AN OPTICAL FLOW ALGORITHM TO IMPLEMENT
VEHICLE COUNTING SYSTEM USING SURVEILLANCE CAMERA
IN IMAGE PROCESSING

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ABSTRACT -- A Vehicle counter is a device used for counting the number of vehicles that enters and exit (entrance of an organization). Most of the time, this system is used near the entrance of a building, so that the total number of vehicles entering in, can be recorded. Vehicle counting system is important in marketing research (Road traffic management) and parking area. Some sensors are used to count the vehicles with different advantage, drawbacks and accuracies such as laser beam, infra-red sensor and thermal sensor. But we design a system that detects, identify and counts the vehicles using a Stationary IP Camera. The objective is to monitor the activities at the entrance of the building (gate) for detecting and counting the vehicles that entering in. It is based on the establishment of correspondences between regions and vehicles, as the vehicles move through the image sequence. We use Background subtraction, which improves the adaptive background mixture model and makes the system to learn faster, more accurate and effective to changing environment. The system is robust because it identifies the vehicles at intersection by rejecting the background and it tracks the vehicles over a specific period of time.

Keywords – vehicle, image sequence, background mixture model.

1 INTRODUCTION

1.1 Surveillance

Surveillance is the monitoring of the behaviour, activities and other changing information, usually of people for the purpose of influencing, managing, directing or protecting. Surveillance is therefore an ambiguous practice, sometimes creating positive effects, at other times negative. It most usually refers to observation of individuals or groups by government organizations.

1.2 Cameras

Surveillance cameras such as these are installed by the million in many countries and are nowadays monitored by automated computer programs instead of humans. Surveillance cameras are video cameras used for the purpose of observing an area. They are often connected to a recording device, IP network and/or watched by a security guard/law enforcement officer. Cameras and recording equipment used to be relatively expensive and required human personnel to monitor camera footage. Now With cheaper production techniques, it is simple and inexpensive enough to be used in home security systems and for everyday surveillance. Analysis of footage is made easier by automated software that organizes digital video footage into a searchable database and by automated video analysis software (such as VIRAT and HumanID). The amount of footage is also drastically reduced by motion sensors which only record when motion is detected.

The use of surveillance cameras by governments and business has dramatically increased over the last 10 years.

1.3 IP cameras

An Internet Protocol camera or IP camera is a type of digital video camera commonly employed for surveillance and which unlike analog Closed Circuit Television (CCTV) cameras can send and receive data via a computer network and the internet. Although most cameras that do this are webcams the “IP camera” is usually applied only to those used for surveillance.

There are two kinds of IP camera:

1.4 Centralized IP camera, which require a central Network Video Recorder (NVR) to handle the recording, video and alarm management.

1.5 Vehicle Counting

Vehicle counting system using image processing is a way to count vehicles. In an organisation it is important to know how many vehicle’s enters and exit every day, from that we
can able know the space that is available in parking area. And also monitors the speed of the vehicles. From this system, we can count the vehicles automatically without the help of sensors. Thus the human resource is reduced. Sensors usage may sometimes lead to incorrect counting and regular replacement of the device.

2 SYSTEM ANALYSIS

2.1 Existing System:
In existing system, the vehicles are counted with the particular frame difference (say 4 frames). Example: (i to i+4) frames.

2.1.1 Drawbacks
- An average vehicle speed is maintained for counting.
- Incorrect counting, if the vehicle position changes.

2.2 Proposed system
In our system, any vehicle can be tracked and counted with the static IP camera. The system can count the vehicles irrespective of their speed that passes in the particular area. Occlusion can be avoided by placing the camera that captures the image in the aerial view.

3 MODULES

3.1 Capturing videos
The video contains the moving and non-moving objects. Using IP Camera that’s Creative Live. The problem with this video camera was all their automatic processes which cannot be turned off such as highlight compensation, background noise removal and environmental side chatter removal. All those automatic processes make the work harder particularly for the segmentation algorithm. But for Vehicle counting we need to capture the vehicle that is moving in each frame of a video.

