SafeDrive: A Robust Lane Tracking System for Autonomous and Assisted Driving Under Limited Visibility

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SafeDrive: Introduction

- SafeDrive is an approach towards robust lane tracking for assisted and autonomous driving, particularly under poor visibility
- SafeDrive attempts to improve visual lane detection approaches in drastically degraded visual conditions without relying on additional active sensors other than those found on a smartphone device.

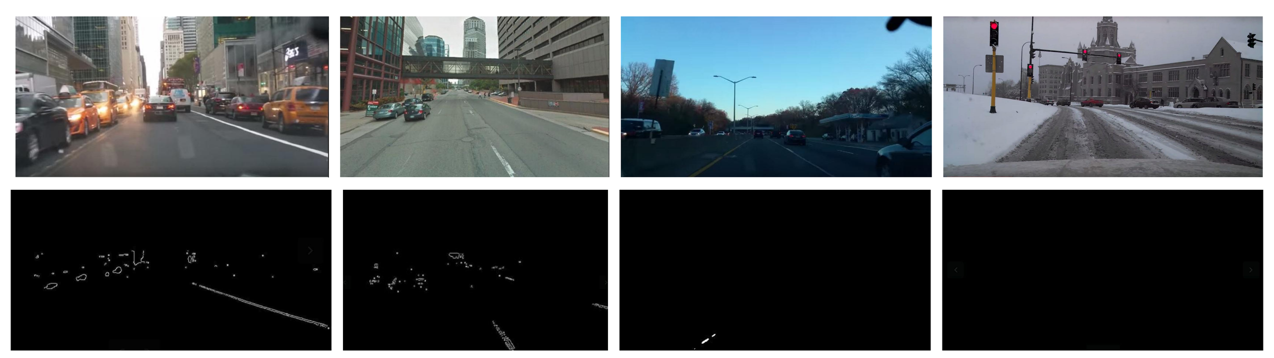

Figure 1: Visual lane tracking on several urban scenes. Top row: a number of images from dash cameras. Bottom row: output of a lane tracking system, demonstrating the challenges arising from variable lighting, occlusion and weather in detecting lane markers reliably.

Motivation

Recent advances in affordable sensing and computing technologies have given new impetus towards increasing autonomy in transportation systems, the most prominent of which is in the area of self-driving cars. Alongside fully autonomous commercial vehicles, mainstream auto manufacturers are equipping their vehicles with more intelligent technology with semi-autonomous, human assistive features to increase safety. However, these additional features are often expensive, require specific vehicle data and power interfaces, limiting their application to newer vehicles. However, to minimize the effect of distracted driving (which has approximately 20 per cent contribution to road fatalities) and improve safety, buyers are opting to buy newer vehicles with these features pre-installed. SafeDrive is a significantly inexpensive approach for robust visual lane detection in severely degraded conditions, without relying on exotic, costly sensors which would be prohibitive for financial and compatibility reasons.

Key Features

- Under poor visibility, the system uses the vehicle's location data to locate alternate images of the road ahead from an available "road-view" database.
- Once these images are acquired, a visual lane detection algorithm is applied to find the lane markers.
- Subsequently, 3D scene is reconstructed using alternate images. Then, current view is registered with the 3D world. Based on this, lane markers are projected onto the current view.
- SafeDrive uses location, orientation and image data from the smartphone device; no other sensors are used.
- An Android^{TM} app called DriveData[1] is currently being used to collect driving data and create our own custom database.

[1]https://github.com/fultonms/drivedata; contribution by Michael Fulton

Methodology

The SafeDrive lane detection process is depicted in the flowchart below.

