Character Segmentation for Automatic Vehicle License Plate Recognition Based on Fast K-Means Clustering

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***Abstract*—Automatic vehicle license plate recognition (AVLPR) system is one of application for transportation area under intelligent transport system. This system helps in monitor and identify the vehicle by reading the vehicles license plate numbers and recognize the plate characters automatically. However, various factors such as diversity of plate character viewpoint, shape, format and unstable light conditions at the time of image acquisition were obtained, have challenged the system to segment and recognize the characters. Therefore, this paper, presents an effective procedure approached based on fast *k*-mean (FKM) clustering. FKM approached have an ability to shortening the time of the image cluster centers process consumed. In addition, the FKM algorithm also able to overcomes the cluster center re-processing problem when constantly added the image in huge quantities. The proposed procedure begins with enhancing the input image by using modified white patch and converted into grayscale image. A total of 100 of images has been tested for the segmentation process with clustering techniques approach used. Template matching is used to standardize the recognition results obtained. The highest achieved was 88.57% of average accuracy for FKM clustering technique compared to k-means clustering where it was only able to achieve an average accuracy of 85.78% and 86.14% for fuzzy c-means. Thus, this show that the most efficient, quicker and more useful algorithm goes to FKM rather than the algorithm for fuzzy *c*-means (FCM) and *k*-means (KM). Therefore, it is possible toward consider the proposed FKM clustering as an image segmentation method for segmenting license plate images.**

Keywords—license plate recognition, image segmentation, clustering algorithm, optical character recognition

I. INTRODUCTION

AVLPR system was firstly introduced in 1976 and today's AVLPR has become an important task in intelligent transport system (ITS) [1]. The beneficial of AVLPR system it is utilized with the point of traffic movement control and utilization of applications security such as carparks, pursuit of wanted vehicles and immigration control [2]. Despite this, the application of AVLPR is difficult due to the sophistication of the image background, non-uniform shape of characters and multiple formats. In addition, most of the number plate identification systems available are very much in line with their own country number plate format [3]. Plus, the position of the number plate in the picture is randomly located. Hence, causing the task for the system to identify the characters have difficulty.

AVLPR consisting of digital image processing technique which able to process the image of license plate and recognized the character of number plate. Image processing started with pre-processing stage. The image quality must be improved to suit with the computational processing. Then, the segmentation stage is extracting the image of characters individually form the plate. The final step is character recognition where the segmented characters need to identify in order to know what character illustrated on the plate. The character segmentation has a significant impact on the success of the AVLPR in identifying the character of the number plate.

Character segmentation is very important in separating the license plate characters from the background image correctly. This is because, incorrect segmentation can lead to incorrect recognition. Thus, the accuracy of the characters' recognition can be decreases. Various types of image segmentation methods have been used by other researchers in an attempt to extract the number plate such as thresholding method, region based, edge based and also clustering based methods [4-6]. Clustering is a one of the unsupervised learning algorithm in image segmentation technique that involves on creating a classes contained similar characteristic and will sorting on data set based on their patterns. KM clustering technique is the most general used in clustering method for segmentation purposed.

Stefanović *et al.* [7] applied KM clustering to analyze the number of clusters to be used on number plate images. A histogram-based windowing method uses some spatial information in order to increases the accuracy of image

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segmentation for license plate in Republic of Serbia. Overall the algorithm gives a good result in segmentation even though the result has slightly error due to the appearance of noise. Subsequently, optimal *k*-means (OKM) clustering has been used by Pustokhina *et al*. [8] in order to segment the license plate images. OKM has been combined with Krill Herd (KH) algorithm to work together with the OKM in segmenting the license plate. Convolution neural network (CNN) is used to recognize the characters. This proposed model has reached 98.1% for overall accuracy. However, this approached also might not give good segmentation performance if KH algorithm is not added together with OKM technique.

