Lane Detection in Adverse Visibility Conditions for Autonomous Driving Assistance

Rohit Kumar Sharma
rsharma54@wisc.edu

Varun Batra
vbatra@wisc.edu

Vibhor Goel
vgoel5@wisc.edu

1 Problem Statement

Given the fact that we are headed towards autonomous driving vehicles, lane detection becomes one of the key aspects for it. Although, there has been some work in the domain of Lane Detection [Lee and Moon, 2018] [Wang et al., 2018] [Leng and Chen, 2010], real time implementation of robust lane detection algorithms is still missing for adverse weather conditions. In fact, Escanilla et al [Hancock and Escanilla, 2018] at UW-Madison have done some novel work in the domain of lane detection last year. Over the years, several works on removal of rain and snow from image scenes [Shibata et al., 2014] [Fu et al., 2017] [Shen et al., 2018] [Li et al., 2017] have been proposed. We wish to research and integrate the task of image de-snowing and de-raining with lane detection to provide assistance in autonomous driving vehicles. If time permits, we would like to explore the problem multiple-lane detection in a video sequence as well.

2 Motivation

Lane detection is one of the most important and preliminary tasks of autonomous driving. Good lane detection can lead to better automation and enhanced driving experience. If the lane detection is not done properly, there can be adverse effects in autonomous driving which may even lead to accidents. Therefore, the accuracy of lane detection is equally important in good conditions as well as in conditions with adverse visibility conditions such as when it rains or snows.

A lot of work has been done in the domain of lane detection and noise removal separately. But, there seems to be no robust solution for filtering the noise from conditions such as rain and snow and then perform lane detection, both the tasks together. Therefore, we propose to achieve this task of lane detection in adverse conditions by employing existing state-of-the-art deep learning based noise removal algorithms and then detect the lanes.

3 Related Work

Our task for image de-snowing and de-raining for lane detection is a combination of three aspects. The first aspect focuses on lane detection. Several authors have proposed techniques for lane detection, especially with the advent of autonomous driving systems. [Kumar and Simon, 2015] presents a comprehensive review of current state of art techniques in lane detection. [Lee and Moon, 2018] propose a robust vision-based lane detection algorithm for tracking lanes in real-time scenarios. They also focus on other aspects such as poor visibility, lack of lane marking clarity, which are especially relevant for our task.

The second aspect focuses on detecting the noise of rain and snow in images. [Bossu et al., 2011] propose a computer vision based system for de-noising the rain and snow on image sequences. The authors use the approach of separating the foreground from background in image sequences using a Gaussian mixture model. In a sequence of images, the dynamic foreground represents the noise due to rain or snow.

[Wang et al., 2017] focus on removing snow or rain from a single image, which identifies with our objective. The paper combines two approach: image decomposition and dictionary learning. [Zheng et al., 2013] use another approach of multi guided filter to remove rain and snow based noise from single image. The authors propose method based on separating the low frequency non-rain and non-snow part from the image.

The third aspect focuses on detection of snow on surface and separating it from lane. The authors in [Shibata et al., 2014] work closely focusing on this aspect, where they detect the road surface conditions based on texture fixtures and Mahalanobis. They first extract the road area from the images, which may contain noise such as rainfall, snowfall and snow. The authors further focus on false detection of snow due to white areas from extra illuminated surfaces in wet images. We aim to further tackle these problems in our approach.

4 Project Outline and Timeline

We propose to achieve the task of lane detection in adverse conditions in a two stage process. The first stage is to pre-process the image to detect the type of noise if any such as rain or snow and filter it out. After filtering the noise from the image, the next stage is to detect and track lanes.

In our actual implementation, we will first create a working baseline model by implementing a simple algorithm to detect lanes in good visibility conditions during daylight. We will then implement advanced de-noising models to enhance the lane detection accuracy for adverse visibility conditions.

The timeline for the project can be found in Table 1. Our work distribution timeline is as follows:

- Feb 14 - Feb 25: Empirically analyze the works done in the domain of de-noising and lane detection. Additionaly, come up with a plan to perform de-noising and merge with some novel lane detection technique.

- Feb 26 - Mar 10: Search and gather permissions to get access to suitable databases. Download and integrate the data with our code base. Collect additional dataset, if needed, for lane detection.

- Mar 11 - Mar 24: Get hold of lane detection and come up with a working code for lane detection with good accuracy.

- Mar 25 - Mar 27: Compiling results and writing the mid term report.

- Mar 28 - Apr 12: Implement the de-noising solution for snow/rain using deep learning techniques.

- Apr 13 - Apr 19: Integrate the lane detection and de-noising solution.

- Apr 20 - May 6: Compiling results for the project presentation and writing the final report.

To evaluate the performance of the model, we want to consider the following scenarios: the predictions of the model are indeed lane boundaries (the model does not predict a sidewalk or a divider as a lane for example) and that if there is a lane in an image, the model does not fail to not detect it. These scenarios can be quantified by metrics such as *precision* and *recall*. Apart from these, we will also evaluate the model based on the *accuracy* and *F-1 score* metrics.

Task #	Milestone	Target Date
1	Literature Survey	02/25/2019
2	Gather Data-set	03/10/2019
3	Implement Lane Detection without Noise	03/24/2019
4	Mid-term Report	03/27/2019
5	Implement De-noising	04/12/2019
6	Integrate De-noising and Lane Detection	04/19/2019
7	Project Presentation	04/22/2019
8	Publish Final Website	05/06/2019

Table 1: Project Timeline

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