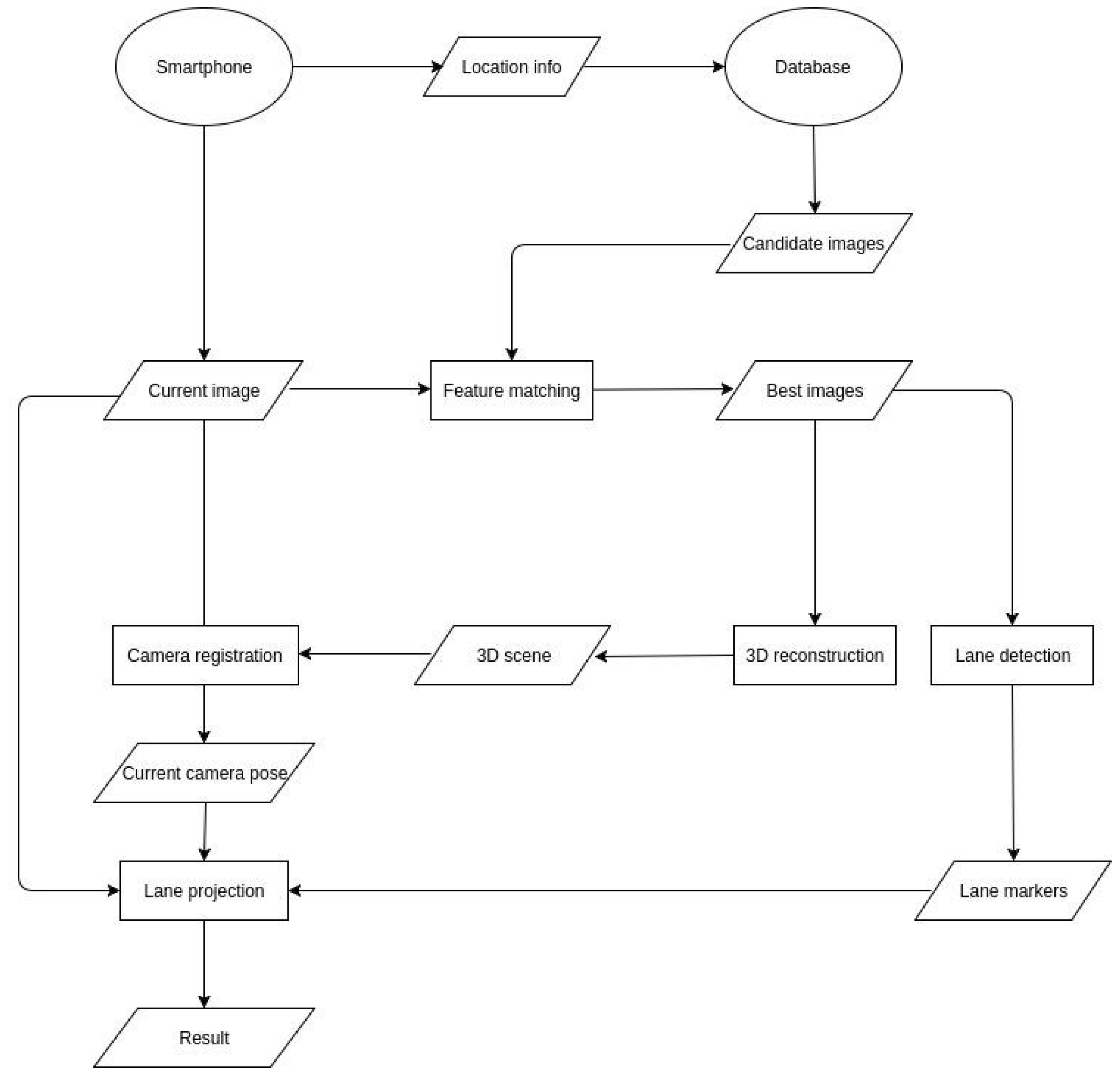

Figure 2. Flowchart of SafeDrive, including feature matching, lane detection, 3D reconstruction, camera registration, and lane projection.

- Best images are selected based on the number of matched feature points.
- Top two best matched images are used for 3D reconstruction.
- In 3D reconstruction, essential matrix is extracted, assuming camera parameters are available.
- Camera registration is done by solving PnP problem on matched feature points.
- Lane markers are detected using color-based matching, exploiting the fact that almost all lane markers are painted either white or black.

Datasets

- Test data collected from driving in various locations in US and Canada.
- Android ^{TM} app called DriveData created to collect data specifically needed by SafeDrive.
- Google Street View^{TM} also used as database source for SafeDrive.

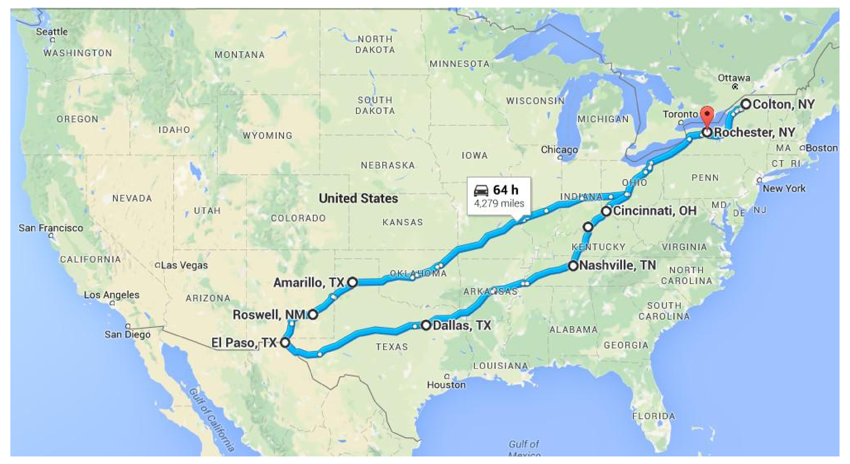

Figure 3. DriveData was used to capture data from long driving runs, such as this one from upstate New York to Colorado, a round trip distance of approximately 4,279 miles.

