License Plate Location Recognition based on Multiagent System

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Abstract

A novel approach is proposed for automatic license plate location recognition based on a fusion Gabor and Multiple Interlacing in a multiagent configuration. License Plate Recognition Systems based on machine vision solely need to increasing speed and accuracy in real applications (i.e. atmospheric dark and glare).

In this model, the images that Speedy-MI agent has not been able to detect, is delegated to the Accurate-Gabor agent by the Moderator agent. The proposed model is implemented and tested on 200 images that is toke from Tehran Control Traffic Apartment. The results show that overall speed and accuracy has been improved.

Keywords: License Plate Location (LPL), Multiagent Systems, Multiple Interlacing, Gabor Transformation.

1. Introduction

During the past few years, intelligent transportation systems (ITSs) have had a wide impact in people's life as their scope is to improve transportation safety and mobility and to enhance productivity through the use of advanced technologies. We will review 4 types of license plate location recognition algorithms in this section.

I) As far as extraction of the plate region is concerned, techniques based upon combinations of edge statistics and mathematical morphology [1-4] featured very good results. In these methods, gradient magnitude and their local variance in an image are computed. They are based on the property that the brightness change in the license plate region is more remarkable and more frequent than otherwise. Block-based processing is also supported [5]. Then, regions with a high edge magnitude and high edge variance are identified as possible license plate regions. Since this method does not depend on the edge of license plate boundary, it can be applied to an image with unclear license plate boundary and can be implemented simply and fast. A disadvantage is that edge-based methods alone can hardly be applied to complex images, since they are too sensitive to unwanted edges, which may also show high edge magnitude or variance (e.g., the radiator region in the front view of the vehicle). In spite of this, when combined with morphological steps that eliminate unwanted edges in the processed images.

II) In [6], a method is developed to scan a vehicle image with N row distance and count the existent edges. If the number of the edges is greater than a threshold value, this manifests the presence of a plate. If in the first scanning process the plate is not found, then the algorithm is repeated, reducing the threshold for counting edges. The method features very fast execution times as it scans some rows of the image. Nonetheless, this method is extremely simple to locate license plates in several scenarios, and moreover, it is not size or distance independent.

III) Fuzzy logic has been applied to the problem of locating license plates [7-9]. The authors made some intuitive rules to describe the license plate and gave some membership functions for the fuzzy sets "bright," "dark," "bright and dark sequence," "texture," and "yellowness" to get the horizontal and vertical plate positions, but these methods are sensitive to the license plate color and brightness and need longer processing time from the conventional color-based methods. Consequently, in spite of achieving better results, they still carry the disadvantages of the color-based schemes.

IV) Gabor filters have been one of the major tools for texture analysis. This technique has the advantage of analyzing texture in an unlimited number of directions and scales. A method for license plate location based on the Gabor transform is presented in [10]. The results were encouraging (98% for LP detection) when applied to digital images acquired strictly in a fixed and specific angle, but the method is computationally expensive and slow for images with large analysis. For a two-dimensional (2-D) input image of size N × N and a 2-D Gabor filter of size W × W, the computational complexity of 2-D Gabor filtering is in the order of $W^2 N^2$, given that the image orientation is fixed at a specific angle. Therefore, this method was tested on small sample images and it was reported that further work remain to be done in order to alleviate the limitations of 2-D Gabor filtering.

There is a more complete review of these methods for recognizing the place of plate in [11,15]. In section 2, some concepts of Multi-Agent systems are described. Section 3 describes the proposed model and it includes agents' descriptions. In section 4, we give the results obtained by applying the method to databases consisting of 200 images from Tehran Control Traffic Apartment. In Section 5 we give a few concluding remarks.

2. Multi-Agent Systems of Artificial Intelligence

An agent is an intelligent computational structure which can be considered as a software program or a robot, having interactions with its environment and independent behavior and working somewhat based on its experiences. By an intelligent structure we mean an agent that works reasonably and flexibly in an environment, involving various occurrences. There are two main reasons to consider multi-agent systems which could have been the basic factors of the developments in this scientific field in recent years. The first reason is that multi-agent systems are capable of playing the main role in computer science and its applications now and in the future, because the growth of the complexity of computer systems and information systems leads to the increase of the complexity of applications, and limitless growth of calculations and centralizing them need processing more various data obtained from different locations. In such scenarios computers are considered as agents and their interactions need to be managed by technology. The second reason is that multi-agent systems are capable of playing an important role in analyzing and directing models and theories of human society's interactions.

Being intelligent means that agents follow their goals and act through optimizing a set of factors of effectiveness. When it is said that agents are intelligent it doesn't mean that they know every thing or they are omnipotent, but that they never make mistakes while functioning. It is better to say that they act reasonably and flexibly based on their information, understanding, and capabilities in various environmental situations.

