VOTING SCHEME BASED ESTIMATION OF VANISHING POINTS FOR ROAD DETECTION

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Abstract
Road detection is an important research topic in computer vision with different applications like autonomous driving [1], vehicle collision warning, pedestrian crossing detection, or road scene understanding. Every year many people lost their life in road accidents because of driver inattention. Vanishing point detection systems are useful in avoiding such accidents as safety is the main purpose of this system. Vanishing point locations play a critical role in determining the perspective orientation of roads. In this paper, an efficient vanishing point detection algorithm for non-structured scenes is proposed. The technique relies on a voting scheme based on well-understood rules for the grouping of lines. Vanishing point candidates are detected with the help of voting scheme. Estimation of the dominant orientation is the first step in vanishing point estimation algorithm. Second step is to estimate the location of the vanishing point from detected vanishing point candidates and finally, orientation consistency ratio is used along with new vanishing point edge Detection algorithm for detecting road boundaries.

Index Terms: vanishing point detection, soft voting, road detection, edge detection.

I. INTRODUCTION

The vanishing point can be defined as a point generated by converged perspective lines, which may be parallel in the real world. Many natural scenes possess sets of lines which are parallel in the 3D world. Many natural scenes possess sets of lines which are parallel in the world. When these lines are projected under perspective projection, the lines project onto the image plane as lines which have a common Intersection point - the vanishing point. If, therefore, we can locate vanishing points in an image, and the lines, which intersect at it, then we have obtained some information about this set of lines which will prove useful when interpreting the world scene from the image [6].

Sets of lines in the 3D world which are coplanar project onto lines whose vanishing points lie along a straight line in the image plane - the vanishing line. Determining two or more vanishing points which lie on a vanishing line gives a very strong cue about the true geometric relationships between objects in the image scene.

The problem of vanishing point estimation has been addressed many times in the past decade. Most of the existing approaches fall into two categories: edge-based methods and texture-based methods. Edge-based methods identify line segments (lane markers and road boundaries) in edge detector outputs and determine the vanishing point by searching a point close to most line segments. First, there are vanishing point detection methods using segmented lines. Locally adaptive soft-voting (LASV) scheme is proposed to overcome this problem. The scheme uses a local voting region, in which Pixels having low confidence texture orientation estimation are discarded. This
vanishing point estimation method is quite efficient because only the selected pixels in the local voting region are used as voters.

To segment the road area, a vanishing-point constrained group of dominant edges are detected based on an Orientation Consistency Ratio (OCR) feature, and two most dominant edges are selected as the road borders by combining color cue. This road detection method integrates texture Orientation and color information of the road, and it handles well changes of illumination and applies to general road images.

II. RELATED WORK

Several vanishing point detection methods have been proposed for various applications. Lot of work has been done in this area. Color cue [7]–[9], Hough transform [10], [11], steerable filters [12], [13], and Spline model [14]–[16] et c. have been utilized to find the road boundaries or markings drawback of this method is that the original distances between lines and points are not preserved, because the straight line is represented as a point in the Hough space [5]. In [11], the J-Linkage algorithm is employed to find a set of vanishing points from a set of edges. They work well on engineered roads such as highways that are painted with parallel lines clearly, but fail in scenes that possess neither strong edges nor contrasting local characteristics.

Texture-based methods, e.g., in [5,6], analyze the dominant orientation of texture in the image to identify dominant orientation rays and determine their intersection as the vanishing point.

The other trend in vanishing point detection is based on accumulated voting of texture orientation in the image. Rasmussen [6] proposes a method to detect vanishing points in the road image using the multi-scale Gabor wavelet filter. In [6], the vanishing point location is voted from the acquired dominant texture orientation at each pixel.

Hui et al. [4] first apply the Gabor filter to compute the dominant orientation at each pixel in a road image, and then detect the vanishing point using distance between vanishing point candidates and every pixel in the local region.

The scheme uses the adaptively sized local voting region, in which pixels having low confidence texture orientation estimation are discarded.

For example, some are restricted to images containing man-made objects, such as indoor images or road images. To overcome the problems, we propose block-wise extraction of perspective lines using edge orientation information. The reason why we extract edge orientation block-wise is as follows. It is hard to extract dominant perspective lines passing point by using line segment method because of unwanted noise edges.

