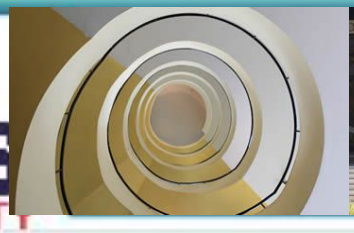




Project Title: Low light object detection in outdoor scenes

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Sumukh Aithal K, PES1201801461
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Project Guide: **Chitra G M**

Problem Statement

Low light object detection in outdoor scenes

- To enhance the vision of the driver with smart algorithms that can work in low light scenarios – dusk, night, in lights from headlights etc.
- The solution should be able to detect common objects like cars, two-wheelers, auto rickshaws, pedestrians, riders in the night/low-light conditions.
- The system has been developed to work in the visible spectrum.

Problem Statement (Continued)

- Dataset used: Indian Roads Dataset: https://idd.insaan.iiit.ac.in/dataset/
- Number of training images: 6993
- Number of classes: 34

Approach

Deep learning Model Used

1. Semantic Segmentation using Deep Lab v3+ model with Xception_65 Backbone.

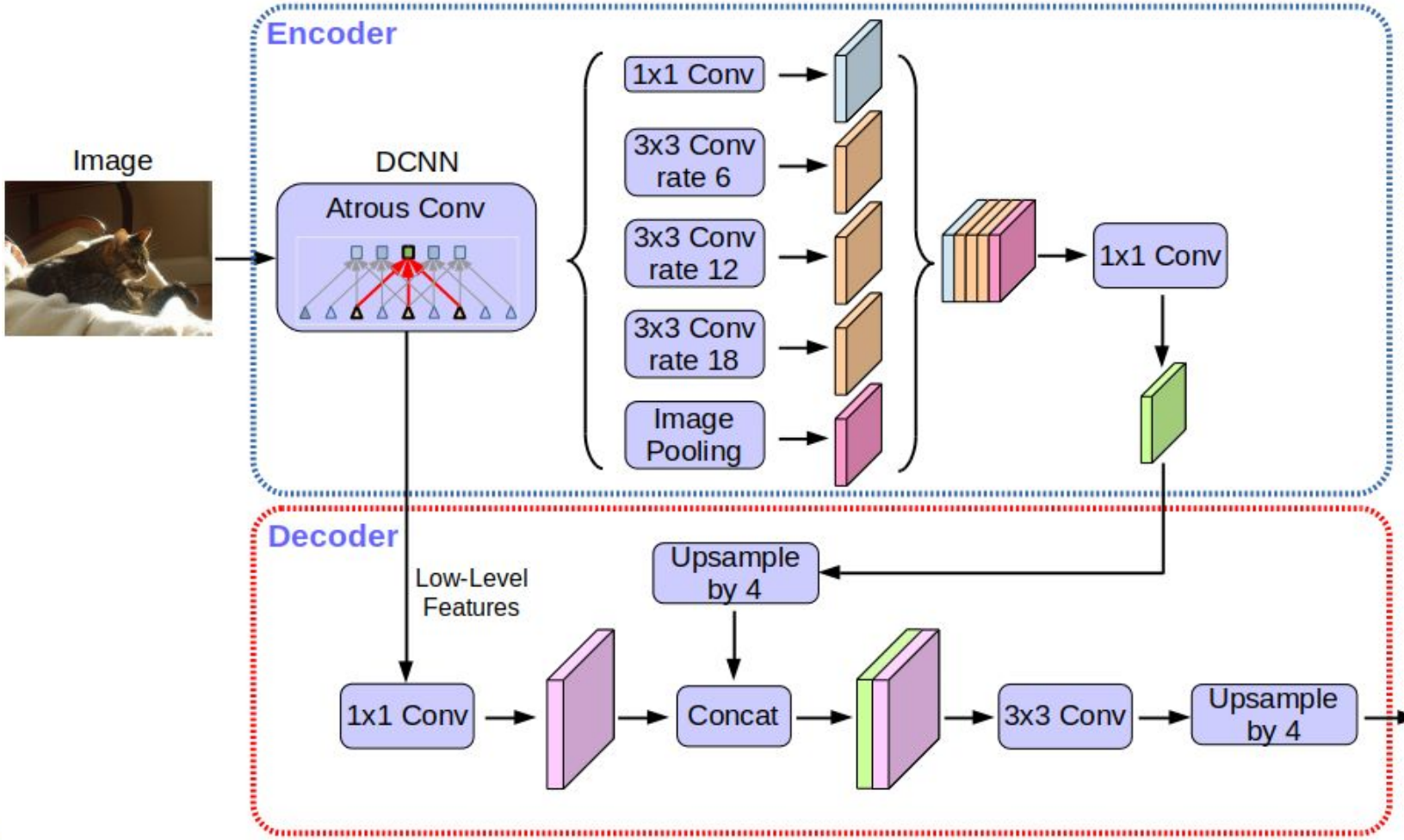
2. Deep Lab v3+ is one of the state of the art models for Semantic Segmentation.

