*A Project Presentation on*

# Safety Recommendation system for Autonomous Driving


**By**

**N. Jaswanth**

**201799003**

**(Team No. 08)**



Indian Institute of Information Technology (IIIT) Sricity

# Outline

- ✓ Autonomous / Self -Assisted Driving - ADAS
- ✓ Problem Statment
- ✓ Popular Datasets & Description - Why only IDD
- ✓ Proposed Novel Solution
- ✓ Experimental Analysis:

a. Challenges Addressed
b. Data-set split ratio
c. Deep Architectures

- ✓ Result Analysis
- ✓ Future work -Next steps
- ✓ Conclusion
- ✓ References

# Introduction

- ✓ Number of annual road traffic deaths - 1.35 million.
  [source: Global status report on road safety 2018, WHO]

- ✓ India - 467,044 road accidents.
- ✓ An increase of 0.5% from 464,910 in 2017.
- ✓ India accounts for 6 percent of the world's road traffic accidents

  [Source: https://morth.nic.in/road-transport]

## Challenges:

- ✓ Chaotic traffic - the target recognition and edge detection become difficult.
- ✓ Changing appearance of the size and color, road material, weather conditions.

## Possible Solution:

- ✓ Active Safety Systems - Advanced Driver Assistance Systems (ADAS)
- ✓ Designed to dynamically assist the driver for safe & collision free driving environment.

# ADAS

**ADAS** – Dynamic, Real-time Driver Assistance Systems

**Core Functionalities:**

- ✓ Lane Assistance
- ✓ Pedestrian Detection
- ✓ Night Vision Assistance
- ✓ Smart Parking
- ✓ Adaptive Cruise Control
- ✓ Traffic sign detection

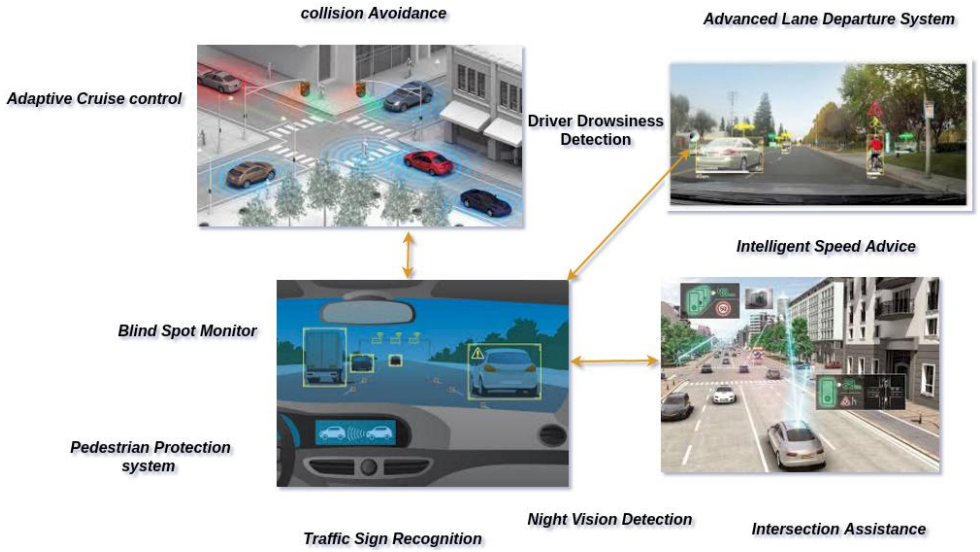



Fig: Illustration of ADAS features

**Need:**

- ✓ Road Safety, Traffic Management
- ✓ Reinforce vehicle understand its environment.

- ✓ Driving conditions in India are highly unstructured and diverse, with interesting behaviors of traffic participants.

# Problem Statement

## Current challenges:

Lane Detection and Analysis : (Indian road Scenario Focus)

Occlusion conditions of road lane.

✓Real time tracking in cast shadows.

✓Improper Lane Markings.

✓Dealing with road surface having different shades from illumination variations.

✓Extreme Curves


Fig: Illustration of Indian Road environments & Traffic scenario

## Parameters:

✓Speed, length

✓Lateral / Longitudinal

✓Proximity of other vehicles

✓Angle of vehicle

✓Pitch, Roll, Yaw, Waypoints.