Yousif *et al.* [9] have proposed an optimized neutrosophic *k*-means (ONKM) for segmentation and recognition purposed. This approached is based on genetic algorithm (GA) which optimizing the neutrosophic set (NS) operations as it uncertainty can be reduced by the use of NS operations on number plate pictures. The additional algorithm is combined with KM to segment the characters of license plate. This approached has achieved 92.50% accuracy of correct identification. This approached have also been compare with traditional method where only achieved 70%. This show that traditional KM clustering not perform well for segmentation approached. However, this approached is limit for Egypt and English license plate and the image tested have constant license plate location and angle.

Brillantes *et al*. [10] proposed 3-class FCM and thresholding to segment the license plate images. Thresholding is often the main choice in image segmentation because to differentiate the context of the foreground object in the image this method is easy to apply maximum average smaller center can be obtained with the use of thresholding algorithm along with the minimum of middle center. Prior to the utilization of 3-class FCM Green pixel levels have been averaged with the aim of identified the license plate series through the agency of HSV image channels. Recognition of characters' process for segmented regions by used the template matching technique. The whole accuracy of the system achieved is 82.50%. This proposed is used for Philippine license plate format and low in number of images used for tested are 20 license plate images only.

Tadic *et al.* [11] have designed a new algorithm by using fuzzy two dimensional gabor filter. The proposed algorithm uses fuzzy logic as it allows the filter parameters to be changed flexibly to the problem's requirements. To optimize the Gabor filter, the filter of parameters is fuzzified. In particular, the Gabor filter's orientation and wavelengths are fuzzified. The procedures presented have achieved 97.90% accuracy for correct recognition. Additionally, a segmentation based on fuzzy logic has also been developed by Olmí *et al.*[12] have also projected a license plate segmentation reached from the fuzzy logic. A hybrid segmentation method proposed combination of KM clustering and fuzzy logic for extracting the license plate images. For this reason, a partition grouping algorithm is built using KM, with K=3, and a fuzzy logic method for selecting the K-group that represents the character. This arrangement has achieved 95.30% of accuracy.

Previous researches show that clustering method is widely used for characters' segmentation approached. Mostly another algorithm needs to be added especially with KM clustering to allow segmentation to be better and achieve higher accuracy. Although fuzzy seems better than KM, it has high sensitivity to noise and computational time is quite long. Therefore, this research will utilize the potential of unsupervised group in image segmentation gleaned from FKM clustering algorithm need to works on the license plate image which have a various intensity level unpredictability. The FKM clustering are being used to explicitly extract characters from the picture context in the license plate. Moreover, FKM clustering being compared with the intention of calculate its segmentation efficiency with two common image segmentation techniques which are KM and FCM clustering.

This paper has been arranged as follows, Section II explained methodology and method approached. The evaluation of the experimental results is show in Section III. Finally, the conclusion is drawn in Section IV.

II. METHODOLOGY

The major reason this study has been proposed is to compare the approached technique with two common clustering techniques and identify whether the approached technique have an ability in given the best performance output in extracting the number plate character or vice versa. Consequently, image processing and license plate identification have been involved in proposed procedures due to the goal in earning the characters are demonstrated in Fig 1.