3. Encoder-Decoder Structure uses simple yet effective method to refine segmentation overlays.

4. Uses Atrous Spatial Pyramid Pooling which probes convolutional features at multiple scales, with image-level features encoding global context and further boost performance.

Reference - https://arxiv.org/abs/1802.02611

Model Visualization



Approach (Continued)

Image Enhancement techniques considered

- Histogram Equalization
- An enhancement algorithm using Exposure Fusion Framework
- Retinex based end to end deep learning model for image enhancement.

Note: All three options were viable for our scenario, so all of them were implemented.

Approach - (Continued)

Software Pipeline used :

Apply image enhancement algorithms before training

↓

Choose an appropriate deep learning model, implement and then train it on these enhanced images.

↓

During inference, apply image enhancement techniques

↓

Inference then involves predicting the input data which might be in the form of an image or a video

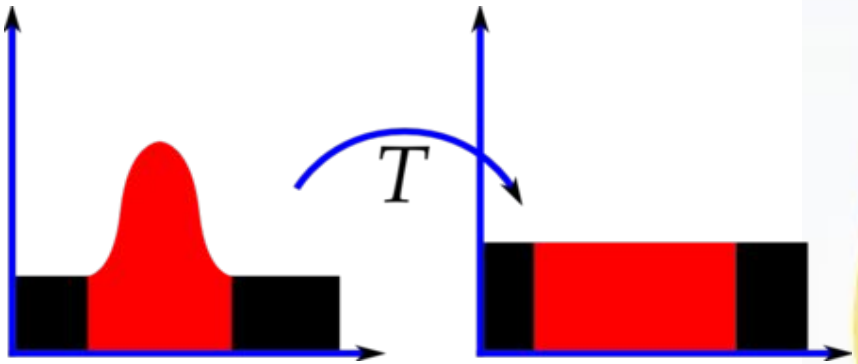
Methodology

Histogram Equalization Technique

- This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values.
- Through this adjustment, the intensities can be better distributed on the histogram.
- This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values.

This method has been carefully selected after a thorough analysis of various image pre processing techniques due to the following characteristics:

1. Simple
2. Low computational cost
3. Highly efficient

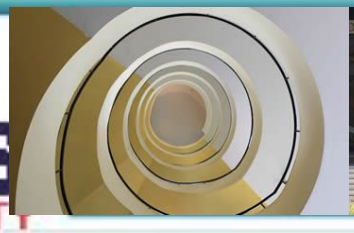


Methodology (Continued)

Contrast Enhancement Algorithm using Exposure Fusion Framework

- This is an image contrast enhancement algorithm to provide an accurate contrast enhancement.
- Specifically, we first design the weight matrix for image fusion using illumination estimation techniques.
- Then we introduce our camera response model to synthesize multi-exposure images. Next, we find the best exposure ratio so that the synthetic image is well-exposed in the regions where the original image underexposed.
- Finally, the input image and the synthetic image are fused according to the weight matrix to obtain the enhancement result. Experiments show that our method can obtain results with less contrast and lightness distortion compared to that of several state-of-the-art methods.