Results

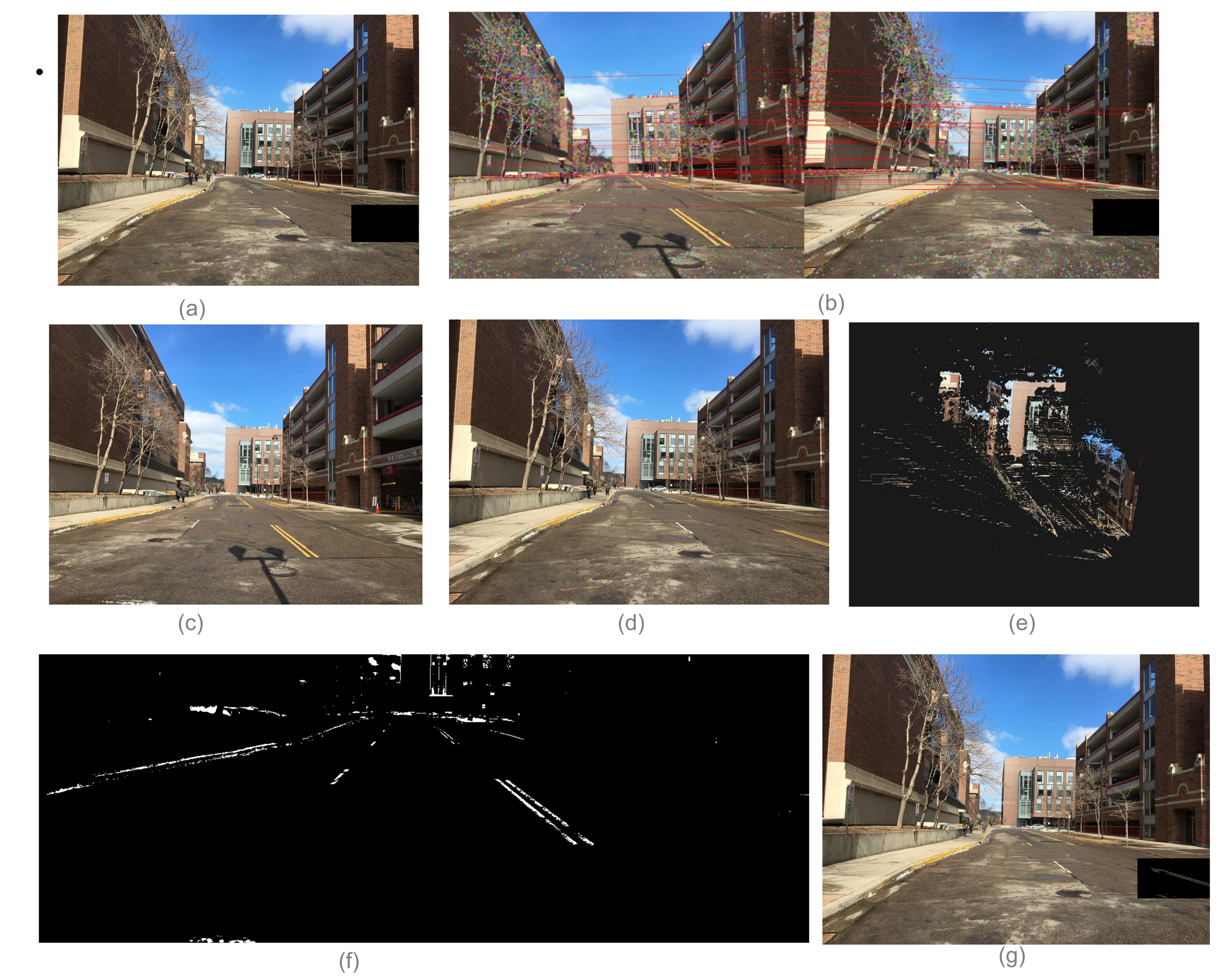

Figure 4: Experimental evaluations. (a) current image from the camera, (b) feature matching of current image against database images, (c)(d) top two images of best match, (e)3D scene reconstructed from c,d (f) lane detection result (g) final result.

Conclusions and Future Directions

SafeDrive[2] is an algorithm for visual lane detection and tracking under poor visibility conditions, and even in cases the road surface is barely visible. This approach leverages the availability of alternate imagery of the same location and the ability to perform lane tracking in such imagery, eventually mapping the lane detection back to the original camera image. With sufficiently robust visual lane-finding algorithms, accurate pose detection, and robust methods to relate the past image with the live frame, we believe this algorithm can significantly improve driver safety.

Current and future work will address the following:

- compressed data handling and optimization for enhanced performance,
- extensive testing on data collected from a diverse set of geographic locations

The ultimate goal for our work is to create an affordable system, and simultaneously improve the quality of autonomous transportation and occupant safety in road-going vehicles.

References

[1] Junaed Sattar and Jiawei Mo. SafeDrive: A Robust Lane Tracking System for Autonomous and Assisted Driving Under Limited Visibility. ArXiv:1701.08449. January 2017.
[2] Speeding-Related Traffic Fatalities by Road Type, Speed Limit, and State: 2009. Online, December 2012.
[3] Sebastian Thrun. Toward robotic cars. Commun. ACM, 53(4):99–106, April 2010.

[2]https://github.com/jiawei-mo/SafeDrive/