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Vehicle detection method for expressway by MPEG compressed domain

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Abstract: A method which extracts traffic information from an MPEG-2 compressed video is proposed. According to the features of vehicle motion, the motion vector of a macro-block is used to detect moving vehicles in daytime, and a filter algorithm for removing noises of motion vectors is given. As the brightness of the headlights is higher than that of the background in night images, discrete cosine transform (DCT) coefficient of image block is used to detect headlights of vehicles at night, and an algorithm for calculating the DCT coefficients of P-frames is introduced. In order to prevent moving objects outside the expressway and video shot changes from disturbing the detection, a driveway location method and a video-shot-change detection algorithm are suggested. The detection rate is 97.4% in daytime and 95.4% in nighttime by this method. The results prove that this vehicle detection method is effective.

Key words: vehicle detection; compressed domain; discrete cosine transform (DCT) coefficient; motion vector

Presently, most researches on video-based vehicle detection aim at image domain. Refs. [1 – 2] determined vehicle passage by detecting the variety of gray-scale values of the pixels in the detection zone or detection line. Ref. [3] detected the vehicle by rebuilding the 3-D model of the vehicle and Ref. [4] by checking pavement signs. These image-domain based detection algorithms generally have huge calculation costs, and the price of corresponding products is very high.

With the development of network and digital video compression technology, the digital video surveillance technique has been widely used in highway monitoring systems[5]. Presently, familiar video compression standards are MPEG-1, MPEG-2 and MPEG-4. These compressed video streams contain texture information of images and matching information of adjacent image frames[6].

Compressed video data is widely used in content searching, shot-change detection, object extraction and so on[7]. Refs. [8 – 9] utilized the DC (direct current) coefficient and the AC (alternate current) coefficient of the DCT (discrete cosine transform) to detect scene switches and gradual changes in the MPEG-2 video stream, respectively. Ref. [10] used the coding type of a macro-block in a P-frame to determine scene switches. Refs. [11 – 12] utilized the DCT coefficient and motion vector to track moving objects. Ref. [13] used the DCT coefficient of the I-frame and the macro-block type of the P-frame to detect traffic flow.

Extracting traffic information from a compressed domain does not need to decompress the image. It has the characteristics of less calculation and lower cost. With the popularization of digital video surveillance, extracting traffic information from compressed digital video streams can offer high-density real-time traffic information to traffic management systems without adding other equipment. So it is significant to study the method of extracting traffic information from compressed video streams.

This paper presents an algorithm which detects traffic data from an MPEG-2 video stream of highway monitoring. Motion vectors of a macro-block are used to detect moving vehicles in daytime, and appropriate checking areas and prior knowledge are utilized to remove noises of the motion vectors, making them more coincident to a vehicle's moving track. At night, the DC coefficient of the DCT is used to detect the headlights of the vehicle, and the method of extracting the DC coefficients in a P-frame is introduced. Techniques to detect lane lines and video-shot changes are also given.

1 Basic Theory

The basic idea behind MPEG video compression is to remove spatial redundancy within a video frame and temporal redundancy between video frames[6]. Frames are divided into 16×16 pixel macro-blocks (MBs) for an MPEG-2. Each MB consists of four 8×8 luminance blocks and two 8×8 chrominance blocks.

DCT-based compression is used to reduce spatial redundancy in 8×8 blocks for the MPEG-2, which realizes the transformation from a spatial domain to a frequency domain and extracts frequency information from the image. Because human eyes are not sensitive to high frequency information, the MPEG-2 adopts a longer quantification step size for high frequency DCT coefficients. Most high frequency DCT coefficients are quantified to zero, and the spatial redundancy of an image is removed.

Usually, images in video stream do not change much within small time intervals, which means adjacent frames are highly related. The MPEG-2 video stream is a sequence of three types of frames: intra-frames (I-frames), forward predicted frames (P-frames), and bi-directional predicted frames (B-frames). The I-frame is a reference frame encoded within itself which compresses an image in a way like the JPEG. The P-frame is encoded by MB motion-compensation based on the previous reference frame; it can also be a reference frame to others. The idea of motion-compensation is to encode a video frame based on the adjacent frames. A B-frame is encoded relative to both the previous reference frame and the next reference frame. In the MPEG-2, motion prediction is used to remove the temporal redundancy of the image sequence.

