

Artificial Intelligence-based Lane Detection Using Satellite Images

Iqra Rehman¹, Hamid Ghous², Mubasher H. Malik^{*3}, Maryem Ismail⁴

^{1,4} Institute of Southern Punjab, Multan, Pakistan

² Australian Scientific & Engineering Solutions, Sydney, New South Wales, Australia

³ Vision, Linguistics & Machine Intelligence Research Lab Multan, Pakistan

Corresponding Author: Mubasher H. Malik (mubasher@isp.edu.pk)

ABSTRACT

Lane detection is one of the most important tasks for tragedy or emergency response using satellite imagery structures. Most researchers adopted Machine Learning (ML) approaches to detect white lines on roads, namely lanes. The literature on lane detection is vast and makes it hard for future researchers to identify the real problem in this area. To identify knowledge gaps, this study compares and analyses the various lane detection and tracking algorithms that have been used in research papers in the past. Additionally, it provides an overview of some of the datasets used in various research papers. The main challenge in detecting the lane using satellite images is the weather, which makes it difficult to achieve the expected objectives.

Keywords: Lane Detection, Machine Learning, Satellite Images, Transfer Learning, Computer Vision, Artificial Intelligence

1. INTRODUCTION

Lane detection is an essential part of the city system, vital to human development in many fields of the undertaking. The lane detection procedure is critical because when an automobile is used on the road, you have to know the exact location of the lanes for you to understand their barriers. Additionally, if a vehicle approaches too closely, it halts entirely. When a specific shape was detected in the image due to satellite imaging technology, traffic signal detection was accomplished by looking at the image's color. Automatic lane detection is possible using Artificial intelligence techniques using satellite imagery structure. Various ML and DL techniques have been employed in the past to meet the set objectives. Many challenges must be resolved, such as the visual issues caused by the various objects surrounding the roads. According to research, most traffic accidents occur when drivers are reckless and don't precisely know where the borders are. Still, due to satellite imagery systems, we can now address this problem. Several problems and challenges have been raised in multiple research papers. Computer vision is a type of artificial intelligence used to train different types of computers to understand the visual images of datasets. Computer vision can be used to extract high-dimensional data from real word images. It also includes how to process, analyze and understand digital images. This image understanding can be viewed as separating all information necessary to build physics, learning theory, and using geometry.

Previous papers have discussed three lane detection approaches: CNN-based, ML, and DL approaches. Only a few studies provide a comprehensive review of the lane detection method using ML and DL techniques. To identify knowledge gaps for future research, this review paper uses various ML and DL techniques to examine the prior literature deeply and thoroughly on lane detection.

2. LITERATURE REVIEW

In the past, many researchers used data mining methods to enhance the detection of lane detection and provide the results to detect the images around the roads so that they receive the sign to stop the cars or vehicles. Different types of image segmentation techniques also have been used in previous papers.

2.1 Pertained CNN-Based Approach

Using satellite images and a Transfer learning (TL) method, a dataset of 53,686 photos from the USA and 1,000 pictures from Nigeria is used to predict street road quality [1]. Twenty-four hundred kilometers of primary road images were taken. Seven hundred twelve images were labeled low-quality roads, and Forty-seven thousand five hundred fifty-seven were labeled as high-quality roads. Bilinear interpolation was adopted for image resizing into 200 x 200 pixels. CNN Architecture Inception ResNetV2, InceptionV2, VGG16, ResNet50V2, DeNseNet201, RESNET50, RESNET152V2, Xception were deployed. The highest accuracy of 99.4% was achieved. In the end, their exploratory look at case on Nigerian roads verified the power of the approach. It showed that a small amount of nearby information might offer enough effects.

To maintain precise, up-to-date data on the rural road network, a data set of 1000 km of roads with a width of 5 to 12 m and 10,000 randomly selected subsamples as images using drawn was collected from Canada. Rapid, Eye participatory GIS and DL are employed in an extraction and updating operation[2]. They used quick eye imagery techniques and pre-

processed ground truth data to extract images with dimensions of 300 x 300 pixels. They employed a DL technique that used accuracy and precision. They achieved an accuracy of 89-91%. But a lot of time has been spent adding new roads regularly.

A dataset of 100 images was used for research on street Extraction of far-off Sensing pictures based on a Convolutional Neural network[3]. They used demising and area detection techniques. They used distinctive methods like DMES, AUA, and CNN. They carried out with 93% accuracy using those strategies [4]. They used thick traces and branched strains and a multi-class category method to beautify the picture exceptionally. They used different methods like CondLaneNet(ResNet-34), SCNN, Enet-SAD, PointLaneNet, CurveLane-S CurveLane-M, CurveLane-L, CondLaneNet-S, CondLaneNet-M, and CondLaneNet-L. They achieved 97% accuracy.

Dataset Frame 6408 and 133235 with a resolution of 1280x720 (TUSimple and CULane) were used for Lane Marker detection from the bottom up through Key Points [5]. They used exclusive methods like SCNN and LaneNet(+H-Net). They completed an accuracy of 96.64%. Various datasets, including TuSimple with 6,408 frames, CULane with 133, 235 frames, and BDD100K with 80,000 frames, have been used to get to know CNN lightweight lane detection use of self-aware distillation [6]. They used TuSimple and CULane image resizing strategies to 368 × 640 and 288 × 800. They used extraordinary methods like ResNet-18, ResNet-34, ENet LaneNet, EL-GAN, SCNN, R-18-SAD (ours), R- 34-SAD (our), and ENet-SAD (our). They carried out with 97% accuracy the use of these techniques. The dataset of TuSimple 6408 frames (1280 × 720) and CULane 133235 frames (1280 × 720) was used for a progressed convolutional neural network-based lane detection technique using self-aware distillation[7]. They used stepped-forward semantic segmentation to improve the result. They used extraordinary techniques like VGG, SAD, SCNN, LaneNet, DC-VGG (ours), and DC-VGG-SAD (ours). They finished with 96% accuracy.

