A literature review of steering angle prediction algorithms for Self-driving cars

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Abstract

A crucial requirement for intelligent, driverless cars is to maneuver without moving out of its drivable region of the road. It is well known that steering angle calculation plays an important role in maintaining the vehicle in the center of the road or within the boundary lanes to meet safety critical requirements. This work presents a review of autonomous steering techniques for self driving cars which is a relatively unexplored task in the fields of computer vision, robotics and machine learning. Our research investigations lead us to conclude that the combination of ResNet50 deep architecture with event cameras can be assumed to give better prediction of the due wheel angle. An overview of future research direction and applications is also given.

A review of the Literature

Steering angle prediction algorithms are divided into two categories as shown in **Fig. 1**.

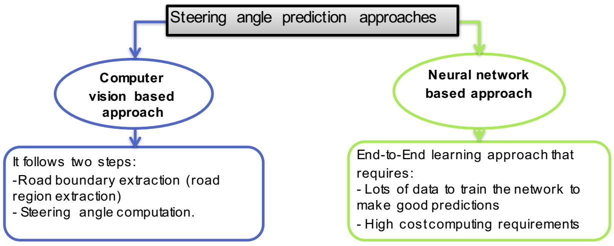

Fig 1: The two main approaches for steering angle prediction

❑Computer vision based approach

❖ Umamaheswari et al.'s method (2015)

Umamaheswari et al. have used Euclidean method to calculate the steering angle. However, it also seems to be limited to the case where both the boundaries or either one of them is visible, also to slow and smooth turns rather than sharp turns.

❖ Ranjith Rochan et al.'s method (2018)

Ranjith Rochan et al. (2018) proposed a novel method for steering angle calculation for autonomous vehicles using computer vision techniques of relatively lower computing cost (see **Fig.2**.)

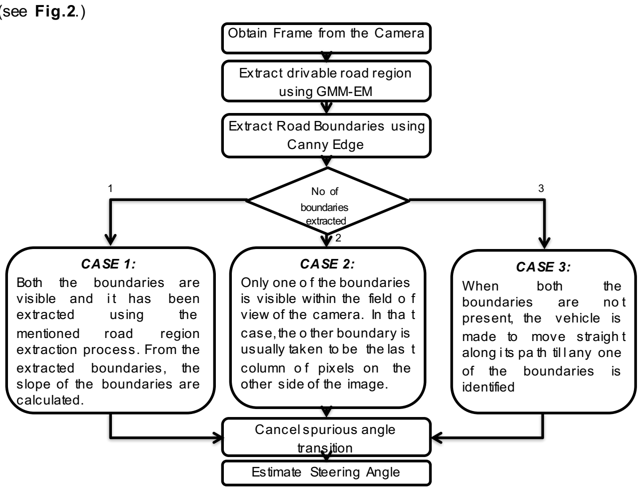

Fig 2: System architecture for steering angle prediction (Ranjith Rochan et al.)

The required steering angle will be the deviation of the point of intersection of the boundaries from the orientation of the vehicle (midline of the image) as shown in **Fig.4**. The root-mean-squared error (RMSE) value is found to be 2.598.

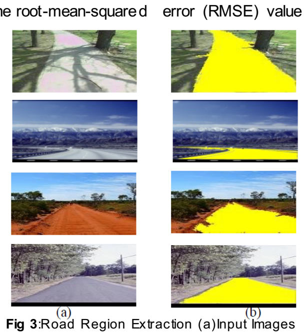

Fig 3:Road Region Extraction (a)Input Images (b) GMM-EM

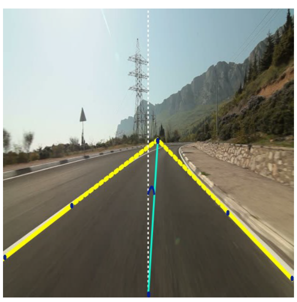

Fig 4: Steering angle calculation

❑Neural network based approach

❖ ALVINN (1989)

ALVINN (1989) was among the very first attempts to use a neural network for autonomous vehicle navigation.
The approach was comprised of a shallow network that predicts actions from pixel inputs applied to simple driving scenarios with few obstacles.

❖ PilotNet (2016)

Bojarski et al. proposed a solution called PilotNet (itself inspired from ALVINN model (1989)).
It is a convolutional neural network (CNN) based approach that maps raw pixels from a single front-facing camera directly to steering commands (see **Figs. 5** and **6**).

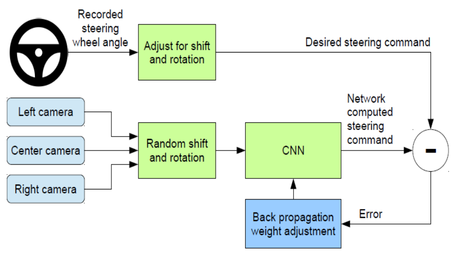

Fig. 5: PilotNet block diagram for training.

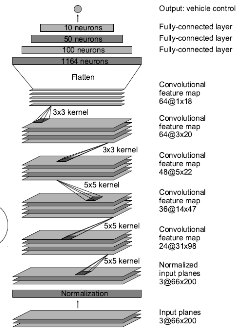

Fig. 6: PilotNet CNN architecture.

❖ Deep-Steering (2017)

Deep-Steering (Chi and Mu) is a method that predicts steering angle in a stateful process. It takes into account instantaneous monocular camera observations and vehicle's historical states.
Experimentals results (see Table 1)

Table 1: Deep-Steering vs PilotNet performance.

Model	RMSE
PilotNet	0.1604
Deep-Steering: ST-Conv + ConvLSTM + LSTM	**0.0637**

❖ Event camera – ResNet50 network (2018)

Maqueda et al. introduced a new approach that predicts steering wheel commands from a forward-looking DVS sensor mounted on a car.
It was done by adapting state-of-the-art convolutional architectures to the output of event sensors as shown in **Fig. 7**.

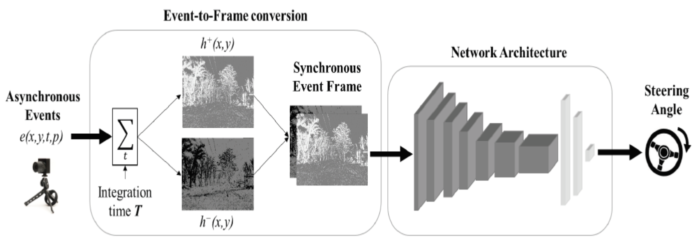

Fig. 7: Block diagram of the event cameras-based approach .

Concluding Remarks and Future Work

A comparaison made between 3 deep networks (**Table 2**) shows that **event cameras** combined with state-of-the-art **ResNet50** network **gives a good results** (RMSE = 4.10°)

Table 2 : Performance analysis between ResNet50 deep architecture that processes event frames against two state-of-the-art learning approaches using grayscale frames.

Architecture	Input images	EVA	RMSE
PilotNet	Grayscale	0.161	9.02°
CNN-LSTM	Grayscale	0.300	8.19°
ResNet50 architecture: (ImageNet initialisation)	**Events**	**0.826**	**4.10°**

It would be our future research subject to study the adaptation of the output of event sensors with "**ST-Conv + ConvLSTM + LSTM**" model since it gives competitive results with traditional cameras.