In [12] use a steerable filter to extract main straight lines, and detect not only lines passing through vanishing point but also other strong edges. Stereo cameras are also used to determine terrain traversability. The one characteristic that seems to define the road in such situations is texture. They compute the texture orientation for each pixel, then seek the vanishing point of the road by a voting Scheme, and finally localize the road boundary using the color cue. This approach belongs to this line of research. Although multiple-sensor method [17] can handle unstructured road case, it is beyond the scope of this paper which only uses visual information. The rest of this paper is organized as follows: a texture orientation estimation at each pixel for which a confidence level is provided in section III. A voting scheme taking into account this confidence level and the distance from the voting pixel to the vanishing point candidate is discussed in section IV. Road border estimation has been done by finding new left and right vanishing points on the horizontal line of the estimated vanishing point and find OCR from that two vanishing points to draw imaginary lines and select road borders in given in section V and finally conclusion is given in section VI.

III. ORIENTATION ESTIMATION

At first a dominant texture orientation (P) is computed at every image pixel=(x, y). Second assuming a straight, planar road, all dominant orientations in the image vote for a single best road vanishing point. In Gabor Filter, For an orientation and a scale(radial frequency), the
Gabor wavelets (kernels, filters) are defined by
\[
\varphi_{\omega_0, \Phi}(x, y) = \frac{1}{\sqrt{2\pi \sigma^2}} e^{-\frac{1}{2} \left(\frac{x^2}{\sigma^2} + \frac{y^2}{\sigma^2}\right)} (\cos\Phi - \frac{y}{\sqrt{2}} + \frac{x}{\sqrt{2}})(\sin\Phi + \frac{x}{\sqrt{2}} - \frac{y}{\sqrt{2}})
\]
(1)
where \(a = \cos\Phi + \sin\Phi, b = -\sin\Phi + \cos\Phi\) and \(c = 2.2\). Consider 5 scales on a geometric grid \((\omega = \omega^0 \times 2^k, \omega^0 = 2.1, K = 0, 1, 2, 3, 4)\) and 36 orientations \((180/5)\). Let \(I(x, y)\) be the gray level value of an image \((x, y)\). Convolution of image \(I\) and a gabor kernel of scale \(\omega\) and orientation \(\Phi\) is defined as in equation number 2.

\[G_{\omega, \Phi} = I \times \psi_{\omega, \Phi}\]
(2)

To best characterize the local texture properties, compute the square norm of this “complex response” of the Gabor filter for each 36 evenly spaced Gabor filter orientations as in equation number 3.

\[I_{\omega, \Phi}(z) = \text{Re}(G_{\omega, \Phi}(z))^2 + \text{Im}(G_{\omega, \Phi}(z))^2\]
(3)
The response image is the average of the responses at the different scales as in equation no 4.

\[R_{\Phi}(z) = \text{Average}_{\omega} I_{\omega, \Phi}(z)\]
(4)
The texture orientation = filter orientation which gives the maximum average complex response at that location

\[\Phi(z) = \text{Argmax}_{\Phi} \Phi(z)\]
(5)
Let \(r_1(z)\) to \(r_{15}(z)\) be the ordered values of the about response for the 36 considered orientations To provide a confidence level to the texture orientation \(\Phi(z)\) at pixel \(Z\), \(r_1(z) = R_{\Phi}(z)\). Choose the average of the responses from \(r_5\) to \(r_{15}\) (\(r_2, r_3, r_4\) corresponds to similar angles to the optimal one) as the mean of the local maximum responses. The confidence in the orientation is given by equation no (6)

\[\text{Conf}(z) = 1 - \text{Average}_{r_5(z), r_{15}(z)} r_1(Z)\]
(6)
This proposed algorithm improves query processing performance by spatial neighborhood of data objects during query execution. Normalize Confidence throughout the image to the range of 0 to 1. In our experiments, the pixels having a confidence score smaller than \(T\) (\(T=0.3\)) are discarded and by considering the remaining pixels as the “voting” pixels. \(T\) can be seen as a threshold put on the normalized confidence score. The confidence voters are marked in red colour.

