# Recognition of Characters and Numbers in Vietnam License Plates based on Image Processing and Neural Network

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### *Abstract*

*Artificial neural network (ANN) have wide applicability in various applications in the life, one of them is apply to recognize characters and numbers, and we know that the Automatic License Plate Recognition (ALPR) is very important in the Intelligent Transportation System (ITS) and it is beginning in research and application in Vietnam. Usually, an ALPR system consists of three parts: 1) license plate location, 2) character segmentation, 3) characters & numbers recognition. In this paper, we proposed an improved method for the characters & numbers recognition part. And then, we apply to recognize characters & numbers of Vietnam License Plates (LP), which combined neural network and image processing technologies. In the training work, we used two networks and back-propagation (BP) algorithm for characters & numbers training with noises, separately, which the computing time and accuracy will be improved. In the using network work, we used the image processing technology for pre-processing to obtain high quality of characters & numbers before put in the trained network to improve accuracy of the system. We tested on 600 Vietnam LP images, which obtained from the actual systems, these images are very different background such as illumination, license angles, size and type, colors, light conditions in Vietnam environment. Our approach is more effective than some of the existing methods and satisfied for all types and color of Vietnam license plates and Vietnam environment.*

*Keywords: License plate location, Pattern recognition, Artificial neural network, Automatic license plate recognition*

## 1. Introduction

Nowadays, the Intelligent Transportation System (ITS) is very important for the development of the transport infrastructure on the world. Specially, in the developing countries such as Vietnam, where the ITS had beginning for application. The Automatic License Plate Recognition (ALPR) is very important part of the ITS. Usually, an ALPR system consists of three parts: 1) license plate location, 2) characters segmentation, 3) characters recognition. In this paper, we will focus in the characters recognition step, there are some techniques proposed for this step such as. Decision trees [1], Hidden Markov model [2], Support vector machines [3], Multi-cluster and Multilayer neural networks [4], LS-SVM [5], Feature salience [6], Novel fuzzy Multilayer neural network [7], Radial basis function neural networks [8], Sliding Concentric Windows and histogram [9], Extension theory [10]. But most of previous methods have some restricted in cases: uncertainty of edges, various types
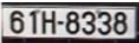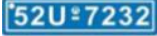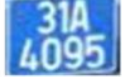
of plate, broken edges, dim lighting, the images are fuzzy, and most of these methods work under controlled conditions, and these images data for testing are not collected in Vietnam, so these algorithms are not satisfied for Vietnam LP and Vietnam environment.

In this paper, we focus on the characters & numbers recognition part and give out an improved method to recognize characters & numbers of Vietnam LP, we will use a Multi Layer Perceptron (MLP) neural network and back-propagation algorithm to recognize characters & numbers of the Vietnam LP. In the training work, we will use two networks for characters & numbers training with noises, which the computing time and accuracy will be improved, in the using network work, we will use the image processing technology for pre-processing to obtain high quality of characters & numbers before put in the trained network to improve accuracy of the system. Specially, we will consider for the specific characteristics of Vietnam LP (size, shape, one-row LP and two-row LP) and we implemented a lot of Vietnam LP images, which obtained from the actual system, these images are very different background such as illumination, license angles, size and type, colors, light conditions in Vietnam environment. The rest of the paper organized as follows: section 2 is feature of Vietnam LP, section 3 proposed a method for Vietnam LP characters & numbers recognition, section 4 is experimental results, section 5 is conclusions, acknowledgements and the last are references.