## Environmental factors:

- Dynamic Constraints in Dense Heterogeneous Traffic
- Weather Conditions
- Drivable area predictions
- Structure vs Unstructure roads
- Road Geometry
- Tracking boundaries for unmarked roads with occlusions
- Radius of curvature
- Distance Estimation

Objective:

Develop Real time Recommender system for Indian Road Driving environments.

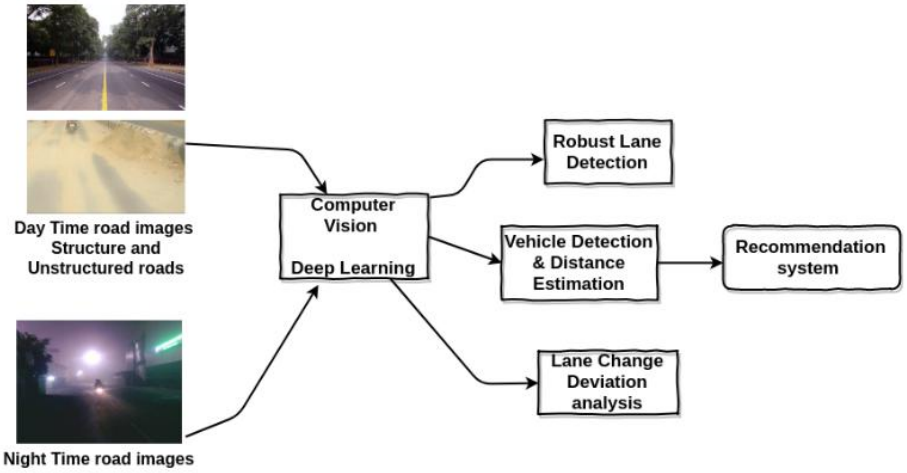



Fig: Proposed pipeline

Proposed Work:

i. Most of the existing solutions provide a functional specific solutions in ADAS considering individually for either in or out-vehicle entities.
ii. Missing the integrated aspects that helps potential drivers in providing safe recommendations.

✓ Proposed solution helps in rigorously monitoring the drivers driveability integrating both in and out vehicle data for safe recommendations.

# Popular Datasets

Kitti - Road segmentation Dataset [1]: Mostly from Karshue, Germany
[Source: http://www.cvlibs.net/datasets/kitti/eval_road.php]

The road and lane estimation benchmark consists of:

A. 289 training
B. 290 test images.

Divided into three different categories of road scenes:

- uu - urban unmarked (98/100)
- um - urban marked (95/96)
- umm - urban multiple marked lanes (96/94)

- State of the art - 97.05% (Max F1 score)

- Our mIoU achieved using FCN model only on kitti dataset is 93%

IDD - Indian Driving Datatset [2]: World's first dataset of unstructured driving scenarios.
Mostly captured driving scenarios from Hyderabad and Bangalore traffic regions in India.

IDD Segmentation Dataset Split: [Source: https://idd.insaan.iiit.ac.in/dataset/details/]

- Train - 6993
- Val - 981
- Test - 2029

- mIoU acived for the road class with DRN-D model - 92.00%
[source: https://idd.insaan.iiit.ac.in/media/publications/idd-650.pdf ]

# Proposed Novel Solution

Work-flow for inward mounted camera:

- ✓ Modelling the Driver Behavior (Road Traffic factors and In-vehicle Action units)

Tasks :

i) Eye Localization: Opening, closing & Half shut.

ii) Facial expression analysis: includes head pose estimation, facial landmarks, facial action units.

- ✓ Multi-task learning via CNNs -> Driver's attentiveness / Not attentiveness.
- ✓ Driver Distraction analysis.

c0: safe driving
c1: texting - right
c2: talking on the phone - right
c3: texting - left
c4: talking on the phone - left
c5: operating the radio
c6: drinking
c7: reaching back
c8: hair and makeup
c9: talking to passenger

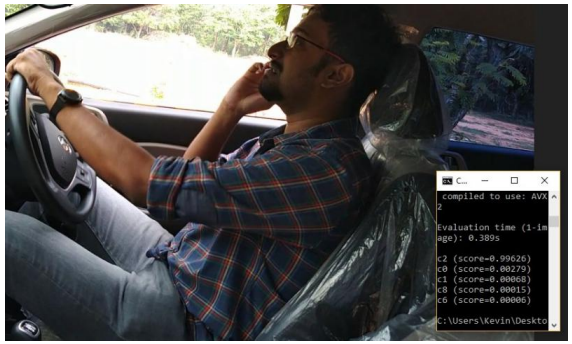






**Fig: Illustration of class wise predictions**

Work-flow for External driving scenario:

- ✓ Road Driveability Navigation - Segmentation Task.
- ✓ Real-time Object Detection.
- ✓ Vehicular behavior analysis using multi-sensor information.