They used distinctive methods like SCNN, VGG-FCN, U-NeT, Tradition, BINARY, AND EMBEDDING set of rules to gain excellent effects to detect lanes from image datasets [8]. Dataset 133235 pics 88880 images for the training set (66.7%) 9675 pictures for the validation set (7.3%) 34680 photographs for the check set (26.0%) to enhance SCNN for lane detection in harsh scenarios [9]. They used the VGG16 encoder technique for picture segmentation. They used one-of-a-kind methods like Spatial CNN (SCNN), Model_Vgg, Mode_bg0.2, Model_data_aug, and Model_resnet and finished with 71% accuracy by using these methods. The summary of pre-trained CNN-based approaches is shown in Table 1.

Table 1. Pre-Trained CNN-Based Approaches

Reference	Data	Pre-processing	Methods	Results
Ethan.B.et.al (2021) [1]	53686 Images of the United States 1000 images of Nigeria	Bilinear interpolation used for image resize 200*200	CNN Architecture InceptionResNetV2 InceptionV2 VGG16 ResNet50V2 DeNseNet201 RESNET50 RESNET152V2 Xception	CNN Architecture=99.4% InceptionResNetV2=78.0% InceptionV2=75.3% VGG16=75.4% ResNet50V2=75.3% DeNseNet201=73.4% RESNET50=72.8 RESNET152V2=72.8% Xception= 70.0%
Sean P.Kearney. et al. (2019) [2]	1000 km roads 5 to 12m in width 10000 random sub-samples	We extracted 300x300 pixels from both the rapid imagery.	CNN	CNN=89-91%
Yuantao Jiang (2019) [3]	100 images	Denoising Edge detection	DMES AUA CNN	DMES=88% AUA=90% convolutional neural network=93%
Lizhe Liu1.X.et.al (2021) [4]	TUSIMPLE CurveLanes, CU Lanes DATASET	Dense lines and fork lines multi-class classification strategy	CondLaneNet(ResNet-34) SCNN Enet-SAD PointLaneNet CurveLane-S CurveLane-M CurveLane-L CondLaneNet-S	CondLaneNet(ResNet-34)=97% SCNN 65.02 Enet-SAD 50.31 PointLaneNet 78.47 CurveLane-S 93 CurveLane-M 81 CurveLane-L 82.29 CondLaneNet-S 85.09

			CondLaneNet-M CondLaneNet-L	CondLaneNet-M 85.92 CondLaneNet-L 86.10
Zhan Qu.et.al (2021) [5]	Fram 6408 And 133235 with a resolution 1280x720 (TUSimple and CULane)	Nil	SCNN LaneNet(+H- Net) EL-GAN ERFNet-E2E PINet(4H)	SCNN 96.53 LaneNet(+H- Net) 96.40 .
Lucas Tabelinil.R.et.al 2020 [10]	TuSimple 3,268 CULane 88,880 LLAMAS 58,269 Datasets with images	Segmentation of map generating	SCNN Cascaded- CNN ENet-SAD (ResNet-18) (ResNet-34) PolyLaneNet	SCNN = 95.97 Cascaded- CNN 90.82 ENet-SAD 95.92 (ResNet-18) 87.87 (ResNet-34) 88.02 PolyLaneNet [23] 90.62 LaneATT (ResNet-18) 96.71 LaneATT (ResNet-34) 96.77 LaneATT (ResNet- 122) 96.06
Yuenan.H.et.al 2019 [6]	TuSimple 6, 408 CULane 133, 235 BDD100K 80, 000 Frams	images are resize 368x640 and 288x800.	ResNet-18 ResNet- 34 ENet LaneNet EL-GAN SCNN R-18-SAD (ours) R-34-SAD (ours) ENet-SAD (ours)	ResNet-18 92.69% ResNet- 34= 92.84% ENet 93.02% LaneNet 96.38% EL-GAN 96.39% SCNN 96.53% R-18-SAD (ours) 96.02% R- 34-SAD (ours) 96.24% ENet-SAD (ours) 96.64%
Xinyu Zhang.et.al 2020 [7]	TuSimple 6408(1280 x 720) Frames CULane 133235 (1280 x 720)frames	improved semantic segmentation	VGG SAD SCNN LaneNet DC-VGG(ours) DC-VGG-SAD (ours)	VGG=94.39% DC- VGG(ours)=94.78% DC-VGG-SAD (ours)=95.67%
Wei Wang.et.al 2020 [8]	Tusimple dataset	Dataset is divided on inherent differences	SCNN VGG-FCN U-NeT Tradition BINARY AND EMBEDDING algorithm	SCNN= VGG-FCN= 0.9308% U-NeT= Tradition= BINARY AND EMBEDDING algorithm=
Yiyun Gu.et.al 2019 [9]	133235 frame image dataset.	VGG16 encoder technique	Spatial CNN (SCNN) Model_Vgg Mode_bg0.2 Model_data_aug Model_resnet	Spatial CNN (SCNN)= Model_Vgg=67.67% Mode_bg0.2=64.71% Model_data_aug=58.48% Model_resnet=16.67%

2.2 Machine Learning (ML) Approach

A dataset of 200 photos with a decision of 240x320 was used for the cause of lane detection primarily based on a machine studying set of rules [11]. They used (Graying, Median clear-out, and ROI) segmentation strategies to create the desired photograph first-class. They used exceptional methods consisting of a brand-new detection algorithm and area of interest segmentation. This algorithm can efficaciously locate a straight or curved lane.

A dataset of 4000 road picture samples was used to motivate an ML technique for detecting and tracking border lanes[12]. They used the information augmentation approach for the image segmentation method. They used one-of-a-kind techniques along with Guassianfilter+Hough, MSER+Hough rework, HSV-ROI+Hough, CNN Based, Improved LD+Hough, and LaneNet. Using these methods, they have done 97% accuracy. Open supply Tensor drift dataset with 720x1280 pixel decision datasets became used because of a fully convolutional neural network for Malaysian lane detection [13]. They used ML AND NanoDegree (MLND) photo segmentation techniques. They used a fully convolutional neural community (FCN) approach and achieved 99% accuracy in this approach. Sentiment Analysis,

Opinion Mining, Agriculture, and Medical Image Processing are other fields where ML algorithms are useful [47],[48],[49],[50],[51],[52]. A dataset of 21,500 pictures was used for OBJECT AND DRIVING DETECTION TECHNIQUES FOR AN AUTONOMOUS CAR USING A MACHINE LEARNING APPROACH [14]. A summary of ML-based research papers is shown in Table 2.