## 2. Features of Vietnam LP

Based on the "Circular 06/2009/TT-BCA-C11 regulations on vehicle registration issued by the Ministry of Public Security" issued on 11/03/2009, the vehicle license plates of Vietnam are defined as following. *Type 1 -* Vehicles of the personal and organized of Vietnam (license plate with white background, black characters & numerals (0…9), serial symbols are one of the 15 digits (F, H, K, L, M, N, P, R, S, T, U , V, X, Y, Z). *Type 2 -* Vehicles of the governmental organizations and the police of Vietnam (license plate with blue background, white characters & numerals (0…9), and a serial of symbols are 5 digits A, B, C, D, E). *Type 3 -* Vehicles of Army of Vietnam (number plate with red background, black numerals (0…9), red characters, there are only type of the one line). The vehicles of this, that have the same size, type of 1 line length of 470mm and height 110mm, type of 2 lines length 280mm and 200mm height. *Type 4 -* Vehicles of the foreigners and foreign organizations: The license plate with the white background, black numbers (0…9), serial symbol is 'NG' with red color (including the type of 1 line and 2 lines). Type of the 1 line has length of 470mm and height 110mm, type of the 2 lines length 280mm and height 200mm. *Type 5 -* Vehicles of the special economic and trade of Vietnam: The license plate with the white yellow background, red letters and numbers (0…9), there are only type of the 2 line. Size of the license plates with length of 190mm and height 140mm. . In this paper, we give out an improved method to recognize for all of types, sizes and dimensions, one-row & two-row types of Vietnam LP described in the Table 1.

**Table 1. Five Types of Vietnam LP**

| Type 1 | Type 2 | Type 3 | Type 4 | Type 5 |
|--------|--------|--------|--------|--------|

# 3. Characters & Numbers Recognition in the Vietnam LP

## 3.1. Architecture of the Proposed Method

In this paper, we focus on the characters & numbers recognition part and give out an improved method to recognize characters & numbers of Vietnam License Plates (LP). We will use a Multi Layer Perceptron (MLP) neural network and back-propagation (BP) algorithm to recognize characters & numbers of the Vietnam LP, the architecture of the proposed method to recognize characters & numbers in the Vietnam LP as Figure 1.
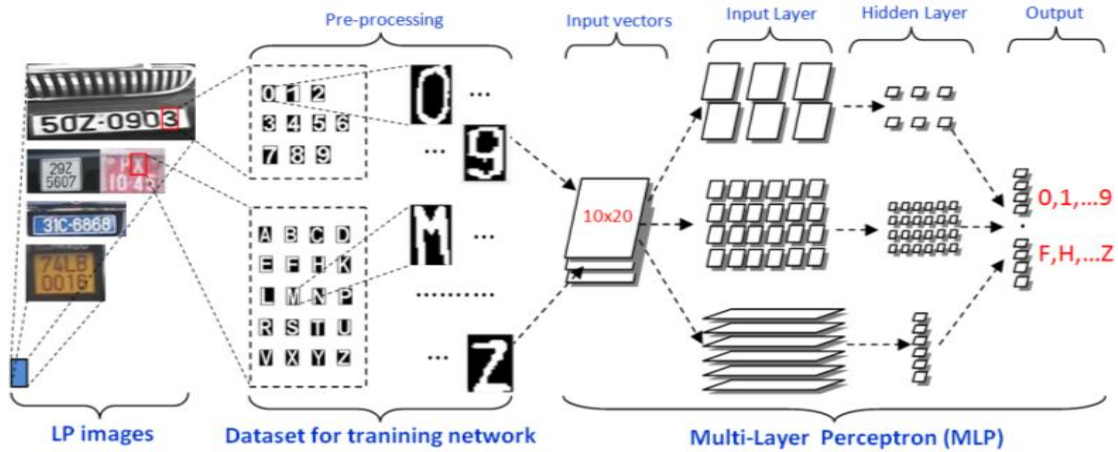


**Figure 1. Architecture of the MLP Network of Proposed Method**

*Datasets and Pre-processing:* Datasets for training obtained from Vietnam LP images, which obtained in the actual system, 10 numbers and 15 characters of Vietnam LP for training of the MLP network such as Table 2. All of characters & numbers were resized in (10x20) pixels for training.

**Table 2. Datasets for Training Network**

| Numbers | 0 1 2 3 4 5 6 7 8 9 |
|---|---|
| Characters | F H K L M N P R S U V X Y Z |

*Parameters of MLP:* Parameters of MLP network such as Table 3, and we will find a set of weighted values that $E(w)$ will be touch minimum.

