# Mobile Vehicle License Plate Recognition

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# Based on ...

- Lajish V.L. and Sunil Kumar Kopparapu, *"Mobile Phone Based Vehicle License Plate Recognition for Road Policing"*, International Conference on Pattern Recognition and Machine Intelligence, PReMI 09, Dec. 16-20, IIT Delhi, 2009.

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- If not acknowledged *All images either from these references of from web*

# Vehicle License Plate

- What?
  - A vehicle registration plate is a metal or plastic plate attached to a motor vehicle on the outside
  - Example 

- Why?
  - for official identification purposes
  - personal vehicle identification

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Because .....

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Unless .... 

# Motivation: General

Automatic vehicle license plate recognition has several applications in intelligent traffic management systems

- Quick identity of a vehicle can be done


Owner
Address
UID
Traffic Violation
Insurance Details

- Play Identify Stolen vehicles
- Automatic toll collection India

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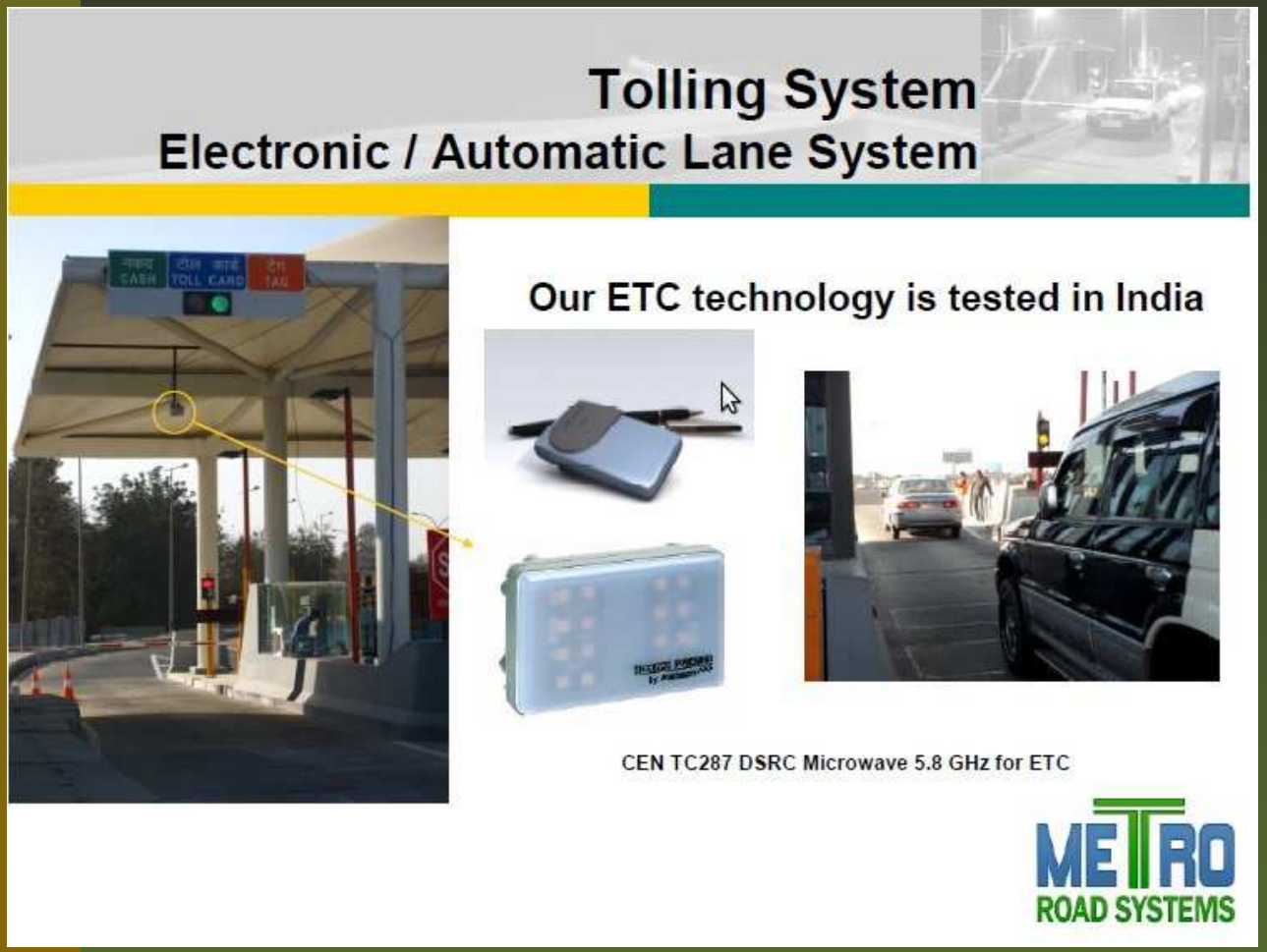
- Automatic toll collection India Solved??

