

Recognizing Moving Vehicles from Parking Lot Scene

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Abstract – Recently surveillance cameras have been widely used in critical areas, such as cash dispenser, finger printing system and various security required areas. While these systems are often used applications of direct image processing, analysis of the images is rarely achieved. This paper studies the possibility of image processing application from a surveillance camera at a parking lot. Using Java Multimedia Frameworks and Java Advanced Imaging the real-time capture and processing were implemented. Then, the moving vehicles from the video stream have been analyzed to recognize the objects. This study demonstrates that the statistics information of the moving objects can be applied to the web-based parking lot information system.

Keywords: Vehicle detection, surveillance camera, parking lot statistics.

1 Introduction

The technology of digital image processing has been deployed everywhere in modern society. The areas of digital image processing are widened by exploiting power of multimedia and computer technology. Some typical applications are cash dispenser with face recognition, video-phone chatting, and finger printing recognition system. The common characteristic of these systems is simply to store images captured by hardware or to apply a set of preprocessing.

However, it is expected to create new information from the captured images in the advanced image processing systems. For example, an ordinary CCD camera installed at a parking lot just transmits images to a designated monitor so that personnel watch any abnormal activity inside the parking lot. If it is an advanced image processing system, it should be able to detect persons who come to the parking lot and to compute and guide available space of the parking lot besides the simple transmission. Another advanced study is found in Haritaoglu et. al.[1]. This study analyzed people's activity from a surveillance camera.

In this paper an advanced technology of digital image processing has been explored with the captured images from a parking lot. A new algorithm is proposed to recognize moving objects and to create valuable

information from the images in real-time. The algorithm is applied to a surveillance camera at a parking lot and tested from the image capture tasks to real-time processing. Preprocessing, such as noise reduction and appropriate thresholds to binary images, is also investigated to find better performance. Possible information creation from the preprocessed images is also demonstrated.

2 Image capture

A video camcorder SONY DVD-803 was installed at a parking lot and captured parking lot scenery in mpeg format 30 frames per second. Java Multimedia Frameworks (JMF) [2] is a Java-based library to handle multimedia. It is useful to capture, playback, record, search, and transmit multimedia information with the JMF. It is also widely used for transmission of motion pictures, internet chatting, and video conference with support of the Real-time Transfer Protocol.

It is found that the current computational power can only grab 14 frames per second, while it computes differential images with two adjacent frames. In order to make the moving displacement larger, every fourth frame is captured and used to compute differential images.

JMF library provides powerful utility tools, such as `grabFrame()` which stores each frame into a buffer. The raw data stored to a buffer can be easily changed to buffered images, which can be used to calculate differential images from two adjacent frames. To be in cooperating with JMF, a mpeg board or graphics card, which can recognize VFW capture protocol, should be installed first. A mpeg board must be installed in a personal computer so that the system can handle video images in real-time.

3 Image preprocessing

The approach of differential images may produce faulty results due to an unstable camera [3]. However, differential images are sensitive to environment and do not require lengthy computation. Furthermore, it is also efficient to apprehend moving objects. In this research differential images are created from consequent captured

frames. Fig. 1 shows an example of consequent frames from a parking lot camera.



Figure 1. Captured adjacent frames

Java Advanced Imaging (JAI) is another Java-based tool developed at Sun Microsystems [4]. It has an enriched set of methods for image I/O of various formats, processing of pixel information, image compression, and computation of differential images. The tool is adopted in this research for rendering and computing of differential images.

Captured images are stored in four planes red, green, blue and alpha. It is not practical to compute all four channels each time. Thus, the effect of each channel is investigated alongside gray images. Each frame is separated into red, green, and blue channels, respectively. Then, a reasonable threshold value is applied to each channel image to measure the number of recognized objects. Fig. 2 displays the number of objects recognized for each channel. Three channels show a very similar number of objects, while a gray image show 80~300% better recognition.

Gray images require computations of two additions and one division for each pixel. Despite the more lengthy process, the higher recognition rate of gray images compared to that of captured each channel, is of greater worth. A simple threshold technique is applied to the gray images in order to extract moving objects. Larger numbers of objects were recognized for lower threshold value. However, static objects were detected as moving objects incorrectly. Thus, the threshold of 95 is chosen as a reasonable threshold value.

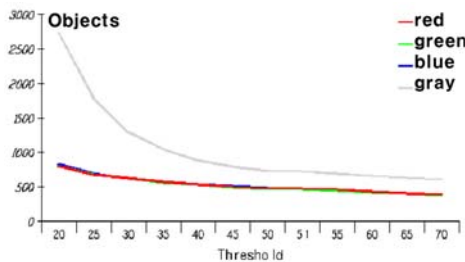


Figure 2. Number of recognized objects

4 Object recognition

The goal of this research is to detect moving objects, such as automobiles and bicycles. Moving objects are

easily detected by their displacements between different time frames. Once the moving objects are guessed, their correct identification can be decided based on the image properties. Thus, the flow of recognition procedure is as follows: computing differential images, applying morphology, and classifying detected moving objects.

4.1 Differential image

Moving objects are detected by differential images at two different time steps t_0 and t_1 . The common moving objects around a parking lot are vehicles, pedestrians, and bicyclists. Pseudo-moving objects, for example, rustling leaves, need to be handled with special procedures. Those objects are usually located in isolated areas, such as garden. Thus, those areas are simply excluded. Fig. 3 shows examples of moving objects by differential images.