The reason for focusing on the processes like problem solving, planning searching, decision making and learning is that showing the flexibility, reasonability and manipulation of such processes is more possible in multi-agent systems.

Interacting shows that agents may be affected by other agents or human while following their goals or doing their duties. Essentially, congruency as a form of interaction is important in order to be constant through the way of achieving goals and completing duties. The two concepts of competition and cooperation are some models of interactions. In cooperative situations several agents with a wide set of knowledge and abilities word together to achieve a shared goal. But in competitive situations agents work against each other, because their goals are contradictory. Cooperative agents try, like a team, to accomplish a job that they can not do separately, therefore they either succeed or fail all together. While competitive agents try to maximize their benefits at other agents' expenses, thus one's success results in the others' failure. By the way it should be emphasized that there is no general agreed upon definition for agents and being intelligent. [12]

A useful list of the theories of multi-agent systems in [13] and a famous text about agents in chapter two of [14], have been presented.

3. Proposed model

We divide all license plate location methods to two parts:

1. Methods which focus on speed and have a high speed. Multiple Interlacing [6] is the highest of them thus is selected here.
2. Methods which try to increase accuracy and lose time to obtain it (i.e. utilizing Gabor filter [10] that is selected here.).

Since we need accuracy only for some of the images and for others immediate methods are adequate, combining these two methods based on agent concepts has been proposed here.

3.1. Speedy-MI agent

This agent obtains the vertical edges of the image and counts the vertical edges in each line, and in the case of being more than, the threshold of being a plate, recognize it as a license plate.

3.2. Accurate-Gabor agent

Accurate-Gabor agent applies the Gabor filter to the image. Figure (2) shows the application of Gabor filter with $\theta = \pi$ and $\lambda = 20$. Gabor filter can reveal the edges in any direction (here in direction π) and change the number of edges in a certain direction. This characteristic helps us very well. The location of the plate in image includes identical vertical edges which are repeated alternatively. We can intensify these edges and modify other edges through this filter. Using this filter and convolution is time consuming.

$$h(x,y) = g(x',y')e^{j\lambda(x\cos\theta + y\sin\theta)}$$

$$(x',y') = (x\cos\theta + y\sin\theta, -x\sin\theta + y\cos\theta)$$

$$g(x,y) = \frac{1}{\sqrt{2\pi\sigma_i\sigma_j}} e^{(x'^2+y'^2)\cos(2\pi x'/\lambda)/\sigma_i\sigma_j}$$

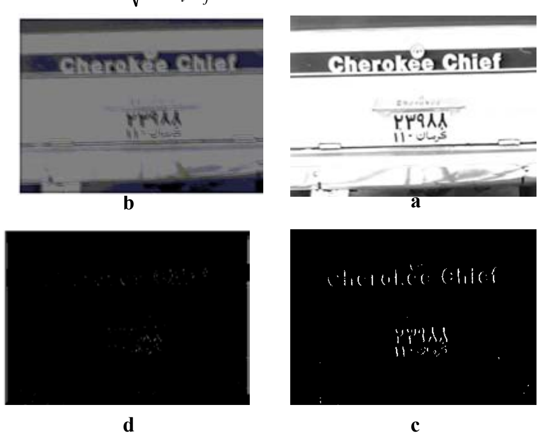


Figure (2): Gabor filter and its application, a) main image, b) image resulted from applying Gabor filter, given that $\theta = \pi, \lambda = 20$, c) images of vertical edges of images a and b

This agent then obtains the vertical edges of the image, searches for a rectangle as large as a plate with the most edges in the image, and gives this location as the location of the plate to the Moderator agent.

3.3. Moderator agent

Moderator agent knows the color, texture and bounds of a license plate and will compare the reported location with its standards and send it as the license plate location to the output, if there is no problem; otherwise, the Moderator agent will activate the Accurate-Gabor agent. Considering the fact that experiments were performed on data [6], the Moderator agent was only the threshold that was easily obtained through image observation and a few tests. But in more real works this agent can be a database including different types of plates and can trained with other methods.

3.4. Proposed system

The model of the proposed system has been presented in Figure (1). First, input image is given to the Speedy-MI agent. This agent counts the vertical edges in each line, and in the case of being more than the threshold, recognize it as a license plate, and delivers it to the Moderator agent. Moderator agent that knows the color, texture and bounds of a license plate will compare the reported location with its standards and send it as the license plate location to the output, if there is no problem; otherwise, the Moderator agent will activate the Accurate-Gabor agent. Accurate-Gabor agent applies the Gabor filter to the image. This agent then obtains the vertical edges of the image, searches for a rectangle as large as a plate with the most edges in the image, and gives this location as the location of the plate to the Moderator agent. If the Accurate-Gabor agent is not able to report the location of plate at the first step, it will be recalled again, and then it will apply the Gabor filter with a changed angle.