**Table 3. Parameters of the MLP Network**

| Parameters | Formulas of MLP |
|---|---|
| Input vectors | $X_j = [x_0, x_1, ..., x_m]^T$ , $j = 1, 2, ..m$ |
| Weight vectors between input & hidden layer | $W_{qj} = [w_{0q}, x_{1q}, ..., x_{mq}]^T, (q = 1, 2, ..l), (j = 1, 2, ...m)$ |

| Weight vectors between hidden & output layer | $W_{iq}(i=1,2,...n),(q=1,2,...l)$ |
|---|---|
| Input function of network | $v_k = \sum_{i=0}^{l} w_{ik}x_i - \theta$, $\theta$ is scalar bias. |
| Activation function | $f(v) = 1/(1+e^{-\lambda v})$ |
| Actual output | $Y_i(i=1,2,...n)$ |
| Input & output signal of hidden layers | $netq = \sum_{j=1}^{m} v_{qj}x_j$ , <br> $z_q = a(netq) = (1-e^{-netq})/(1+e^{-netq})$ |
| Input & output signal of output layers | $neti = \sum_{q=1}^{l} w_{iq}z_q$ , $y_i = a(neti) = (1-e^{-neti})/(1+e^{-neti})$ |
| Squares error | $E(w) = \frac{1}{2}\sum_{i=1}^{n}(d_i - y_i)^2$ , $w$ is weights, $d_i$ is desired output. |
| Actual output of characters | $y_i = a(neti) = [y_0(F), y_1(H),..., y_l(Z)]^T$ |
| Actual output of numbers | $y_i = a(neti) = [y_0(0), y_1(1),..., y_l(9)]^T$ |

### 3.2. Training of MLP Network with Back-propagation Algorithm

In the training task, we will use two networks for characters & numbers training with noises, in each network we will adjust the weights of each unit in such a way that the error between the desired output and the actual output is reduced, we compute the error derivative of the weights. In other words, it must calculate how the error changes as each weight is increased or decreased slightly, the MLP network trained with input vector $X_i$ and desired output $D_j$, m input layers (m=200), 1 hidden layers (l=10), n output layers (n=15 for characters recognition, n = 10 for numbers recognition). Five steps of training MLP network use back-propagation algorithm as following:

**Step 1:** Read input vector $X_i$ (for characters and numbers), all of samples have dimensions are (10x20) pixels and recorded in a two dimensions array [10 20]. Clear all previous values, and then initialize the weights vectors $W_{qj}$, $W_{iq}$, biases, learning rate $\eta$, error max $E_{max}$, k=1 and E=0.

**Step 2:** Computing for actual output of network from input signal of hidden layer (Equation 1), output signal of hidden layer (Equation 2), input signal of output layer (Equation 3), final we have output signal of output layer is Equation 4

$$netq = \sum_{j=1}^{m} v_{qj}x_j \qquad\qquad (1)$$

$$z_q = a(netq) = (1-e^{-netq})/(1+e^{-netq}) \tag{2}$$

$$neti = \sum_{q=1}^{l} w_{iq} z_q \tag{3}$$

$$y_i = a(neti) = (1-e^{-neti})/(1+e^{-neti}) \tag{4}$$

**Step 3:** Computing for squared errors according to Equation 5

$$E(w) = \frac{1}{2} \sum_{i=1}^{n} (d_i - y_i)^2 \tag{5}$$

**Step 4:** Update of weigh matrix according to Equation 6, and then based on the gradient method with delta rule in the Equation (7).

$$W(k+1) = W(k) + \Delta w_{iq}(k) \tag{6}$$

$$\Delta w_{iq}(k) = -\eta(\partial E / \partial w_{iq}) = -\eta \left( \partial E / \partial y_i \; \partial y_i / \partial neti \; \partial neti / \partial w_{iq} \right)$$
$$= \eta * (d_i - y_i) * a'(neti) * z_q \tag{7}$$

where, $\partial E / \partial y_i = -(d_i - y_i)$, $\partial y_i / \partial neti = a(\sum_{q=1}^{l} w_{iq} z_q)'$, $\partial neti / \partial w_{iq} = z_q$.

