Image Processing Techniques for Traffic Data Extraction from Aerial Imagery

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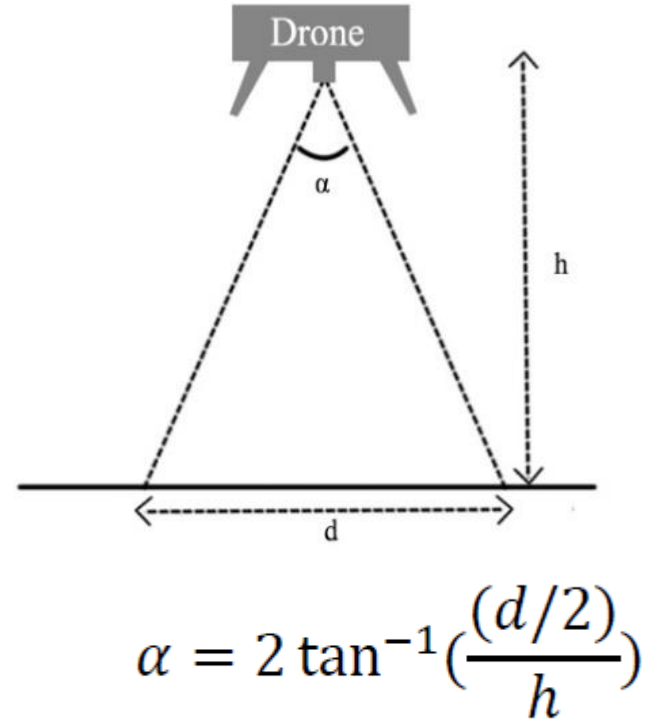
Introduction

- Traffic Data
  - Classified count
  - Density
  - Speed
- Density
  - Number of vehicles in a section of roadway
  - Proximity
  - Difficulty
- Classification
  - Designing pavements
  - Environmental impact studies
  - Studying maneuvering characteristics

Aerial Imagery

- Platforms
  - UAV (Unmanned Aerial Vehicle)
  - Aircrafts
  - Helicopters
  - Balloons
- Field of View - 60° to 150°
- Advantages in Traffic Studies

$$\alpha = 2\tan^{-1}\left(\frac{(d/2)}{h}\right)$$

Source: https://upload.wikimedia.org/wikipedia

Distortions

- Barrel Distortion

  - The apparent effect is that of an image which has been mapped around a sphere (or barrel).

  - As the field of view increases, barrel distortion effects increases

  - This means that the image magnification decreases with distance from the optical axis.

  - Some cameras come with auto calibration

Source: Nasim Mansurov. 2013. What is Distortion?. [ONLINE] Available at: https://photographylife.com/what-is-distortion.
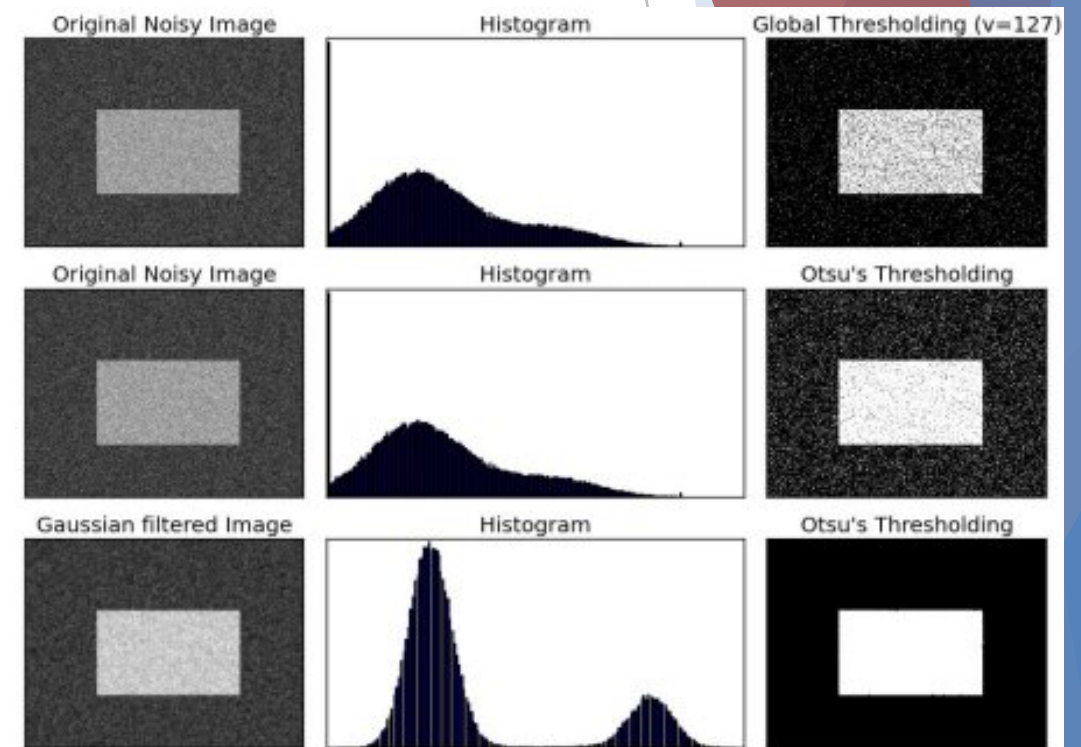
Data Collection