References:
https://www.researchgate.net/publication/318730125_A_New_Image_Contrast_Enhancement_Algorithm_Using_Exposure_Fusion_Framework






Methodology (Continued)

Retinex based end to end deep learning model for image enhancement.

- Retinex based deep learning model is learned on a particular dataset, including a Decom-Net for decomposition and an Enhance-Net for illumination adjustment.
- In the training process for Decom-Net, there is no ground truth of decomposed reflectance and illumination.
- The network is learned with only key constraints including the consistent reflectance shared by paired low/normal-light images, and the smoothness of illumination.
- Based on the decomposition, subsequent lightness enhancement is conducted on illumination by an enhancement network called Enhance-Net, and for joint denoising there is a denoising operation on reflectance.
- This model is end-to-end trainable, so that the learned decomposition is by nature good for lightness adjustment.

References: https://arxiv.org/abs/1808.04560

Methodology

- All the above techniques were implemented in python using modules opencv and numpy.
- In the following slides we see a detailed comparison on the three methods of image enhancement techniques which were implemented.
- The following results are obtained after performing inference on the pre trained Deep lab v3+ model.
- The images used for inference are from the Intel Indian Driving Roads (IDD) Dataset .

Results

Using Histogram Equalization Technique

Results

Enhancement Results

Using Contrast Enhancement Algorithm Exposure Fusion Framework

Results

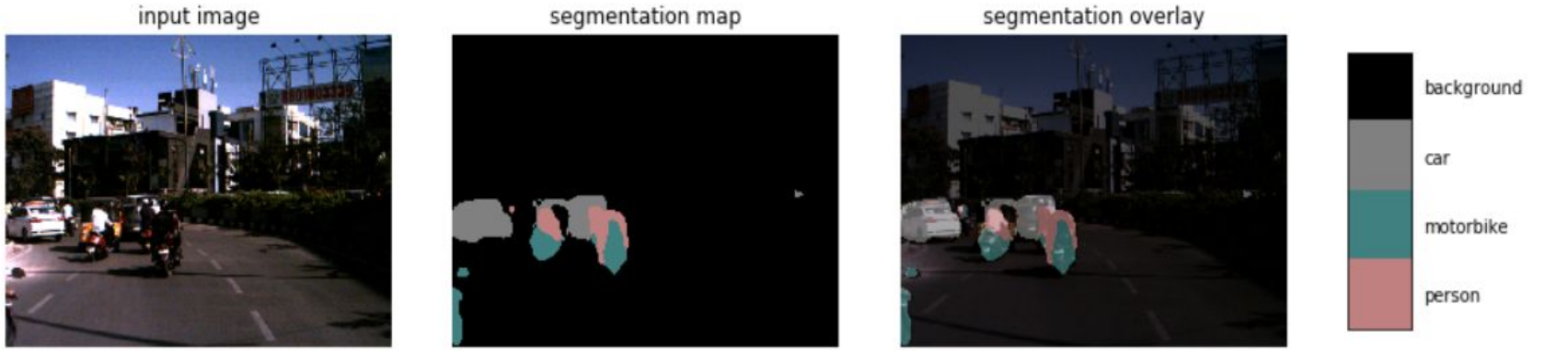
Using Retinex based deep learning model

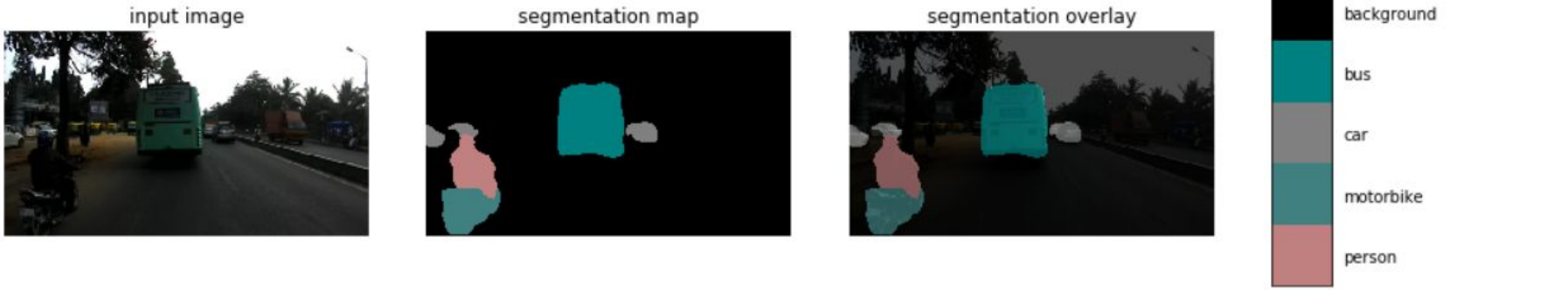
We now perform inference on all the images including low light images along with enhanced images from all the three techniques

We also use the Deep Lab V3+ model with `77.31% mIOU score`

Results - Inference

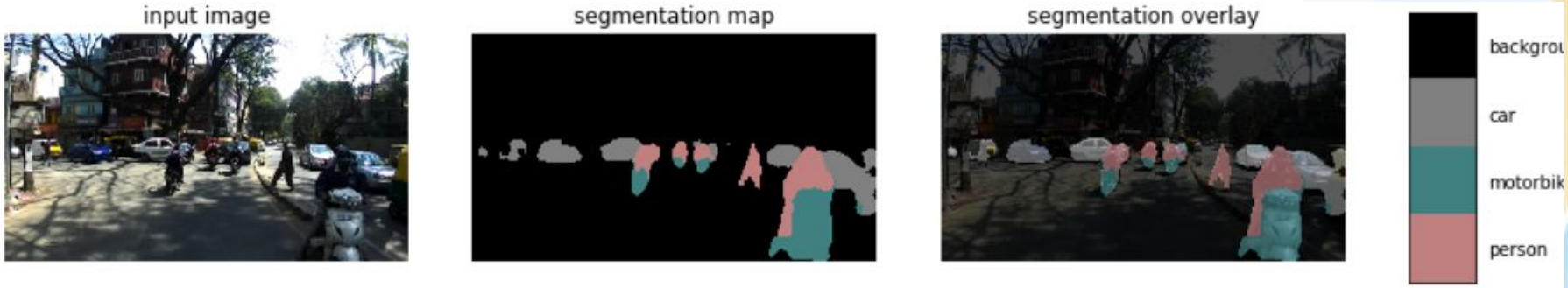
Images in low light Conditions without enhancement





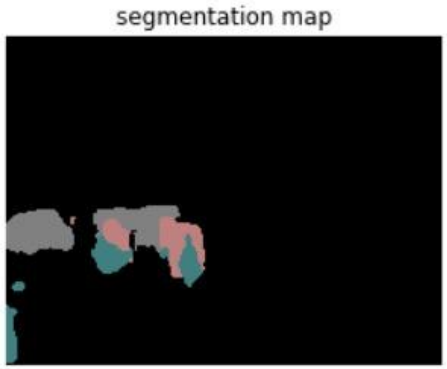
Results

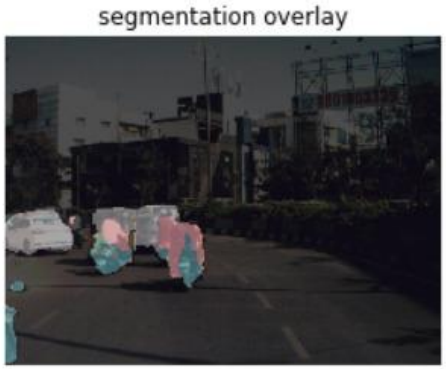
Images in low light Conditions without enhancement

