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Research paper

Vehicle Detection and License Plate Recognition System

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Abstract

Moving object detection is an important process in most video-based applications such as video surveillance, traffic monitoring, human motion capture, etc. Background subtraction and color image segmentation methods are widely used for detecting moving objects in a video stream that help detecting features of the moving object for further video processing. In this paper, moving object detection system is proposed based on both background subtraction, color segmentation, license plate recognition methods. This method builds a background model and normally distributed each pixel in the image sequences and calculating the difference between each image in the sequence and this background model for foreground extraction and detecting movement areas from the background model and then the background model is updated. Color segmentation is applied to separate features based on colors. The system detects vehicles enter parking gate and allow only a specific vehicle type depending on vehicle color and license plate. License plate recognition depending on vehicle type is implemented after color segmentation. Experimental results of implementing the proposed method using video sequences provided by surveillance camera show superior performance and the system detects moving objects successfully.

Keywords: *Object Detection;* Background Subtraction; Background Update; Foreground Extraction; Color Segmentation

1. Introduction

Motion detection is an important field for many computer vision applications due to its importance in extracting moving objects from a video sequence that can be used in video surveillance, human-machine interaction, and recognition [1]. Detecting of moving object is a basic portion in visual surveillance systems. Moving object can be located and detected from image sequence (video stream), by subtracting specific area of interest in the given sequence and segmenting the motion areas in order to perform recognition and tracking. However, due to wide range of real time applications such as gait recognition people counting and traffic surveillance, there are many challenges with detecting the moving objects in term of accuracy and rapidity such as lighting conditions and camera shake [2].

Object detection is the preface of object recognition when an image is inspected and targeted object is detected before applying recognition process. Using both background subtraction and image color segmentation has a significant impact on object detection which affects the performance of finding potential objects in the scene [3]. Most of the moving-object detection methods used in computer vision applications have been based on three main approaches: (1) background subtraction, (2) inter-frame differencing (3) optical flow [2].

Background Subtraction technique models a static scene called (background) as a reference then, comparing each image in the sequence with the corresponding model based on the difference image between current frame and background frame that thresholds, segments and distinguishes the unusual movement or motion areas (foreground) that represent the moving objects. This method can obtain a complete object detection or moving objects as shown in Figure 1, but at the same time it's sensitive to dynamic environment.

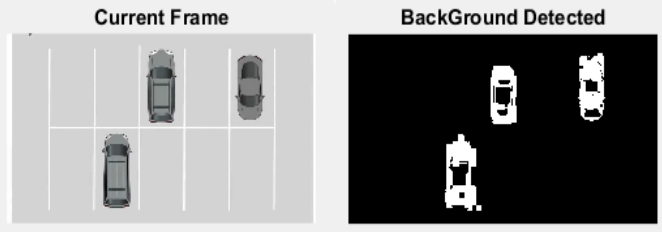

Fig. 1. An Example of Object Detection.

Inter-Frame Differencing technique uses thresholding to obtain the motion region. It calculates the difference between several consecutive images. For the dynamic scene, this method can operate quickly and has strong adaptability, but objects have incomplete detection and poorly presented. Optical Flow technique considers the light changing tendency of each pixel in the scene. This method detects any moving-object without priori information. It is generally slow and has heavy computation load so it needs relevant hardware. this makes real-time implementation difficult. It's also easily affected by noise [1].

Background subtraction is a common pre-processing video analysis and modeling technique used in computer vision systems. Background subtraction basic principle which is used in Simple moving-object detection algorithms is comparing a static background image frame with the current image frame (comparing pixel by pixel) of a video sequence. This technique detects the significant difference between background model and current frame that occur in a specific movement zone. Therefore, it detects objects by distinguishing the foreground (moving object) from the background (static/slow moving parts) in the scene [4][5].

Generally, background subtraction has to develop a model which requires a fixed camera then calculating the difference between

the current and the background images in the sequence. Finally, threshold operation is applied to determine whether a specified pixel belongs to the background or belongs to the moving object. The result of this process is used for the segmentation step. When both background pixel and moving-object pixel intensities are similar then, this pixel will be considered as a background pixel after segmentation step.