3.2 Vehicle Counting Model
The vehicle Counting Model is composed of four subsystems (Background Process, Segmentation, Tracking and Counting and Display Results). All those subsystems will be described later. The model uses three global variables which are the Count_In (represents the number of people enter), the Count_Out (represents the number of vehicle exit) and the Connection (represent the socket connection using TCP/IP protocol between the computer which execute the model and the main computer of the building; this connection is done at the launching of the program). The Edit Parameters block allows fixing different parameter such as the position of the virtual line or the minimum and maximum area for each blobs detected.

3.3 Background Process Subsystem
The Background Process is composed of two main blocks which are the motion Detector Block and the Background Estimation Block. The input of this subsystem is a color image (current frame of the video camera). The three outputs are the existence of background, the background image and the current frame transformed in intensity. The Pulse Generator is a block which allowed creating a pulsation (in this case the amplitude of the pulsation is 1 and its length is very small) every each period (the time of this period is customizable).

The Motion Detector block is enabled every each period while the Pulse Generator Block create a pulsation and determine the existence of motion during the current scene represented by its output (Boolean). Its input is the current frame of the video transformed in intensity. To detect the motion this block make an absolute difference between two consecutive frames (current frame and previous frame) and find the maximum value of this frame differencing operation. But in order to have the previous frame, a block Memory is needed. This block allow to memorize the last value of its input (i.e. The last value of the current frame is just its previous frame).

3.4 Segmentation Subsystem
The Segmentation subsystem is enabled when the background image exists and make a binary image which represent the foreground and the background. Two inputs are needed to make the segmentation, one is the current frame transformed in intensity and the other is the last updated background image. Its outputs are respectively the segmented image (binary image) and a boolean which represent the existence of moving objects (presence of foreground in this binary image). And the second case is the presence of big variations means that there is moving objects in the scene.

3.5 Tracking and Counting Subsystem
The Tracking and Counting Subsystem is enabled when there is moving objects in the current frame (i.e.: the segmented image is not an empty image). Its input is the binary image (segmented image) and its outputs are just the different positions of bounding box for the display. Three cases are distinguish, the bounding
box will be displayed in Blue the moment when it go through the virtual line and count as a IN or OUT, displayed in Magenta if the bounding box cuts the virtual line and else displayed in Green. The algorithm launch a Blob analysis to detect all the blobs checking the constraints of minimum and maximum areas. To track the different blobs the algorithm need to memorize the position of each bounding box and centroid.

4 PROJECT DESCRIPTION
4.1 Problem Statement
In this system the videos are captured at the surveillance area with the help of IP cameras. The vehicles that are crossing the entrance are detected and counted. When vehicle entering or exiting of the field of view in group, it is very hard to distinguish all the vehicle in this group. The advantages of this method is it avoids the problem of occlusion when groups of people pass through the camera's field of view. To determine the direction of people, a space-time image is used. The output count which is useful for managing vehicles in the parking area of an institution and several organization etc., It avoids vehicle occlusions in entrance of the organisation. This is a secure system where the vehicles are detected and stored in server. This system will also help to reduce the man power.

4.2 Overview of the project
In this project, a stationary IP Camera is placed near the entrance of the building, the video is recorded and saved in the server as a file. By fetching the video from the server as the input, the code is executed and the required output is obtained.

4.3 Input design
Input design is one of the most expensive phases of the operation of computerized system and is often the major problem of any recognition system. A large number of problems in the system can usually be tracked back to fault input design and method. Needless to say, therefore the input data is the life block of a system and has to be analyzed for getting inputs as images and decided with the most consideration.

4.4 The decisions made during the input design are

- To provide cost effective method of input to the system.
- To achieve the highest possible level of accuracy in recognition system.
- To ensure that input is properly captured to produce successful result.