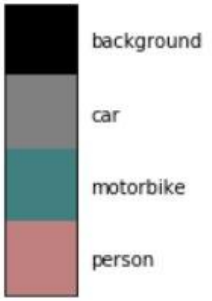


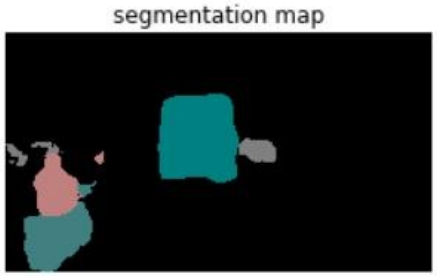
Results - Inference

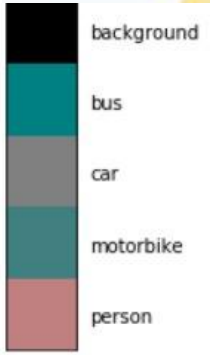
Histogram equalization





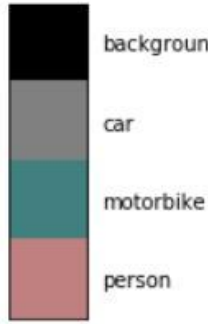






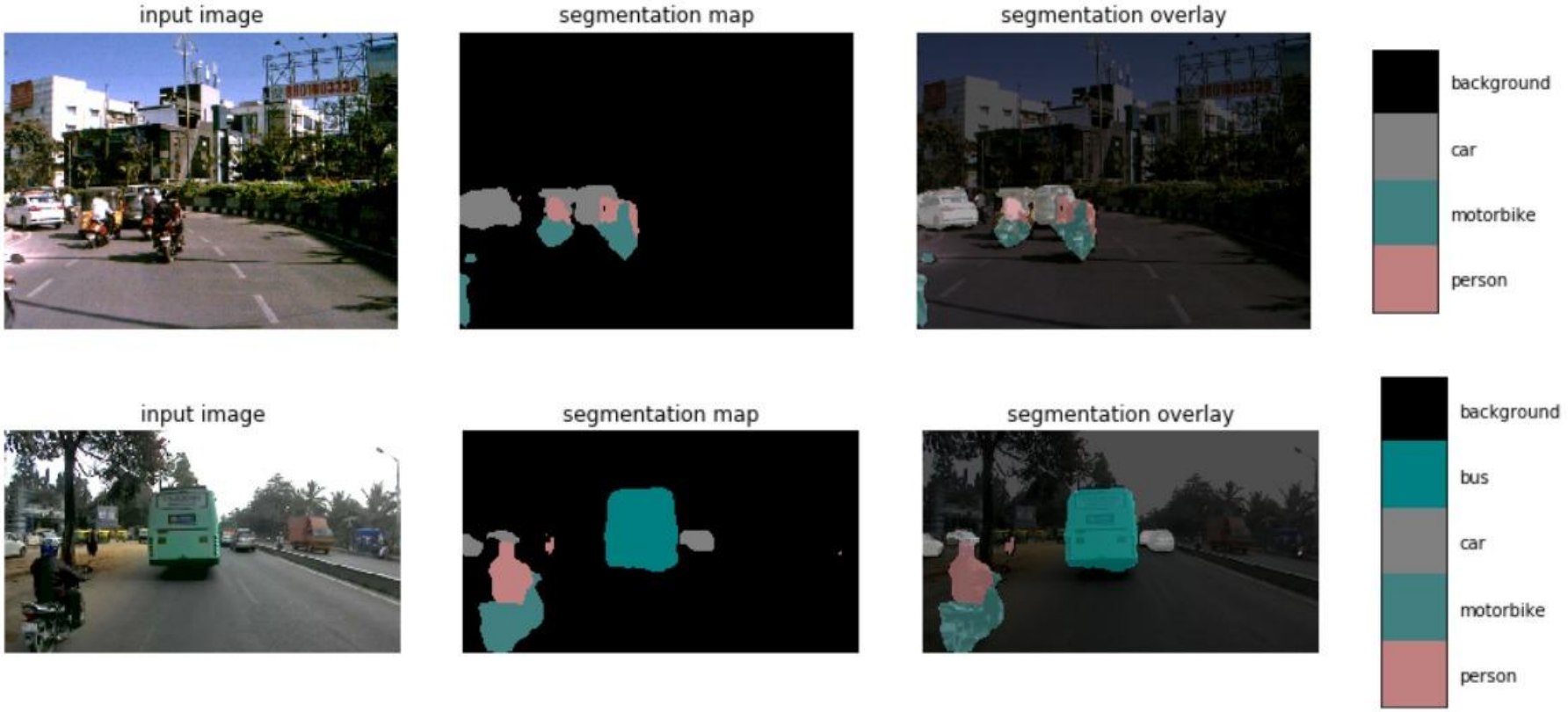
Results - Inference

Histogram equalization



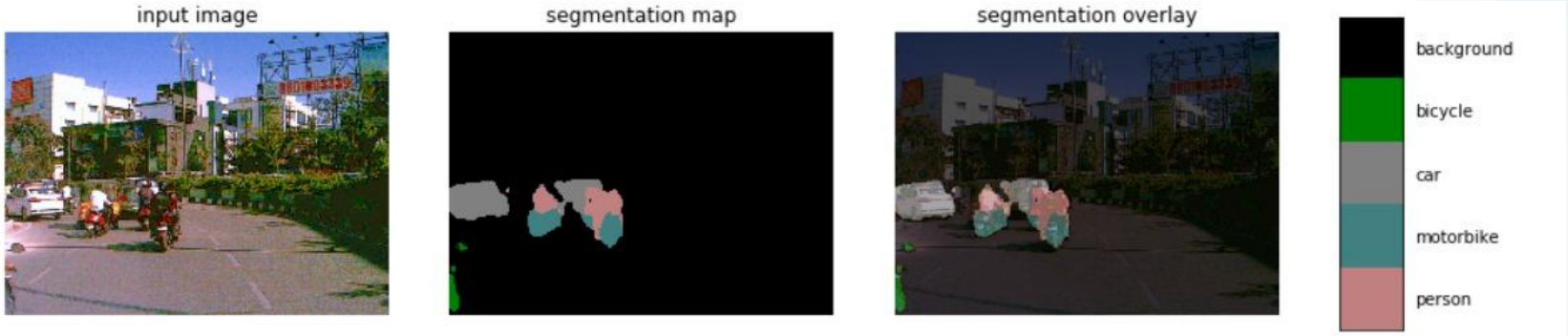
Results - Inference

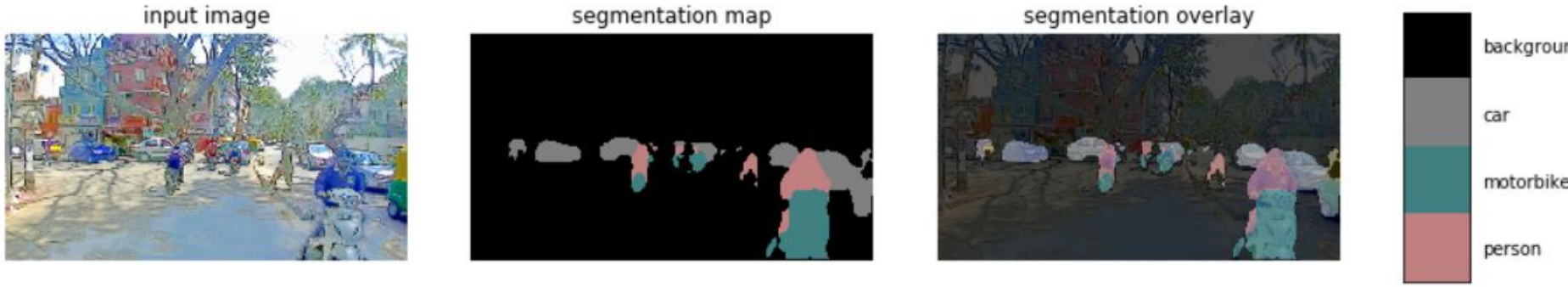
Contrast Enhancement Algorithm using Exposure Fusion Framework