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In the MPEG-2 stream, the DCT coefficients contain image texture information, and motion vectors contain the information of motion prediction of adjacent images. They are two important parameters for the method proposed in this paper.

2 Vehicle Detection Based on Motion Vectors

The motion compensation in the MPEG-2 adopts a macro block estimation method. It is hypothesized that all objects in the image move translationally, and every point of the object has the same speed and direction. Therefore, supposed pixels in every macro block are making translational motions equivalently, within a certain range nearby the corresponding location in an adjacent frame. Thus, the optimally matched macro block can be found by a certain matching criterion. The relative displacement between the optimally matched macro block and the current block is the motion vector.

The motion vector used for encoding in the MPEG-2 is not perfectly consistent with the object movement in a real image. So using motion vectors as image segmentation criteria directly is not suitable. Ref. [11] suggested filter motion vectors with a method based on probability, and in Ref. [12], median filtering was proposed.

Through large amounts of statistics and analysis on MPEG-2 sequences, it can be concluded that:

1) If the distance between the vehicle and the camera is moderate, values and directions of the motion compensation vectors of the vehicle images will usually accord with the vehicle's real motion, as shown in Figs. 1(a) to (c).

2) If the vehicle is far away from the camera, its image will be too small in the video frame, and so will the motion vectors. It is not suitable for vehicle identification.

3) If the vehicle approaches the camera, its image will occupy a long area in the video frame. Since the texture and color of the vehicle roof are often monotone, motion compensation of those MBs which are parts of the vehicle will frequently be inconsistent with the vehicle's motion. The values and directions of the motion compensation vectors appear quite disorderly.

The luminance and texture of a bituminous pavement image are quite consistent, so it often occurs that one pavement image MB matches an MB in some other place in a previous frame. Such MBs and motion compensation vectors are "isolated points", which could be removed by comparing the adjacent macro-block. A method which can remove "isolated points" is defined as

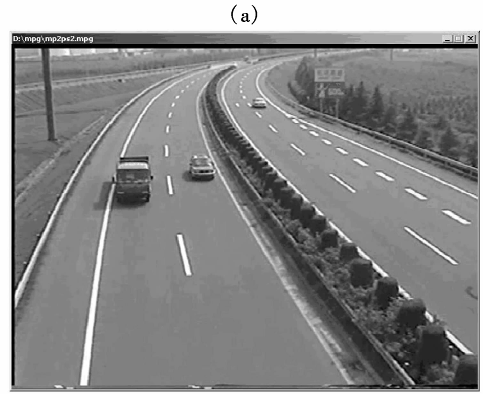
$$\boldsymbol{P}'_{\mathrm{MV}} = \begin{cases} \boldsymbol{P}_{\mathrm{MV}} & \text{if the difference of motion vectors between a current MB and its adjacent MBs is less than some threshold} \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

where $\boldsymbol{P}_{\mathrm{MV}}$ is the original value of the motion compensation vector of an MB. Fig. 1(c) and Fig. 1(d) illustrate the effects of removing "isolated points".

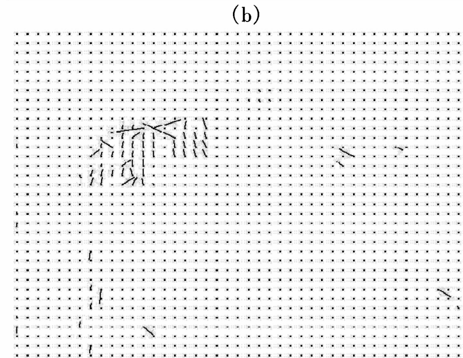
When illumination is sufficient, the sensitivity of vehicle detection by motion vectors is high, and it is insensitive to the fluctuations in illumination. The motion vector is an ideal classification basis. But at night, illumination is low and image detail is fuzzy; motion vectors in the MPEG-2 stream are often inconsistent with the actual motion of vehicles, so motion vectors cannot be used to detect vehicles.

Another merit of detecting vehicles using motion vectors is that the velocity of vehicles can be calculated accurately through photogrammetry.

