Smart Moving Vehicle Counting

Abdulamir A. Karim,Ph.D. (Asst.Prof.) * Shatha Talib Rasheed*

Abstract

The moving vehicle detection and counting in video is a substantial field of computer vision. In traffic observation, the number of vehicles detected might be used to survey or control the traffic signal, therefore several counting methods have been suggested. The proposed system used static camera to capture AVI video format, several main steps that applied to detecting and counting the moving vehicle in the input video. This steps are: frames extraction, frames preprocessing, features extraction, vehicle detection and vehicle counting in one side road and in two side road. The experiments showed reliable and efficient results of the moving vehicles in any traffic sense within 99.25% accuracy of one side road counting processes and within 95.23% accuracy of two side road processes.

Keywords: Vehicle counting, object detection, two frame difference, feature extraction.

*****University of Technology

1. Introduction

Detection and counting of moving objects are an important and challenge task in the computer vision field. The number of vehicles found can be used for surveying or controlling the traffic signal. Moving object counting has implemented in video surveillance, traffic rules contravention and security tasks. Recently, an important number of tracking methods have been suggested in order to be used in many critical process of the daily lives such as computing crowding of the traffic in highway and retain track for the vehicles that cross state-aid streets and highways [1]. The video monitoring systems that vision-based show a lot of benefits. Video analysis and the video surveillance offer practical and also quick information that are resulting in traffic flow and to ensure greater safety [2].

Therefore, an efficient system that afford significant and functional detection and counting mechanism for observe density of vehicles at the highways is proposed in this paper.

The paper begins with a summarized overview of a related work, then a description of the method, with the Architecture and Modelling is followed also, vehicle detection, and vehicle counting has been described. The paper achieves with the results and the final conclusions.

2. Related Work

In this section some of the previous works on the object detection and counting will be discussed briefly:

Nada Mahdi, 2007 [3] have developed a technique for motion detection of entering and exiting motion via detect the existence of edges intensity in a frame that has a fixed distance far from intensity edges in the prior frame. The proposal presents an operational computer vision system for detecting and tracking object motion, by using the background paradigm and current image from the video can detect the foreground pixels. This pixel-level detection process is dependent on the background model in use. The distance values are analyzed for all kinds of objects having different activities in digital video, and with a perfect choice of a threshold value the motion is classified as partial or global motion.

Vibha L, et al, 2008 [4] have proposed a model that detects unknown knowledge such as vehicle recognition and traffic flow counting. The goal of this method is monitoring the activities at motion crossing points for the sake of detecting blockages, and afterwards, make a prediction of the activity streaming that helps to regulate traffic. The suggested method for vision-based counting and detection of vehicles monocular image stream for movement scenes are recorded by a static camera.

P.M.Daigavane and P.R.Bajaj, 2010, [5] have suggested the image segmenting background elimination relying on morphological transformation for counting and tracking cars on highways. This approach used erosion and dilation on various frames. The proposed methods performs a segmentation of the image via preserving necessary borders, and that works on improving the adaptive background mixture structure and makes the framework learn in a faster manner and all the more precisely, it also adapts efficiently to changing situations. The goal of this research is creating system for automatic vehicle counting and detecting on highway.

Pranab K.Dhar, et al, 2012 [6] have proposed a real time moving object detecting approach in view of the improved edge detection and angle orientation masking for video surveillance structure. The suggested approach chips perform at latest progressive borders and utilizes edge detection in order to identify the moving object. In the suggested system, gradient map images are initially produced from the information and background images with the use of a gradient operator. The gradient contrast guide is afterwards found from gradient guide images.

Liang, 2015 [7] **has** presented a new algorithm that classifies and counts vehicles on highway depend on regression analysis. This method needs no clear tracking or segmentation of discrete vehicles, which is typically a significant part of many present methods. So, this algorithm is mainly useful when there are severe vehicle resolution or blockings is low, in which extracted features are extremely undependable.

3. Proposed Vehicle Counting Method

When using a moving camera, the global motion comparison and estimation to indemnity the variation in the background because of the camera motion. So in this work, a static camera is used and here the video clips' background under consideration is constant.

The modelling and architecture of the suggested algorithm are shown in Figure (1). In which the suggested method are as follows: First the video read and then converted each frame to grayscale format. Then image smoothing is used for two primary purposes: to give an image a softer or special effect or to eliminate noise. Image smoothing is accomplished in the spatial domain by considering a pixel and its neighbors and eliminating any extreme values in this group. This is done by Gaussian blur filter.