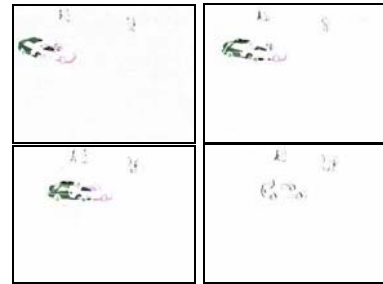


Figure 3. Series of detected moving objects

4.2 Morphological operations

The next step is to transform differential images to binary images with appropriate threshold values. However, many edges are either disconnected or too fine to be recognized. Thus, morphological operations [6] are applied to the binary images. Typical operations of morphology are dilation, erosion, opening and closing.

Geometrically, the dilation of A by B has the effect of expanding an image, and erosion of A by B has the effect of shrinking an image. The opening operator smooths sharp positive edges and eliminates small isolated points. The closing operation smooths sharp negative edges and fills the gaps of an image. Fortunately our target image is binary image so that these morphological operators work easily.

The first goal of image processing pipeline is to make the thin binary edges clearer and thicker, while unnecessary edges are all eliminated. In order to make edges thicker a dilation operation with 3x3 templates has been applied. The operation closing tends to smooth sharp sections, to eliminate small holes, and to fill in gaps. In some cases, the dilation operation works better when combined with the closing operation. Fig. 4 shows newly defined objects after morphology operations.

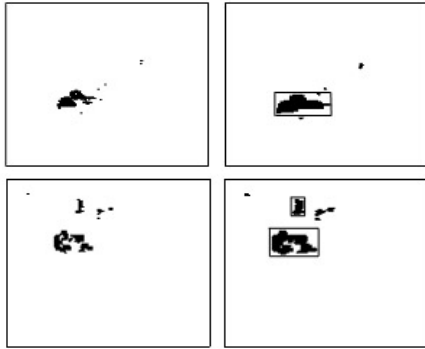


Figure 4. Before and after morphology application
(a) Automobile (b) Automobile and a person

4.3 Classification of objects

The final step to classify object is to disseminate image information. It is found that geometric information of images is useful criteria to classify objects. Image statistics is used to identify moving objects from the final images. Although an object is detected as moving, it may not be a vehicle, if the area of moving object is too small. Thus, the area and the ratio of width and height are used as critical parameters. Usually, the area of vehicles is approximately 1600 in terms of numbers of pixels. The area of pedestrians is approximately 160 pixels. The ratio of width and height of the bounding box of objects provides reasonable criteria for vehicles and pedestrians. The ratio of vehicles is about 4:1; while the one of pedestrians is 2:5.

5 Web-based recognition

It is necessary to transmit information about recognized objects through network in order to share the information. The information of media can be transfer by using a method `startBroadcast()`. Images of each frame is bundled and unbundled by `packetizer()` and `depacketizer()` from a source site to a destination site. Both sites of the source and the destination must have JMF and database installed to transmit and to receive information. Figure 5 shows the screen captured shot of client site.



Figure 5. Captured screen from a client site

Currently both actual video frames and the image of detected objects are transmitted to requesting client sites. The result can be statistically analyzed at both of source and destination sites. The total number of empty parking lot is known from the beginning. As one vehicle arrives and parks itself or it leaves the parking lot, the total number of available parking space can be decreased and increased, respectively. The statistical information can be accessed by mobile computers in future. Thus, this system can help drivers can find the best parking space as convenient as possible. The similar concepts can be applied to many other areas.

6 Conclusions

A new parking lot monitoring system has been implemented for surveillance camera images using the Java Multimedia Frameworks and the Java Advanced Imaging libraries developed Sun Microsystems. This system does more than a simple function of transmit parking lot scenery to a monitor. It captures images from the installed camera outside and classifies objects as either moving vehicles or a pedestrian.

The developed parking lot system can cooperate with web service in future to provide parking lot information to mobile users. It can report status of a parking lot, such as full or empty. If the parking lot has spaces, it can report drivers where the free spaces are available so that drivers do not need to drive all around inside the parking lot. Because the system can recognize moving vehicles individually, it can be also used to do statistical reports about the daily usage of a parking lot.

7 References

- [1] Ismail Haritaoglu, David Harwood, Larry S. Davis, "Real-Time Surveillance of People and Their Activities," IEEE Tans, Vol.22, No.8, Aug. 2000.
- [2] Sun Microsystems, Inc, "Java TM Media Framework API Guide", JMF 2.0 FCs, 1999
- [3] Lim, JS and Kim, WH, "Multiple Pedestrians Detection and Tracking using Color Information from a Moving Camera", KIPS Transactions: Part B V. 11B, no. 3, pp. 317-326, June, 2004
- [4] Sun Microsystems, Inc, "Java TM Advanced Imaging", <http://java.sun.com/products/java-media/jai/docs/previous.html>
- [5] Shin, CH and Lee, JS, "The Interesting Moving Objects Tracking Algorithm Using Color Information on Multi-video Camera, KIPS Transactions: Part B, V. 11B, no. 3, pp. 267-274, June 2004.
- [6] Gonzales, Rafael C., and Woods, Richard, "Digital Image Processing", Addison-Wesley Publishing Company, 1992