- Location - Porur junction, Chennai

- Resolution – 12 MP - 2700 x 1500 pixels

- Frame Rate – 30fps

- Field of View - 90°

- Height – 50 m

- Aprrox Dimensions

  - Car -

  - Two Wheeler

  - Truck

Sample Shot

Morphological Operations & Thresholding

- Morphological operations
  - Erosion
    - Enlarges the dark regions, and shrinks the bright regions
  - Dilation
    - enlarges bright regions, and shrinks the dark regions
  - Opening
  - Closing
- Thresholding
  - Otsu Thresholding
    - The algorithm assumes that the image contains two classes of pixels following bi-modal histogram
    - Optimum threshold separating the two classes so that their combined spread (intra-class variance) is minimal,

Source:http://opencv-python-tutroals.readthedocs.io/en/latest/_images/otsu.jpg

Results

- Only a small percentage of two wheelers were detected as majority of them were removed in the process of thresholding and noise removal
- Multiple detections were obtained for the same car as the front and rear windshields were removed in thresholding

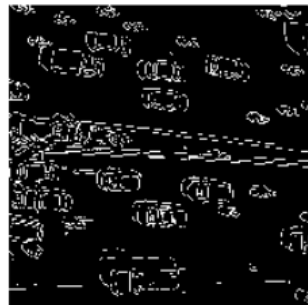| Counting Two Wheelers	Two Wheeler (2W)	Light Motor Vehicle (LMV)	Heavy Motor Vehicle (HMV)
Counting Accuracy	55.55%	71.67%	56.25%

Edge Detection

▶ Detecting sudden changes in the pixel intensity

▶ Contrast Stretching

▶ Canny Edge Detection was used

▶ 'σ', indicates the size of the Gaussian filter kernel
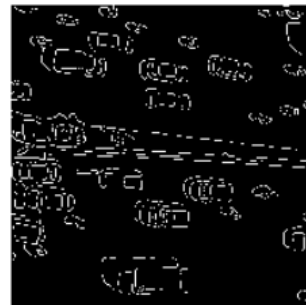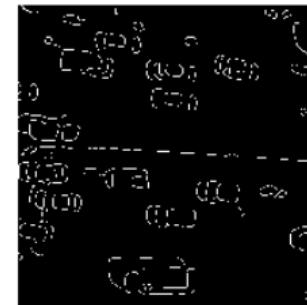