# Videos show - problem Solved?

- "Lets verify! Number Plate in USA"

# Videos show - problem Solved?

- "Lets verify! Number Plate in USA"
- Uses $\mu$wave Tag!



# License Plate Recognition Systems

*LPR systems are usually designed to read vehicles license plate and automatically recognize license plate number of vehicles passing through a certain point.*

- Several existing systems (bing it!)
- In all the existing systems
  - the camera is fixed and of high resolution
  - only able to scan the vehicle passing through a particular point
  - at a particular speed or stationary vehicles

# Is the problem Solved?

- Developer library for vehicle license plate recognition (http://www.dtksoft.com/dtkanpr.php)
- Supports several countries
- However,
  - Fixed camera
  - Certain constraints on the image quality

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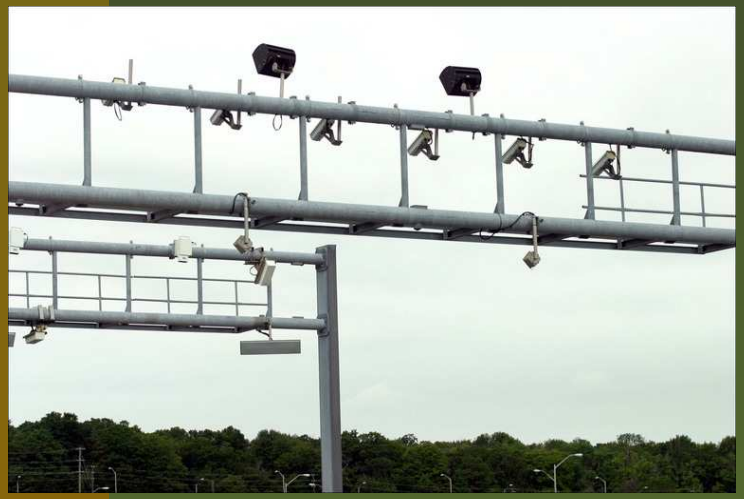

Toll Equipment in Ontario

# Motivation: Specific

- Complete System
- System that enables get instant details of a vehicle
- should be easy to use,
- should be mobile,
- work 24 x 7
- Should work for Indian conditions
- Should be scalable
- Should be inexpensive (camera; camera mounting)

# Overview

- End to end usable License Plate Recognition System
  - mobile phone based,
  - client-server architected
  - automatically recognize non-uniform license plates,
- Two Parts
  - mobile client which enables capture of the license plate of a vehicle and send the image to a remote server and
  - server which has a LPR software and access to an external database with vehicle information

# Overview: Second Level

- The client application runs on a mobile device and
- a server application hosted centrally
  - with access to vehicle information database
- The solution enables
  - capture of license plate image by the phone camera
  - passes to the server;
  - Recognition of the license plate number
  - Retrieve data associated with the number plate
  - Push data to the mobile device, instantaneously

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Figuratively ...