There are two main principle challenges with this technique, the maintenance of the temporal and permanent variation in background where the difference of luminance between any two moments is less than a specified threshold. So, updating background image is required in each image [1].

Color image segmentation is a central process used for image analysis, object detection and pattern recognition. In foreground detection, color image segmentation is commonly used technique for distinguishing objects from their background by partitioning an image into multiple homogeneous and meaningful regions with respect to identical set of properties. Color segmentation is used in many computer vision applications such as object recognition, data compression, tracking and image retrieval. Segmentation algorithms depend on different parameters such as gray-level, color, texture, depth or motion [6][7]. Color segmentation can be used to isolate a chosen color as shown in Figure 2.

Fig. 2. An Example of Color Segmentation.

Color segmentation methods can be classified into three main techniques each has its advantages and limitations: Image-domain based techniques, which perform segmentation through utilizing color features and spatial relationship between color in its homogeneity evaluation. Physics based techniques, which carries out color segmentation through utilizing the physical model of the reflection properties of material. Feature-space based techniques which perform segmentation through utilizing color features as the key with ignoring spatial relationship between colors [8].

Since the number of vehicles on the road increases the monitoring process of these vehicles become a difficult problem especially for security reasons [9]. One of the most important parts of a common intelligent transportation is the license plate recognition system which is a part of image processing theme [10]. License plate recognition can be used in any expressway monitoring system, smart parking system, space management, stolen vehicle identification, etc. with different standers where stationary image or video data is collected using a camera and the license plate is recognized without human intervention [11]. The license plate recognition system is shown in Figure 3.

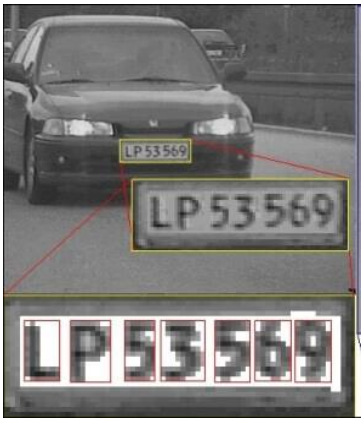

Fig. 3. License Plate Recognition System.

In this paper, different vehicles can be detected using background subtraction algorithm which detect the moving vehicles in a video sequence. Then, color segmentation is used to separate a specific vehicle color which can be useful in our system to avoid vehicle with yellow color to enter a specific area. Finally, License Plate Recognition is used depending on vehicle type and province.

2. Related Work

Moving object detection is an interesting research topic due to its wide range of real-world applications. There are many existing algorithms that focus on detecting objects from a video sequence. Many of these algorithms used either pixel based, region based or frame-based method. Background subtraction techniques that have been developed for object detection algorithms have main approach of preserving a model of a comparatively static background while detecting foreground objects as outliers. With the static camera constraint which is normally assumed, pixel-based approach is motivated assuming that pixels are statistically independent and the background distribution is estimated for each pixel [12].

Over last years, several studies have been published illustrating the evolution of object detection methods and background subtraction algorithms. In [13] a new detection system with an improved background subtraction algorithm is presented which is named as Multimode Background Subtraction (MBS V0). This algorithm is based on Multiple Background Model which can handle sudden illumination changes by using of appropriate color spaces. The new algorithm conducts multiple pixel-wise models of the scene with frame level constraint which extends its applicability to both static and moving camera scenarios.

In [1] a moving object detection method is proposed that used both RGB color space and the background subtraction method for detecting the moving object in a video sequence. This method uses the spatial color information to generate the background of each color space (R, G, and B) of the sequence. Then the background is subtracted by computing the absolute difference before computing the binary image of the moving objects using a threshold which is also used to update the background at each new image. Using of spatial color information was robust to environmental illumination change.

