Street Light Mapping Using Computer Vision

Anonymous ECCV submission

Paper ID ***

Abstract. The abstract should summarize the contents of the paper. LNCS guidelines indicate it should be at least 70 and at most 150 words. It should be set in 9-point font size and should be inset 1.0 cm from the right and left margins. . . .

Keywords: We would like to encourage you to list your keywords within the abstract section

1 Introduction

According to the report, Road Accidents in India - 2016 [1] by Ministry of Road transport and Highways, India, the number of road accidents due to poor lighting conditions of the road, amount to roughly 0.8% of the total road accidents in India, out of which nearly 1.1% turn to be fatal accidents whereas 1.0% accidents result in injuries to the people. In India, it can be found that the number of roads with not enough street lights or the number of lights needed for a well lit area is lesser. This results in pitch dark roads making it difficult for citizens to commute, hence resulting in accidents.

Fig. 1. Road with no street lights and a well lit road.

A system to monitor lights in every city of India is highly needed to reduce the number of accidents. Manual monitoring of street lights is a tedious task. To have an individual go all over an area to capture information about whether street lights are working or not and then map them to an open map is not a scalable approach. This approach can help cover certain areas of a city but to significantly bring down the number of accidents, a need for a system that can be widely used is needed.

In this paper, we present an approach that with the help of videos captured by a camera placed in a car during both day time and night time trips, we can detect street lights that are on or off and then map them to a map. This information will help a driver to make an informed decision about the best lit path to choose to travel at night. A map with street light positions will also help the government to know about the dark patches on the road and will indicate where extra street lights need to be installed.

In the past, authors in [2] have tried to detect street lights at night using the traditional approaches such as Support Vector Machines, Discriminant Analysis and Naive Bayes Classifier. The detection of street lights in [2] has only been done at night. The paper also focuses on the height of the street lights and the intensity of light emitted by the light. In this paper, we use state of the art deep learning approach like YOLO [3] to detect and classify the street lights during both day and night time and use keypoint based tracking algorithm [4] to track the lights and get an estimate location to mark the light on a map. Street light detection is challenging due to a number of issues, including occlusion from trees, objects with similar features such as level crossing, poles with wires, etc. The lights covered at night time do not much contain information about the pole due to the high intensity light of street lights that is spread in the frames captured by the cameras.

Fig. 2. An overview of our approach.

2 Method

Our approach for street light mapping and detection has been performed on a set of videos captured with a camera placed in a car mounted on the dashboard on the streets of Bangalore. Along with the data captured from a camera, GPS data is also calculated. Using the given set of videos first a training set is prepared that is used to train the YOLO [3] model for detection of street lights. With the help of the detection model, we try to capture the different properties of the street lights present in an area. The deep neural network helps to detect a street light and then also indicate whether the light is on or not. This helps to give an information about the working street lights. Once we have the bounding boxes for the street lights, it is fed to the CMT [4] algorithm for tracking the street lights. This helps to monitor the same street light for an area. Once the region of interest by the tracking algorithm and the bounding box by the YOLO detection have an intersection of less than 0.5, then the initial bounding box for the tracking algorithm is changed. This helps us to estimate an approximate position of the current street light. The GPS coordinates are present for each frame. The frame where a street light was last seen is known to us using tracking, this helps to mark the position of every street light on the Google map. The method is described in greater detail in the upcoming sections.

2.1 Data Annotation

To create a dataset for training the neural network, two different approaches were followed and observed. In the first approach, only the horizontal part of the street light was marked as can be shown in figure 3. And in the second approach, both the horizontal and the vertical part of the pole of street light as seen in the figure were used to create a dataset. It was observed that taking into consideration the pole of the street light improved the accuracy of the system as it was able to capture larger information about the street light. This also reduced the number of false positives such as level crossing while detection and branches of the tree.

Fig. 3. Horizontal annotation and vertical annotation

2.2 Training Data

The YOLO model was trained on 832x832 sized images of street lights with both on and off classes. For the on street lights, 1488 images were taken and annotated whereas for the off class, 3400 annotated images were taken. To also train the negative to understand the negative samples, around 200 images of trees and the electric poles were used to decrease the number of false positives. 10% of images of each class were used for validation of YOLO[3]. Training on images of size 832x832, helped the network to learn smaller objects better.

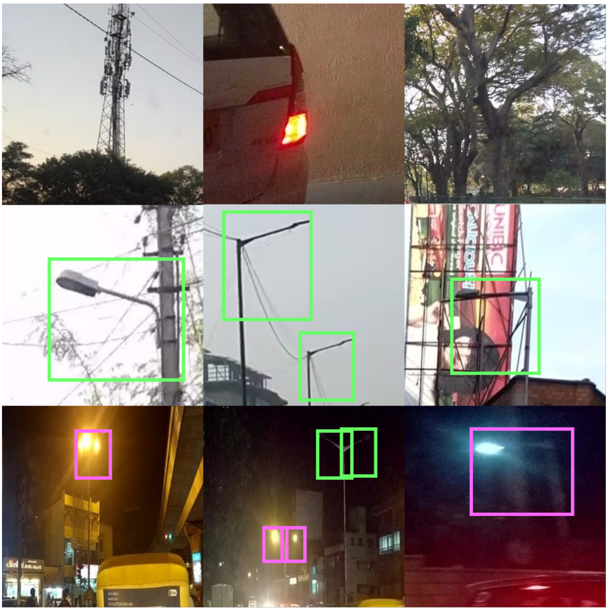

Fig. 4. Example of training data for day and night scenes.