4. Experiments and results

This system has been tested on data [6]. Figure (3) shows the way of obtaining vertical edges by applying sobel filter. In Figure (4), the way of obtaining the license plate location through the multiple interlacing method can be seen.

In Figure (5), there are two examples of images in which the plate location can not be recognized by the multiple interlacing method.

Figure (6) shows the location which have been recognize wrongly by the multiple interlacing method. The phrase "Cherokee Chief" in Figure (5-a) and the light reflection in Figure 5-b caused these errors.

Regarding the threshold bounds obtained through the investigation of the data base images, the Moderator agent has returned these images. Figure (7) is the result of applying Gabor filter to the images of Figure (5) and it is noticed that an accurate location of plate has been recognized by the sliding window and counting the edges.

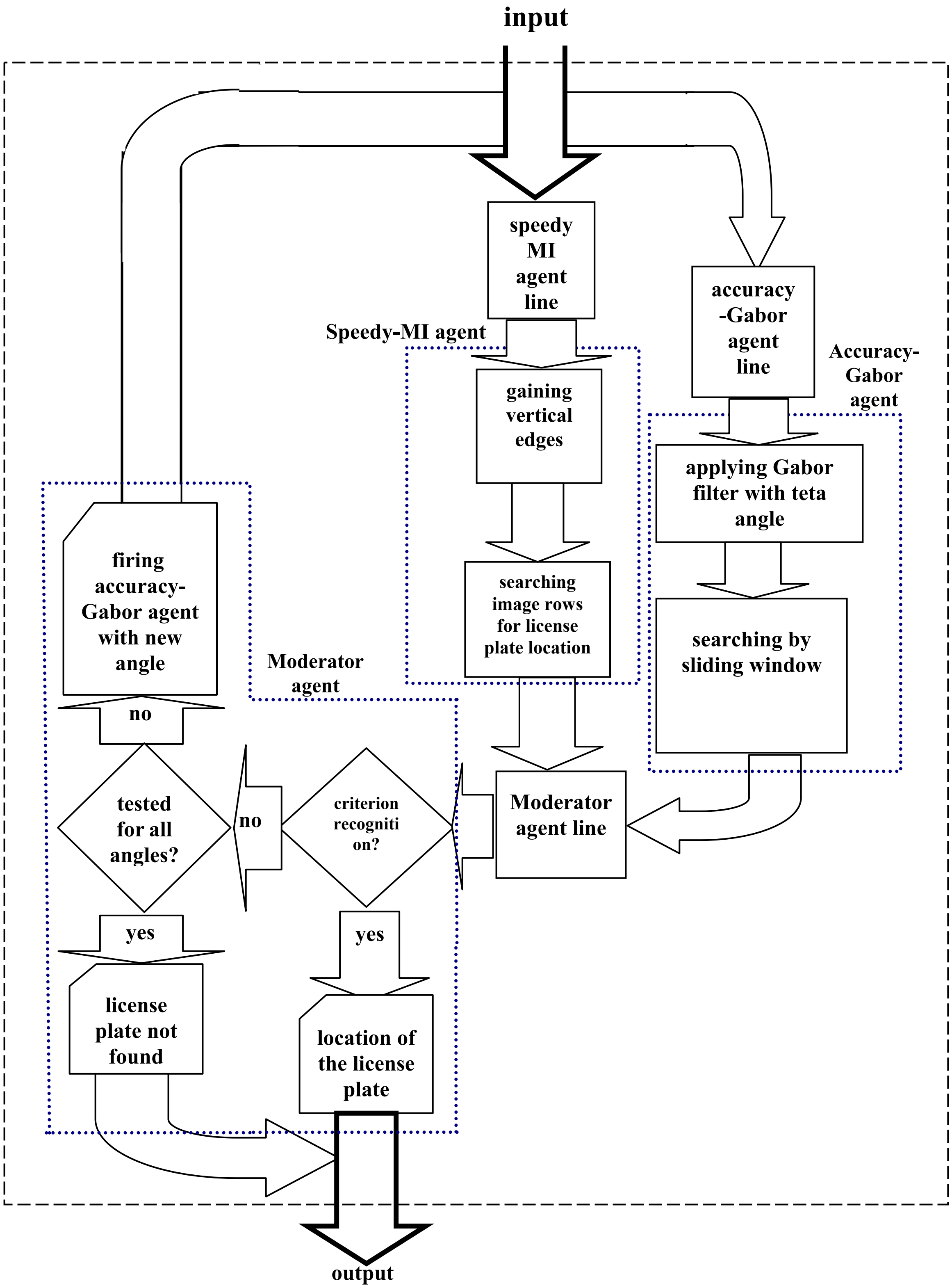
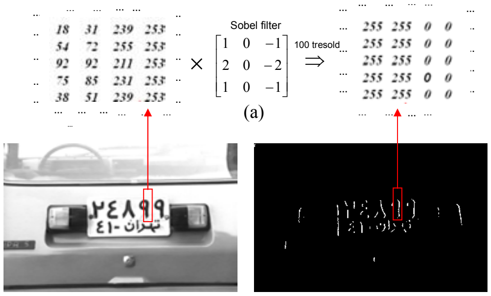