After that the absolute difference is done to detect object by two frame difference approach, the proposed system involves several steps which are; preprocessing, feature extraction and counting. Besides that, each step has it benefits for the counting process. Here the proposed method steps described in details:

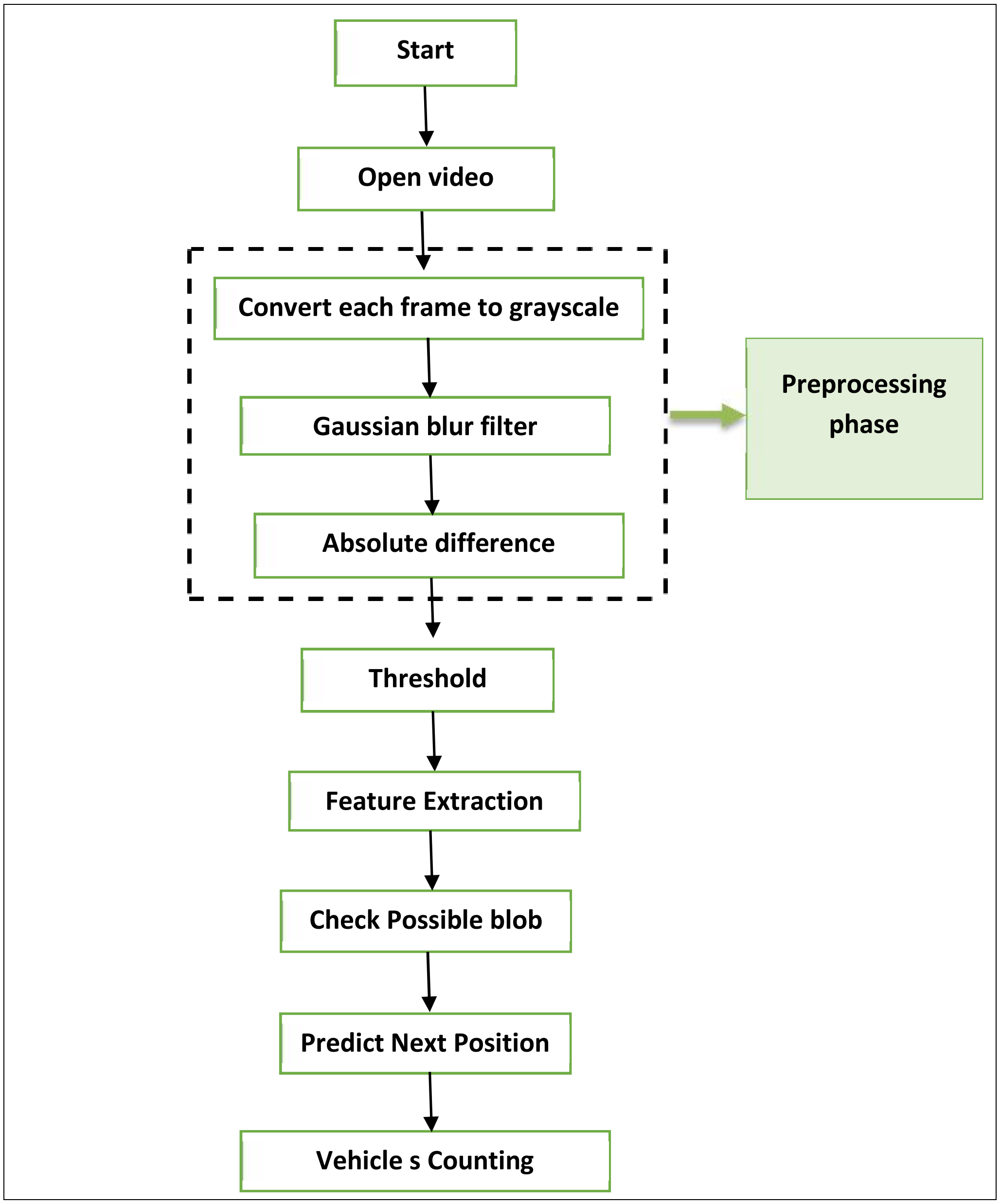


Figure (1): Block Diagram of the Proposed Vehicle Counting Method

3.1 Converting Current Color Frame to Grayscale

Most of the benefits of converting a color image to grayscale domain are that to have less data because the grayscale domain has one channel rather than three channel of RGB domain which leads to fast processing during other phases (feature extraction and training phase) and less influence by the brightness which is considered in many cases as a noise. Algorithm (1) describes how to convert color frame to gray frame:
In the proposed work, the luminance method is used to convert color image to grayscale as explained in equation (1) [8].
(i,j)= (0.2989 $*$ R) + (0.5870 $*$ G) + (0.1140 $*$ B ….(1)
Where R=read, G=green, B =blue