In [14] an adaptive background subtraction method derived from ViBe method is presented. This novel method depends on a spatiotemporal binary similarity descriptor instead of pixel intensities as its main component in a video sequence. Overall performance of the algorithm is improved in terms of keeping memory usage, complexity and speed at especially for online applications.

In [15] an object detection method is proposed for objects moving on an underwater video. This technique is designed to be used for underwater surveillance system. The background model in this method based on adaptive modeling, where the intensity of pixels in the background is updated based on inference of the background intensity before.

In [16] a new approach of motion detection is proposed that measures the change in the scene using Mutual Information. This approach uses mean-shift algorithm for frame regions segmentation where pixels in a frame belong to an object. Then a Mutual information measurement is applied between the segmented region and the incoming frame. The proposed algorithm improves the performance of pixel-based Background Subtraction technique through a hierarchical model of Background Subtraction algorithm.

In [17] object detection and segmentation algorithm is presented in a video sequence which is based on background subtraction method (object detection) and segmentation method (edge detection and thresholding) algorithms. This technique can extract moving objects from various sequences.

In [18] an algorithm for detecting moving objects is proposed in a general 3D scene formulated as a thresholding scheme in the video sequence captured by freely moving cameras. The algorithm per-

forms (RSVD) decomposition on multiple blocks of a specified trajectories to extract the coarse foreground region then, it uses both fast motion inpainting method and adaptive thresholding method to reconstruct the background motion of pixels in foreground region to be subtracted. The detected foreground is further refined by the mean-shift segmentation method.

In [19] motion information is extracted using a video sequence with large number of images. This method reduces the problem of holes in dynamic background updating video by using Three frames differencing (instead of two frames) and background subtraction.

Many research papers and approaches have been proposed to ensure the rapidity of color image segmentation. In [20] an algorithm for detecting face and facial features automatically from the color images is proposed. The algorithm is based on color segmentation and region localization to detect facial features. This method reduced the brightness problem and eliminated the illumination variation problem.

In [21] a combination method of the three colors spaces, namely HSV, YCbCr and Normalized RGB is proposed for skin color segmentation. This method gives a significant performance but its accuracy depends on the variety of lighting conditions in the scene.

In [22] an adaptive detection algorithm is proposed for arena of a soccer robot, position, role and orientation of robots. This algorithm uses an Adaptive edge detection method in arena detection and Histogram as adaptive color segmentation in robot detection in dynamic environment. The performance of this algorithm affected by camera displacement and lighting condition.

In [23] a new approach is proposed for color segmentation that is used to segment text from background in historical documents. This color segmentation approach uses Markov random fields technique. It can handle different kinds of noise and image distortions by reducing set of required parameters to segment text written in different colors.

In [24] a fuzzy color segmentation and recognition method of vision scene of robot based is proposed. This method uses a combination of fuzzy color quantization and edge extraction of a color space (HSV) that can avoid redundancy color and improves the speed of color recognition and post image processing of robot.

In [25] a technique for face skin color detection and recognition of a particular person in a crowd is presented. This technique uses head shape classifiers for segmenting the face images of a particular person. Variants that are trivially, came across by the partial face is demonstrated.

In [26] a region-based object recognition method is proposed to identify objects from a complex scene. Color image segmentation is performed by a simplified pulse-coupled neural network (SPCNN) for both object model and test images. Then region-based matching is conducted between them. This method is well preserved both temporal (SPCNN) pulsing information and the spatial distributions of objects or images.

In [10] license plate recognition system for Iraqi cars is presented. this system locates and detect characters within license plate relying on edges and position. then, characters are recognized using template matching for a prepared Eigen value template. finally, the Euclidian distance classifier is used for taking a decision. the proposed system shows an accurate recognition results but there are some difficulties in segmenting and matching when the images are collected with different weather conditions and illumination with various degrees of distortion and erosion.

In [11] a new license plate recognition system for identifying characters of the new Iraqi license plate depending on plate image recognition is proposed. First, the vehicle image is captured using a static camera then this image is processed to get the plate location and separate it using segmentation technique. an optical character recognition technology which is template matching is used for text recognition. finally, the recognized characters is compared with vehicle plates numbers in the database. the presented system has a good result in team of recognition rate but the adhesion and fracture on the plates can affect its performance.

