Traf: A Camera Based System for Traffic Flow Analysis

Abstract—In this paper, we present a camera based system(Traf) to count automotive vehicles for traffic flow analysis use. The system employs the method of background subtraction by comparing differences between foreground and background. The background model is initialed by averaging first 50 frames, and adapted to environment change by introducing an adapting parameter λ. Compared to state-of-art method, it is more robust, adaptive and economical.

I. Introduction

II. System Design

A. Overview

The system consists of 3 main modules, video collector, vehicle counter and flow analyzer as Fig 1. Video collector is designed to collect the original video sources and transform them into a unified format for further use. Flow analyzer is designed to calculate the result and provide suggestion for traffic use. The vehicle counter is the core module of the system, which is further divided into 4 steps as, detector, tracker, follower and generator.
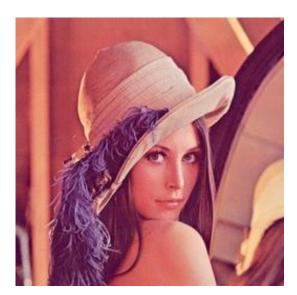

Fig. 1. System diagram

B. Background Subtraction

As the monitoring camera is deployed with a fixed position, videos collected from this kind of devices would have a stable background. And the automobile vehicles forms the foreground motions. Hence, content of each frame image contains two parts, foreground and background. To detect the vehicles, we utilize background subtraction method, which can be described as:

$$F = I - B \tag{1}$$

Where I is derived from frame image, B is the corresponding background, and F is hence the detected foreground.

Frame images from video usually have more than one channel, and they may vary from different types and sizes. This makes it hard or impossible for directing subtraction calculation. Hence, we introduce a collector module to unify the original frame images, as Fig.2

Fig. 2. Frame image unifying

After unifying operation, we do background subtraction, and get the foreground image F as Eq.1. F is mainly consisted of 2 area, the black and the gray. They stands for the background and the foreground separately. However, the gray parts is distributed all the image, making it hard for automobile vehicle detection. Ideally, the gray area of F should gather together as an island. But due to camera performance, environment disturbance and so on, the image carries noise. Even worse,some parts of automobile vehicle may have coincident color with the background overlapping, this would results in gabs and separations. To solve the problem above, we take following strategies as Fig.3. First, we employs a Guassian filter with 4*4 size window to reduce noise. Second, we transform the result into binary image with Eq.**??**, the result $Mask$ may consists of several neighbor areas. To make it a nice mask for describing the position of automobile vehicle, we employed dilation. Next, we applied erosion for a better result.

$$mask = sign(v) = \begin{cases} 1, v \geq \delta \\ 0, v < \delta \end{cases} \tag{2}$$

Fig. 3. Frame image pre-Detection

C. Background Model

Frame images consists of two parts, foreground and background. If there were no automobile vehicles within the frame image, the background is hence equal to the frame image. But this is not always the case, as the automobile vehicles are running on the road from time to time. Even worse, background may change due to light, wind and so on. So a steady background model is essential to the robustness of the system. Traf first builds the initial background model by averaging first 50 frame images. The result is shown as Fig 4.

Fig. 4. Frame image unifying

To adapt to environment change, Traf employs an adaptive parameter λ as equation 3.

$$M_t = (1 - \lambda)M_{t-1} + \lambda B_t \tag{3}$$

where M_t and M_{t-1} are the background model at time t and $t-1$, B_t is the background derived from frame image at time t.

$$F_t = I_t - M_{t-1} \tag{4}$$
$$B_t = y(F_t) * M_{t-1} + (1 - y(F_t))I_t \tag{5}$$

Item B_t is built from the mask of foreground and background model at time t. The mask is derived from a sign function as:

$$y = sign(F) = \begin{cases} 1, F \geq \epsilon \\ 0, F < \epsilon \end{cases} \tag{6}$$

D. Motion Detection and Tracking

E. Traffic Flow Analysis

III. IMPLEMENTATION AND EVALUATION

A. Setup

B. Methodology

C. Result

IV. CONCLUSION