Algorithm (1) Converting Color frame to Gray Frame

Input: Color frame //captured color frame

Output: Gray frame // converted color frame to gray frame

Begin

Step1: Read color frame

Step 2: Convert color frame to gray frame

```
  For i= 0 to n−1              // n is the width of the frame
      For j=0 to m−1          // m is the height of the frame
gray frame(i,j)=0.2989*R(i,j)+0.5870*G(i,j)+0.1140*B(i,j);
      End for j
   End for i
```

Step 3: Return gray frame

End

3.2 Image Smoothing

Image smoothing is used for two primary purposes: to give an image a softer or special effect and to eliminate noise. Image smoothing is accomplished in the spatial domain by considering a pixel and its neighbors and eliminating any extreme values in this group. This is done by Gaussian blur filter.

Usually, image processing software will provide blur filter to make images blur. There are many algorithms to implement blur [9] , one of them is called Gaussian Blur algorithm. It utilizes Gaussian distribution to process images. The Gaussian blur theory can be understood as taking a pixel as the average value of its surrounding pixels.

For the sake of reducing the noise of the image and reducing details as show in figure (2) below.

a) Before Gaussian Bluer (b) After Gaussian Bluer

Figure (2): Gaussian Blur Filter Effect.

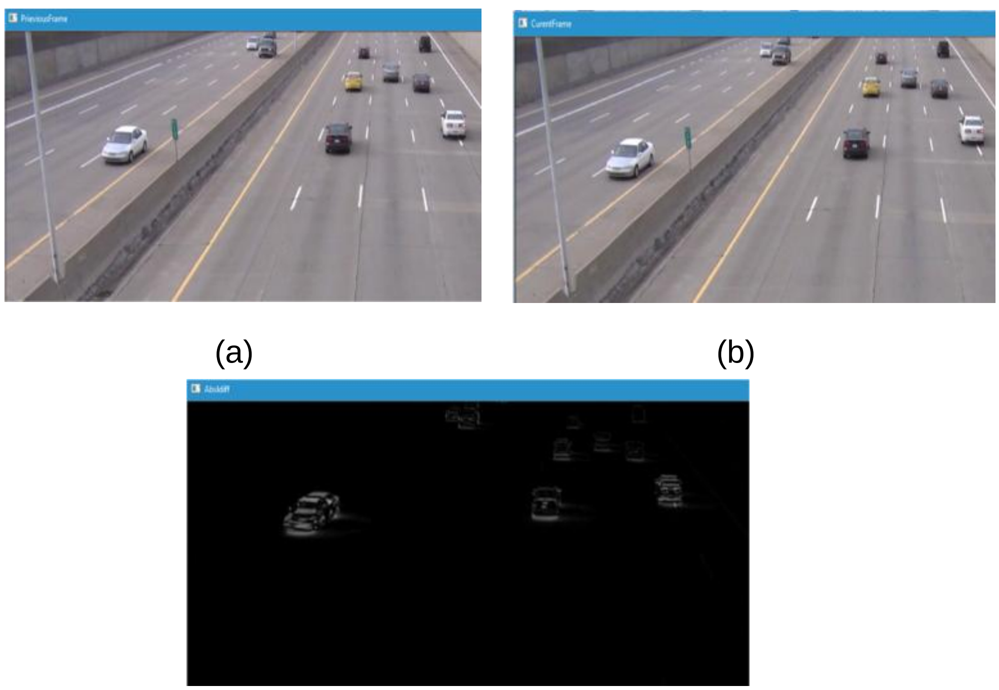
3.3 Two Frames Difference

Detecting the moving item from a series of frames acquired by a still camera is done with the use of frame difference approach. The aim of the method is detecting the moving items via the calculation of the difference between the current frame and the reference frame. This approach is the widely used approach of motion detection. It adopts pixel-based difference for the sake of finding the moving item.

The two frame difference is known as the Inter frame difference as well; in addition, it is known as the Basic frame difference approach as well. For detecting the moving item, considering two successive frames, for example, current frame and preceding frame, obtained from the continuous video stream. At first, compute the absolute difference between the two frames, which is represented by equation (2), and known as the difference image. Then, applying optimal value of threshold to the difference image. This value is the binary threshold for the image. In case that the value of pixel of the difference image is larger than or identical to the threshold, then it would be considered as a Foreground Pixel, Region of Interest (Binary „1" would be given to the foreground object), otherwise as a Background Pixel (Binary „0" would be given for the background element), as in equation (3), thus detecting the moving object. Figure (3) show the frame difference method [10] .