# Architecture: At a Glance

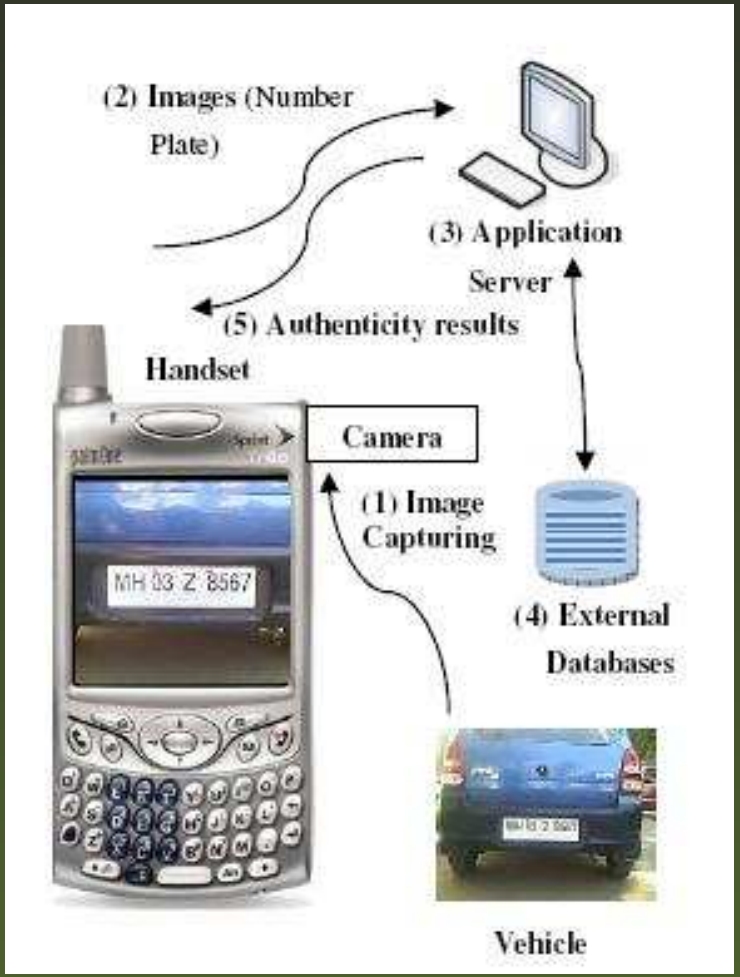
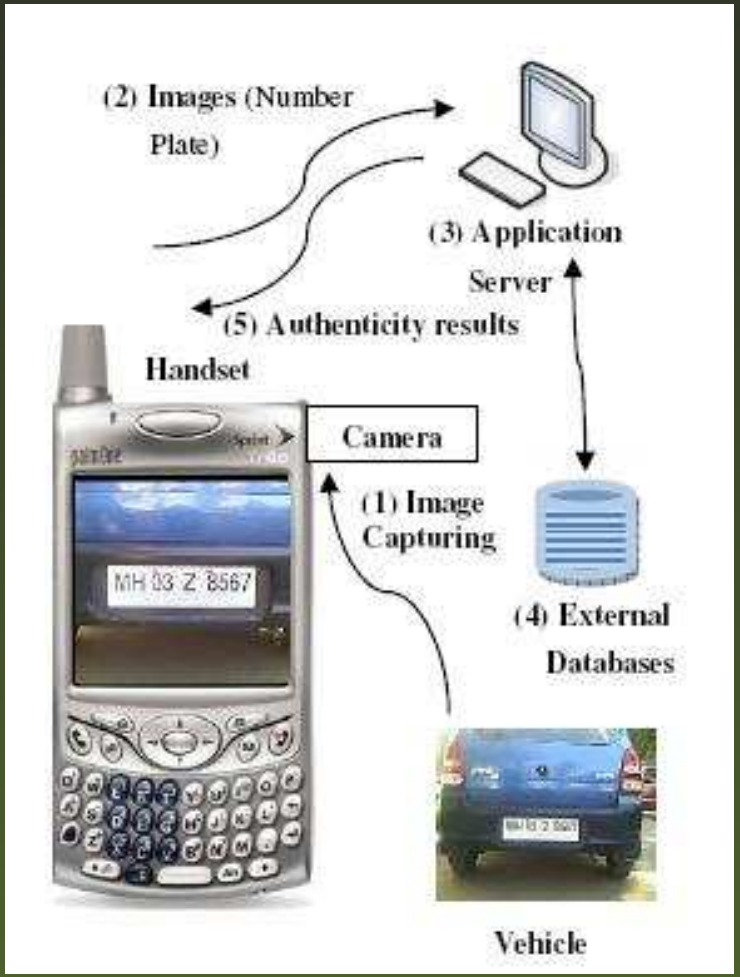