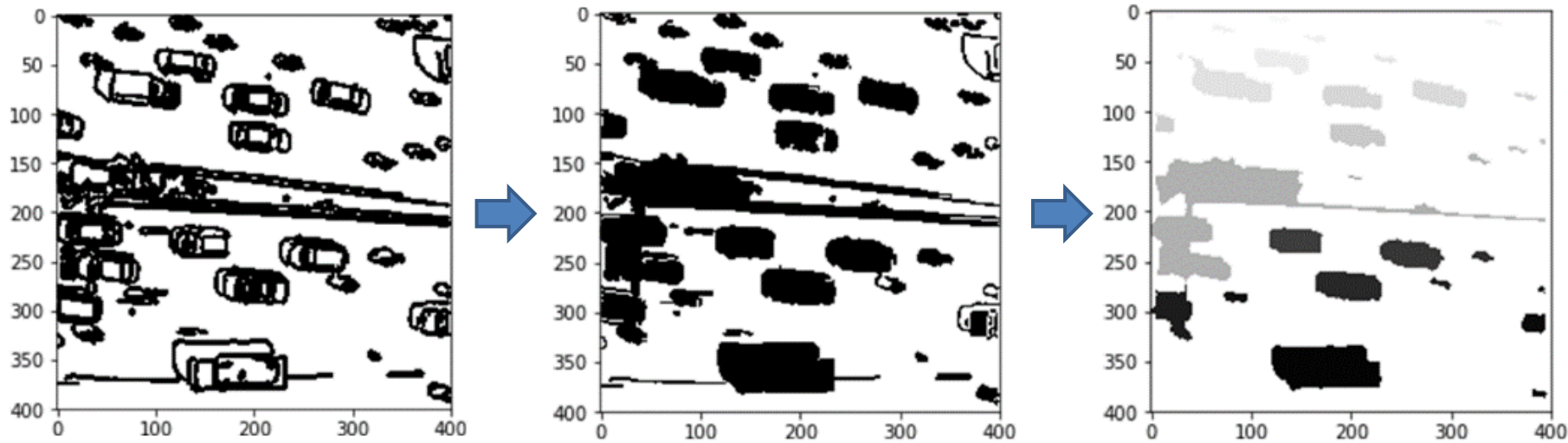Normal image   Canny filter, $\sigma = 1$ Canny filter, $\sigma = 2$ Canny filter, $\sigma = 3$
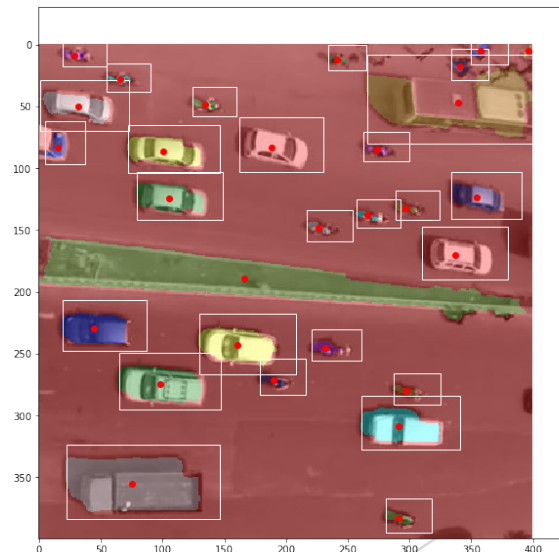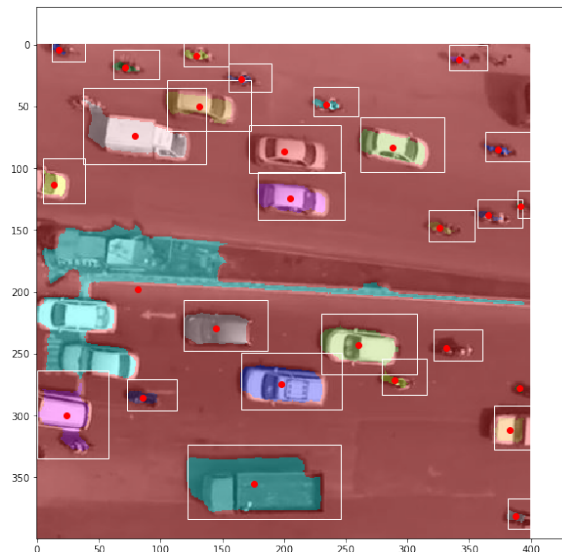
Further Processing
(Dilation, Filling, Thresholding and Noise removal)

Results

▶ The edge detection technique was found to perform better than Otsu thresholding and the accuracy of detection in all three classes have increased

▶ Even dark vehicles and two wheelers, which were not detected in the earlier approach, were detected

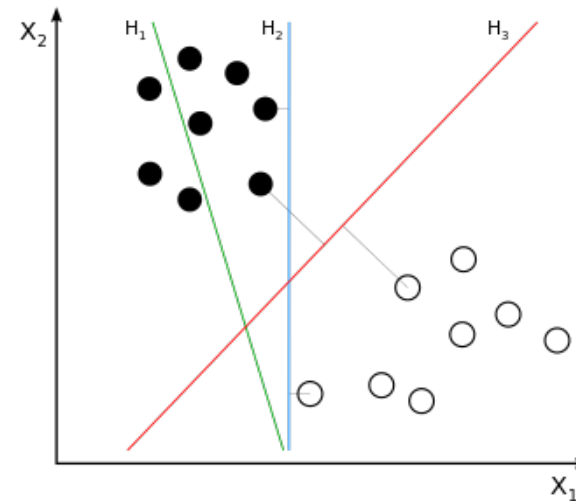▶ However, in some cases, it merged two vehicles due to overlapping shadows

