License Plate Matching using Neural Networks

Kelvyn SOSOO (GMU)  David OUYANG (CSUST)  Mengjun WANG
(CSUST) Mentors: Lee HAN (UTK) & Kwai WONG (UTK)
Background

- License Plate Recognition (LPR) technology is used to gather vehicle location data.
- Location Data includes instances of Amber Alerts, Toll Roads Speed/Travel Time, etc.
- The License Plate Matching (LPM) method incorporated includes a 97% match rate of vehicles, and a 60% read accuracy.
- Programs Used: Python, Matlab

GOAL: Raise the 60% by using Image Processing. Find a new measure to matching plate by using supervised learning.
How It Works

- Capture images
- Image recognition
- Plate matching
Procedure

Screen the License Plate images

Image Processing to segment every Character

Matching two string

Neural network training
Image Processing
Step 1: Manipulation of Data

[Image of a license plate]

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2010-05-27</td>
<td>06:08:15.200000</td>
</tr>
<tr>
<td>2</td>
<td>2010-05-27</td>
<td>06:57:52.700000</td>
</tr>
<tr>
<td>3</td>
<td>2010-05-27</td>
<td>08:35:40.520000</td>
</tr>
<tr>
<td>4</td>
<td>2010-05-27</td>
<td>09:04:17.330000</td>
</tr>
<tr>
<td>5</td>
<td>2010-05-27</td>
<td>09:13:15.730000</td>
</tr>
<tr>
<td>6</td>
<td>2010-05-27</td>
<td>12:30:27.910000</td>
</tr>
<tr>
<td>7</td>
<td>2010-05-27</td>
<td>14:52:51.240000</td>
</tr>
<tr>
<td>8</td>
<td>2010-05-27</td>
<td>14:59:15.240000</td>
</tr>
<tr>
<td>9</td>
<td>2010-05-27</td>
<td>15:00:35.960000</td>
</tr>
<tr>
<td>10</td>
<td>2010-05-27</td>
<td>15:01:10.170000</td>
</tr>
<tr>
<td>11</td>
<td>2010-05-27</td>
<td>15:12:58.100000</td>
</tr>
<tr>
<td>12</td>
<td>2010-05-27</td>
<td>15:13:56.770000</td>
</tr>
<tr>
<td>13</td>
<td>2010-05-27</td>
<td>15:16:17.660000</td>
</tr>
<tr>
<td>14</td>
<td>2010-05-27</td>
<td>15:40:27.030000</td>
</tr>
<tr>
<td>15</td>
<td>2010-05-27</td>
<td>15:56:24.700000</td>
</tr>
</tbody>
</table>

[Image of a label with text: DHALIWAL]
Step 2: Image binarization

```
ret, imgf = cv2.threshold(img, 0, 255, cv2.THRESH_BINARY + cv2.THRESH_OTSU)
fig.add_subplot(2, 2, 1)
plt.imshow(imgf, cmap = 'gray')
cv2.imwrite("thresh{}.jpg".format(i), imgf)
P1 = cv2.imread("thresh{}.jpg".format(i))
grayscaleimg = cv2.cvtColor(P1, cv2.COLOR_BGR2GRAY)
```
Step 3: Read the Number of Black Pixels Vertically

np.argmin(row_nz[0 : floor(len(row_nz)/2)]) == 59  row_nz(59) = 43
np.argmin(row_nz[floor(len(row_nz)/2) : ]) == 95  row_nz(95) = 45

Two key points coordinate:  (59, 43)  (95,45)
Step 4: Read the Number of White Pixels Horizontally

KEY POINT (CUT POINT): [33, 40, 54, 72, 86, 104, 120, 150]
Outcome
Supervised Learning: Neural Network

- Previous slide presented the outcome of Character Segmentation
  - It is very time consuming to transfer the characters to the proper label/category
- Instead of spending countless hours manually moving files, Data Augmentation was implemented
- Categories included A-Z and 0-9
Attempts

- Two different training datasets were tested: Grayscale and Binary Images
Midterm Performance

- After four epochs, the model was able to reach a validation accuracy of 95.18%
Final Performance

Train on 31723 samples, validate on 5599 samples

Epoch 1/3
31723/31723 [-------------------------------------] - 153s 5ms/sample - loss: 1.1023 - acc: 0.6947 - val_loss: 0.1719 - val_acc: 0.9489

Epoch 2/3
31723/31723 [-------------------------------------] - 169s 5ms/sample - loss: 0.2075 - acc: 0.9367 - val_loss: 0.0764 - val_acc: 0.9791

Epoch 3/3
31723/31723 [-------------------------------------] - 177s 6ms/sample - loss: 0.1232 - acc: 0.9608 - val_loss: 0.0580 - val_acc: 0.9812

- After three epochs, the model was able to reach a validation accuracy of 98.12%
Model Usage

- Characters from separate folders/license are identified
- Stored as strings in csv file
1. $v(j)$, $u(i)$ are both the arrive time.
2. max, min are the speed of passing LPR stations.
3. The distance between two stations is $L$.

Goal: To judge whether different plate characters are from the same car.

\[ \frac{L}{\text{max}} \leq v(j) - u(i) \leq \frac{L}{\text{min}} \]
Self-learning

1. Use the time constraints to find all possible plates matches.
2. Put all these selected plates into a set named candidate set ‘S’, every string in the set named S(i).
3. Get several pairs of plates. Look for the smallest edit distance required to transform each other,
4. Choose the one which shows up firstly.
For example, there are two plate strings. A8CI213 & ABC123

Character-transition Matrix

(1) Find every pair of possible match.
(2) Calculate the edit distance path.
(3) Find all the associated characters.
(4) Calculate the Character-transition matrix.
(5) Iterating and updating the matrix until it is not change.

The edit distance between two different license plates and the edit paths on grids.
**Association Matrix**

Self-learning:
By iterating to calculate the transforming probability between different characters.

$$p(b|a) = \frac{\rho_{ab}}{\rho_a}$$

$P_{ab}$ is the value of every grid in the Character-transition matrix.
$a$ is the sum of every row in the Character-transition matrix.

Obtain an **association matrix** by calculating the conditional probability.
**Final Association Matrix**

This is a 37 by 37 matrix. 0-9 & A-Z & SPACE

The x axis is LPR 1 reading.
The y axis is LPR 2 reading.
The value of every grid is the conditional probability of two characters being misread at two sites.
Matching

For instance, there are two pairs of license plates:

44S5H2  4455HZ
4415HZ  4455HZ

Which is the match one??

\[ d(x \rightarrow y) = \min \{ \sum_{k=0}^{n} \log \left( \frac{1}{p(i_k, j_k)} \right) \} \]

\( d(x \rightarrow y) \) is the cost of transforming \( x \) to \( y \).

The minimum one is the match one.

44S5H2 & 4455HZ
Matching with FuzzyWuzzy

- Based on Fuzzy Logic / Levenshtein Distance formula
- Simple and fast way of string matching
Future Works

- Improving efficiency of MATLAB matching code
- Improve character segmentation
- Find fully autonomous implementation of license plate matching
THANKS FOR LISTENING, ANY QUESTIONS?