2.3 Detection Using YOLO [3]

The darknet YOLO v2[3] was trained on the training dataset to get detection results. The training was stopped when a significant drop in the loss was not observed. Weights after 7000 iterations were used as it gave a better recall and IOU on validation set. The testing was done on images of size 1024x1024 to be able to detect smaller objects.

2.4 Tracking Lights using CMT [4]

The bounding boxes obtained from YOLO are used as initial bounding box for the tracking algorithm. For a frame with multiple street light detections, the box with the largest area is picked assuming it will be nearest the street light for the particular frame. For every frame, the box with the largest area is picked as the initial box for tracking. CMT then using the initialized region finds keypoints for the same object in the subsequent frames. If the box marked by CMT algorithm and the YOLO detection box has an overlap region of less than 0.5 then it indicates that a new light is present in the frame. Hence, CMT takes the new street light region as the initialization region.

2.5 Mapping Lights on Google Map

With the help of the CMT [4] algorithm, we know the position of street lights present. CMT gives us the frame where a street light was last spotted which corresponds to the position of the street light. The GPS coordinates corresponding to every frame are present. This gives us the GPS location of the street light of an area. Hence, using this information we mark the lights of an area on the Google Map.

3 Experiments and results

The proposed approach is carried out on videos of the road captured from a mobile application. The experiments were done for detection task and tracking. The dataset used for the same is described in detail as such.

3.1 Dataset

The number of images used for training and testing YOLO for classes on and off street light 1488 and 3400 respectively whereas 1992 negative images were used. The train and test split for YOLO was 90% and 10% respectively. The images were picked from day and night trips recorded in Bangalore. The final testing and statistics are reported on two videos - a day and a night trip of duration 1 hour and 45 mins respectively.

3.2 Detection

Dataset	Day Trip	Night Trip
Frames	1260	2748
Average Precision	0.506	0.69
Precision	0.837	0.79
Recall	0.592	0.84
F1 Score	**0.693**	**0.814**

Table 1. Quantitative results

After training the model on around 7000 images, we were able to get good results. Training the model on only images with on and off classes gave very high number of false positives and hence a lower precision value. Training with the negative images gave a better F1 score and also a higher precision value for the detection. The results can be seen in Table 2. The F1 score achieved for day time images is **0.693** whereas F1 score for night time video is **0.814**. Our main aim is to eventually detect all the street lights irrespective of the fact of it being covered in every frame. Hence, if we consider all the street lights that were detected even once we achieve an accuracy of **84.4%** on the day video of duration 1 hour whereas for the night time video, we achieve an accuracy of **93.75%** for the duration of a 45 minutes video. There are 3651 frames in the day trip video with 336 street lights that are detected and 62 that are not detected. In the night trip video of 45 min, with a frame rate of 1 fps, there are 2748 frames, with 315 street lights detected and 21 street lights not detected.

Fig. 5. Qualitative results of YOLO detection

3.3 Mapping

The street light detections from YOLO[3] were used to track the street lights further. The original CMT [4] code was modified to work for multiple street lights in a video. To test the tracking code for multiple street lights, it was tested on video snippets covering different scenarios. The different videos are video covering street lights on a highway, covering street lights on a street, and a video covering street lights at night. As soon as the overlap region between the current region of interest and previous region region of interest is almost 0, then this frame is marked as the end of the street light. A map of street lights can be seen in Figure 7.

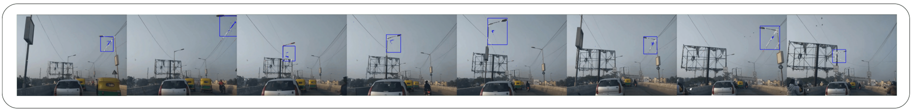

Fig. 6. Tracking of street lights on a highway

4 Conclusion

In this paper, we present a system that can help detect street lights with an accuracy of 84% for a day time video and 94% for a night time video. Good detections help us track the street lights in a better way. Hence, after detections we have tracked the street lights which help us to get an estimate of the location of the street light and help us to put it on a map. Having this layer of information on the Google Maps will help a driver to choose a better route and avoid accidents. This will also help the government to install street lights on dark unlit roads.

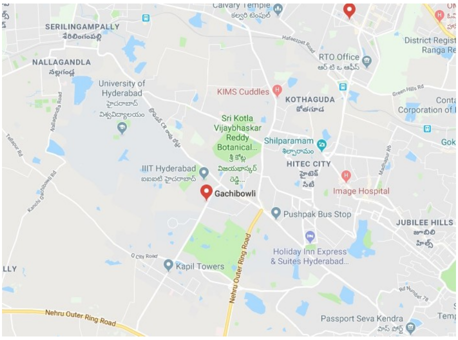

Fig. 7. .

5 Future Work

This work can be further extended to other signs present on the road such as traffic signs and street signs. A map view of the road artifacts will be beneficial for better road understanding. This system can also be further extended to a real time system can be run on the mobile phone. This will make the system portable and faster to map the roads on the map.

References

1. of Road Transport, M., Highways: Road accidents in india - 2006
2. Kumar, S., Deshpande, A., Ho, S.S., Ku, J.S., Sarma, S.E.: Urban street lighting infrastructure monitoring using a mobile sensor platform. IEEE Sensors Journal **16**(12) (June 2016) 4981–4994
3. Redmon, J., Farhadi, A.: Yolo9000: Better, faster, stronger. arXiv preprint arXiv:1612.08242 (2016)
4. Nebehay, G., Pflugfelder, R.: Clustering of Static-Adaptive correspondences for deformable object tracking. In: Computer Vision and Pattern Recognition, IEEE (June 2015)