System analysts decide the following input design details like, what data item to input, what medium to use, how the data should be arranged or coded data items and transaction needing validations to detect errors and at last the dialogue to guide users in providing input. Input data of a system may not be necessarily a raw data captured in the system from scratch. These can also be output of another system or sub-system. The design of input covers all phases of input from the certain of initial data to actual entering the data to the system for processing.

Input provided for the system

- A live video is captured at the entrance of the organisation.
- The video which are of noise are enhanced using erosion, dilatation method and stored.
- All the above mentioned information is gathered with the help of IP Camera located at the entrance of building.

4.5 Erosion
The first morphological operation used is the erosion. It's a basic operation and its primary feature is to erode away the boundaries of the different foreground regions. Thus this foreground objects will become smaller (little of them will totally be vanished) and holes in objects will be bigger.

4.6 Dilatation
Like the erosion, the dilatation is the second basic operation and its primary feature is to dilate the boundaries of the different foreground regions. Thus this foreground objects will become bigger and holes in objects will be smaller (little of them will totally disappear).

Let X is a subset of E and let B denote the structure element. The morphological Erosion is defined by:

4.7 Opening
The opening operation is a combination of the two basics operation (Erosion and Dilatation). It's the dilation of the erosion and its primary feature is too eliminating noise (small objects). This operation will separate blobs which are linked with a small layer.

Let X is a subset of E and let B denote the structure element. The morphological Erosion is defined by:

$$\theta(B) = \delta(\varepsilon(B)) = (X \ominus B) \ominus B$$
4.8 Tracking

Once the segmentation is done, another image processing must be launched in the binary image. In fact, in order to track objects, the first step to do is to identify all the objects on the scene and calculate all their features. The performance of the blob analysis depends totally of the quality of the segmentation. With a bad segmentation, the blob analysis can detect some not interesting blobs or worse can merge some different blobs due to lighting condition or noise in the image.

5 Counting

The counting process consists to determine the direction of blobs which cross a virtual line in order to increment the good counter.

In this method we use just one virtual line which demarcate clearly the IN area and the OUT area. This method was preferred for the final prototype because of its simplicity. To count people, the algorithm just look the position of the bottom segment of each bounding box in two consecutive frames. If, in frame T, the segment is under the virtual line and, in the next frame, the same segment is upper then the algorithm increment it’s IN count value. But it is really important to use also the bottom segment of bounding box for the OUT count (or else, the algorithm can make error of counting like count several times a person IN without count him OUT; for example a person which make small round trip next to the IN area). The other way to count using one virtual line is to look the position of the centroid of each blobs.

5.1 Output design

Output design generally refers to the results and information that are generated by the system. For many end-users, output is the main reason for developing the system and the basis on which they evaluate the usefulness of the application and its result. The objective of a system finds its shape in terms of output. Outputs of a system can take various forms. The users of the output, its purpose and sequence of details to be printed are all considered for input. The output form a system is the justification for its existence. Interactive outputs are those, which the user uses in communication directly with the computer.

6 SYSTEM IMPLEMENTATION

This system helps us to count the vehicle that passes in a particular area using a static IP camera. It involves Image Capturing, Pre-processing phase, Segmentation phase, Optical flow algorithm, Tracking and Counting.

Phase 1: Image Capturing

Here the image is captured using the URL address of the camera in the infinite loop. As soon as the program is executed, it renders the image one by one into the system. We can store the image data in the database or just count it without storing the image.

Phase 2: Pre-processing

Before performing any video processing operation the quality of the frame is very essential. In this phase improving the quality of frame is taken into the consideration and the video is tested with three types of noises salt and pepper noise, Gaussian noise and periodic noise. These noises have more chances to distract the quality of video frames. The each noise types are denoised using various filtering techniques and the best suited filters are taken into the consideration for different noises.

1. Select three videos which contain three different noises like -Salt and pepper noise/Gaussian noise /periodic noise.
2. Convert videos to Frames
3. Apply various filters in the noise generated frames
4. Identify the best suited filter using the PSNR and MSE
5. Use the resultant frames for further processing.