Image from *[1] PReMI 2009*

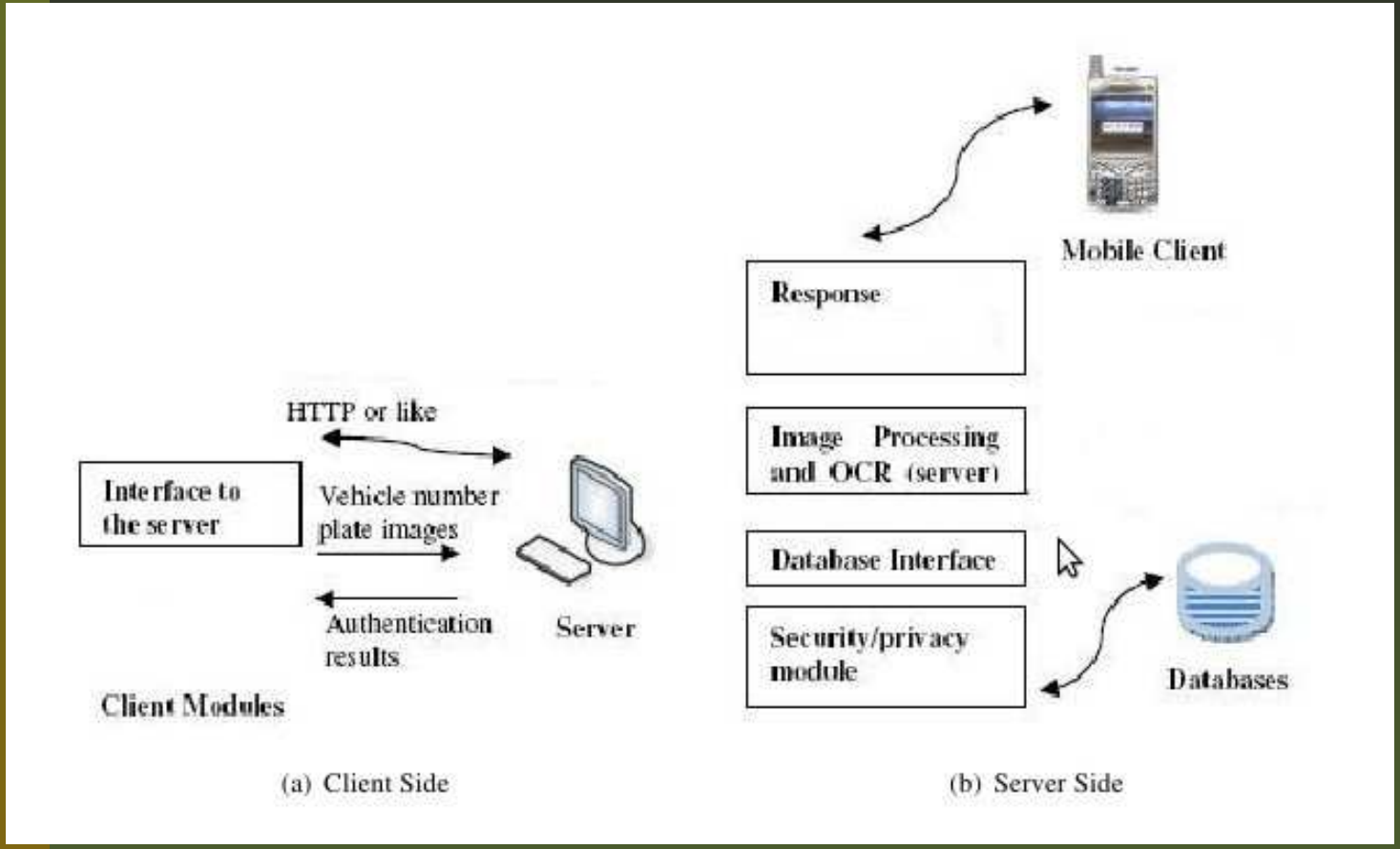
# Architecture: At a Glance




A working prototype implemented in lab environment.

Image from *[1] PReMI 2009*

# Architecture: End to End

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# Characteristics of a License Plate

- Consists of alpha numeric
- There is a definite naming convention
- Generally at fixed location
- Embossed
- Have high contrast
  - black on white or white on black
  - black on yellow
  - white on red (Canada)

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*Almost all of them violated on Indian Roads*

# License Plate Database

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# License Plate Database

- No known database of vehicle number plates!
- Collected our own (several hundreds; 800+)
- Different mobile phone cameras
- different resolutions
- different distances,
- lighting conditions
- different angles
- Shadows on the plate

# License Plate Recognition: Steps


Number Plate Images from mobile phone camera

Image Pre-processing Color to Gray conversion

Binarization

Character Segmentation

Character Recognition

Post processing

MH 01 GA 5448

# License Plate Recognition: Steps

- Image pre-processing
  - Typically color $\rightarrow$ gray
- Binarization
  - Retain all text region of license plate
- Heuristic filtering
  - Eliminate non-text region
- Character recognition
  - OCR

# Binarization

- Use?
  - important pre-processing step in image analysis
- What?
  - Separating the foreground and the background
- Why?
  - to acquire some useful information in the image for processing

# Binarization

- How?
  - determine a gray threshold $G_T$ some objective criteria
  - assigns each pixel $I_{xy}$
    - if $I_{xy} > G_T$ then $I_{xy}$ is foreground
    - if $I_{xy} \leq G_T$ then $I_{xy}$ is background

# Binarization Types

- 40 different $G_T$ determining algorithms[a]
  - Histogram shape-based methods,
  - Clustering-based methods,
  - Entropy-based methods,
  - Object attribute-based methods,
  - Spatial methods and
  - Local methods based on the local characteristics of each pixel

[a] M. Sezgin and B. Sankur. Jrnl of Electro. Imging, 13(1):146165, 2004.

# Otsu's Thresholding

Given an image with $L$ gray values.

- Otsu's method involves
  - iterate through all $L$ possible threshold values and
  - for each $L$ as threshold create two groups of pixels (foreground, background)
  - calculate a measure of spread for the pixel levels for each group
  - Threshold criteria – the sum of foreground and background spreads is at its minimum

Otsu Method (http://www.labbookpages.co.uk)

# Otsu: $M \times N$ image $L$ gray values

- Compute the histogram ($H = h_1, h_2, \cdots h_L$)
- Let $k \in [1, L]$ be the threshold
  - $0$ to $k$ (group $f$); $k+1$ to $L$ (group $b$)
  - $W_b(k) = \frac{1}{MN} \sum_{i=0}^{k} h_k$; $W_f(k) = \frac{1}{MN} \sum_{i=k+1}^{L} h_k$
  - $\mu_b = \frac{\sum_{i=0}^{k} i*h_i}{\sum_{i=0}^{k} h_i}$; $\mu_f = \frac{\sum_{i=k+1}^{L} i*h_i}{\sum_{i=k+1}^{L} h_i}$
  - $\sigma_b^2(k) = \frac{\sum_{i=0}^{k} (i-\mu_b)^2*h_i}{\sum_{i=0}^{k} h_i}$; $\sigma_f^2(k) = \frac{\sum_{i=k+1}^{L} (i-\mu_f)^2*h_i}{\sum_{i=k+1}^{L} h_i}$
  - $\sigma^2(k) = W_b(k)\sigma_b^2(k) + W_f(k)\sigma_f^2(k)$ (intraclass variance)
- Choose $G_T = k$ for which $\sigma^2(k)$ is minimum