$$\text{Diff\_image} = |(\text{Current frame}) - (\text{ Previous frame})|\ | \quad \ldots\ldots\ldots (2)$$

$$\text{Region\_of\_Interest}= \left\{ \frac{1 \ \ (if\ |Diff\ image| >= threshold\ )}{0 \qquad\qquad else} \right\} \ldots\ldots\ldots (3)$$



(a) (b)

(c)

Figure (3): a) Previous Frame (b) Current Frame (c) Difference Frame

Algorithm (2) Two Frames Difference

Input: Color Video

Output: Diff (i,j)=(different of frame // Motion object detected in each frame

Begin
Step 1: Read the input video.
Step 2: Convert video to gray scale format.
Step 3: do while end of file
Step 4: Read frameK1, frame k+1.
Step 5: Apply Gaussian blur to these frames.
Step6: For all frame row i
For all frame column j, do
Diff(i,j)= $\left| f_k(i,j) - f_{K+1}(i,j) \right|$ // Where f(i,j) is the pixel of the input video
If diff(i,j)> Threshold then
g(i,j)=1
Else
g(i,j)=0
End for j
End for i
End do
End

3.4 Conversion to Binary Image (Using a threshold)

Following the frame difference procedures of every one of the pixels in various frames containing grayscale image is producer which has to be converted to binary image via the use of a threshold value and then the moving item has been recognized. When the pixel corresponds to the moving object is set to 1 and the remaining is the background which is set to 0, as shown in Algorithm below:

Algorithm (3) Convert Grayscale to Binary Image.
Input: Gray frame, T= (30) // T = Threshold
Output: Binary frame

Begin

Step1: For m = 0 to N // N: represent number of frames

Step2: For i= 0 to h // h: represent high image

For j= 0 to w //w: represent width image

Step3: If image [i,j]> T then

Image [i,j]= 1 // For object

Else

Image [i,j]= 0 // For background

Step4: Return number of frames

End.

3.5 Detecting Connected Areas

The filtered pixels of objects are grouped into connected areas (blobs) and labeled from detection algorithms that generally include noise and thus are inappropriate for further processing without special post-processing. Individual blobs corresponding to items are found; the dimensions of those areas are found. In this approach, it is important to detect all objects since foreground pixels map that contains the foreground pixels, it may contain one object or more than one moving objects. This is done by making scan to the pixels map vertically line after line until get line that don't contain any foreground pixels, then labeled object that is scanned as new object with new number. Figure (4) shows this operation.

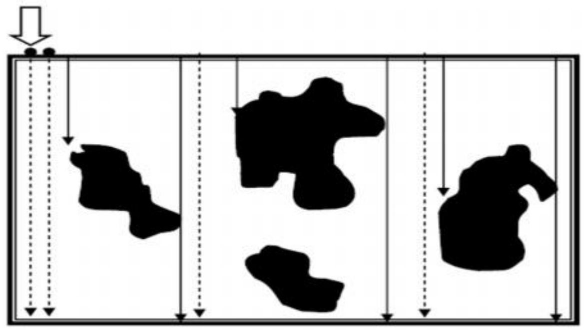


Figure (4): Scanning Foreground Region to Detect Multi-Object Vertically.

Then the system makes scanning horizontally to ensure there is no object in the same line and if there it gives it new number see Figure(5).

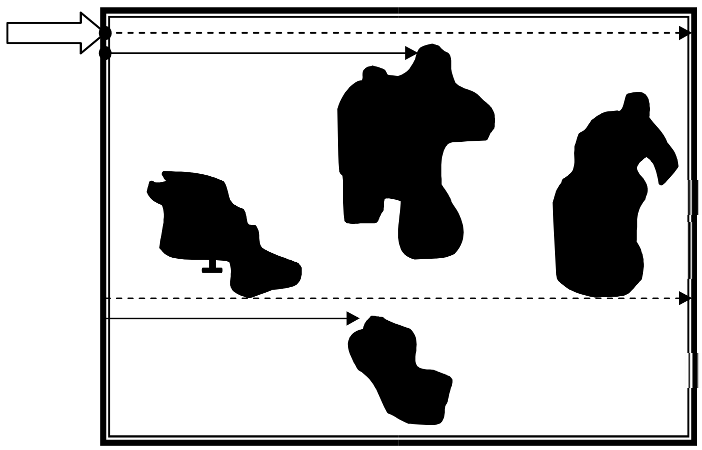


Figure (5): Scanning Foreground Region to Detect Multi-Object Horizontally.