We computed weights values between hidden layer & output layers is updated by Equation (8) and $\delta_{oi}(k)$ is error of output of output layer, this error will be calculate according to Equation (9)

$$W_{iq}(k+1) = W_{iq}(k) + \eta * \delta_{oi}(k) * z_q(k) \tag{8}$$

where, $q = 1, 2, ... l$, $i = 1, 2, ... n$

$$\delta_{oi}(k) = (d_i(k) - y_i(k)) * y_i(k) * a'(neti(k))$$
$$= (d_i(k) - y_i(k)) * y_i(k) * (1 - y_i(k)) \tag{9}$$

where, $i = 1, 2, ... n$

Weights values between input layer & hidden layers is updated by Equation (10) and $\delta_{nq}(k)$ is error of output of hidden layer will be calculate according to Equation (11).

$$v_{qj}(k+1) = v_{qj}(k) + \eta * \delta_{nq}(k) * x_j(k) \tag{10}$$

where, , $q = 1, 2, ... l$, $j = 1, 2, ... m$

$$\delta_{nq}(k) = \left( \sum_{i=1}^{n} \delta_{oi}(k) * W_{iq}(k) \right) * a'(netq(k))$$
$$= \left( \sum_{i=1}^{n} \delta_{oi}(k) * W_{iq}(k) \right) * y_{nq} * (1 - y_{nq}) \tag{11}$$

where, $i = 1, 2, ... n$

**Step 5:** If the $E < E_{max}$ then end, else if we give k=1 and E=0 and return step 1.

We will create a network that can handle noisy input vectors, to do that, the network first trained on input vectors and then the network trained on noisy input vectors. After training done using back-propagation with 932 epochs for the characters network and 345 epochs for the numbers network, or until the network sum-squared error falls beneath 0.1 for the both network, we have results of training performance for the characters MLP network and for the numbers MLP network as Figure 2 (a,b)
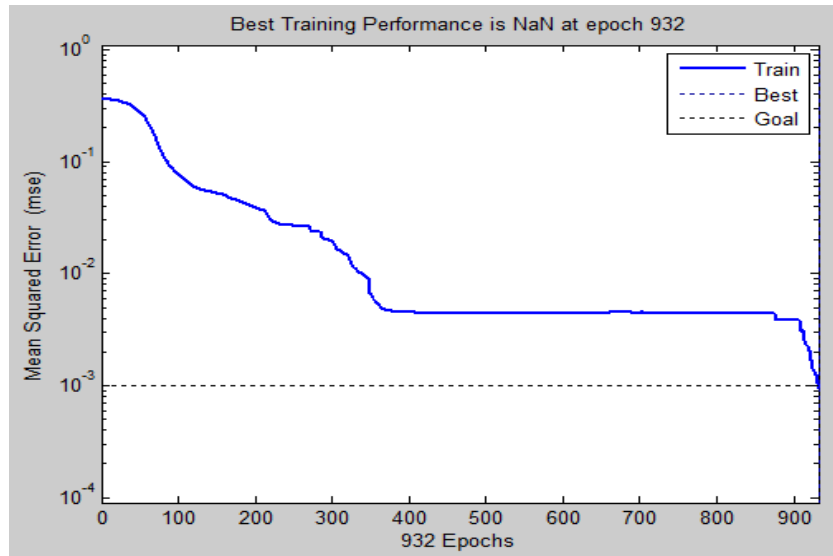


(a)
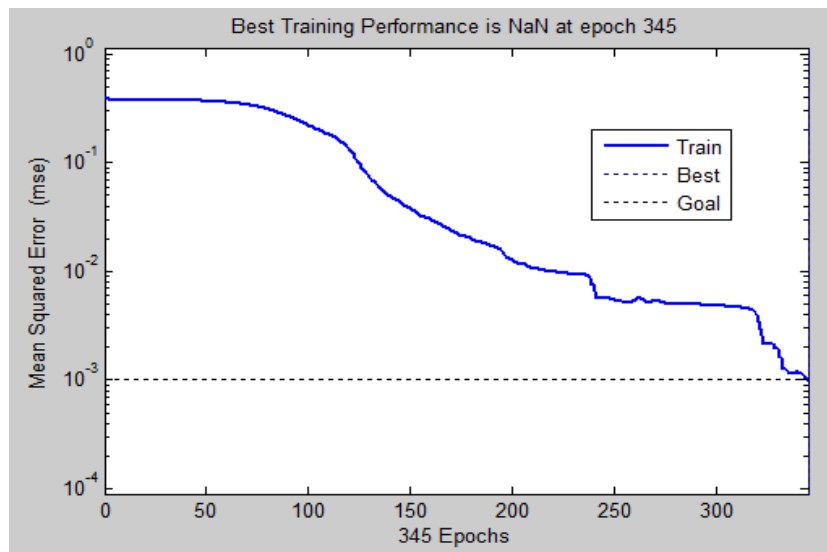


(b)