Phase 3: Segmentation

To classify the foreground object from the background segmentation operation is performed by background modeling technique, frame differencing. It takes less processing time. The steps are:

1. Read the first input frame and consider it as background frame
2. Convert the background frame to grey scale
3. Set the Threshold value
4. Set the variables for frame size such as width and height of background frame
5. Perform the following processing starting form the second frame till the end of last frame in the video

A. Read the frame
B. Convert the frame to grey scale
C. Find the frame difference between current frame with previous frame
D. Diff_frame = frame t – frame t-1
D. Classify the pixel whether it belongs to background or foreground
If the value of Diff_frame > Threshold value then
Pixel belongs to foreground
Store it in a new foreground vector array
Else
Set the corresponding foreground vector value to zero
End If
E. Now makes the current frame as previous frame and next frame as current frame
6. Loop until end of the frame in the video.

Phase 4: Optical flow Algorithm

4.1: Object detection
The object detection is performed by extracting the features of each object. Based on the dimension of every object it has its own specific feature. In this method, the pixels are calculated based on the vector position and it is compared in frame sequences for the pixel position. In general the motion is correspond to vector position of pixels. Finding optic flow using edges has the advantage (over using two dimensional features) that edge detection theory is well superior, compared with that of two dimensional feature detection. It has the advantage over approaches which attempt to find flow everywhere in the object.

4.2: Motion Estimation
Optical flow is used to compute the motion of the pixels of an image sequence. It provides a dense pixel correspondence. The problem is to determine where the pixels of an image at time t are in the image at time t+1. Large number of applications uses this method for detecting objects in motion.

4.3: Optical flow Algorithm
Optical flow computation is based on two assumptions:
The experimental brightness of any object point is constant over time. Close to points in the image plane move in a similar manner (the velocity smoothness constraint). Suppose we have a continuous image; \( f(x,y,t) \) refers to the gray-level of \( (x,y) \) at time \( t \). Representing a dynamic image as a function of position and time permits it to be expressed.
- Assume each pixel moves but does not change intensity
- Pixel at location \( (x, y) \) in frame1 is pixel at \( (x+\Delta x, y+\Delta y) \) in frame2.
- Optic flow associates displacement vector with each pixel.

Phase 5: Tracking
Object tracking refers to the process of tracing the moving object in progression of frames. The task of tracking is performed by feature extraction of objects in a frame and discovering the objects in sequence of frames. By using the location values of object in each frame, we can determine the position and velocity of the moving object.

5.1: Distance
Using the centroid the distance traveled by the object is determined. The formula used for computing distance is Euclidean distance formula. The co-ordinate points are the pixel positions of moving object at first stage to the last stage.
Algorithm for calculating distance is explained as follow
- Find the centroid position of each object in the frame.
- Evaluate the distance between two centroid objects in the frame.
- For (current position=first value: last value) of X resolution
- For (current position=first value: last value) of Y resolution
- Store all the resultant distance values in an Array

5.2: Velocity
The velocity of moving object is calculated by the distance it traveled with respect to the time. Euclidean distance formula is used to calculate the distance between the sequences of frames.

Phase 6: Counting
The number of objects that are tracked in a frame is displayed.

7 RESULTS AND DISCUSSION
Thus by this Vehicle counting system using image processing, we can easily allocate the space for limited number of vehicles inside a building or parking area of an organization. We can provide secure parking facility, even any unwanted activities like vehicle theft can be found. Traffic monitoring is also possible by our system. This system gives scope for further analysis like vehicle identification and Number plate tracking.

8 CONCLUSION & FUTURE ENHANCEMENTS
Vehicle counting is an easy and simple application when compared using sensors. It is an interesting topic in image processing.

In this system, the vehicles are counted using...
image processing with the help of a static IP camera. The entire process is done using the matlab tool.

Future enhancement of our project is to classify the vehicles and track the vehicles using the number plates

**Input:**

![Input Image](image)

**Figure 1 Input**

**Output:**

![Output Image](image)

**Figure 2 Output**

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