# Fast Approach

- Image Pre processing
- **Binarization for text region extraction**
  - Global Otsu method
  - local Otsu method
  - **Proposed local edge based method**
- Character segmentation
- Character recognition

# Reiterating Problem

- LPR systems are designed to automatically recognize license plate number from images of the vehicle
- Systems are readily available for mass surveillance (use fixed, high resolution camera)
- Propose a **mobile** phone based **fast** LPR system to assist the traffic police to
  - Identify vehicle involved in road accidents
  - monitor and issue memo for violation of traffic rules
  - trace stolen vehicles
  - trace VIP escorting vehicles

# Global Otsu's Method

Histogram of the image has bimodal distribution and finds an optimal threshold.

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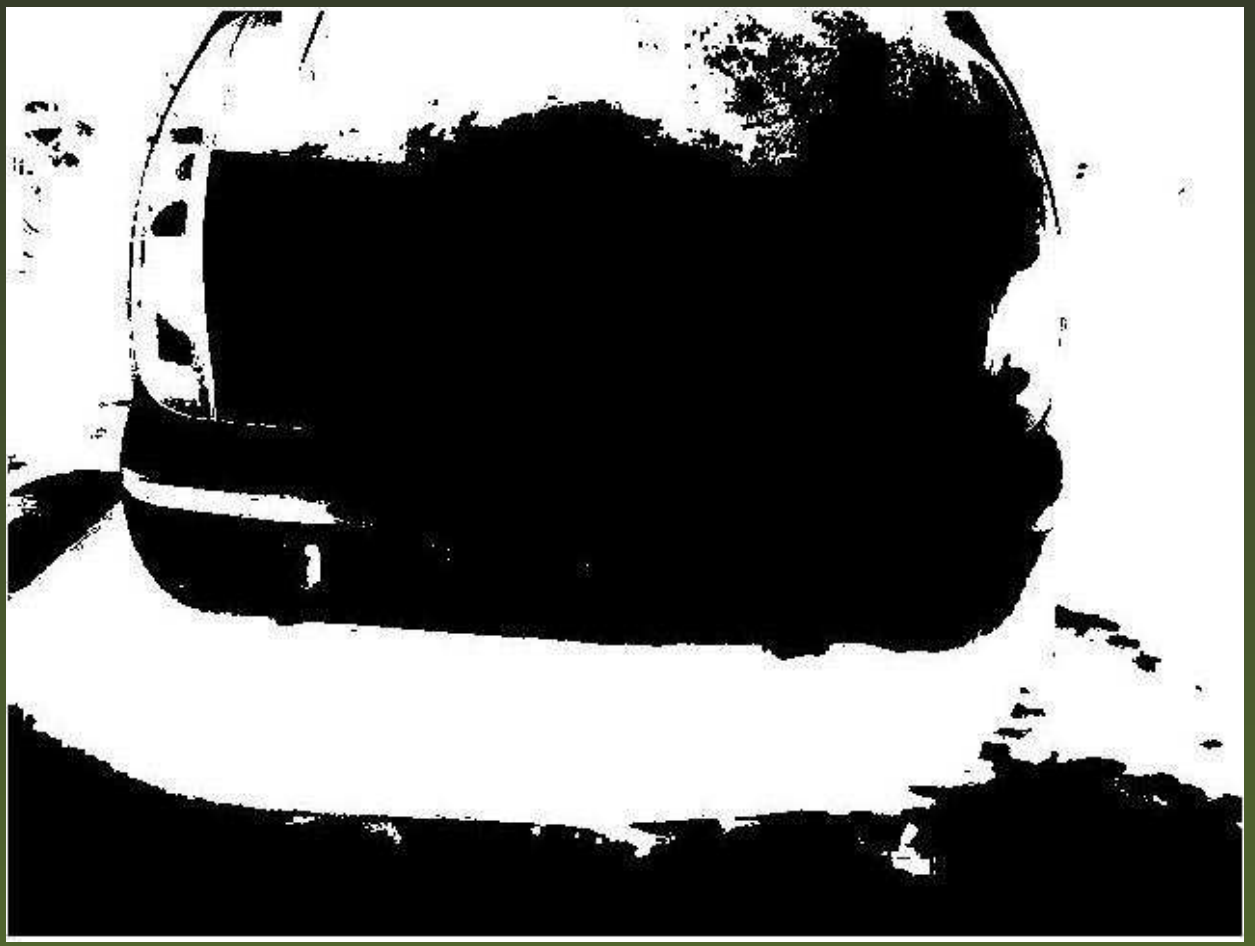

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Histogram of the windowed image has bimodal distribution finds optimal threshold for each window.