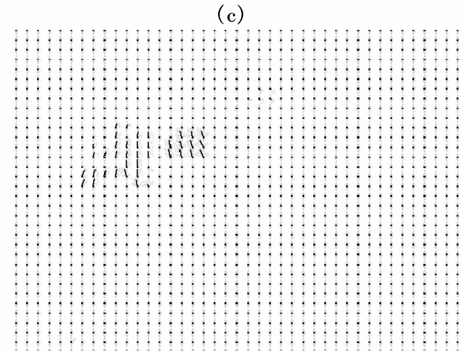
(a)



(b)



(c)



(d)

Fig. 1 Motion vectors of P-MB in a P-frame. (a) I-frame picture; (b) P-frame picture; (c) Motion vectors in P-frame; (d) "Isolated points" are removed

3 Vehicle Detection Based on Luminance

Algorithms making use of the variety of luminance and hue are also common in vehicle detection. Similar information can be extracted from the compressed domain of an MPEG-2 stream.

In the MPEG-2, DCT-based compression is used to reduce spatial redundancy. The DCT is similar to the fast Fourier transform(FFT), and it can be expressed as

$$G(i,v) = \frac{1}{2}C(v)\left[\sum_{j=0}^{7} f(i,j)\cos\frac{(2j+1)v\pi}{16}\right] \quad (2)$$

$$F(u,v) = \frac{1}{2}C(u)\left[\sum_{i=0}^{7} G(i,v)\cos\frac{(2i+1)u\pi}{16}\right] \quad (3)$$

where

$$C(k) = \begin{cases} \sqrt{2}/2 & k=0 \\ 1 & k! = 0 \end{cases}$$

The DCT realizes the transformation from spatial domain to frequency domain. The top left DCT coefficient in the matrix is usually bigger than the other 63 coefficients, and is equal to the mean value of the input matrix. This coefficient is called the DC coefficient and the other coefficients are called AC coefficients. For the brightness block, the DC coefficient represents the average brightness of the image block.

The I-frame is an intra-frame, and its DC coefficient of the DCT can be extracted directly from the data stream. But in order to reduce temporal redundancy, the I-frame generally appears once every 0.5 s. This frequency is too low for vehicle detection. The P-frame appears approximately once every 0.1 s. This detection frequency meets the requirement. But the P-frame does not directly contain DCT information of image blocks.

Each MB in a P-frame can be encoded either as an I-MB or as a P-MB. An I-MB is encoded just like an MB in I-frame. A P-MB is encoded as a 16 × 16 pixels area of the previous reference frame, plus an error term. Thus the DCT coefficient of a P-frame MB(DCT_p) is the sum of the DCT coefficient of its matching MB(DCT_{REF}) and that of the error MB(DCT_{ERR}), which can be demonstrated as

$$DCT_P = DCT_{ERR} + DCT_{REF} \quad (4)$$

DCT_{ERR} can be extracted from the MPEG-2 stream directly. DCT_{REF} is the DCT coefficient of the previous reference block. The previous reference block is located among four MPEG-2 image blocks commonly, as shown in Fig. 2. DCT_{REF} should be regenerated based on the DCT coefficients of these MPEG-2 image blocks.

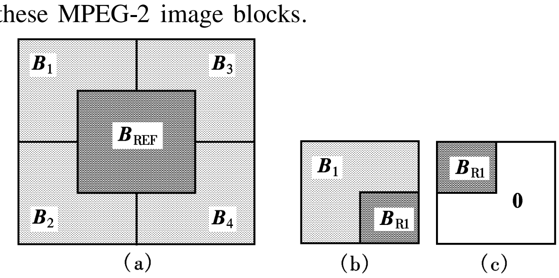


Fig. 2 DCT coefficient restoration algorithm for P-frame. (a) Reference block; (b) Image block $\boldsymbol{B}_1$; (c) Image block after conversion

Ref. [14] proposed to derive the DCT coefficient of a reference block by converting the motion compensation operation to matrix multiplication. In Fig. 2, let $\boldsymbol{B}_{R1}$ represent the intersection part of the reference block located in the unit block $\boldsymbol{B}_1$, then the image block in Fig. 2(c) can be expressed as

$$\boldsymbol{B}'_1 = \boldsymbol{H}\boldsymbol{B}_1\boldsymbol{G} \quad (5)$$

where $\boldsymbol{H} = \begin{bmatrix} \boldsymbol{0} & \boldsymbol{I}_h \\ \boldsymbol{0} & \boldsymbol{0} \end{bmatrix}$, $\boldsymbol{G} = \begin{bmatrix} \boldsymbol{0} & \boldsymbol{0} \\ \boldsymbol{I}_k & \boldsymbol{0} \end{bmatrix}$, h is the height of the intersection, k is the width, $\boldsymbol{I}_h$ is the unit matrix of h order, and $\boldsymbol{I}_k$ is k order one.