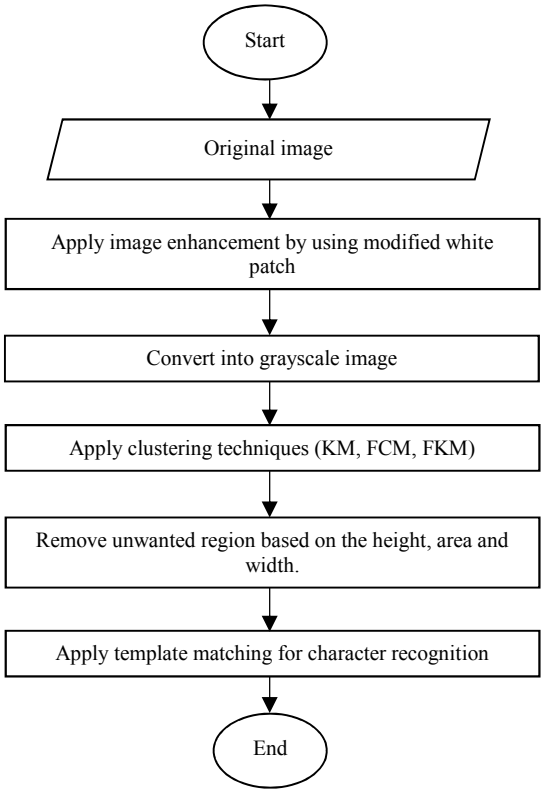

Fig. 1. The workflow of proposed procedure.

A. Data Acquisition

The data acquisition process is done by using a Fujifilm Digital Camera with a resolution of 14 megapixels. A total of 100 Malaysia vehicle license plate images have been collected for use in this research. These images are captured from three different angles of camera position which are +45, -45 and zero degrees as shown in Fig. 2. Moreover, the distances used are also different, i.e. the images are captured at a distance between 1.5m to 2.0m. Variations of car position in image can also indirectly test the ability of image processing techniques used in extracting images.

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(a) +45° (b) 0° (c) -45°

Fig. 2. The position of captured image.

B. Pre-processing of License Plate Image

The main cause of system failure to segment and recognize characters correctly is due to the low quality of the input image. This can be caused by the non-uniform of lighting condition such as cloudy day. Based on non-uniform condition of the image, image enhancement based on modified white patch has been used to improve the quality images of the low light conditions. This is because, modified white patches algorithm able to add lightness towards the low light conditions image. Modified white patches is the image enhancement technique used to improve the license plates image condition from low light conditions. The modified white patches algorithm works based on image pixel sampling concept where the mean of highlight pixels is calculated [13].

Since the enhanced image is in colour image, next task is conversion of the colour picture to a grayscale image level. Basically, colour pictures has three colour component which are red, green and blue (RGB). This can lead to the misleading in segmenting the license plate compared to grayscale image. Furthermore, the best segmentation performance result for AVLPR mostly produced from grayscale image instead of using the RGB image.

C. Character Segmentation Based on FKM Clustering Algorithm

Image segmentation is a critical process in image processing because it is the cause of the success of a AVLPR succeeds in producing good accuracy results. This step is to separate the images into different region based on the pixel characteristics. In this study, the grayscale image will be processed by using segmentation techniques which is the clustering algorithm. Clustering is an unsupervised method aimed at grouping a collection of data set into reasonable classes dependent on separations between information focuses which is the points carry an information. KM, FCM and mean shifts are amongst these common clustering algorithms that are often selected during the operation of extracting target region upon variations of license plate image. For example, the data allocation principal by transferring data to the closest cluster which KM clustering used is generated from the idea to shorten the Euclidean distance estimation.

Since segmentation is extremely important in extracting the license plate, this research aims to utilizes FKM for character segmentation and compared with common clustering techniques which are KM and FCM. K-means clustering formulae works reached from natural distance of the information of input points individually and form a classes. In addition, KM perform well with a variety of data sets, but their good performance is limited mainly to compact groups. A set of data by let $X = \{x_1, x_2, \ldots x_n\}$, where n is the set of data points $V = \{v_1, v_2, \ldots v_n\}$ is the responding set centers, where c is the number of clusters. KM algorithm goal's to minimise the objective function $J(V)$, a square error function in this case:

$$J(V) = \sum_{i=1}^{c}\sum_{j=1}^{c_1}\left\|x_{ij} - v_j\right\|^2 \quad (1)$$

where, Euclidean distance is calculated in between x_{ij} and v_j is $\left\|x_{ij} - v_j\right\|$. c_i is the quantity of the information focuses in the cluster i. The i^{th} center v_i can be calculated as [15]:

$$v_i = \frac{i}{c_i}\sum_{j=1}^{c_i} x_{ij}, i = 1 \ldots c \quad (2)$$

It can be defined the process of this algorithm as follows:

1) Select c cluster at random.
2) Calculate the distance between each centre and all of the data points.
3) Emanated from the minimum distance, data is allocated to a cluster.
4) Using step 2, recalculate the centre positions.
5) The distance between each data point and each centre is recalculated.
6) If no data has been reassigned, pause, or else repeat step 3.