4. Features Extraction

Once the system has segmented into regions it extracts features of the corresponding objects from the current image. The proposed system detect objects features by get features that reflect to size and shape information in addition to statistical features. The combined set of features is usually very effective to distinguish object and provide more reliability. Several features are extracted from the binary images which depend on the shape of the moving objects [11].

4.1 Width and height

The first extracted features are width and height of the objects. Width of the vehicle in the sub-image is determined via successively penetrating every one of the columns in the sub-image to locate the first and last pixels in the image and store their column numbers.

The width of the image is found via the subtraction of the column number of last pixel from the column number of first pixel, see figure (6) below:

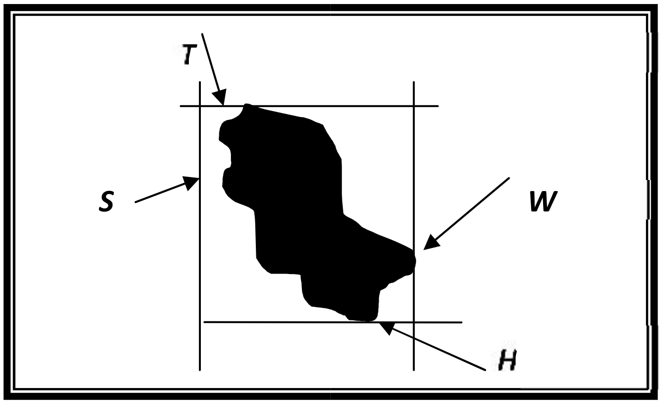


Figure (6) The Dimensions of Object.

However, height of the object in the sub-image is calculated via consecutively probing every one of the rows in the binary image. The 1st and last pixels of the image are located and the corresponding row numbers are stored. The image's height is found via the subtraction from the row number of last pixel to the row number of 1st pixel.

4.2 Centroid

The second extracted feature is the centroid. The centroid represents the center of mass of the objects in sub-image depending on the width and height whose centers represent the centroid point.

For the sake of calculating the center of mass point, ***Cm*** = ($\boldsymbol{X_{Cm}}$, $\boldsymbol{Y_{Cm}}$), of an object ***O***, the system uses the following equation:

$$\text{Center of mass} = \frac{X\min + X\max}{2}, \frac{Y\min + Y\max}{2} \qquad \text{…… (3)}$$

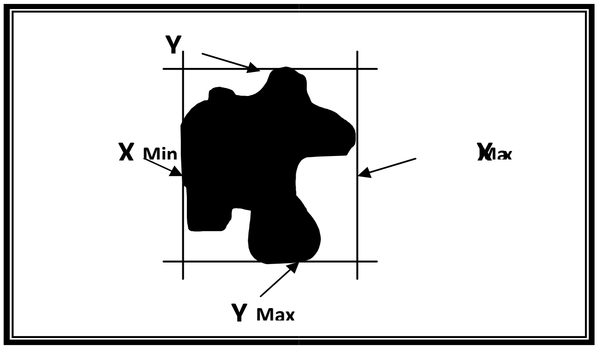


Figure (7) The Dimensions To Find Center of Mass of Object.

5. Vehicle Counting

Transportation research involves counting number of vehicles on road as well as finding the density of traffic in a particular area. There are many methods of detecting vehicles on road such as motion detection, installing lasers on both sides of the road, etc., which is tedious and involves large number of hardware. The propose method uses image processing techniques to count the number of vehicles on one side road and in two side road. The number of vehicles found can be used for surveying or controlling the traffic signal.

This proposed system of counting vehicles involves comparing the difference between two frames to detect the moving object. When comparing two images the distinction between images could be obtained, based on the obtained distinction, the vehicles can be detected and hence the number of vehicles as well as count can be calculated.

In order to track and then count any detected object in the input image, a hypothetical or fictitious line is supposed to be existing across from Y-AXIS of the image frame. So when a moving object such as a car crosses this line, it's recorded and its counter is increased.

One variable preserved, in other words, count which keep track of the number of cars and when a different object is encountered, immediately after it crosses the line, the counter is increased, else it treats as a portion of a previously present object and the existence of this object is ignored. This idea apply to the entire sense and the final count of the objects is saved in the variable count. So it is a very well precision that carried out for the object counting. Occasionally due to occlusions a very important problem has to be avoided in which two objects treated as a single entity and are merged together.

5.1 Car Counting in One Side Road Algorithm

The first suggested algorithm that counts the cars on one side of the road. As show in algorithm (4), as there's a counting process, the counter is initially set to 0, then a horizontal line will be drawn along the video scene in from Y-AXIS and select its position by test to put the line in the right position to be considered as a passing sign, in case a car touches that line, it will be counted, and the counter will be incremented.