Figure (1) proposed system model



(a)

(b) (c)

Figure (3): obtaining vertical edges through applying the given sobel filter, a) main image, b) vertical edges of main image

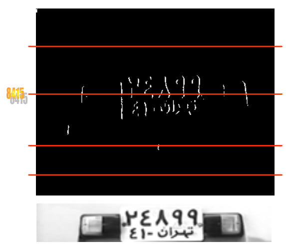
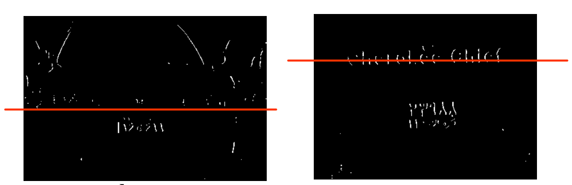


Figure (4): obtaining location of the license plate by the multiple interlacing method

b a

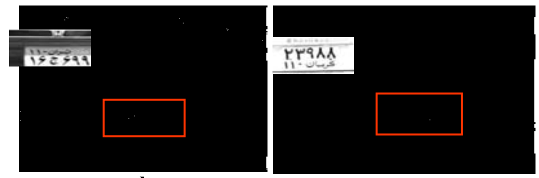
Figure (5): images in which location of the plate can not be recognized by the multiple interlacing method



b a

Figure (6): locations which are recognized wrongly by the multiple interlacing method. Images are related to illustration (5)

The proposed system recognized the license plate location of all the images included in the experimental data and achieved an accuracy of 100 percent (the Moderator agent has been better than [14]). Table (2) highlights important issues concerning various LPR systems and proposed system.



b a

Figure (7): applying Gabor filter to the images of illustration (5) and obtaining the license plate by means of sliding widow

5. Future works

First, establishing a database of various kinds of plates and finding the correlation between the founded plate and database license plates. Second, using more accurate criteria for the Moderator agent seem to be essential. Considering the ability of the system, we can increase the license plate recognition agents easily, and perhaps raise the effectiveness and accuracy in real application.

6. References

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Table (2), Performance of the LPR systems [11]

NO of tested image	Scientific background	Time (Sec)	Platform & Processor	Location Rate	NO
200	**Multiagent**	**~1.6**	**Matlab 7.1, P IV**	**%100**	**1**
40	Connected component analysis	~4	Matlab 6.0, P II	%100	2
1000 Video Seq.	Tabbed delay line NN (TDNN)	~1	Visual C++, P II	%100	3
784	Edge statistic and morphology	~0.1	PIV, 2/4 GHz	%100, %100, %99.7	4
10000	Mathematical morphology	~0.1	P IV, 1/7 GHz	%99.6	5
805	Hough transform	0.65	Visual C++, PIV 1.4 GHz	%98.8	6
131	A supervised classifier trained on the texture features	~34	AMD, Athlon 1.2 GHz	%98.5	7
300	**Gabor transform**	**3.12**	**P IV 1.4GHz**	**%98**	**8**
1065	Fuzzy logic color rules	~5.7	P IV 1.6 GHz	%97.6	9
100	Fuzzy logic rules	2	Workstation SGINDIGO2	%97	10
158	AdaBoost (Adaptive Boosting) meta-algorithm	Not reported	Not reported	%95.6	11
400	**Multiple Interlacing**	**2**	**Visual C++, P IV**	**%95**	**12**
104	Magnitude of the vertical gradients and geometrical features	Not reported	C++, P II, 300 MHz	%94.7	13
1000	Sub-machine-code Genetic Programming	0.15	P III, 600 MHz	%94	14
330	Generalized symmetry transform and image warping	1.3	Visual C++, AMD athlon 900MHz	%93.6	15
315	Wavelet transform based method	Not reported	Borland C++, PIV 1.6 GHz	%92.4	16
Not reported	Block-based technique between a processing and a reference image motorcycle vehicles are also identified	~1.3	Not reported	%92.3	17
450	SVM(support vector machine), CAMShift(countineus adaptive meanshift algorithm)	~1.3	C++, P III 800 MHz	%89	18
Not reported	Discrete Time Cellular NN	Not reported	Not reported	%85	19
Not reported	Pulse Coupled NN (PCNN)	Not reported	pulse-Coupled NN processor	%85	20
100	real-coded genetic algorithm (RGA)	0.18	P III, 500 MHz	%80.6	21
10000	Fuzzy logic	Not reported	Not Respond	٪75.4	22