3. The Proposed System

In this paper, Moving-object detection contains three main parts: The first part, is subtracting the region of motion from the image sequence, the second part, is classifying those motion regions, the third part, allow vehicles to enter a specific area depending on vehicle type. The proposed system used both background subtraction, color segmentation, and license plate recognition to detect and classify moving cars with different color in the street or parking entrance from input video sequence. The input video data was captured using a static video camera and pre-processed for frames extraction. Background subtraction is used for detecting moving objects in videos. This method will detect the moving objects by comparing the current frame with a background frame. Then Color segmentation will isolate the selected color after background subtraction. License plate recognition can be used to recognize vehicle type. The proposed system is shown in Figure 3.

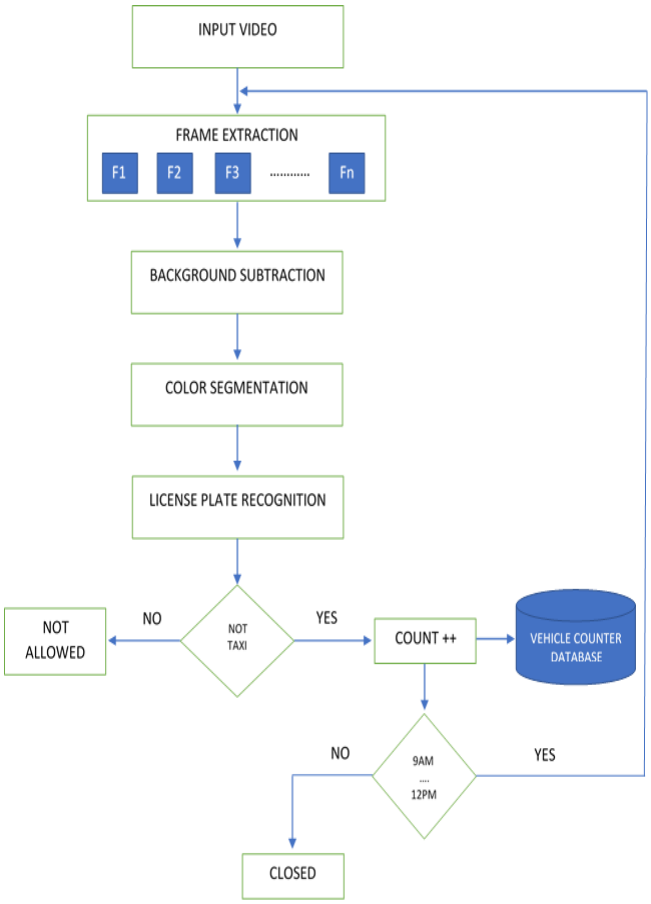

Fig. 3. The Proposed Object Detection and Color Segmentation System.

3.1 Background Subtraction

Many background subtraction algorithms generally have the following scheme: First, is Background initialization, where the background model is built with a specific number of frames using statistical, fuzzy or neuro-inspired way. Second, is Foreground detection where a comparison process is applied between the background model and the current frame. Third, is Background update where the background model learned from initialization step is updated after images are analyzed with considering to learning rate [27].

Background subtraction techniques have different ways for updating the background model and comparing a pixel value to this model. Also, background subtraction model can be adopted to consider ghosts, shadows and camouflage, etc. [28][16].

3.1.1 Background Initialization And Normal Distribution

To obtain the background model the background image with no objects needs to be acquire. Then, the subtraction process is applied on video sequence frames to detect the moving object. In this work, the first frame of the sequence is considered as the initial background. Then normal distribution is determined for each pixel in the frame. The intensity of each pixel is considered as the initial mean value.

3.1.2 Foreground Extraction

In this step, the difference between current frame and background frame is calculated. Since All pixels in the first frame is considered as background, so All pixels in the current frame should be examined with the first frame to determine whether its belong to background or object based on threshold operation. Threshold value is computed from the absolute differences between the current image and background.