The standard image contains a lot of pixels. According to the traditional KM clustering, the distance value in each loop must be determined between each pixel and each clustering core [13]. Hence, a lot of time is consumed by this event. In order to resolve the k-mean constraint, fuzzy *c*-means have used cut-off membership to decide the cluster centre for each allocated results. In this process, pixels may be part with more for one cluster, the membership level set is related within each pixel. Fuzzy *c*-means needs a cluster center with an objective feature. Fuzzy *c*-means produces a fuzzy partition matrix. The algorithm is works according to the following [16]:

1) Initialize C_k fuzzy centroids K=1, ..., *nc* with anywise. Here also the number of clusters is *nc*.
2) Redo, then compute a fuzzy membership $U(k) = [uij]$, which indicates the information point i member towards cluster j via;

$$u_{ij} = \frac{\left(\frac{1}{\left\|x_i - c_j\right\|}\right)^{\frac{1}{m-1}}}{\sum_{j=1}^{nc}\left(\frac{1}{\left\|x_i - c_j\right\|}\right)^{\frac{1}{m-1}}} \quad (3)$$

3) Use the measured fuzzy membership to modify the fuzzy centroids, where its fuzzy parameter is symbolized as m, and the sum of data points is n..

$$c_j = \frac{\sum_{j=1}^{n}(u_{1j})^m x_1}{\sum_{j=1}^{n}(u_{1j})^m} \quad (4)$$

4) Keep continue iterations unless $\|U^{(k)} - U^{(k-1)}\| < \varepsilon$, thus operation STOP

For each data point x_i, assign x_i to cluster j where u_{ij} is the maximum among $U^{(k)}$ for K=1, …, *nc*, or $u_{ij} > a$. Nevertheless, this algorithm is also susceptible the cluster centers headed for the initialization. Limitations of the FCM algorithm, regardless of whether the resulting licence plate images are under-segmented or over-segmented, can lead to poor segmentation efficiency [17].

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Therefore, this study established a FKM method that certainly able to reduce the duration of time consumed to process the store of image cluster centres yet in additional overwhelms the cluster centre retraining issue as huge quantities of images which is nonstop increasing the image quantities into database. Earliest, this analysis brings into being the degree of the image database histogram value through statistics. In case that, there is a color model for a *n* color space image, articulate as $r=(r_{1,i_1}, r_{2,i_2}, \ldots, r_{n,i_n})$, where $i_1, i_2, \ldots, i_n = 1, 2, \ldots, L$, which there are n elements in each pixel of the image. The *n* color spaces $h(r_{1,i_1}, r_{2,i_2}, \ldots, r_{n,i_n})$ is obtained from detached function of the histogram, anywhere $(r_{1,i_1}, r_{2,i_2}, \ldots, r_{n,i_n})$ the colour model number of pixel is $h(r_{1,i_1}, r_{2,i_2}, \ldots, r_{n,i_n})$. The discrete function of the histogram value is $h(r_{R,i_1}, r_{G,i_2}, r_{G,i_3})$, where $i_1, i_2, i_3 = 1, 2, \ldots, L$, or wholly coloured of pixel levels r_{R,i_1}, r_{G,i_2} and r_{B,i_1} which presuming that instead of the *j*th image has *Mj* pixels, the database image of three color channels contained *N* images. Thus, FKM use the distinct feature of the scale histogram range and centre training made by KM algorithm intending to obtained the cluster of image database [18]; A comprehensive overview of the measures as follows.:

1) Presuming that K clusters are there, where k=1, 2, …, K and there are n core vectors in each cluster:

$$C_k = (C_{k,1}, C_{k,2}, \ldots, C_{k,n}) \quad (5)$$

2) Calculate the Euclidean distance to the cluster center ck from each level value, and value of individually level will allocated to the cluster which nearest cluster centre. For instance, the Euclidean distance of the kth cluster vector where k=1, 2, ..., K in between value r and cluster centre ck range is:

$$d(r, c_k) = \sqrt{(r_1 - c_{k,1})^2 + (r_2 - c_{k,2})^2 + \ldots + (r_n - c_{k,n})^2} \quad (6)$$

Where *k*=1, 2, . . ., K. Since value of the colour scale r nearest with the cluster centre which is cluster c_k, this value has been allocated.

3) Determine the mean value of each cluster 's levels and every cluster is take as the current core of each cluster.

4) Stop training if and only if the first one cluster is identical with current cluster centre or else steps 1 until will repeated.

D. Remove the Unwanted Region Based on characteristic of license plate characters

After the images have been segmented by using clustering algorithm, the next step is to remove the unwanted regions. Steps to remove unwanted areas are very necessary because with the presence of these unnecessary regions can lower the percentage for the identification of the character. Therefore, unwanted region is removed based on characteristic of license plate characters. License plate characters have been measured their height (46-107), width (14-93) and 442 areas per character pixels. By using this measurement, regions that are out of the license plate characteristic range will be selected as unwanted region and removed from the segmented image.

E. Character Recognition Based on Template Matching

Segmented region remains from the previous step is followed by an optical character recognition (OCR) process to determine a character classes from the segmented regions. During this process, bounding box technique has been used to lock every segmented region in the image for recognition process. The license plate recognition system is used to individually verify the match of each character with the total alphanumeric database using accessed template matching. In a larger source image, the matching method moves the layout to any imaginable location and processes a numerical file that illustrates how well the format coordinates the images in that location. Matching is performed based on pixel from database by pixel from segmented region assumption. Thus, the types of characters can be recognized from this matching process.

III. Result and Discussion

Within this part, the comparison of fast *k*-mean, KM and FCM have been tested on 100 images with different distances and angles of car positions. Fig. 3 shows three different cars which labeled as Car A, Car B and Car C. This is an example of a car image taken from the camera with a distance variation that is between 1.5 m and 2.0 m and the vehicle plate.

(a) Car A

(b) Car B

(c) Car C

Fig. 3. Samples of captured images.

Modified white patch has been applied towards input image in an attempt to increases the image quality especially for images that have been captured on the cloudy day. Image captured as it will be appearing a little darker than usual as can be seen in Fig. 3(a). Fig. 4 shows the image become brighter after apply modified white patch. Basically, captured image is in RGB image. This leads to the difficult situation of segmenting the picture. Thus, the input image is converted into grayscale image as shown in Fig. 5 by taking the weighted average sum of RGB values.

Fig. 4. Modified white patch image.

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Fig. 5. Grayscale image.

Then the process proceeds with the segmentation method. Fig. 6 illustrates the segmented image after applying clustering algorithm. After segmentation, some undesired region has also been segment together. To eliminated the undesired region, the characteristic of license plate character act as indicator in removing the unwanted regions. The regions have more or less pixels than the highlight characteristic will be removed. It can be seen the differences in between image Fig. 6 and Fig. 7. The large and small region sizes are completely removed. Only remains the license plate characters and the regions that have the same size with the character characteristic.

Fig. 6. Result of segmented image by using FKM clustering.

Fig. 7. Unwanted region removing image.

Subsequently, bounding box as shown in Fig. 8 is made to enclose the segmented region in the image to support the recognition process become easier. Lastly, the recognition process by using template matching have been made and the result is portrayed on text file as shown in Fig. 9.