Table 2. Researcher's Contribution using ML Approach

Reference	Data	Pre-processing	Methods	Results
FAN Chao, XU Jing-bo, DI Shuai 2013 [11]	we captured 200 images WITH a resolution of 240x320	(Graying and Median filter and ROI)	A novel detection algorithm AND Dividing the region of interest	The proposed algorithm achieved good results.
Satish Kumar Sattia , K. Suganya Dhara , P. Srinivasanb 2020 [12]	4000 image samples of road	data augmentation	Guassiantfilter+Hough transform MSER+Hough LaneNet	Improved LD+Hough= 96% LaneNet 97%
N. J. Zakaria, H. Saruchi , N. Hassan 2018 [13]	Open source Tensor flow with datasets had a resolution of 720x1280 pixels	Machine Learning NanoDegree (MLND)	FCN model	FCN =99%
Raja Muthalagu1 , Anudeep Sekhar Bolimera2 , Shaun Fernandes4 2021 [14]	21,500 images	minimalistic lane detection approach	PolyLaneNet (Tabelini et al., 2020) SCNN (Pan et al.2018) Proposed CNNs approach	PolyLaneNet =93.36% SCNN =96.53% Proposed CNNs approach 93.12%

2.3 Deep Learning (DL) Approach

A geospatial and OSM dataset of hundreds of pictures has been used to detect difficult-to-see roads in low-resolution satellite TV for computer time series statistics[15]. As a segmentation method, they used the Detection method based on the DL technique AND VGI. They used particular techniques inclusive of convolutional layers with 3x3 clean out, U-internet model, U-internet+ model, U-net+ Time (flat) version, U-internet+ Time(3D) model, and U-internet+ Time(3-d) version executed quality outcomes than one of a kind fashions. Frame 6408 and 133235 datasets with 1280x720 selection (TUSimple and CULane) were used for ultra-fast structure-aware Deep Lane Detection [16]. They used the region (grid) desire method at the lines for great consequences. They used different styles of techniques like Res18-Seg, Res34-Seg, LaneNet, and EL-GAN. They completed an accuracy of 96.39%.

The Geospatial dataset and OSM have been used to detect hard-to-see roads in low-resolution satellite TV for computer television for computer time collection statistics [15]. A detection method primarily based mostly on deep studying method and VGI with convolutional layers with 3x3 filtering strategies changed into used. The Simple dataset, which includes 3626 schooling and 2782 test pictures, was used to learn lane detection and direction prediction for actual-time independent driving[17]. They used specific strategies like 2TCNN and 3TCNN. The usage of those techniques completed an accuracy of 0.946%. The photograph dataset of video frames 7823, 9196, 8273, 4187, and 3911 changed for powerful lane detection using the deep lane characteristic extraction technique [18]. They used inverse perspective mapping (IPM) and a separated Gaussian filtering method for photograph segmentation. They used precise techniques, which include Aly's approach, Shu-Chung Yi's technique, and Line phase Detector (LSD), and achieved 98% accuracy in the usage of the one's strategies. Tulane and TuSimple datasets of 133,235 snapshots, 88,880 pix for schooling, 9,675 images for validation, and 34,680 snapshots for testing were used for lane detection with the use of FCN [19]. They used traditional photograph processing and computer imaginative and prescient techniques to segment the picture. They used the MLND-Capstone method, which offers proper documentation, and the code is simple to understand.

A dataset of 200 images was taken for the cause of lane detection for a self-driving car using Deep Neural Networks and Raspberry Pi [20]. They used the transfer-studying method as a pre-processing technique. They used specific techniques like the CNN model and the Deep Neural community. Using those techniques, they were executed with ninety six% accuracies.

For Lane Detection: A Survey with New results [21], the TTLane dataset of 13200 pictures emerged as used. They used deep studying as a pre-processing technique. They used high-quality strategies like SCNN, R-CNN, MLD-CRF, and HD Maps Modeling techniques. They achieved a 0.72% accuracy rate. A summary of literature using deep learning methods is shown in Table 3.

Table 3. Researcher's Contribution using DL Approach

References	Data	Pre-processing	Methods	Results
Stefan Oehmcke. et al. (2019) [15]	Geospatial and OSM dataset	DL technique AND VGI Convolution layers with 3x3 filter	U-Net model U-Net+ Model U-Net ₊ model	U-Net ₊ Time(3d) model=90%
Zequn Qin.H.et.al (2020) [16]	Frame 6408 And 133235 with resolution 1280x720 (TUSimple and CULane)	selecting locations (grids) on rows	Res18-Seg Res34-Seg Lane-Net EL-GAN	Res18-Seg= 92.69 % Res34-Seg= 92.84% Lane- Net=96.38% EL-GAN= 96.39 %
Der-Hau Lee.et.al (2021) [17]	TuSimple set consists of 3626 training and 2782 testing images	2TCNN and 3TCNN	2TCNN = 0.943% and 3TCNN= 0.946%	
Guizhen Yu.et.al (2020) [18]	Video frames 7823, 9196, 8273, 4187, 3911	inverse perspective mapping (IPM) and separated Gaussian filtering	Aly's method Shu-Chung Yi's method line segment detector (LSD)	Aly's method=89.94% Shu-Chung Yi's method=85.86% line segment detector (LSD)=98%
Dun Liang.et.al 2020 [21]	TTLane dataset 13 200 images	DL	SCNN Mask R-CNN MLD-CRF HD Maps Modeling Method	SCNN= 0.585% Mask R-CNN= 0.506% MLD-CRF= 0.150% HD Maps Modeling Method= 0.722%

2.4 Model-Based Approach (Robust Lane Detection)

For Lane-AF: sturdy Multi-Lane Detection with Affinity Fields, unique datasets consisting of TuSimple of 6,408 frames, CULane of 133,325 frames, and LLAMAS of 100,042 frames were used [22] used numerous techniques together with a prediction of binary segmentation masks, in step with-pixel affinity array, and cluster strip pixels. They used distinctive techniques like ResNet-18, PolyLaneNet, Cascaded-CNN, Lane-Net, ENet-sad, SCNN, ResNet-34, PINet, LaneATT (ResNet-18), LaneATT (ResNet-34), LaneATT (ResNet-122) and LaneAF (DLA-34. They completed with 97% accuracy.