The video must be divided into frames, and then each frame will be converted from the original RGB format into gray level format. This operation is performed in order to minimize the size of the data and focus on the valuable details. Then Gaussian blurring algorithm will be applied to each frame in order to smooth the images.

Afterwards, the frame difference operation is applying in order to detect the moving objects in the frame, thereby detecting the cars.

After that the threshold of value 30 will be applied in order to remove unnecessary data that might be in the detected object. Then to obtain and prediction possible blobs to make counting operation must make scan to the pixels map vertically line after line until get line that don't contain any foreground pixels, then labeled object that is scanned as new object with new number.

By getting the center mass of each blobs and draw horizontal line as threshold line to consider it as a passing point to each blobs if blob's center position reach threshold line then vehicle is recorded and the counter will be incremented by 1, else it treats as a portion of a previously present object and the presence of object is ignored. In the end giving total number of cars passing by.

Algorithm (4) Car Counting in One Side

Input: Road video.

Output: Total cars counter.

Start

Step1: Initialize Car counter = 0 // use to count number of cars in video sense

Step2: Read video frame**.**

Step3: Initialize horizontal line points:

Start point P1(x_0.h,y_0) // x,y represent points selected by test

End point P2(x_0.h,y_1) // h represents line level

Draw line (P1,P2).

Step4: Convert RGB frames to gray scale by apply algorithm (1).

Step5: Apply Gaussian blur to each frame.

Step6: Detect moving objects frame by frame by apply absolute difference by apply algorithm (2).

Step7: Convert gray scale image to binary image by apply algorithm (3).

Step9: Scan pixels map vertically and horizontally line after line until get line that don't contain any foreground pixels, then labeled object that is scanned as new object with new number.

Step 10: Find center of mass (Cm) to each blobs by apply equation (3)

Step 11: If Cm of possible blob reach the horizontal line then Increase Car counter by one.

End if

End

5.2 Car Counting in Two Side Road Algorithm

The second suggested algorithm that counts the cars on two side of the road. that is presented in algorithm (5), the difference in previous algorithm(4) that this suggestion is used for counting car in road contain two side to show in which side car is passed more than another.

So by getting the center mass of each blobs and draw horizontal line as threshold line to consider it as a passing point to each blobs, in this case must detect blob's direction if it in right side or in left side. In case of object is detection in right side, if blob's center position reach threshold line and vehicle is recorded then the counter will be incremented by 1, else it treats as a portion of a previously present object and the presence of object is ignored. And in case of objects is detection in left side then the counter will be decremented back. which means that in case where the counter's value is a positive number, that indicates that the cars passing by the right side more than number of the cars passing by the left side. While the negative value of the counter indicates the opposite. And finally, in case that the counter is equal to zero, that means that the number of the cars passing by both sides are equal.

Algorithm (5) Car Counting Two Side

Input: Road video.

Output: Total cars counter in two sides.

Start

Step1: Initialize Car counter = 0 // use to count number of cars in two side

Step2: Read video frame**.**

Step3: Initialize horizontal line points:

Start point P1(x_0.h,y_0)

End point P2(x_0.h,y_1)

Draw line (P1,P2).

Step4: Convert RGB frames to gray scale by using algorithm (1).

Step5: Apply Gaussian blur to each frame.

Step6: Detect moving objects frame by frame by using absolute difference by apply algorithm (2).

Step7: Convert gray scale image to binary image by apply algorithm (3).

Step8: Scan pixels map vertically and horizontally line after line until get line that don't contain any foreground pixels, then labeled object that is scanned as new object with new number.

Step 9: Find center of mass (Cm) to each objects by apply equation (3)

Step 10: If Cm of possible blob reach the horizontal line in right side road then increase Car counter by one.

Else if Cm of possible blob reach the horizontal line in left side road then decrease Car counter by one.

End if

St**ep 11:** If Car counter result is positive then number of cars passing by the right side is more than number of cars passing by the left side.

Else if Car counter result is negative then number of cars passing by the left side is more than number of cars passing by the right side.

Else if Car counter result is zero then number of cars in right side are equal to number of cars in left side.

End

6. Measuring Search Effectiveness [12]

The implementation is evaluated by using 4 measurements of accuracy which are accuracy rate, precision, recall and F-measure.