Using DCT, it can be deduced from Eq. (5) that

$$\mathrm{DCT}(\boldsymbol{B}'_1) = \mathrm{DCT}(\boldsymbol{H}\boldsymbol{B}_1\boldsymbol{G}) = \mathrm{DCT}(\boldsymbol{H})\,\mathrm{DCT}(\boldsymbol{B}_1)\,\mathrm{DCT}(\boldsymbol{G}) \quad (6)$$

Applying formulae similar to Eq. (3), the content of the reference block in image blocks $\boldsymbol{B}_2$, $\boldsymbol{B}_3$, and $\boldsymbol{B}_4$, which are called $\boldsymbol{B}'_2$, $\boldsymbol{B}'_3$, and $\boldsymbol{B}'_4$ respectively, can be obtained. Their DCT coefficients can be calculated according to Eq. (6). The reference block $\boldsymbol{B}_{REF}$ is the composition of $\boldsymbol{B}'_1$, $\boldsymbol{B}'_2$, $\boldsymbol{B}'_3$, and $\boldsymbol{B}'_4$.

$$\boldsymbol{B}_{REF} = \boldsymbol{B}'_1 + \boldsymbol{B}'_2 + \boldsymbol{B}'_3 + \boldsymbol{B}'_4 \quad (7)$$

Since the DCT is a linear transformation, the DCT coefficient of $\boldsymbol{B}_{REF}$ can be obtained as

$$\mathrm{DCT}(\boldsymbol{B}_{REF}) = \mathrm{DCT}(\boldsymbol{B}'_1) + \mathrm{DCT}(\boldsymbol{B}'_2) + \mathrm{DCT}(\boldsymbol{B}'_3) + \mathrm{DCT}(\boldsymbol{B}'_4) \quad (8)$$

After the DCT coefficients of all the image blocks in the I-frames and P-frames of the image sequences are extracted, certain blocks in the image can be appointed to monitor the variations in their DC coefficients of the DCT. When the variance exceeds some threshold, this place can be thought as having a vehicle passing.

In daytime, detecting vehicles with DC coefficients of the DCT of MPEG-2 image blocks is greatly influenced by environmental illumination[15], and is not sensitive to vehicles whose luminance is close to that of the road surface. But at night, vehicles usually turn on head lamps when running, and the luminance of the lightened region is much higher than those of the others. Traffic flow can be counted as "head lamps" with the variance in the DC coefficient of the DCT. The speed of vehicles can be estimated by the moving speed of high luminance image blocks in the image sequence.

When detecting vehicles by "head lamp" counting, the influence of mirror images of head lamps on wet or snowy road surfaces should be considered. As this detector is limited to be used on expressways, the distance between vehicles on the same lane is comparatively long. Therefore, when two high-luminance regions are on the same lane and rather close, they may be merged and recognized as one vehicle.

4 Driveway Region Location and Video-Shot-Change Detection

In the closed-circuit television (CCTV) monitoring system of expressways, cameras often pan. Vehicle detection using DC coefficients of image blocks need the background of the scene be still and the location of detection area is determined beforehand. At the same time, in order to prevent moving objects outside the expressway from disturbing the examination, we need to determine where the driveway lies in the video frame.

All the vehicle detection methods introduced above suppose that the camera is fixed, which is quite impossible for expressway monitoring. So methods to determine adaptively detection areas should be introduced, then when a camera pans, video-shot-changes can be detected in a timely manner and the detection area can be relocated. The area of detection is always located on the driveway, so we need to develop a driveway image location method.

4.1 Driveway region location

Ref. [16] used the double-threshold value method to extract white lane lines, and then used feature points to track them. This algorithm works in an image domain.

The luminance of a bituminous pavement image is quite consistent, so the DC coefficients of the DCT of the pavement image blocks within one frame are also normally consistent. The DC coefficients of the DCT of lane-line image blocks are obviously higher than those of the pavement image, thus the DC coefficients of the image blocks can be used to locate the driveway region.

Fig. 3 is a curve of DCT's DC coefficients of 88 blocks whose original image is a slice in Fig. 1(a).

