7. CONCLUSION AND FUTURE IMPROVEMENTS

Some future works can be done in order for the improvement and extension of our work for better performance. This work is efficient when as it works well with normal lighting conditions. However, it needs much improvement to address different use cases. Just to clear this case an example can be seen where it can be improved, a portion of the lane is a freshly paved and is different in color with the other portion of the lane which is an older paved road.

Another improvement that can be done on this algorithm is in cases where the camera is hit by the direct sunlight falling on it which has glare as a result, and in other high contrast cases where the lane lines appear to be washed out making it harder to detect.

To address such type of situation it can be done by dynamically adjusting the contrast of the images to ensure that the lane lines in the images are not washed out and also make sure that whether the algorithm has a good dynamic range in all lighting conditions.

In cases of curvy roads and roads which have a slope, it would make really difficult to warp the images properly and it may lead to cause problems for the algorithm. To address this issue a dynamic region of interest for each image frame can be created.

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