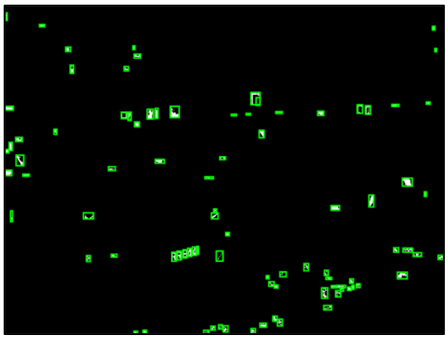


Fig. 8. Bounding box used for template matching proces.

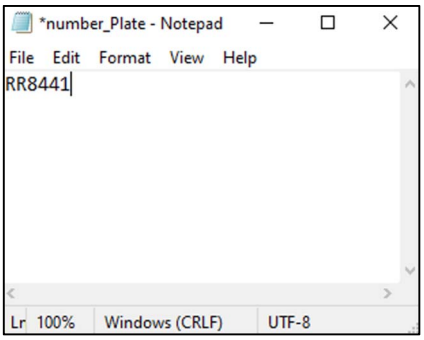
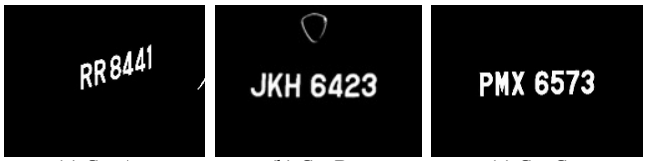


Fig. 9. Result obtained from template matching process.

Figs. 10, 11 and 12 demonstrate the result of image segmentation of each clustering techniques. From observation, it shows that all three clustering technique can perform well in segmenting the image. Thus, furthered evaluation have been made by using template matching. Template matching will have matched the characters in database with the segmented regions and the character can be recognized.



(a) Car A (b) Car B (c) Car C

Fig. 10. Results of segmentation using KM clustering.

(a) Car A (b) Car B (c) Car C

Fig. 11. Results of segmentation using FCM clustering.

(a) Car A (b) Car B (c) Car C

Fig. 12. Results of segmentation using FKM.

Table 1 displayed the result of average accuracy of recognition for each clustering algorithm. From this table, FKM has achieved the highest average accuracy with 88.57%. This is followed by FCM with 86.14% of average accuracy and 85.78% for KM clustering. This shows that every

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clustering algorithm has its own characteristics, even though it comes from the same community. Time processing for each clustering technique in producing result for segment one image and noise produce have been recorded. As can be seen, instead of FKM has produce the highest average accuracy, FKM is also the most faster technique to segment the image in one time but this technique produces lots of noise. However, the characteristic of the noises is not the same as characteristic of the characters. Thus, recognition process can be easily identified without being interrupted by noises. Meanwhile, FCM take a few times to be extracted and produce the result of recognition characters although less noise produces from this technique compare to KM and FKM. Plus, FCM very sensitive to the initial local minima cause over-segment of the region. This is why average accuracy obtained by FCM clustering is lower than FKM clustering. After all, this show that the approached method is very efficient in processed the images and able reducing the run time processing.

TABLE I. COMPARISON RESULT OF CLUSTERING TECHNIQUES

Clustering Algorithm	Average accuracy (%)	Advantages	Disadvantages
FKM clustering	88.57	Short in run time; 21.97s	Produces fewer noises
KM clustering	85.78	Moderate run times; 86.01s	Noisy
FCM clustering	86.14	Less producing noises.	slowest times run; 106.32s

IV. CONCLUSION

In summary, FKM clustering algorithm has been introduced with a focus on segmenting the license plate characters. The comparisons of FKM, KM and FCM have been made to measure segmentation performance in segmenting the license plate image. Overall, FKM algorithm has shown quite encouraging results compared to KM and FCM clustering by achieved 88.57% accuracy of average recognition over 100 car images. Plus, the present method used shorten the computer processing time for segment the characters against other methods. Thus, this research shows that FKM algorithm has better competence opposed to KM and FCM clustering.

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