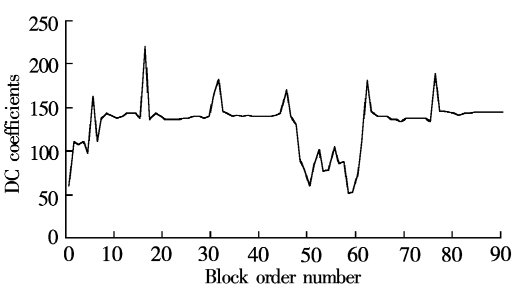


Fig. 3 DC coefficient curve

The average gray scale value of the line is about 140, and the flat part of the curve corresponds to the location of bituminous pavement, while the peaks represent lane-lines. This curve accords well with the original image.

4.2 Video-shot-change detection

The detection area should be re-set after video-shot changing. Refs. [8 − 9] suggested to examine video-shot-change with DCT coefficients, but the algorithm cannot determine the direction of the change, and is sensitive to the change of luminance.

In the MPEG-2 stream, the P-frame is composed of two types of MBs. One type is an intra-coding MB, which means that no matching image area is found in the reference frame; the other is a forward-predicting MB, which means that the MB is matched with some area in the reference frame.

In the MPEG-2 stream, the motion vector of the MB is decomposed into a horizontal motion vector and a vertical motion vector. If the absolute value of the horizontal motion vector is greater than that of the vertical motion vector, the MB is considered moving horizontally; otherwise, it is moving vertically. Applying this rule, MBs can be divided into five classes: moving left, moving right, moving up, moving down, and still.

If the number of intra-coding MBs is greater than some pre-defined threshold, the camera is considered to be panning, and the detection area should be re-set.

5 Results and Analysis

Therefore, this algorithm can be separated into the following steps:

Driveway is located first by a driveway location algorithm. The transverse detection area, whose preferred width is 8 MB, is set in the middle of the image. After location, image blocks outside the driveway will be ignored.

The image is segmented by region growing. Image blocks whose motion vectors are greater than some threshold in daytime as shown in Fig. 4, or whose DC coefficients of the DCT are greater than some threshold at night, will be used as region growing seeds, as shown in Fig. 5. Segments will be eliminated if their block number is less than a given value.

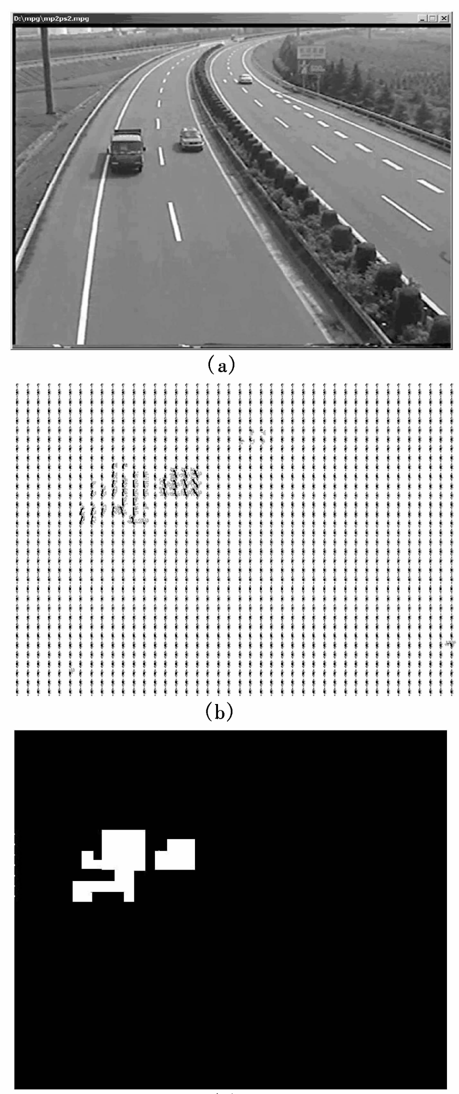


Fig. 4 Segmented region chosen by motion vectors. (a) P-frame picture; (b) Motion vector; (c) Segmented region