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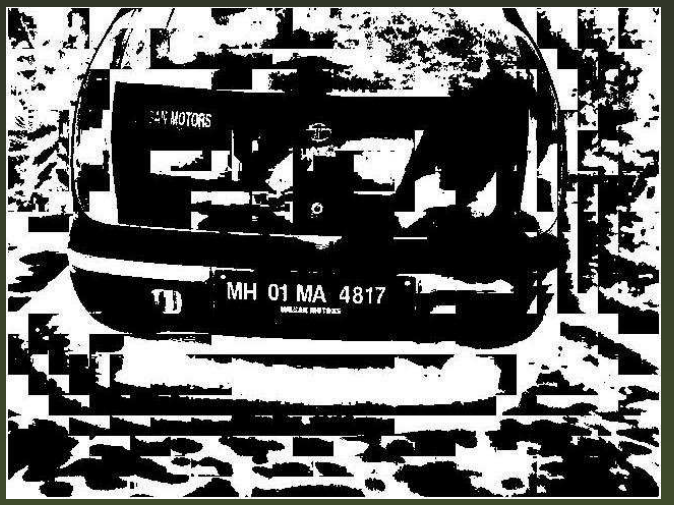
# Otsu Method (Iterative)

Global

- Complete Image
- Threshold: One
- Text lost
- Comp Expensive




Local

- Window: $40 \times 40$
- Thresholds: Several
- Artifacts
- Comp Expensive

# Otsu Method (Iterative)

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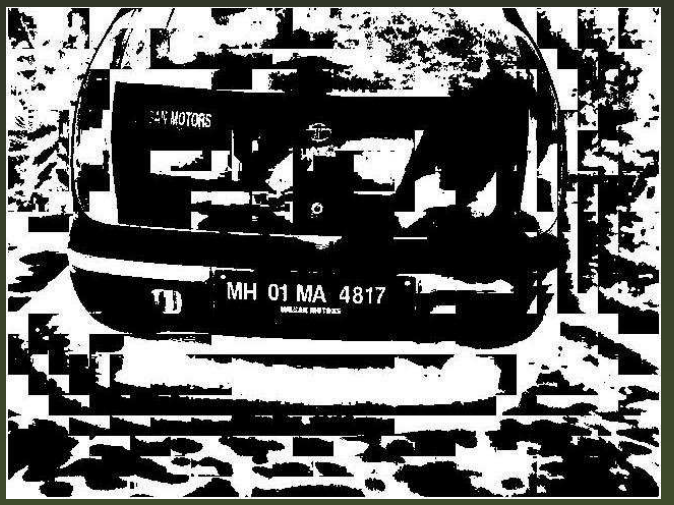



Local

- Window: $40 \times 40$
- Thresholds: Several
- Artifacts
- Comp Expensive

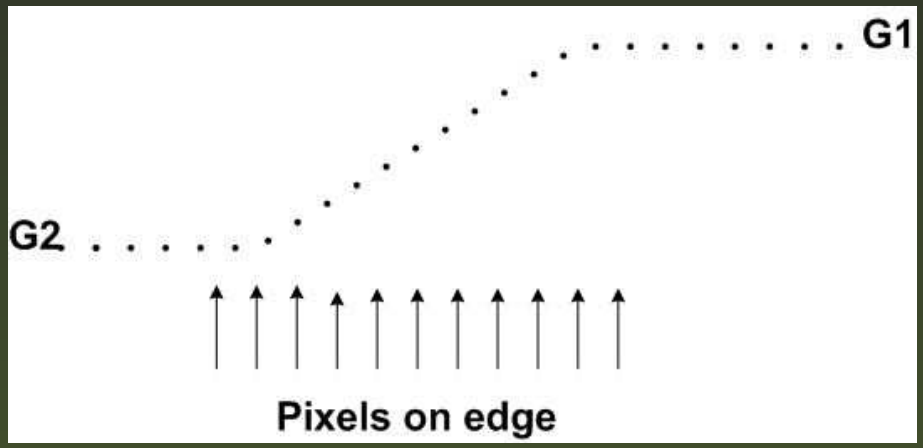
*Artifacts can be removed by overlapping windows*

# Local Edge Based Approach

- Principle
  - No iterations
  - Compute only when required

# Local Edge Based Approach

- Observation




- Foreground and background represented by gray levels G1 and G2
- Gray levels change gradually
- Pixels marked by arrows are edge pixels
- Binarization threshold $G_T$ st $G_1 < G_T < G_2$
- $G_T$ is the average gray value of pixels on edge.