TuSimple datasets of 6408 pix with 1280 * 720 choices and CULane 133 235 photos with 1640 * 590 decisions had been used for RS-Lane: A strong Lane Detection approach based totally on ResNet and Self-interest site visitors Distilling 30]. They used a bilinear interpolation approach to downsample the photographs to 512 × 288. They used several techniques with SCNN, LaneNet, FD50, ENet-sad, U-speedy, EL-GAN, and RS-Lane (ours). They performed with 96% accuracy.

The Simple lane dataset, which includes a series of 3,626 photograph sequences, was modified for the cause of robust lane detection from non-forestall using scenes using deep neural networks[13]. Together, they used DCNN and DRNN image segmentation techniques. They appreciably utilized precise strategies: SegNet, UNet, SegNet 1 × 1, UNet 1 × 1 SegNet FcLSTM, UNet FcLSTM, SegNet ConvLSTM, UNet ConvLSTM, SegNet three-D and UNet three-D and finished an accuracy of 98.5% the usage of the one's strategies. Model-based approaches are summarized in Table 4.

Table 4. Model-Based Approach

References	Data	Pre-processing	Methods	Results
Hala Abualsaud.et.al 2021 [22]	Dataset TuSimple CULane LLAMAS # Frames 6,408 133,325 100,042	Prediction of binary segmentation masks and per pixel affinity fields cluster lane pixels	ResNet-18 PolyLaneNet Cascaded-CNN LaneNet ENet-SAD SCNN ResNet-34 PINet LaneATT(ResNet-18) LaneATT (ResNet-34) LaneATT (ResNet-122) LaneAF (DLA-34)	ResNet-18 87.87 PolyLaneNet 90.62 1.7 Cascaded-CNN 90.82 LaneNet 94.80 ENet-SAD 95.92 SCNN 96.53 ResNet-34 96.77 PINet 97.20 LaneATT(ResNet-18) 96.71 LaneATT (ResNet-34) 96.77 LaneATT (ResNet-122) 96.06 LaneAF (DLA-34) 96.49
Ronghui Yueying.et.al 2021 [23]	TuSimple 6408 1280 * 720 CULane 133,235 1640 * 590	bilinear interpolation reisz images 512 × 288	SCNN LaneNet FD50 ENet-SAD U-fast EL-GAN RS-Lane (ours)	SCNN 96.53% LaneNet=96.38% FD50 95.20% ENet-SAD 96.64% U-fast 96.06% EL-GAN 96.39% RS-Lane (ours) 96.37%
Ronghui Yueying.et.al 2021 [23]	TuSimple 6408 1280 * 720 CULane 133,235 1640 * 590	bilinear interpolation to downsample the images to the size of 512 × 288	SCNN LaneNet FD50 ENet-SAD U-fast EL-GAN RS-Lane (ours)	SCNN 96.53% LaneNet=96.38% FD50 95.20% ENet-SAD 96.64% U-fast 96.06% EL-GAN 96.39% RS-Lane (ours) 96.37%

3. COMPARISON OF DIFFERENT METHODS AND APPROACHES FOR LANE DETECTION ALGORITHMS

A dataset of 53,686 images of us 1,000 pictures of Nigeria was used for top-notch street prediction, excessive selection of satellite tv for pc television, laptop imagery, and switch studying [1]. They covered 2400 km of primary roads and diagnosed 712 low satisfactory roads and 47,557 roads as exceptional high roads. Using a bilinear interpolation method, they resized the photos to 2 hundred x 2 hundred pixels. They used CNN architecture Inception ResNetV2, InceptionV2, VGG16, ResNet50V2, DeNseNet201, RESNET50, RESNET152V2, and Xception and achieved 99.4% accuracy. Sooner or later, their exploratory look at case on Nigerian roads showed the electricity of this approach and will provide sufficient outcomes with a small amount of nearby data. A dataset of 650 randomly reshuffled picture information of Mumbai for street detection from satellite tv for pc television for computer snapshots has been taken from fundamental road facts of India 205-2016 [24]. Otsu's picture segmentation technique ended up accomplishing the input images. They used first-rate strategies, i.e., the Novel approach, the Otsu technique, and the Histogram Equalization technique. With the use of terrific methods, they completed excellent effects. This technique confirmed the right edges of the communications. A dataset of greater than a hundred images of 5001x5001 pixels and two hundred pics of 2163x2163 pixels were taken from Chinese roads to extract roads from VHR far-off sensing pix through Gabor-confined item segmentation [25]. They carried out a segmentation method of bilateral filtering to guard images, and every other Laplacian operator approach as a convolutional kernel becomes used to enhance photograph incredible. Diverse techniques of zang.et.al, Lei. et.al and a -a level approach combining component records and region characteristics had been used. They completed an accuracy of 0.95%.

The IKONOS dataset of the 11,000 populace of Italy was acquired for rapid road extraction for emergency conditions with the segmentation of satellite pics [26]. They used a mathematical morphology approach to pre-process the photographs used within the take-a-look-at data set. They used one-of-a-kind sorts of strategies, object picture evaluation, Structural method, and rapid avenue Extraction and performed high accuracy to obtain first-class results. A near-picture dataset of almost 33,968,739 near-roads of the whole world has become used for the cause of an automated technique for extracting the centerline of roads from post-earthquake aerial pics [27]. They used a diffusion of segmentation of these

photographs and the morphological picture filter approach. They used the Miso street centerline correction method to remove smaller items and finished with 95% accuracy. However, this approach must be increased within destiny.

