Ridgeness for Detecting Lane Markings

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***Abstract*—Edges are usually in the core of lane markings detection. Here we propose *ridgeness* as low–level image descriptor, expecting to perform better than edges in adverse circumstances.**

***Index Terms*—Image processing, lane detection.**

I. Introduction

THE main social challenge of automotive industry is to develop low cost advanced driver assistance systems (ADAS) able to increase traffic safety. Since vision is the most used human sense for driving, some ADAS features rely on camera based systems [1]. For instance, lane departure warning and lateral control could be reached by detecting the lane markings of the road using computer vision techniques, and this is the problem we address here. In fact, many works have been done on detection of lane markings [1], which is not surprising since it is a difficult problem due to different common situations: shadows, vehicles occluding the marks, dirty, etc.

Basically, the different proposed algorithms have a first step to collect evidences of where the lane markings are, and a second step that uses them to fit a lane model. Tracking is also added to get rid of clutter and facilitate real–time. The first step is usually based on image edges, relying both in high values of the image gradient magnitude and expected gradient orientations. However, the gradient magnitude can be also high due to the contrast between the asphalt and road elements (*e.g.* vehicles) but it can also be low because shadows, wear marks, etc. Moreover, the gradient orientation tends to be noisy because its local nature.

II. Lane Markings as Ridges

In this paper we propose an alternative to edges, in particular, we propose *ridgeness* with the aim of being more robust in the mentioned challenging situations. In general, by ridges of a luminance image we refer to the central lines of the elongated bright structures appearing in it. This nomenclature comes from seen an image as a landscape, since then these central lines are the top of the landscape's ridges. Ridgeness stands for a degree of how much a pixel resembles a ridge.

In our case we see a lane marking as an elongated mountain and, then, its ridge is the longitudinal center of the painted line. Therefore, a ridgeness measure must have high values near this center and low far. If we want the ridges we can threshold the ridgeness.

There are different mathematical definitions to characterize ridges. However, in [2] we proposed one that compared favorably to others and that we have adapted for the problem at hand. For the sake of simplicity, instead of reproducing here the definition we comment its benefits for detecting lane markings and present examples.

First, the proposed ridgeness measure is invariant under monotonic grey–level transforms of the input image, which, in practice, helps to the lane detection task in presence of shadows. Second, the process of obtaining the ridgeness measure also yields the *dominant gradient orientation* of the original image. Therefore, we have a more robust image orientation measure than the image gradient itself. Thanks to that, we can remove ridgeness at pixels whose associated orientation is not coherent with the expected for the lane markings. Figures 1 and 2 show the ridgeness obtained in different difficult situations.

To asses the usefulness of this low–level descriptor we devised a method to delimit our lane:

1) Compute the ridgeness.
2) Obtain a *bird–view* of the ridgeness.
3) Perform the Hough transform of the bird–view.
4) Search the maximum of the transform and map it back to the original image, which gives a straight line that goes through the center of either the left or the right mark of our lane. If it corresponds to the left one, then we search another maximum in the Hough transform around a region where the right mark is expected. (Analogously if the right mark is found first).

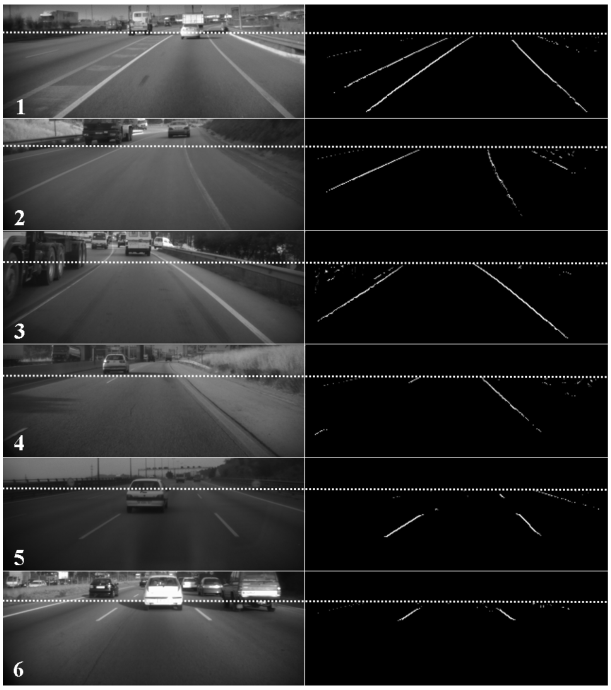

Fig. 1. Right column: ridgeness of lane markings. The dotted line is the fixed horizon. In the original images we see deteriorated lane markings: (1) mainly the left line; (2) the right one; (3) the left one (partially black because of wheel residues after some hard brake); (4) the right one. (5–6) White vehicles in the scene.

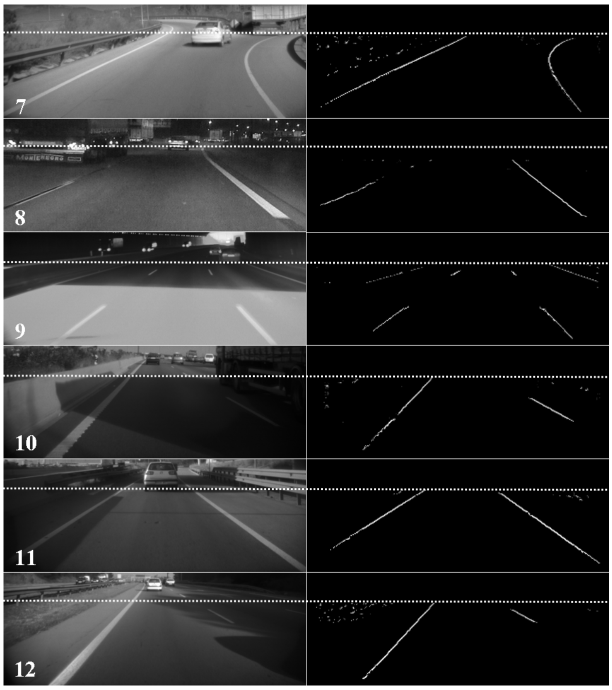

Fig. 2. (7) High curvature right curve. (8) Night image with a dirty left discontinuous line. Shadows: (9) entering a tunnel; (10) the left line is partially in shadow and the right is completely; (11) The left line is completely in shadow; (12) The discontinuous right line completely in shadow.

With the second maximum mapped back to the original image we have the two straight lines that delimit our lane. Besides, we control the temporal coherence of the extracted lines and identify lane changes (Fig. 3). For 640×480 images the whole algorithm runs in about 15 *ms* in a 2.0 GHz Pentium.

Fig. 3. Lane change in presence of a truck. The system identifies the manoeuver and only shows the line we are crossing (2 and 3).

III. Conclusions

In the context of lane markings detection from a forward–facing camera, we have introduced ridgeness as low–level image descriptor. We have illustrated how this measure is able to output high values indicating the presence of lane markings, and only lane markings, even in challenging situations. We have used ridgeness in a first prototype that delimits the lane and detects lane changes by approximating lane markings with straight lines of maximum ridgeness accumulation. As future work we plan to obtain curves from the same ridgeness information.

References

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