IV. SOFT VOTING TO FIND VANISHING POINT

Different voting schemes like “Hard-voting” strategy has been used in, leading sometimes to large errors in the estimation of the vanishing point and a ”Soft-Voting” scheme where the voting score received by a vanishing point candidate from a voter is a value taking into account the distance between the vanishing point candidate and the voter. Candidate vanishing point each pixel in the top 90% portion of the whole image is a realistic assumption for general road images. For each point of the image, we define a voting region \(V_r\) as the intersection of the Gabor response image with a half-disk below centered at \(V\) as in fig 4.1.

\[\text{Vote}(p, v) = \begin{cases} 1 & \text{if } \gamma \leq 5/1 + [\gamma d(P, V)]^2 \\ 1 + 2d(P, V) & \text{Otherwise} \end{cases}\]
(7)
The ratio $d(P,V)$ is the distance between $P$ and $V$ to the diagonal length of the image where $\gamma = \langle (PV), Op \rangle$ be the angle in degrees between the direction $(PV)$ and the texture orientation at $P$. The points that are far away in the region $V_r$ are taken into account only if the angle $\gamma < 3^\circ$ but points closer to $V$ will be taken into account if $\gamma \leq 5^\circ$. vanishing point candidates in the top end of the image who has an advantage of receiving more votes than the lower vanishing point candidates. At the end, the vanishing point is detected as the candidate that receives the largest Voting score.

(a)  
(b)  
(c)  
(d)  

Figure 4.1. (a) Image of confidence map (b) Image of confidence overlap (c), (d) Vanishing point detection.

V. ROAD BORDER ESTIMATION

The detected vanishing point used to provide constrained dominant edge detection method to find the two most dominant edges of the linear road images. Based upon the two dominant edges, we can roughly segment the road area and update the vanishing point estimated by LASV with the joint point of the two most dominant edges. In [3] a general road border using vanishing point constrained edge detection occurs in linear images only, fail to estimate road borders on curved road images, highly illuminated. The main difference between this method and my proposed method is that by using control points that obtained using OCR and color hue. It is achieved by optimizing a criterion, which is the difference between the average values of some characteristic (e.g., R, G, B color cues) within the image road region and that characteristic in the region outside the road.

However, it usually fails for both cases where there is little difference in color between road and off road regions, and where the color is not homogeneous in road region. In [7] another method was used to improve lane detection accuracy under different road conditions for intelligent vehicles, by boundary detection algorithm based on color features and OCR.

Road border detection is a key issue for autonomous driving in urban traffic. A road area detection algorithm based on color images composed of two modules: boundaries are first Estimated based on the intensity image and road areas are subsequently detected based on the full color image.

The initial vanishing point is estimated using LASV. Draw a horizontal line segment from the estimated vanishing point. By using color difference of the adjacent pixels on the line we can find out the left and right vanishing points $V_L$ and $V_R$ on the line of the initial vanishing point. From that left vanishing point, $V_L$, draw imaginary lines by finding out orientation consistent ratio (OCR). If $L$ is a line consisting of a set of discrete oriented points/pixels. For each point, if the angle between the point’s orientation and the line’s direction is smaller than a threshold, this point is viewed to be orientationally consistent with the line. OCR is defined as the ratio between the number of orientationally consistent points and the number of total points on the line. Most dominant road boundary are found out from the left vanishing point, $V_p1$, from a set of imaginary rays which originate from the estimated vanishing point.

Two measures are computed: the sum of the OCRs of each ray and its two direct neighbors and the color difference between the two neighboring regions of each ray as shown in equation number 8.

$$b = \text{arg } \max (\text{diff}(A_1, A_2) \times \text{OCR}) \quad (8)$$

where $A_1$ and $A_2$ is the two direct neighboring regions on either side of the $i$th ray.
and a $\text{diff}(A1,A2)$ is the color difference of $A1$ and $A2$

$$\text{Diff}(A1,A2) = \frac{\left| \text{mean}(A1) - \text{mean}(A2) \right|}{\text{var}(A1) + \text{var}(A2)}$$ (9)

Using OCRs and color hue, find out control points which is used in new vanishing point edge detection algorithm to draw the border line.

(a)                              (b)                    (c)

Figure 4.1. Road Estimation (a), (b) Sketching of imaginary lines, (c) Detection of border in a road image.

VI. CONCLUSION

A novel method to perceive the general road region from a single image is proposed based on road vanishing point detection using voting scheme. With the help of detected vanishing points dominant edges are detected. In the voting procedure, only the pixels of a local voting region with high confidence score are used, which reduces the computational complexity and improves the accuracy significantly. This proposed method outperforms well the state-of-the-art vanishing-point detection methods.

REFERENCES