**Fig: Illustration of road segmentation for driveable area recommendation in Heterogeneous traffic**

# Experimental Analysis

Tasks done:

- ✓ Semantic Segmentation for driveable area (road/free-space) navigation.
- ✓ In-vehicle custom Data-set with distraction analysis.
- ✓ Road Lane Annotation

Segmentation Models used:

- ✓ FCN [3]
- ✓ Unet [4]
- ✓ FPN [5]
- ✓ Linknet [6]

Data-set:

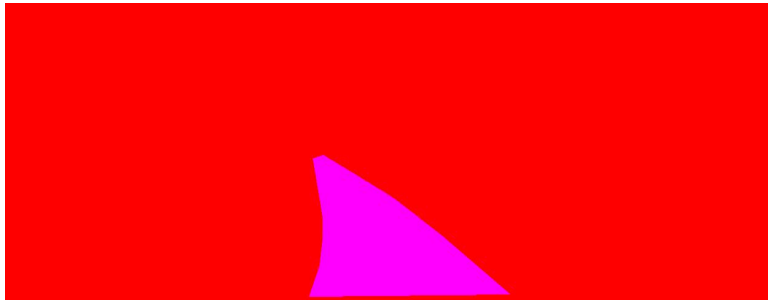
- ✓ Kitti
- ✓ IDD

Why only IDD dataset:

- ✓ Heterogeneous and chaotic traffic scenes
- ✓ Indian road driving environments - Less disciplined traffic

# Challenges

## Data-Preprocessing (Kitti):



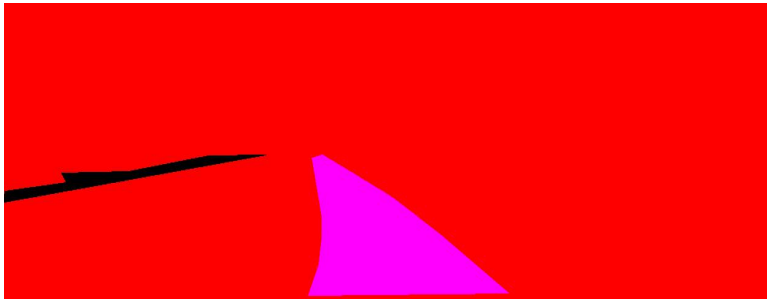


Fig: Illustration of Kitti Dataset samples after pre-processing

Fig: Visual illustration of IDD predictions trained using FCN with both kitti and few samples of IDD

**Challenges with Kitti dataset:**

- ✓ Less samples (train-289, test-290)
- ✓ Less heterogenity road and environmental factors
- ✓ Disciplined traffic - well structured roads
- ✓ RGB channel - 24 bit