**Figure 2. a) MLP network training performance for characters network, b) MLP network training performance for numbers network**
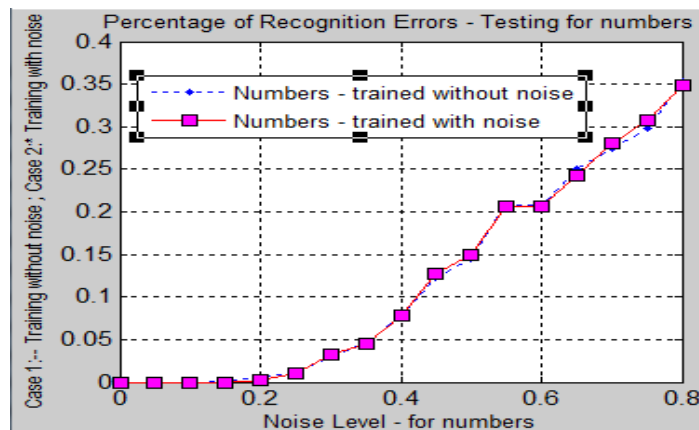
### 3.3. Testing of MLP Network

In the testing of MLP network, the reliability of the neural network characters & numbers recognition system measured by testing the network with hundreds of input vectors with varying quantities of noises. Testing of the network at various noise levels, noise with a mean of 0 and a standard deviation from 0 to 1 added to the input vectors.

The output of the MLP network for the characters recognition is then passed through the competitive transfer function so that only one of the 15 outputs (representing the characters), has a value of 1. And the output of the MLP network for the numbers recognition is then passed through the competitive transfer function so that only one of the 10 outputs (representing the numbers), has a value of 1. The solid line on the graph in the Figure.3 shows the reliability for the network trained with and without noise. The reliability of the same network when it had only been trained without noise is shown with a dashed line in the Figure.3. Finally, the MLP network could be trained on input vectors with greater amounts of noise if greater reliability were needed for higher levels of noise. Results of performance for the MLP network trained with and without noise of the recognition network for the characters and numbers such as Figure 3(a,b).
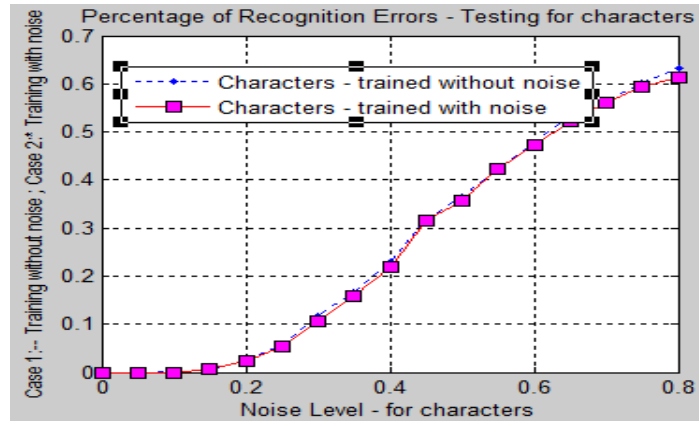


(a)



(b)

**Figure 3. a) Testing of trained MLP network for the characters, b) Testing of trained MLP network for the numbers**

### 3.4. Using of MLP network to recognize characters & numbers in the Vietnam LP

After finish of the training and testing for the MLP network with the back-propagation algorithm, we will use two trained networks to recognize all of the characters and numbers of Vietnam LP. Before put characters & numbers in to the trained network, we will use the image processing technology for pre-processing to obtain high quality of characters & numbers (dilate the supplied image using a line structure element whose width is 2 pixels).