# Local Edge Approach: Algo

- Step 1 : Calculate edge image, say Kirsch Edge
- Step 2 : Remove small intensity edges
- Step 3 : Choose window $W \times W$ ($W = 40$).
- Step 4 : Mark edges in window of the edge image
- Step 5 : If edge present, compute average gray value of all edge pixels in the gray image
- Step 6 : Binarize the gray image (window) based on the threshold selected in Step 5.

# Local Edge Approach: Algo

- Step 7: If there is no edge in the windowed image, set all pixels in the window to the binary value at $(W/2, W)^{th}$ pixel.
- Step 8: Repeat Steps 4 - 7 by sliding window from left to right and from top to bottom without any overlaps.

# Comparisons: Level 1


(a) Global Otsu


(b) Global edge


(c) Local Otsu


(d) Local edge

# Comparisons: Level 2


(e) Global Otsu


(f) Global edge


(g) Local Otsu


(h) Local edge

# Comparisons: Level 2


(i) Global Otsu


(j) Global edge


(k) Local Otsu


(l) Local edge

- Local methods are better that global methods
- Edge based methods are better that Otsu (bonus time complexity)

# Comparisons: Level 2


Original


Binarized :Global Otsu


Binarized: Global Edge


Close view of license plate


Binarized: Local Otsu


Binarized: Local Edge

# Character Segmentation

- Binarized image have both text and non text connected components.
- Heuristic filtering are used to segment text components from binarized image.
- Heuristic filtering is based on:
  - Area
  - Connected components shouldn’t touch the boundary of image.
  - Aspect ratio
  - Density
  - Each connected component should have a neighbor with nearly similar height and CG