# Challenges

**Data-Preprocessing (IDD):**

#14008 samples
Train : 9805, Validation : 1401, Test : 2802

Fig: Illustration of various IDD Dataset samples after pre-processing

# Deeper Architectures

## U-net model:

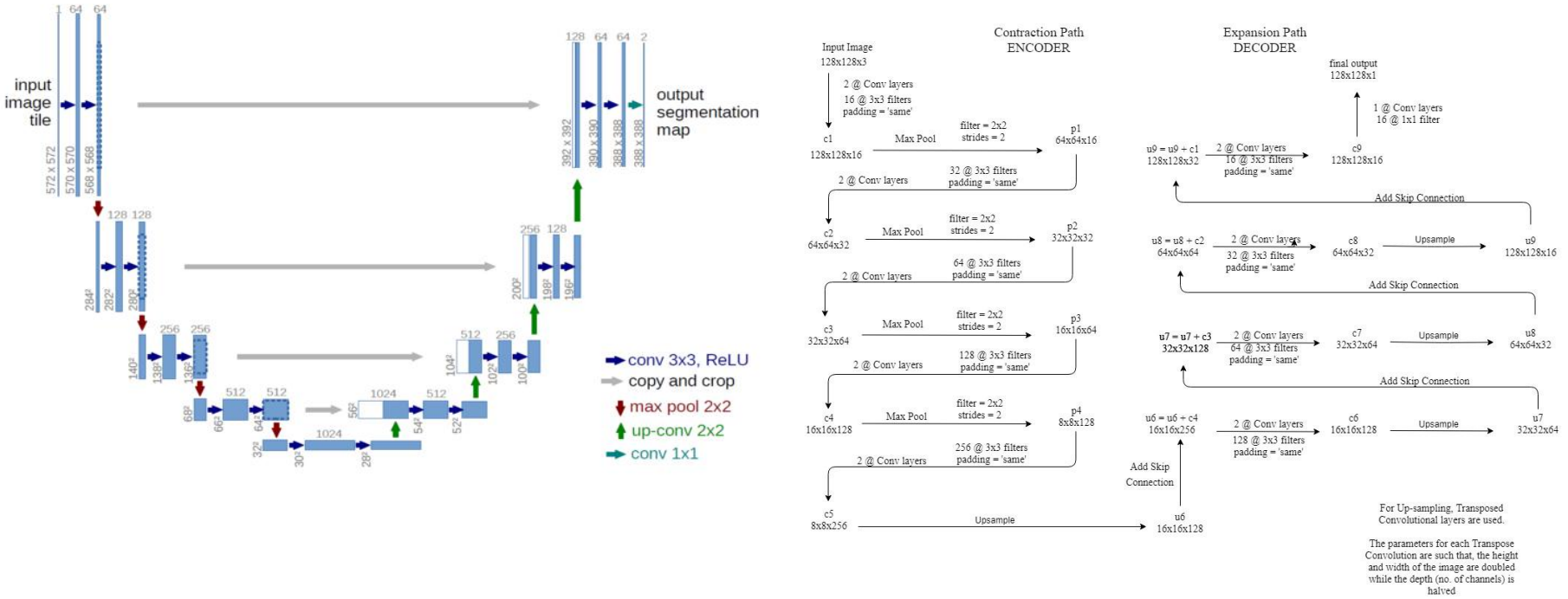



Fig: U-net Architecture Detailed illustration

## Linknet model:

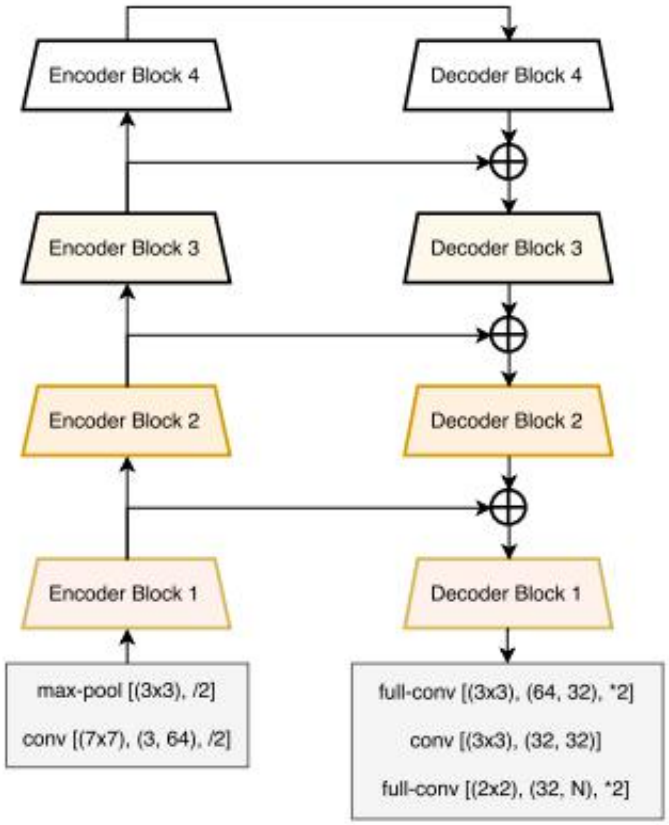



Fig: Linknet Architecture

## FPN model:

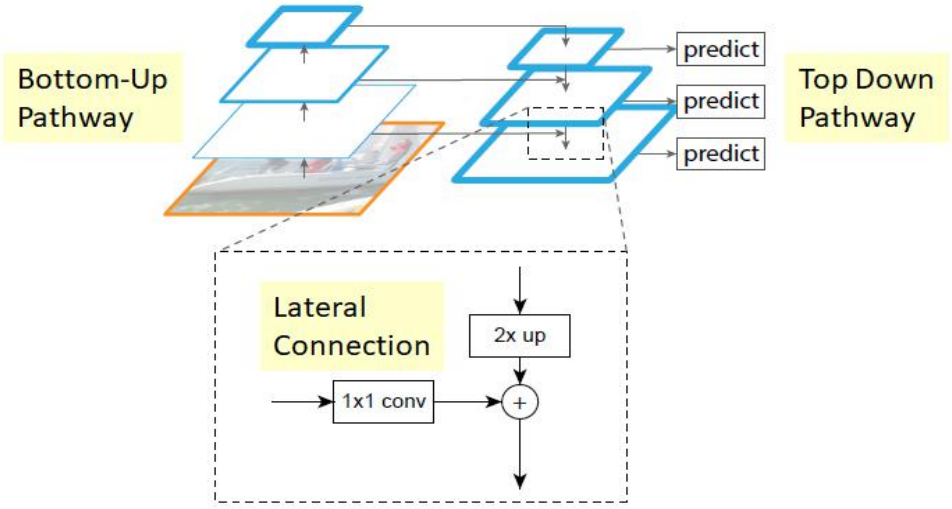
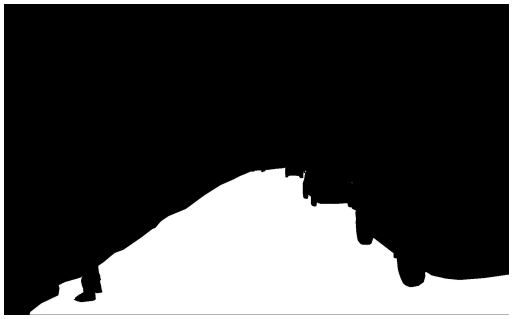



Fig: FPN Segmentation Proposal

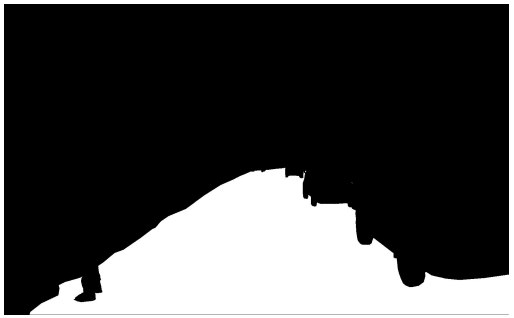
# Result Analysis

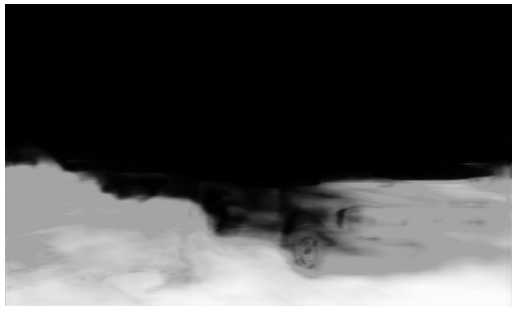
| No | Data set | Split | Model | Hyper-parameters | Train Loss | Train Accuracy | Val Loss | Val IoU | Tested on | Test Loss | Test mIoU | SOTA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Kitti | Train - 289<br>Test - 290 | FCN | vgg16<br>#Epochs(100)<br>Opt: SGD<br>LR: $10^{-4}$<br>Momentum-0.9 | 0.1073 | 0.9037 | --- | --- | kitti + few samples of IDD | 0.026 | 93% | **97%** |
| 2. | IDD | Train (70%)-9805<br>Val (10%)-1401<br>Test (20%)-2802 | Unet | Resnet34<br>#Epochs - 08<br>Opt - Nadam<br>LR: 0.002<br>Dim: 512 x 512<br>Loss: bce_jaccard<br>Metric: IoU | 0.2331 | 0.8542 | 0.2973 | 0.8136 | IDD | 0.23 | 87% | **92%** |
| 3. | IDD | Train (70%)-9805<br>Val (10%)-1401<br>Test (20%)-2802 | Linknet | Resnet18<br>#Epochs - 04<br>Opt - Nadam<br>LR: 0.002<br>Dim: 1024 x 512<br>Loss: bce_jaccard<br>Metric: IoU | 0.6743 | 0.5752 | 0.7226 | 0.5568 | IDD | 0.66 | 59% | |
| 4. | IDD | Train (70%)-9805<br>Val (10%)-1401<br>Test (20%)-2802 | FPN | Resnet101<br>#Epochs - 02<br>Opt - Nadam<br>LR: 0.002<br>Dim: 512 x 512<br>Loss: bce_jaccard<br>Metric: IoU | 0.3172 | 0.8069 | 0.4571 | 0.7331 | IDD | 0.377 | 78% | |