For the characters recognition, the target vectors defined with a variable called target, each target vector is a 15-element vector with a 1 in the position of the character it represents, and 0's everywhere else. For the numbers recognition, the target vectors defined with a variable called target, each target vector is a 10-element vector with a 1 in the position of the number it represents, 0's everywhere else, the results of the recognize all of the characters and numbers of Vietnam LP obtained such as in Figure 4(a,b).
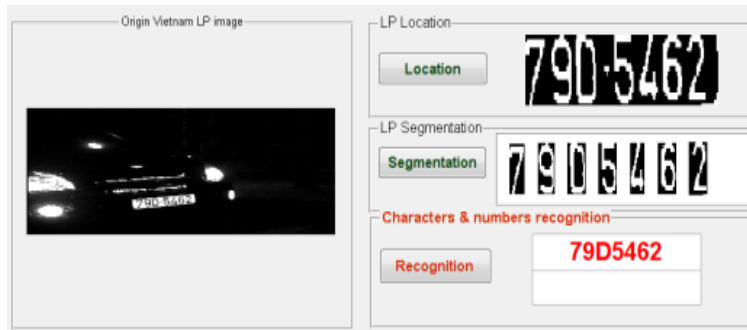


(a)



(b)

**Figure 4. (a) Recognition results for one-row Vietnam LP, (b) Recognition results for two-row Vietnam LP**

## 4. Experiments Results

We implemented with PC Intel(R) Core(TM)2 Duo CPU T7250 @2.00GHz, RAM 1.00 GB, Windows Vista Version 6.1 (Build 7600) 32-bit Operating System and MATLAB Version 7.8.0.347 (R2009a). We implemented on 600 Vietnam vehicle images, which obtained from the actual system. These vehicle images are very difference background such as: difference illumination, difference license angles, difference size and type of license plates, difference colors, difference light conditions in Vietnam

environment, some experiment examples for one-row types of Vietnam license plates are shown in Figure 5(a, b, c, d, e, f, g, h).
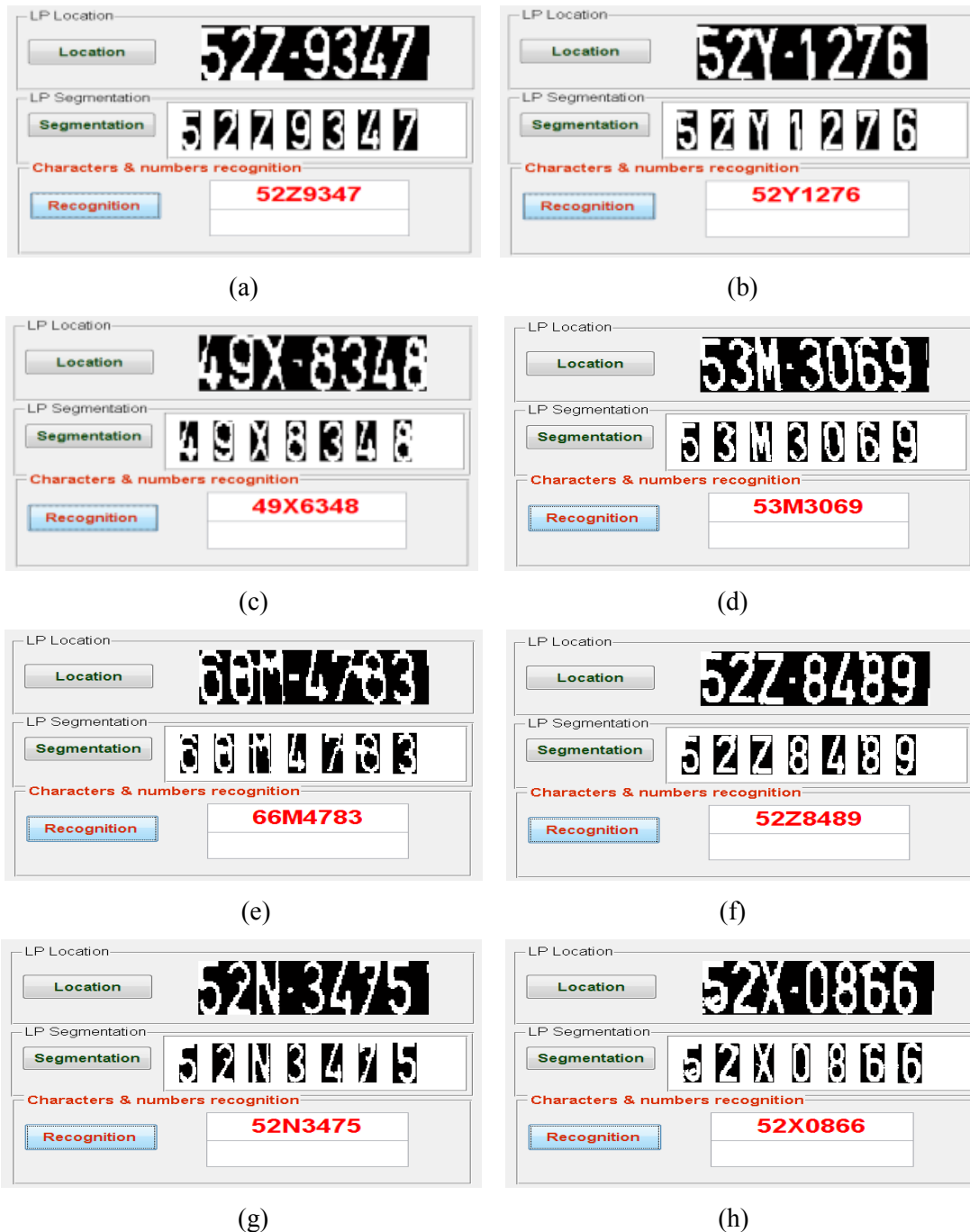