A dataset of diverse street images was used for automated road extraction from excessive-resolution satellite TV for computer photos [28]. They used distinct segmentation strategies, including continuity selection-making and vectorization strategies. They used distinct kinds of Gradient Orientation and facet detection techniques and did high accuracy and identified street segments on high-decision satellite TV for computer images. The dataset from the net consists of 192 road pix for the cause of a reliable technique for Detecting avenue regions from a single image based on coloration Distribution and Vanishing point location [29]. They used the Gabor filters segmentation approach to enhance the pictures. They used vanishing component estimation based on a mild balloting scheme, which fits better with actual avenue pictures with specific textures, colorings, and shapes.

Using Image mining, a dataset from Lidar and aerial pix of China were used for street detection from satellite photographs [30]. They used distinctive varieties of segmentation techniques. They used NDVI AND NDWI SVM photo mining to provide excessive consequences. They used distinct techniques consisting of an object fuzzy rule-based approach and accomplished 90 five% accuracy. For the motive of avenue detection from satellite tv for pc images inside the developing international, the Space-Net dataset containing lots of pictures comes to be used [31]. They used the OSM segmentation approach to enhance fantastic pix. They used distinctive varieties of techniques like hyperparameter tuning, Raster imaginative and prescient package deal, Las Vegas and Khartoum model to get the favored results. Khartoum version attains a bargain with greater reasonable consequences than specific models. A city aerial photo dataset with a choice of 1.2 meters in line with pixel, the Urban1 dataset covers 500 square kilometers, the Urban2 dataset covers 50 square kilometers and ends up used to gain knowledge of to hit upon roads in excessive-decision aerial pics [32]. They used a huge-scale studying approach and an unsupervised learning device as a pre-processing technique for photo enhancement. They used unique strategies like ROTATE, PRETRAIN, POSTPROC, Gaussian-binary RBM model, and Gaussian-binary RBM version. They provide dough consequences than unique models. The ISPRS aerial photo and IKONOS dataset come to be used. A hybrid technique to reinforcement studying for road detection [33]. They used a pre-processing technique to downscale the pix by using 10 to smooth the edges of the roads. They used one-of-a-kind methods, a hybrid method, and fashions: a probabilistic technique, a RLSNAKE method, a pc vision technique, and a technique based on the possibility principle to remedy street mining issues. The usage of a hybrid model, they done excessive results.

The Br 232 highway dataset between km 141 and 356 became used for the cause of some distance flung sensing done to the extraction of avenue geometric abilities based totally on the most effective direction wooded region classifiers [34]. They used SVM, and ANN is the class process for pre-processing to enhance the effects. They used strategies like Gaussian clear out, photograph Acquisition OPF, and SVM and performed with ninety seven% accuracies. A dataset of 1711 aerial pictures of the open avenue dataset changed into used for the cause of extracting excessive-decision some distance off sensing street photos derived from DenseUNet [35]. They used the FCN segmentation method. They used unique techniques like U-internet, SegNet, FRRN-B, GL-Dense-U-net, and DenseUNe. They carried out an accuracy of 78.48%. A dataset of 38 SPOT pictures of period 320x320 and the whole variety of roads in these pictures is 70 for the cause of street detection from satellite tv for pc photographs the usage of pinnacle-exceptional are looking for[36] They used the strategies of image rolled first with a filter out produced via way of digitization to increase the first-class of the photos. They used Geman's algorithm to achieve excessive exceptional consequences. A dataset of 20,000 pictures of Seoul, South Korea, turned out to be used for lane and street marking detection and reputation [37]. They used an image segmentation method, in which the photo is divided into an 8x8 grid to beautify the photo. They used awesome sorts of strategies which include the VPGNet model, 2-task (revised), 3-task (revised), four-challenge (VPGNet), FCN-8s (pixel annotated and FCN-8s (grid annotated). They used RANSAC, the Hough transform, the canny algorithm, the automobile instantaneous directional enhancement method, and Lane Line Fitting Based on a Polar Coordinate System. Using these methods, they achieved 99% accuracy. A comparison of different methods is shown in Table 5.

Table 5. Comparison of Different Methods

References	Data	Pre-processing	Methods	Results
J.D.Dorathi Jayaseeli D.Malathi (2020) [38]	200 images	Image thresh holing is the Image segmentation Technique	Gaussian Smoothing Symmetry Duality GA-Method ICSA Method	Gaussian Smoothing=0.89% Symmetry Duality = 0.92% GA-Method= 0.93% ICSA Method=0.97
Li Chen.et.al (2018) [25]	Over 100 images size of 5001x5001	Laplacian operator as a convolution kernel	Zang et LA Lei et am Proposed	Zang et LA=0.44% Lei et am=0.84% proposed=0.95%

Table 5. Comparison of Different Methods

References	Data	Pre-processing	Methods	Results
	pixels 200 images size of 2163x2163 pixels			
Vincenzo.B.et.al (2016) [26]	11000 inhabitants population IKONOS dataset	Mathematical Morphology	Object based Image Analysis structural Methodology	Fast extraction of Roads
Zhumei.L.et.al (2018) [27]	Road images of 33,968,739 length of almost roads of whole world.	Morphological Filter	Road Centerline Correction Method Miso Method remove Minor Objects.	Road Centerline Correction Method= 95% Tans Method=91% Mia os Method=43%
Jose Hormese.et.al (2016) [28]	Null	Decision making based on continuity and vectorization procedure	vectorization approach Null Gradient Orientation Edge detection	identifies the road segments in a high resolution satellite image
Neethu.J.et.al (2015) [29]	192 road images From web and dataset used by Kong et.al	Gabor filters	Vanishing point estimation based on soft voting scheme	It performs better with real-road images of varying texture, colour and shapes.
Fereshteh.M.et.al (2015) [30]	Lidar data and aerial Images	Image mining NDVI AND NDWI	SVM Fuzzy rule based OBJECT based method	OBJECT based method =95% accuracy
Yoni.N.et.al (2019) [31]	SpaceNet dataset OSM datsa	Hyper parameter tuning Raster vision package	Las Vegas Khartoum model Khartoum model	Khartoum model Produce much more reasonable results than other mmodels
Volodymyr.M.et.al (2008) [32]	Urban aerial imagery with resolution of 1.2 meters per pixel, Urban1 dataset covers 500 square kilometers, Urban2 dataset covers 50	Large scale learning approach Unsupervised learning procedure	OTHER, ROTATE, PRETRAIN,POSTPROC,Gaussain- binary RBM MODEL	Gaussain-binary RBM MODEL Provide batter results than other models.