# Result Analysis - Predictions

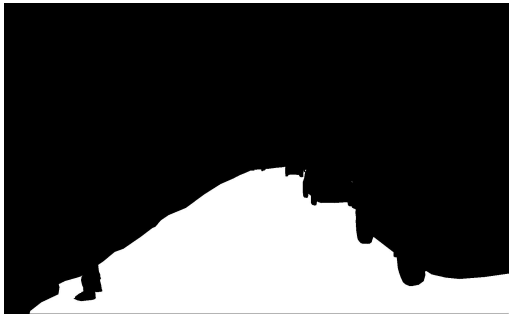


Resultant prediction for Unet model





Resultant prediction for Linknet model



Resultant prediction for FPN model

# Future work- Next steps

Work Done:

- ✓ Road Driveable area detection using semantic segmentation model.
- ✓ Lane annotation (Partially done).
- ✓ Worked on mapping the sensor readings [7] with frame - addressing correspondance issues.
- ✓ Integrated multi- threaded architecture design for both In-Out vehicle analysis.

Work to be Done:

- ✓ Integrate Multi-sensor information with Lane annotations - predict vehicle behavior.
- ✓ Mathematical modelling of Lane - Radius of curvature analysis.
- ✓ Work on Latest SOTA models for Object detection.

# Conclusion

- ✓ We proposed a noval multi-threaded architecture considering both In-Out vehicular environments. Most of the existing solutions provided so far considers the western datasets such as kitti, cityscapes, BDD and Nuscenes etc. However, this datasets donot provide enough challenges that are required for dynamic heterogeneous road traffic scenarios.
- ✓ As part of this work, we build our custom dataset with 10 categories for In-vehicle driver distraction anlysis. For road driveable detection and navigation, we used IDD dataset for training and evaluation.
- ✓ Further, the proposed framework monitors the in-vehicular driver distractions from set of action events aligning with external road traffic scene.
- ✓ Potentially, this could help in complete monitoring of drivers driveability patterns and recommends safety warnings for collision free driving environments.

# References


[1] http://www.cvlibs.net/datasets/kitti/eval_road.php [last accessed: 21st, November, 2019]

[2] https://idd.insaan.iiit.ac.in/dataset/details/ [last accessed: 21st, November, 2019]

[3] Long, Jonathan, Evan Shelhamer, and Trevor Darrell. "Fully convolutional networks for semantic segmentation." Proceedings of the IEEE conference on computer vision and pattern recognition. 2015.

[4] Ronneberger, Olaf, Philipp Fischer, and Thomas Brox. "U-net: Convolutional networks for biomedical image segmentation." International Conference on Medical image computing and computer-assisted intervention. Springer, Cham, 2015.

[5] Lin, Tsung-Yi, et al. "Feature pyramid networks for object detection." Proceedings of the IEEE conference on computer vision and pattern recognition. 2017.

[6] Chaurasia, Abhishek, and Eugenio Culurciello. "Linknet: Exploiting encoder representations for efficient semantic segmentation." 2017 IEEE Visual Communications and Image Processing (VCIP). IEEE, 2017.

[7] https://play.google.com/store/apps/details?id=com.peterhohsy.gsensor_debug&hl=en_IN
[last accessed: 21st, November, 2019]

[8] https://medium.com/@jaswanth.n/road-segmentation-from-scratch-using-deep-learning-towards-autonomous-driving-19e5ced680b8

# Thank You