3.1.3 Background Update

Due to critical situations such as presence of noise, light changes and temporal/permanent variations in background, the background model must be updated in each new frame of the image sequence to adapt it over time.

Background subtraction method steps are as follows:

Step 1: Reading the background image.

Step 2: Reading the current frame.

Step 3: Converting image frame from RGB to HSV color model .

Step 4: Converting image from HSV to Grayscale model.

Step 5: Converting Grayscale to Binary image.

Step 6: performing Median Filter to remove noise.

Step 7: Boundary label the filtered image.

Step 8: Tracing region boundaries in a binary image.

Step 9: Displaying the result.

3.2 Color Segmentation

After background Subtraction, color segmentation is performed in the proposed algorithm. The aim of this step is to separate features based on colors from frames of the image sequence. In color images, hue, saturation and intensity value are useful for determining boundaries. Color segmentation technique used in this paper is based on converting image color space into HSV model. So, color can be classified in ranges of hue and specified depending on saturation and value.
When the car is detected and classified correctly it is counted as an authorized object in vehicle counter database. Then the vehicle validation is checked if it is within the working hours to be passed through the entrance.

Color Segmentation Method steps are as follows:

Step 1: Reading background Subtraction resulting image.

Step 2: Selecting specific color for segmentation.

Step 3: Normalizing color values by Multiplying with 255. Where values are between 0 to 1.

Step 4: Comparing frame image pixels with the color rang.

Step 5: Isolating the selected color from the frame image.

3.3 License Plate Recognition

Iraqi License plates include more than one style, colors and fonts. The registered vehicle type is depending on the license plate color which include different colors (white, red, yellow, blue, green, and black). In last few years, a German company designs a new license plate. This proposed system will also work on the new Iraqi license plate to be detected from vehicles license plate which can be captured using a mobile camera [29]. The new Iraqi license plate is divided into several regions as shown in Figure 4.

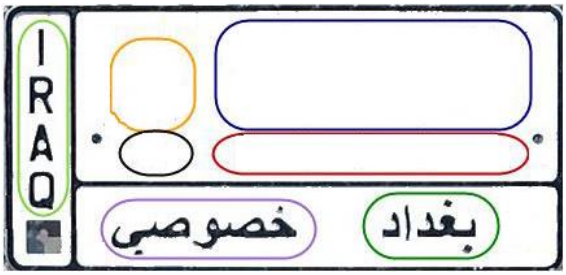

Fig. 4. The New Iraqi License Plate Layout

3.3.1 Image Acquisition and Pre-Processing

The first step is to capture images of Iraqi vehicles by using a digital camera which can be located in different locations. The camera image quality is very important to achieve high recognition rates. The captured images are converted to gray-scale format which is needed. Image pre-processing techniques can be applied for image enhancement. Median filter is applied to remove noise from images and this can be very important in recognition process especially that median filter will also make high frequency more concentrated [11][29].

3.3.2 Edge Detection

Edge detection is needed to finding vehicle boundaries within the selected image. Sobel operator which uses two masks (vertical and horizontal) is used on the selected image to detect and localize edges. Then, the image is converted to binary image format which is useful because the needed information can be obtained from the imagination of the object [9].

3.3.3 Image Segmentation

Image segmentation is an important and critical stage in any vehicle license plate recognition system. The segmentation process aims to divide the license plate into different regions then segment each number, character and word into sub images [29].

3.3.4 Character Recognition

In this stage, first the numbers are segmented (each number into sub-image) by using labeling connected components. Each number, letter, province and type should be resized to the size of the preloaded templates [9].
Images of numbers from 0 to 9, Iraq provinces, letters and types of cars in Iraqi LP all these variables are stored in the form of cell in which each matrix represents a character. The separated images of numbers, letters, provinces and type are correlated with templates (each part with its saved templates) which are reloaded into the system. Once the correlation is completed, the template with the maximum correlated value is declared as the character present in the image and prints it into a text file [29].