Table 5. Comparison of Different Methods

References	Data	Pre-processing	Methods	Results
	square kilometers			
N.Botteghi.et.al (2021) [33]	ISPRS aerial image and IKONOS dataset	Images are downscale by 10 , smoothing of road edges.	Hybrid method consist on two Models:Probabilistic method and RLSNAKE method ,Computer vision and probability theory based method	Solve the road extraction proables.
Maria Maia.et.al (2020) [34]	Br 232 Highway Between km 141 and 356	SVM AND ANN are Classification approaches, Gaussian filter, Image Acquisition	OPF SVM	OPF=97.00% SVM=94.92%
Jiang Xin.et.al (2019) [35]	1711 aerial images of open Road dataset	FCN	U-Net SegNet FRRN-B GL-Dense-U-Net DenseUNet	U-Net=58.92% SegNet=61.35% FRRN-B=76.51% GL-Dense-U-Net=78.48% DenseUNet=78.25%
Yan Rianto.et.al (1999) [36]	38 SPOT images with size 320x320	Image is convoluted rst by a lter made	Geman's Algorithm	N/A
Seokju.L.et.al (2017) [37]	20,000 images of Seoul, South Korea	image is divided into a grid 8x8	VPNet model 2-Task (Revised) 3-Task (Revised) 4-Task (VPNet) FCN-8s (Pixel-annotated FCN-8s (Grid-annotated	VPNet model=0.87 2-Task (Revised)=0.85 3-Task (Revised)=0.72
Netalee.E.et.al (2020) [39]	dataset contains 327K images	comprised of two processing pipelines: in image view (top) and in Bird Eye View (bottom)	3D-LaneNet synthetic-3D-lanes	3D-LaneNet= 0.74% synthetic-3D-lanes= 0.9%
Lichao Chen.et.al (2020) [40]	133,235 images at resolutions of 1640 × 590	Acquire image ,Crop and select ROI	ENet_LGAD SIM_CycleGAN+ERFNet	ENet_LGAD =91.2% SIM_CycleGAN+ERFNet= 91.8% ERFNet-E2E=91.00% ERFNet-HESA=92.2% ERFNet_VP =91.9% Nb_SINet=92.24%
Jamel Baili.et.al [41]	N/A	ROI (Region Of Interest) RGB -->	Kalman Filter and implement a LDW System in an embedded processor	N/A
Byambaa Dorj.et.al 2015 [42]	N/A	A least-square estimation technique And image transform approach	parabolic model least-square method integrated curved line detection	N/A
Davy Neven.et.al 2018	tuSimple lane	Image enhancement	LaneNet method CURVE FITTING USING H-NET	N/A

Table 5. Comparison of Different Methods

References	Data	Pre-processing	Methods	Results
[20]	dataset	binary segmentation instance segmentation	H-Net	
Wouter Van.et.al 2019 [43]	TuSimple 3626 images	Weight map for each lane line	XingangPan DavyNeven Baseline	XingangPan= 96.53% DavyNeven = 96.40% Baseline 95.10%
Mylavarapu.et.al 2020 [44]	Total Number of Frames= 1261	Canny edge detection and Hough transform	Linear SVC Advanced Lane Detection and HLD	Linear SVC=98 %
Vighnesh.D.et.al 2021 [45]	N/A	Digital Image processing techniques 1: Thresholding 2: Warping	bilateral filtering, Gaussian blurring and median blurring	Gaussian blurring achieved the best results.
Jianjun Hu.et.al 2020 [46]	Caltech data sets 5683 frames of road images	Image Grayscale Processing Image Enhancement Processing	RANSAC Hough transform and the Canny algorithm automobile instantaneous directional enhancement method	RANSAC= 97.2% Hough transform and the Canny algorithm= 87.6% automobile instantaneous directional enhancement method= 89.2%

3.1 Gaps in existing works

Different lane detection algorithms are now used for automatic lane detection using high-resolution satellite images. Most of these techniques have been developed with the detection of straight lanes in mind, while researchers have largely disregarded curved lanes. Thus, the gaps in the literature are as follows:

1. Many researchers have ignored curved lane images in favor of straight lane images.
2. The improvement in Hough Transform has been disregarded for a better Lane Detection algorithm.
3. Different researchers have also ignored the effect of fog on Lane Detection.

4. DISCUSSION

According to a review of the literature on lane detection and tracing, few datasets have been used or are available to researchers. According to the literature review, the following table summarizes the key data sets that have been used or are available to researchers, including the name and detailed description of these data sets. It is expected that many more datasets will be collected and used by researchers as advancement in this field continues to grow daily. We can infer from the literature review that various methods, including CNN, DL, ML, Robust Base Model-Based Approach, Gaussian Smoothing, Symmetry Duality, GA-Method, and ICSA Method, have been employed by researchers. The ground truth data set is used to validate the performance of all algorithms. A list of available datasets is shown in Table 6.

Table 6. Dataset Features and Links

Dataset	Features	Available	Reference
CU Lane	55 hours video 133235 frames, 88880 for the training set, 9675 for validation set and 34680 for test set	Yes	1. https://drive.google.com/drive/folders/1mSLgwVTiaUMAb4AVOWwlCD5JcWdrwpvu 2. https://xingangpan.github.io/projects/CULane.html
Caltech	10 hours video of resolution 640 ×	Yes	1.