(a)

(b)

(c)

(d)

(e)

(f)

(g)

(h)

**Figure 5. Some of Results for one-row of Vietnam LP**

Some experiment examples for two-row types of Vietnam license plates are shown in Figure.6(a,b,c,d,e,f).

(a)

(b)

(c)

(d)

(e)

(f)
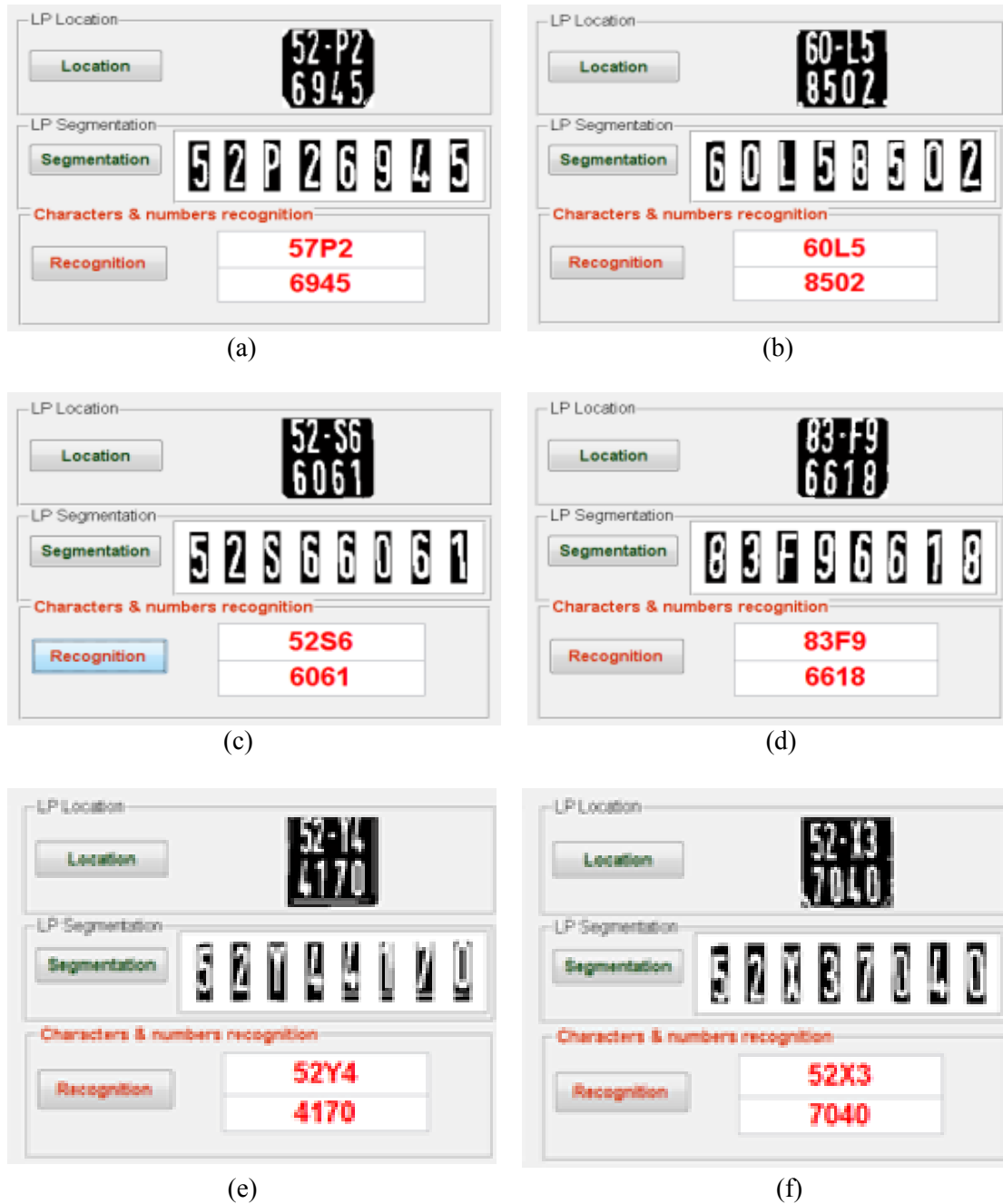
**Figure 6. Some of Results for two-row of Vietnam LP**