# Character Segmentation: Output


Original


Binarized using local Edge


After Heuristic filtering


Original

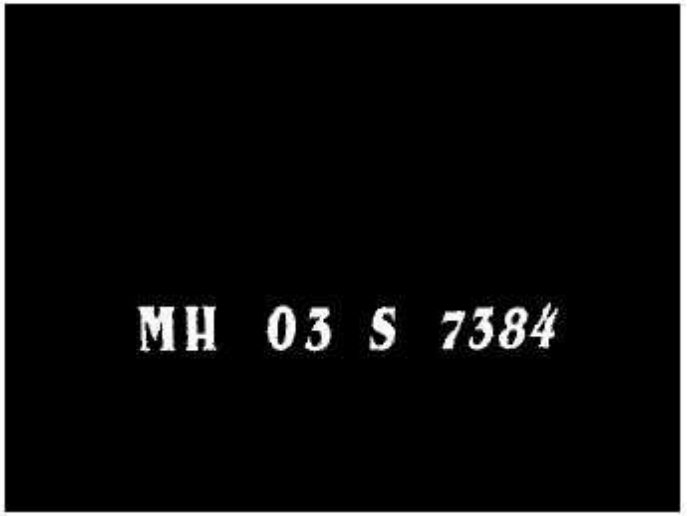

Binarized using local Edge


After Heuristic filtering

# Illumination Effect


Nov. 24,2010, 9.22


Nov. 24,2010, 18.07




# Orientation Effect

# Resolution Effect

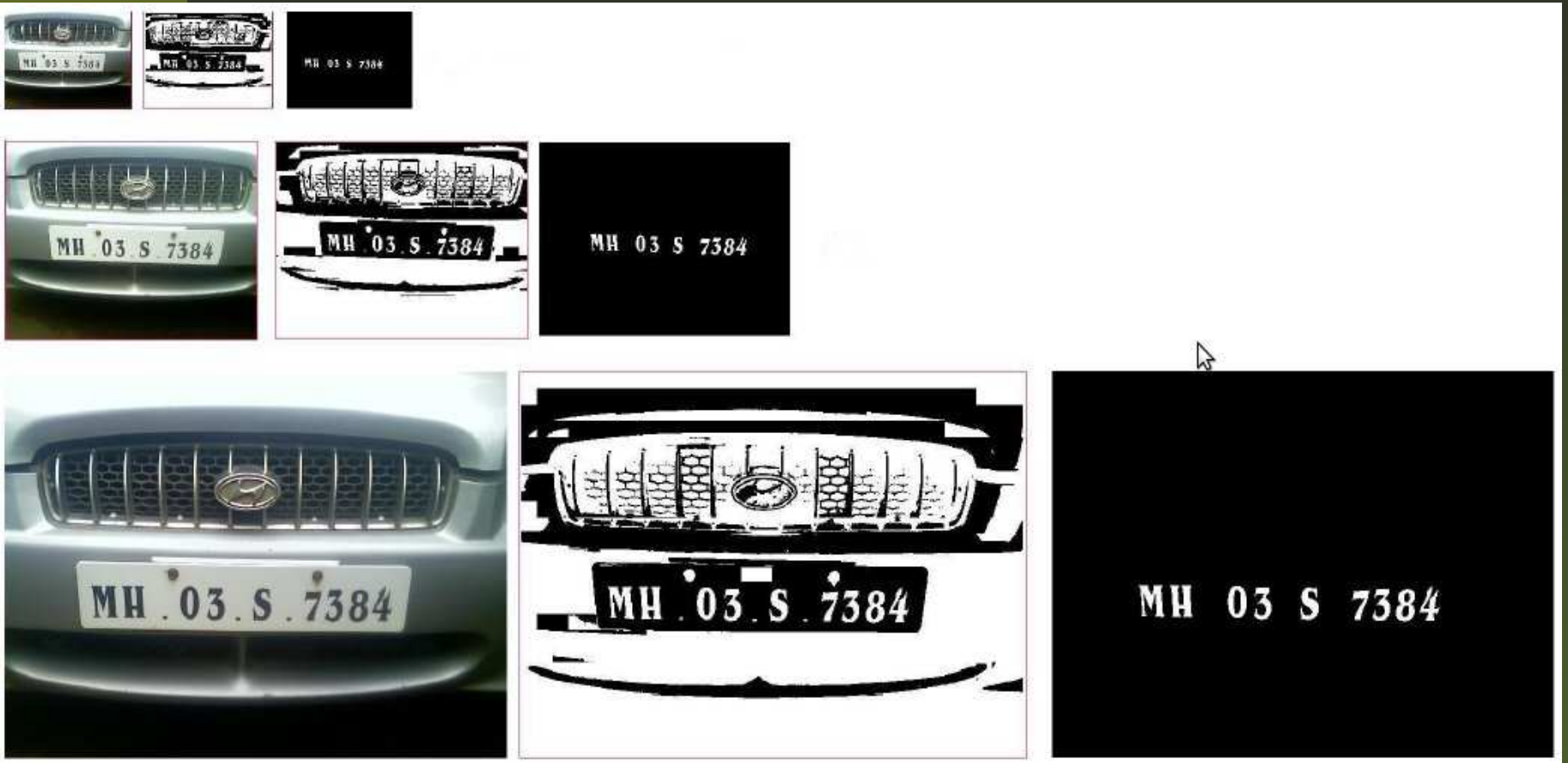



Image with 3 different resolutions : 160×120 (low), 320×240 (medium), 640×480 (high)
OCR Output : HHD3S7384, MH03S7384, MH05S7384

# Resolution Effect

| Resol. | G.Otsu | G.Edge | L.Otsu | L.Edge |
|---|---|---|---|---|
| Small | No output | MN03S 384 | ML03s Eb | HHD3S7384 |
| Medium | MH05S7384 | MH03S7384 | MU0ss7384 | MH03S7384 |
| Large | MH05S7584 | MH03S7584 | MH05S7584 | MH05S7384 |

# Overall Results

Performance Analysis Results (total characters: 3945)

| Algorithm | Char. Extrat | Non-text Chars | Preci-sion | Recall | time (sec) |
|---|---|---|---|---|---|
| G.Otsu | 2428 | 236 | 0.91 | 0.61 | 1.9 |
| G.Edge | 2702 | 217 | 0.92 | 0.68 | 1.74 |
| L.Otsu | 3335 | 218 | 0.94 | 0.84 | 4.33 |
| L.Edge | 3556 | 244 | 0.94 | 0.90 | 2.67 |

$$precision = \frac{relevant \cap retrieved}{retrieved}$$

$$recall = \frac{relevant \cap retrieved}{relevant}$$

# Vehicle Plate Recognition

- Segmented connected components from the binarized images
- Used Tesseract OCR for character recognition.
- 3945 text characters present in the set of 400

| Binarization | Performance |
|---|---|
| Global Otsu | 2035 (51.58%) |
| Global Edge | 2280 (57.79%) |
| Local Otsu | 2820 (71.48%) |
| Local Edge | 2932 (74.32%) |

# Potential Applications

- Traffic Police as an effective tool for policing
  - supporting tool for quick investigation to identify stolen vehicles
  - automatic cross check with a database of stolen cars or unpaid fines
- RTO officials
  - to check vehicles fitness certificate
  - verification of taxation, insurance
  - verification pollution control certificate *at any point of time*

# Potential Applications

- Security Guards (at parking areas, toll road etc)
  - used as an access control for authorized members in a secured area
  - used to monitor and manage parking lots, issue parking fee
- Citizens (General Public)
  - allow to register complaint against taxi/auto irregularities
- Campus Monitoring

# Conclusions

- Build an end to end system
- Image processing and Pattern recognition techniques to enable an Usable solution
  - Proposed local edge based fast binarization technique
  - Technique extract characters from license plate images reliably
  - Method is faster compared to local Otsu's method due to it's non iterative nature.
  - Method performs better in terms of precision and recall.
  - Method performs well under various illuminations, orientations and resolutions.

# Thank You

- Queries?
- Comments!
- More Comments?

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