The Precision is defined as the ratio between the number of true positive (TP) and the total number of TP and false positive (FP) as in Equation 4.

$$(\text{Precision}) = \frac{TP}{TP + FP} \tag{4}$$

While the Recall is obtained by the ratio between the number of true positive (TP) and the total number of TP and false negative (FN) as in Equation 5.

$$(\text{Recall}) = \frac{TP}{TP + FN} \tag{5}$$

These two measures are employed for class discrimination as focused in this paper. The accuracy rate (AR) can be defined as in Equation 6.

$$\text{AR} = \frac{\text{TP}}{\text{Total number of test images}} * 100\% \tag{6}$$

However, the error rate (ER) can be defined as in Equation 7.

$$\text{ER} = \frac{\text{FP}}{\text{Total number of test images}} * 100\% \tag{7}$$

Finally, the F-measure (F1) is used for computing the test accuracy based on the precision and recall in Equations 4 and 5. F1 can be found using Equation 8.

$$F1 = 2.\frac{(\text{Re}\,call)(\text{Pr}\,ecision)}{\text{Re}\,call + \text{Pr}\,ecision} \tag{8}$$

And similarity (S) is: $S = \dfrac{TP}{TP + FP + FN}$ (9)

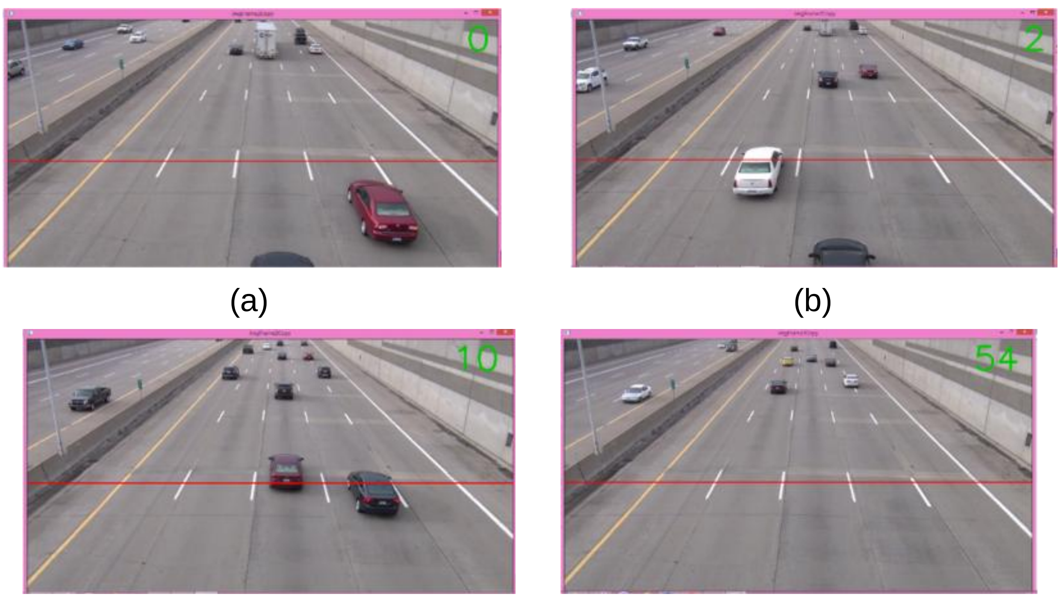
7. Results and Discussion

The system is implemented by using C++ visual studio where is a very effective tool for image processing. This system has two segment part, the first one was set for counting the number of cars passing by one side of the road. The second one was made for counting cars passing by both sides of the road.

a) The First Part of the Program

It is the segment that counts the cars on one side of the road only. By using algorithm (4) and the detailed steps of this implementation are depicted in the images below:

As seen in figure (8) the counter is initially equal to 0. And it increments as soon as cars pass the car is considered to pass when it reach the red horizontal line crossing the frame.



(a) (b)

(c) (d)

Figure (8) a. The Initial State of the Program Where the Counter is Equal to Zero
b. The Counter is Equal to 2 after two cars have passed
c. The Counter is Equal to 10 after 10 cars have passed
d. The Counter is Equal to 54 after 54 cars have passed

The result of implementation the program of one side counting is shown in table (1) below:

Table (1) Car Counting in One Side

Input Video	Video time	Time duration	No. of detected car	No. of actually detected car	No. of missed car
V1	0.26	1.35	27	27	0
V2	0.33	3.28	56	56	0
V3	0.7	1.36	18	18	0
V4	1.8	4.26	86	90	4
V5	0.5	0.10	8	8	0
V6	1.42	3.08	45	45	0

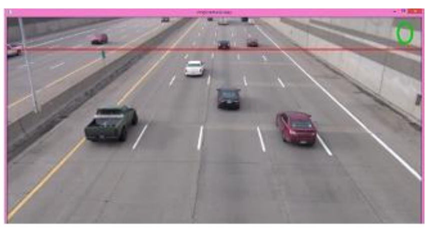
Table (2) Accuracy of One Side Car Counting