Results - Inference

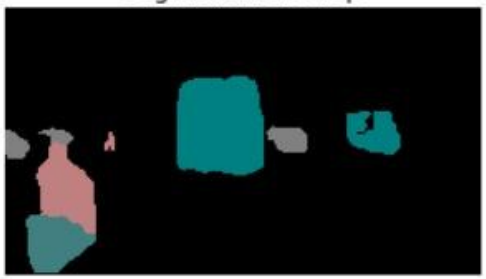
Retinex based end to end deep learning model

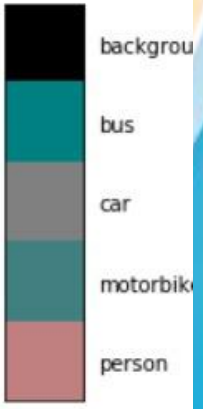




Results - Inferenence

Retinex based end to end deep learning model





Results

Conclusion

We have observed very keenly on the performance of all the enhancement techniques and have selected the ***Contrast Enhancement Algorithm using Exposure Fusion Framework*** from all the three techniques used here

Some observations:

- Retinex based end to end deep learning model enhancement technique was providing a very artificial image as its output
- Retinex based methods suffer from halo-like artifact in the high contrast region
- HE-based methods always suffer from over-enhancement and lead to unrealistic results
- Histogram Equalization is computationally efficient ,quick and can be used when computational resources are limited.

Novelty

- Implementing and using ***Contrast Enhancement Algorithm Exposure Fusion Framework*** in low light conditions for Advanced Driving Assistance Systems
- Using a **deep learning model** for image enhancement instead of the traditional methods
- Custom Training on 6 classes from scratch for the Indian Roads Dataset
- Comparison of various enhancement techniques and segmentation after applying these techniques

Results

- Apart from this we have also **trained a custom model** on the INTEL IDD dataset with 6 classes namely Background,Auto-rickshaw,Car,Two-wheeler,Pedestrian,Rider.
- We have trained this model from scratch and achieved mIOU score of 57.6%
- Model trained for 20 hours.

Screenshots of **intermediate** training stages of the model while training on **Intel Dev Cloud**

```
WARNING:tensorflow:From /glob/intel-python/python3/lib/python3.6/site-packages/t
ensorflow/python/ops/math_ops.py:3066: to_int32 (from tensorflow.python.ops.math
_ops) is deprecated and will be removed in a future version.
Instructions for updating:
Use tf.cast instead.
Train on 6293 samples, validate on 700 samples
Epoch 1/100
6293/6293 [==============================] - 21605s 3s/step - loss: 0.5264 - mean_iou: 0.2687 - val_loss: 0.7395 - val_mean_iou: 0.4410
Epoch 2/100
4768/6293 [=====================>........] - ETA: 1:21:51 - loss: 0.2722 - mean_iou: 0.4735
```

Potential Future Works

- Training particularly on pedestrians at low light which the model finds it difficult to detect.
- Improvement in mIOU Score
- Using a much more computationally efficient model.

Key Learnings

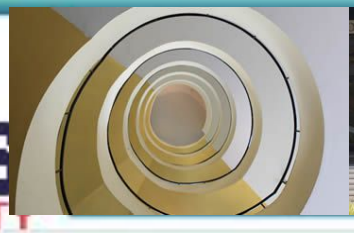
1. Learnt a lot of key image enhancement techniques like Histogram Equalization,Retinex model and other state of the art techniques.

2. Learned in detail the workings of various models like DeepLabv3+, Mask-RCNN.

3. To perform data preprocessing and convert the json files to masks.

4. Performing Segmentation on the dataset from scratch on a custom dataset

5. Using the Intel AI DevCloud






Thank You