The result of the experiment shown in Table 4, the rate of accuracy is 98.33% for one-row LP and is 97.67% for two-row LP, detail of amount and rate of successfully and fail are described in the Table 4.

**Table 4. Experiment Results of our Method**

| Types of LP | Image | Successful image | Rate of accuracy | Average rate of accuracy |
|---|---|---|---|---|
| One-row LP | 300 | 295 | 98,33% | 98,00% |
| Two-row LP | 300 | 293 | 97,67% | |

We will compare our method performance to some of previous method in the [2, 3, 4, 5, 6, 7, 8, 9] in the Table 5 following. We see that, the rate of accuracy of our method is higher than most of previous works.

**Table 5. Comparison our Method to some of Previous Methods**

| Ref. | Recognition rate (%) | Recognition time (s) | Training time (min) |
|---|---|---|---|
| Our method | 98.0 | 0.137 | 5.5 |
| Ref. [2] | 97.5 | no report | no report |
| Ref. [3] | 98.4 | 0.3-1.9 | 0.4-7.2 |
| Ref. [4] | 91.0 | no report | no report |
| Ref. [5] | 94.0 | 0.87 | no report |
| Ref. [6] | 93.1 | no report | no report |
| Ref. [7] | 87.2 | no report | no report |
| Ref. [8] | 88.3 | < 0.2 | 6 |
| Ref. [9] | 82.5 | no report | no report |

## 5. Conclusions

This paper proposed an improved method to recognize characters & numbers of Vietnam License Plates (LP), we will use a Multi Layer Perceptron (MLP) neural network and back-propagation (BP) algorithm to recognize characters & numbers of the Vietnam LP. In the training work, we will use two networks for characters & numbers training with noises, which the computing time and accuracy will be improved, in the using network work, we will use the image processing technology for pre-processing to obtain high quality of characters & numbers before put in the trained network to improve accuracy of the system. Specially, we will consider for the specific characteristics of Vietnam LP (size, shape, one-row LP and two-row LP) and we implemented 600 Vietnam LP images, which obtained from the actual system, these images are very different background such as illumination, license angles, size and type, colors, light conditions in Vietnam environment. Our approach is more effective than of some the existing method earlier and satisfied for all types and color of Vietnam license plates and Vietnam environment.

## Acknowledgements

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