Input Video	TP	FP	FN	Precision	recall	F1	S	AR	ER
V1	27	0	0	1	1	1	1	100%	0
V2	56	0	0	1	1	1	1	100%	0
V3	18	0	0	1	1	1	1	100%	0
V4	86	3	1	0.96	0.98	0.96	0.95	95.5%	3.33
V5	8	0	0	1	1	1	1	100%	0
V6	45	0	0	1	1	1	1	100%	0

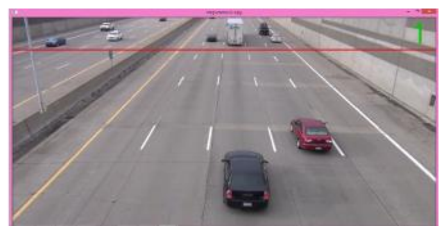
The accurracy rate average result of six tested video was 99.25% .

b) The Second Part of the Program

This segment deals with counting the cars on both sides of the road, the counter works bothways, or in other words, the counter is global, which means, it increments if a car passes by one of the sides and decrements when a car passes by the opposite side, which means that in case where the counter's value is a positive number, that indicates the cars passing by the first side exceed the number of the cars passing by the other side. While the negative value of the counter indicates the opposite. And finally, in case that the counter is equal to zero, that means the number of the cars passing by both sides are equal. Figure (9) show's the implementation of this segment.



(a)



(b)

Figure (9) a. The counter is +1 after a car passed by the Right Side

b. The counter is back to 0 After a car passed by the Left Side

The second implementation of the Program that counts the cars on right and left sides is shown in table (3) below:

Table (3): Car Counting in Two Side

Input Video	Video time	Time duration	No. of detected car in RS	No. of detected car in LS	Car Difference between TS	No. of actually car difference
V1	**0.33**	**2.78**	**56**	**46**	**10**	**10**
V2	**0.9**	**0.74**	**7**	**10**	**3**	**3**
V3	**0.13**	**0.89**	**15**	**21**	**7**	**6**

Table (4) Accuracy of Two side Car Counting

Input Video	TP	FP	FN	Precision	Recall	F1	S	AR	ER
V1	10	0	0	1	1	1	1	100%	0
V2	3	0	0	1	1	1	1	100%	0
V3	6	1	0	0.85	1	0.91	0.85	85.7%	14.2

The accurracy rate average result of six tested video was 95.23% .

8. Conclusions

The suggested approach is capable of processing the pre-processing step for detecting moving object, counting and classification vehicle based on its size features that will successfully be applied in all frames of videos. Some important conclusions will be presented as follows:

1. Identifying the threshold is identified for all the samples in the pre-processing process during conversion of the gray scale to binary scale to remove unwanted data and remove shadow. Selecting a low value for the threshold results in keeping some pixels of shadow that can't be found and eliminated, and selecting high threshold value results in misclassifying the object pixels as shadow.
2. Selecting high value of threshold for extracting the moving item (binarization) results in eliminating some pixels that actually belong to the item, while choosing a low value of threshold results in unwanted blobs and the best threshold value is T=30. Which it has been deduced from several experiments.
3. The first suggested algorithm is object counting in one side road, the average of accuracy rate for all video samples in this algorithm is 99.25%.
4. The second proposed algorithm is object counting in two side road, the average of accuracy rate for all video samples in this algorithm is 95.23%.

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الحساب الذكي للمركبات المتحركة

أ.م.دعبدالأمير عبدالله كريم*   شذى طالب رشيد*

المستخلص

حساب وتحديد المركبات المتحركة في الفديو يعتبر حقلا اساسيا في الرؤيا الحاسوبية, وفي مراقبة حركة المرور، يمكن استخدام عدد المركبات التي تم تحديدها لكشف إشارة المرور أو التحكم فيها, لذلك العديد من نظريات الحساب تم اقتراحها. النظام المقترح استخدم كاميرا ثابته لأستخلاص فديو بصيغة AVI, للنظام المقترح خطوات رئيسية قابلة للتطبيق على الكشف والحساب والتصنيف فيما يخص المركبة المتحركة في الفيديو المدخل. هذه الخطوات هي: استخلاص الاطارات, معالجتها, استخلاص الميزات, تحديد وحساب المركبات في جانب واحد و في جانبين. ولقد أظهرت التجارب نتائج حساب موثوقة و فعالة فيما يخص المركبات المتحركة تحت أي وعي مروري بدقة قدرها 99.25% من خلال عملية حساب على جانب واحد، و 99,23% في عملية حساب على جانبين.

*الجامعة التكنولوجية