Counting	Two Wheelers (2W)	Light Motor Vehicle (LMV)	Heavy Motor Vehicle (HMV)
Counting Accuracy	82.70%	84.40%	93.75%

Classification
Support Vector Machine(SVM)
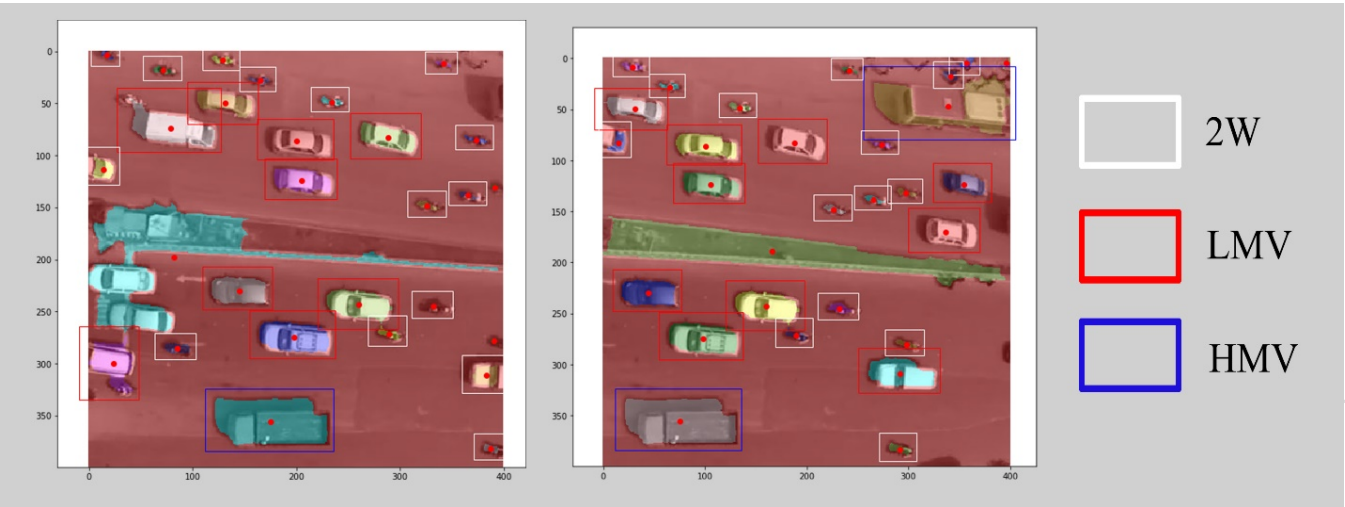
- Supervised machine learning models used for classification

- Linear Classification

- Three Categories

  - Two Wheelers (2W)

  - Light Motor Vehicle (LMV)

  - Heavy Motor Vehicle (HMV)

- Input variables

  - Perimeter

  - Area

Source:https://upload.wikimedia.org/wikipedia/

Results

- High accuracy can be observed for classification in all three categories, as there was significant variation in areas and perimeters amongst the three categories.

Classification	Two Wheelers (2W)	Light Motor Vehicle (LMV)	Heavy Motor Vehicle (HMV)
Classification Accuracy	97.75%	94.5%	100%

Limitations

- Considers shadows along with objects
- The method does not perform well incase of bunching of vehicles
- Inclement weather conditions, lighting and night time
- Requires calibration with height variation for classification
- With increase in height, detection of two wheelers gets harder

Other Techniques

- Background Subtraction
  - Video should be stable
  - Fixed camera
- Template matching
  - Wont work for heterogeneous traffic conditions like India
  - Needs lot of templates
- Deep Neural Networks
  - YOLO (You Only Look Once)
    - Requires huge training dataset
    - Cannot detect 2 wheelers

Further Work

- Video Stabilization
- Tracking
  - Speed
- Occupancy
- Headway