	480 Hz 250,000 frames, 350,000 boundary boxes		https://drive.google.com/u/0/uc?export=download&confirm=Mzuk&id=1WoodNzCVxoTrcY1CfuF2cpCrVQZcf10M 2. http://www.vision.caltech.edu/Image_Datasets/CaltechPedestrians/
KITTI	It includes features such as stereo, optical flow, and visual odometry. It includes boundary boxes, monocular images, 7481 training images, and 7518 test images in addition to an object detection dataset.	yes	http://www.cvlibs.net/datasets/kitti/
Tusimple	The dataset contains 6,408 road images from US highways, with 3,626 for training, 358 for validation, and 2,782 for testing.	Yes	https://github.com/TuSimple/tusimple-benchmark/issues/3
UAH	Raw real-time data, GPS and accelerometer data, and accelerometer data processed as continuous data for lane and vehicle detection, for example, or for open street map data. Data has been processed as events. Semantic data (final and online).	Yes	Limited accessibility for the researchers.
BDD100K	100,000 videos for more than 1000 hours include roads and road side areas, semantic segmentation (full Frame).	Yes	https://mc.ai/bdd100k-dataset/
DIML	Over 200 indoor/outdoor scenes are captured by the Kinect V2 and zed stereo camera, which produce 13,000 videos and 13,000 annotated videos.	Yes	http://diml.yonsei.ac.kr/dataset/
LLAMAS	100,000 annotated images at a resolution of 1276 x 717 pixels, with annotations ranging more than 100 meters.	Yes	https://paperswithcode.com/dataset/llamas

5. CONCLUSION

Various methods have been used to put in force a photo-processing machine for lane detection. Lanes may be detected speedy and appropriately via applying lane detection photograph pre-processing, and this system will provide the outcomes we need. The first step can be to become aware of the region of interest, and then we can pass on to the following section of this study's task. Selecting best the white and yellow areas further reduces the processing time of our strategies. Vehicle detection and class can also be performed. This could be useful for spotting and responding to street symptoms and automobiles. If the car is inside a positive distance from the stop sign, the algorithm will prevent the automobile for a few seconds to assist the driving force. It also reacts to motors by coming to a whole forestall in the event they get too close. These implementations ensure that car drivers follow the regulations of the street and do their first-rate to save road accidents and deaths. In the future, the proposed set of rules can be skilled to understand and reply to various avenue symptoms.

6. FUTURE WORK

Future research will take place in a variety of directions. Consideration should first be given to more effective CNN architectures. The second is that supervised learning is more difficult and expensive. Semi-supervised algorithms have been developed to enable semi-supervised semantic segmentation. Then, as the current segmentation architecture depends on experience design, automatic ML may offer updated perspectives for additional extraction in the future.

REFERENCE

- [1]. Brewer, E., Lin, J., Kemper, P., Hennin, J. and Runfola, D, Predicting road quality using high resolution satellite imagery. A transfer learning approach. p.e0253370, 2021: p. 16(7).

- [2]. Kearney, S.P., et al., Maintaining accurate, current, rural road network data: An extraction and updating routine using RapidEye, participatory GIS and deep learning. *International Journal of Applied Earth Observation and Geoinformation*, 2020. 87: p. 102031.
- [3]. Jiang, Y., Research on road extraction of remote sensing image based on convolutional neural network. *EURASIP Journal on Image and Video Processing*, 2019. 2019(1): p. 1-11.
- [4]. Liu, L., et al. Condlanenet: a top-to-down lane detection framework based on conditional convolution. in *Proceedings of the IEEE/CVF International Conference on Computer Vision*. 2021.
- [5]. Qu, Z., et al. Focus on local: Detecting lane marker from bottom up via key point. in *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*. 2021.
- [6]. Hou, Y., et al. Learning lightweight lane detection cnns by self attention distillation. in *Proceedings of the IEEE/CVF international conference on computer vision*. 2019.
- [7]. Zhang, X., et al., Improved lane detection method based on convolutional neural network using self-attention distillation. *Sensors and Materials*, 2020. 32(12): p. 4505.
- [8]. Wang, W., H. Lin, and J. Wang, CNN based lane detection with instance segmentation in edge-cloud computing. *Journal of Cloud Computing*, 2020. 9(1): p. 1-10.
- [9]. Gu, Y., Y. Zhang, and Z. Xiao, Improvements of SCNN on lane detection in harsh scenarios.
- [10]. Tabelini, L., et al. Keep your eyes on the lane: Real-time attention-guided lane detection. in *Proceedings of the IEEE/CVF conference on computer vision and pattern recognition*. 2021.
- [11]. Fan, C., J. Xu, and S. Di, Lane detection based on machine learning algorithm. *TELKOMNIKA Indonesian Journal of Electrical Engineering*, 2014. 12(2): p. 1403-1409.
- [12]. Satti, S.K., et al., A machine learning approach for detecting and tracking road boundary lanes. *ICT Express*, 2021. 7(1): p. 99-103.
- [13]. Zakaria, N., et al., Fully convolutional neural network for Malaysian road lane detection. *International Journal of Engineering & Technology*, 2018. 7(4.11): p. 152-155.
- [14]. Muthalagu, R., et al., Object and Lane Detection Technique for Autonomous Car Using Machine Learning Approach. *Transport and Telecommunication*, 2021. 22(4): p. 383-391.
- [15]. Oehmcke, S., et al. Detecting hardly visible roads in low-resolution satellite time series data. in *2019 IEEE International Conference on Big Data (Big Data)*. 2019. IEEE.
- [16]. Qin, Z., H. Wang, and X. Li. Ultra fast structure-aware deep lane detection. in *European Conference on Computer Vision*. 2020. Springer.
- [17]. Lee, D.-H. and J.-L. Liu, End-to-end deep learning of lane detection and path prediction for real-time autonomous driving. *Signal, Image and Video Processing*, 2022: p. 1-7.
- [18]. Yu, G., et al., Efficient lane detection using deep lane feature extraction method. *SAE International Journal of Passenger Cars-Electronic and Electrical Systems*, 2017. 11(2017-01-1970).
- [19]. Zhang, S., A.E. Koubia, and K.A.K. Mohammed, Traffic lane detection using fcn. *arXiv preprint arXiv:2004.08977*, 2020.
- [20]. Jain, A.K. Working model of self-driving car using convolutional neural network, Raspberry Pi and Arduino. in *2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA)*. 2018. IEEE.
- [21]. Liang, D., et al., Lane detection: a survey with new results. *Journal of Computer Science and Technology*, 2020. 35(3): p. 493-505.
- [22]. Abualsaud, H., et al., Laneaf: Robust multi-lane detection with affinity fields. *IEEE Robotics and Automation Letters*, 2021. 6(4): p. 7477-7484.
- [23]. Zhang, R., et al., RS-lane: a robust lane detection method based on ResNeSt and self-attention distillation for challenging traffic situations. *Journal of advanced transportation*, 2021. 2021.
- [24]. Mokhtarzade, M. and M.V. Zoj, Road detection from high-resolution satellite images using artificial neural networks. *International journal of applied earth observation and geoinformation*, 2007. 9(1): p. 32-40.
- [25]. Chen, L., et al., Road extraction from VHR remote-sensing imagery via object segmentation constrained by Gabor features. *ISPRS international journal of geo-information*, 2018. 7(9): p. 362.
- [26]. Barrile, V. and G. Bilotta, Fast extraction of roads for emergencies with segmentation of satellite imagery. *Procedia-Social and Behavioral Sciences*, 2016. 223: p. 903-908.
- [27]. Liu, Z., J. Zhang, and X. Li, An automatic method for road centerline extraction from post-earthquake aerial images. *Geodesy and Geodynamics*, 2019. 10(1): p. 10-16.
- [28]. Hormese, J. and C. Saravanan, Automated road extraction from high resolution satellite images. *Procedia Technology*, 2016. 24: p. 1460-1467.
- [29]. John, N., B. Anusha, and K. Kutty, A reliable method for detecting road regions from a single image based on color distribution and vanishing point location. *Procedia Computer Science*, 2015. 58: p. 2-9.
- [30]. Massoumi, F. and M. Afzali, Road Detection from Satellite Images Using Image Mining. 2015.
- [31]. Nachmany, Y. and H. Alemohammad. Detecting roads from satellite imagery in the developing world. in *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops*. 2019.
- [32]. Mnih, V. and G.E. Hinton. Learning to detect roads in high-resolution aerial images. in *European conference on computer vision*. 2010. Springer.

