**Introduction**

The paper introduces a new method for 3D lane detection that is based on a bird's eye view (BEV) representation. The method uses a simple and efficient network to extract features from the BEV image and then classifies the features into lane or non-lane. The method is able to effectively detect lanes in images that are affected by heavy shadows, severe road mark degradation, and serious vehicle occlusion. The method achieves state-of-the-art results on a number of datasets.

The paper reviews the related work on 3D lane detection. The authors discuss the different approaches that have been used for 3D lane detection, including methods based on 2D lane detection, methods based on 3D LiDAR, and methods based on BEV. The authors also discuss the challenges of 3D lane detection, such as the variety of road conditions, the occlusion of lanes by vehicles, and the shadows cast by vehicles.

**Methodology**

The BEV-LaneDet method is based on the following steps:

* The image is converted to a BEV representation.
* A simple and efficient network is used to extract features from the BEV image.
* The features are classified into lane or non-lane.
* The lane boundaries are refined using a post-processing step.

The BEV representation is a top-down view of the road, which is used to simplify the lane detection problem. The simple and efficient network consists of a series of convolutional layers and fully connected layers. The features extracted by the network are used to classify the pixels in the BEV image as lane or non-lane. The post-processing step refines the lane boundaries by smoothing the edges and filling in gaps.

**Virtual Camera**

The BEV-LaneDet method uses a virtual camera to project the image to a BEV representation. The virtual camera is positioned above the vehicle and has a wide field of view. This allows the method to capture a large portion of the road in the BEV image.

**MLP Based Spatial Transformation Pyramid**

The BEV-LaneDet method uses an MLP based spatial transformation pyramid to extract features from the BEV image. The MLP based spatial transformation pyramid consists of a series of convolutional layers and fully connected layers. The layers in the pyramid are arranged in a hierarchical manner, which allows the method to extract features at different scales.

**Spatial Transformation**. A vital module of 3D lane detection is the spatial transformation from front-view features to BEV features. The spatial transformation module is a trainable module that is flexibly inserted into the CNN to implement the spatial transformation of the input features, and it is suitable for converting front-view features into BEV geometric features. There are four kinds of commonly used spatial transformation modules.

**Key-Points Representation**

The BEV-LaneDet method uses a key-points representation to represent the lanes in the BEV image. The key-points representation consists of the following features:

**Confidence:** The confidence of each key-point indicates the probability that the key-point is a lane point.

**Offset:** The offset of each key-point indicates the distance of the key-point from the center of the lane.

**Embedding:** The embedding of each key-point is a vector that represents the features of the key-point.

**Lane Height:** The lane height is the height of the lane in the BEV image.

**Total Loss**

The BEV-LaneDet method uses a total loss to train the network. The total loss is a combination of the following losses:

**Cross-entropy loss:** The cross-entropy loss is used to classify the key-points as lane or non-lane.

**Smooth L1 loss:** The smooth L1 loss is used to regress the offset of the key-points.

**Euclidean loss:** The Euclidean loss is used to regress the embedding of the key-points.

**Inference**

The BEV-LaneDet method uses a greedy algorithm to infer the lanes from the key-points. The greedy algorithm starts at a random key-point and then greedily adds key-points to the lane until the lane is complete.

**Experiments**

The BEV-LaneDet method was evaluated on two datasets: the OpenLane dataset and the Apollo 3D synthetic dataset. The method achieved an F-score of 89.3% on the OpenLane dataset and an F-score of 88.5% on the Apollo 3D synthetic dataset.

**Conclusions**

The BEV-LaneDet method is a simple and effective method for 3D lane detection. The method is able to effectively detect lanes in images that are affected by heavy shadows, severe road mark degradation, and serious vehicle occlusion. The method achieves state-of-the-art results on a number of datasets.