4. Result and Discussion

The Proposed system is implemented on MATLAB R2016a simulation tool. The experimental environment of our system is Microsoft Windows 7 Ultimate 64-bits platform runs on PC with Intel Corei7 2.4 GHz processor and 8GB physical memory. The Proposed object detection method is performed and successfully tested on video sequence captured by real-time camera and benchmarked using a sequence with frame rate of 30 frame/second and 540x320 frame size.
This section is divided into three parts: implementation of background subtraction, implementation of color segmentation, and implementation of license plate recognition. In each part, the result will be shown and discussed depending on different images captured by a static camera. Increasing the number of frames per second will increase the detection accuracy.

4.1 Implementation of Background Subtraction

In this implementation, the first frame is known as background image where no moving objects are found; while $frame_2$ to $frame_n$ is known as current frames where changes can be detected in any second. Background frame will be compared with each current frame. If the two images are the same that means there is no objects or changes in the video. Otherwise, when the two images are different that means there is an object enter the specific area.
Figure 4 shows a sampled frame from a video sequences and also shows the detection results based on background subtraction method. The results contain the detection of the moving-object based on background subtraction. This result show that the background is separated effectively and accurately detecting the objects in the video sequence.

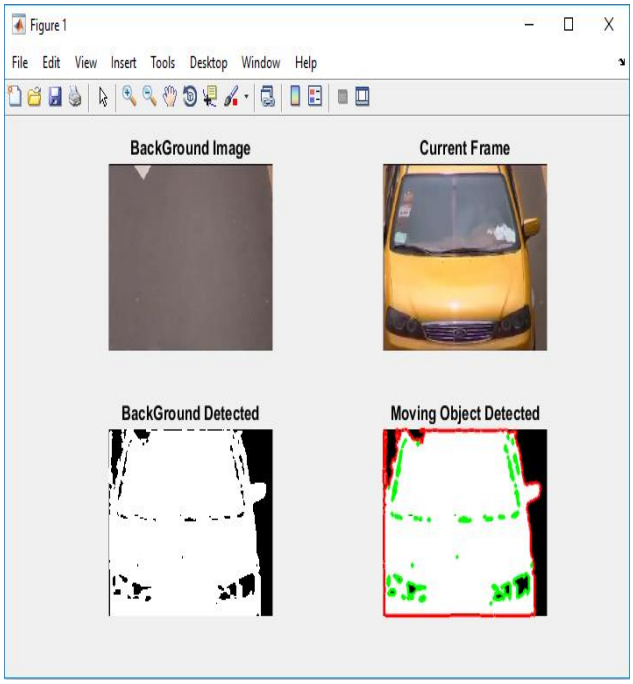

Fig. 4. Background subtraction of moving vehicle.

Figure 5 shows another sample frame from a video sequence of traffic intersection. In this situation, any car enters the area will be detected and also this helps to detect if any car breaches the traffic signs. Three cars in different locations are found and successfully detected.

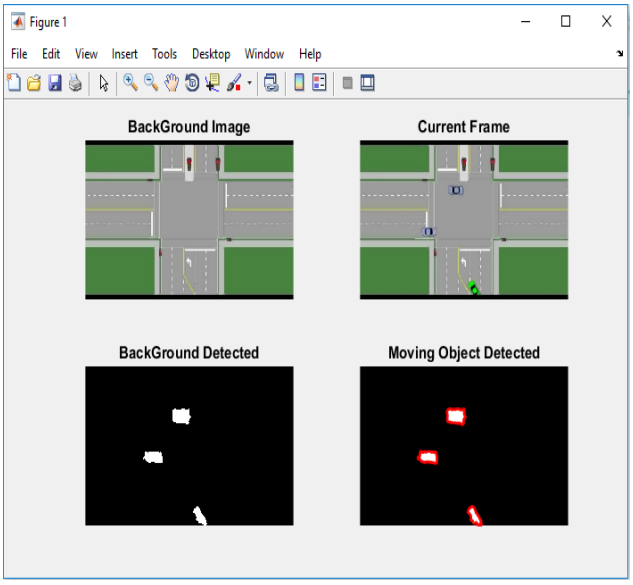

Fig. 5. Background Subtraction of Moving Vehicles in Traffic Intersection.