- [33]. Botteghi, N., B. Sirmacek, and C. Ünsalan, Rlsnake: a Hybrid Reinforcement Learning Approach for Road Detection. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, 2021. 43: p. 39-45.
- [34]. Macedo, M., et al., Remote sensing applied to the extraction of road geometric features based on optimum path forest classifiers, northeastern Brazil. *Journal of Geographic Information System*, 2020. 12(01): p. 15.
- [35]. Xin, J., et al., Road extraction of high-resolution remote sensing images derived from DenseUNet. *Remote Sensing*, 2019. 11(21): p. 2499.
- [36]. Rianto, Y., S. Kondo, and T. Kim, Detection of roads from satellite images using optimal search. *International journal of pattern recognition and artificial intelligence*, 2000. 14(08): p. 1009-1023.
- [37]. Lee, S., et al. Vpgnet: Vanishing point guided network for lane and road marking detection and recognition. in *Proceedings of the IEEE international conference on computer vision*. 2017.
- [38]. Jayaseeli, J.D. and D. Malathi, An efficient automated road region extraction from high resolution satellite images using improved Cuckoo search with multi-level thresholding schema. *Procedia Computer Science*, 2020. 167: p. 1161-1170.
- [39]. Efrat, N., et al., Semi-local 3d lane detection and uncertainty estimation. *arXiv preprint arXiv:2003.05257*, 2020.
- [40]. Chen, L., et al., Real-time lane detection model based on non bottleneck skip residual connections and attention pyramids. *Plos one*, 2021. 16(10): p. e0252755.
- [41]. Baili, J., et al. Lane departure detection using image processing techniques. in *2017 2nd International Conference on Anti-Cyber Crimes (ICACC)*. 2017. IEEE.
- [42]. Dorj, B. and D.J. Lee, A precise lane detection algorithm based on top view image transformation and least-square approaches. *Journal of Sensors*, 2016. 2016.
- [43]. Van Gansbeke, W., et al. End-to-end lane detection through differentiable least-squares fitting. in *Proceedings of the IEEE/CVF International Conference on Computer Vision Workshops*. 2019.
- [44]. Kalyan, M.V.P., D.R.K. Reddy, and P.Y. Reddy, Design and Development of Automated Lane Detection Using Improved Canny Edge Detection Method. *PSYCHOLOGY AND EDUCATION*, 2020. 57(9): p. 1350-1358.
- [45]. Devane, V., et al. Lane Detection Techniques using Image Processing. in *ITM Web of Conferences*. 2021. EDP Sciences.
- [46]. Hu, J., et al., research on lane detection based on global search of dynamic region of interest (DROI). *Applied Sciences*, 2020. 10(7): p. 2543.
- [47]. Ghous, H. a. (2022). Early Detection of Breast Cancer Tumors Using Linear Discriminant Analysis Feature Selection with Different Classification Methods. *International Journal of Information Systems and Computer Technologies*, 1(1).
- [48]. Ghous, H. a. (2022). Structural Review on Plants Leaves Disease Classification Using Machine and Deep Learning Methods. *Southern Journal of Research*.
- [49]. Hussain, M. a. (2022). Computer Vision Approach for Liver Tumor Classification Using CT Dataset. *Applied Artificial Intelligence*, 1--23.
- [50]. Ilyas, H. a. (2021). Chronic kidney disease diagnosis using decision tree algorithms. *BMC nephrology*, 22(1), 1-11.
- [51]. Nida Alyas1, M. H. (2021). Sentiment analysis Using Machine Learning and Deep Learning:. *International Research Journal of Engineering and Technology (IRJET)*, 109.
- [52]. Qadri, S. (2021). ROLE OF MACHINE VISION FOR IDENTIFICATION OF KIDNEY STONES USING MULTI FEATURES ANALYSIS. *Lahore Garrison University Research Journal of Computer Science and Information Technology*, 5(3), 1--14.