Background subtraction method shows high accuracy and the implementation was successful. This can help in many different situations where the detection of objects is required such as: tracking a person path, detecting soccer players movement in the match, detecting how many students enter the class, etc.

4.2 Implementation of Color Segmentation

In this implementation, the detected object frame of the background subtraction step is used to isolate the selected color. Color segmentation method shows a good result and the implementation was successful. The selected color will be shown in the color isolation image while other colors will be gray.
Figure 6 shows the demonstration of the color isolation method of the proposed system on the result of the background subtraction phase which contains an image frame of the detected object. The normalized color segmentation method performs superior for background color removal of the frame image.

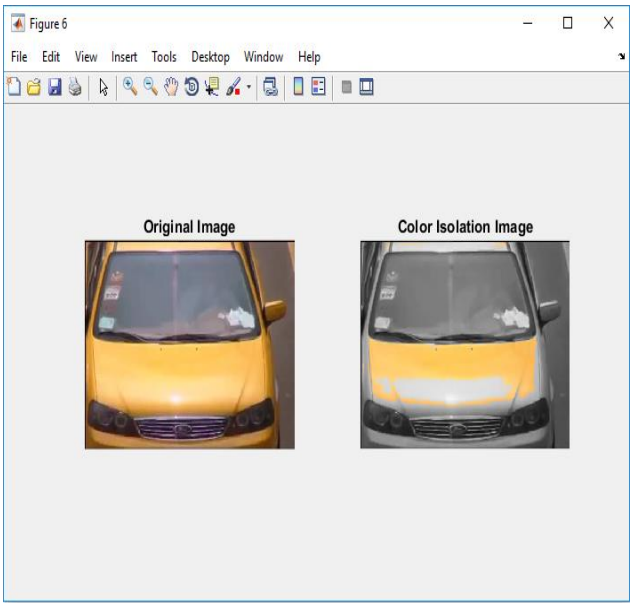

Fig. 6. Color Isolation of Moving Vehicle with Yellow Color

4.3 Implementation of License Plate Recognition

In this implementation, the image captured by using a digital camera with a specific distance. Two regions are selected from the Iraqi license plate which are: car type and province. These two regions are selected to know the vehicle type and province which make our system more efficient because yellow vehicles are not always taxi vehicles. Then, after color segmentation each vehicle type are checked again to avoid false results.
In the recognition step, the license plate type and province will be compared with a template database to find the minimum distance between test images and training set images which will lead to the actual vehicle type and province. The database images for vehicle type and province are shown in Figure 7. The recognition results are shown in Table 1 and Table 2. The average time of license plate recognition for each license plate is 4 seconds.

Fig. 7. Iraqi License Plate Type and Province Database

Table 2: License Plate Province Recognition Result

Image Template	Test Images	Correct	Wrong	Percentage
بغداد	10	10	0	100%
النجف	10	10	0	100%
كربلاء	10	9	1	90%
المثنى	10	10	0	100%
ديالى	10	10	0	100%
القادسية	10	8	2	80%

Table 3: License Plate Type Recognition Result

Image Template	Test Images	Correct	Wrong	Percentage
خصوصي	30	30	0	100%
اجرة	30	28	2	93.3%

5. Conclusion

In this paper, a combinational method of background subtraction along with color segmentation and license plate recognition is proposed for detecting moving objects (vehicles) from a video sequence in outdoor environment (street or parking entrance). In this work moving object is detected by performing background subtraction then the detected object is isolated using Color segmentation and license plate recognition. In this system, License Plate Recognition depending on vehicle type and province. The vehicle number is not considered in this work because the system needs to focus on vehicle type and province and this will make the system much faster. Experimental results demonstrated that the proposed system can successfully detecting and isolating moving objects from video frame image. Detected objects boundaries are not completely accurate but it does not affect the detection results.

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