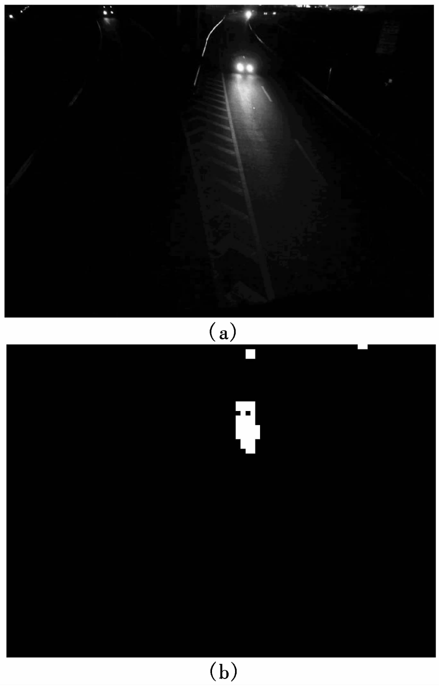


Fig. 5 Segmented region chosen by DC coefficients of DCT. (a) Picture in nighttime; (b) Segmented region

When region growing seeds are chosen by DC coefficients of the DCT, segmented regions close to each other will be merged and regarded as one vehicle.

Each segmented region will be regarded as a vehicle, and vehicle counters will increase when a region enters the detection area for the first time.

An inherent difficulty of video-based vehicle detection is the handling of overlapping. It is also a difficult point for detection algorithm based on a compressed domain. An algorithm based on a compressed domain accepts image blocks and image MBs as basic units. The resolution is low and it is difficult to extract vehicle edges in compressed domains. So there exists a certain probability of omission.

It is also found that the installation position affects the detection greatly. Take a camera which is installed 4. 5 m high beside the road as an example. One of its video sequences in daytime has 457 vehicles in it. Taking 15 vehicles which are almost overlapped out of consideration, our algorithm scored an accuracy of 91%, with 38 vehicles missed and 2 fake ones. The main cause of omission is regarding 2 vehicles driving parallelly as one. And the reason for wrong identification is mistaking the shadow of a large vehicle as a vehicle.

When the camera is located high or right above the driveway, overlapping can be avoided effectively, and vehicles can be correctly segmented. Another merit is that the width of a vehicle can be calculated by counting MBs occupied by the vehicle image. If the width of the detected object is bigger than that of the lane, it will be counted as 2 vehicles. The width of lane can be calculated using the method described in section 4. 1. Take another camera which is installed above the road as an example. One of its video sequences in daytime has 225 vehicles. Our algorithm scored an accuracy of 97. 4%, with 5 vehicles missed and 1 mistaken. The accuracy obviously increased.

The location and the monitoring angle of the camera also greatly influence the detection at night. According to statistics, when the angle between the camera and the driveway is small, the head lights of vehicles will shoot into the camera directly. This will produce a big light spot in the image, and a vehicle cannot be identified exactly. Take the camera installed 4. 5 m high beside the road as an example. One video sequence of nighttime has 127 vehicles, our algorithm missed 23 of them, and the accuracy was only 81. 9%.

If the angle between the camera and the driveway is large, the head lights of vehicles cannot shoot into the camera directly. Take a camera which is installed 6 m high above the road and with an angel of 45° against the driveway surface as an example. One video sequence of nighttime has 87 vehicles, our algorithm missed 4 and mistook none, and the accuracy was 95. 4%. Detection precision is improved. Here, the reason for missing is that when two vehicles driving parallelly are close to each other, the head light spots of one vehicle may overlap the other.

6 Conclusion

Experiments reveal that extracting traffic information from an MPEG-2 compressed domain is feasible. The motion-vector-based vehicle detection method is sensitive, hard to be disturbed by environmental luminance variance, and capable of detecting vehicle speed. On the other hand, this method accepts image blocks and image macro-blocks as basic units, which results in low resolution and a probability of omission. This should be improved with engineering optimization techniques.

With the progress of video compression technology, the unit of coding should be much slighter. For example, in the prediction mode of H. 264, one MB can be segmented into 7 dimensions of different modes. This multi-mode MB segmentation is flexible and subtle, and is more suitable to the actual shape of moving objects in the image. With such help, the traffic information extracted from compressed data will be more straightforward and exact.

References

[1] Chuai Jinhua, Li Xulong, Xu Hongke. Traffic flow detection method based on video images processing [J]. *Journal of Chang'an University: Natural Science Edition*, 2005, **25**(5): 86 - 89. (in Chinese)

[2] Ju Yongfeng, Zhu Hui, Pan Yong. Vehicle flow detection algorithm based on computer vision [J]. *Journal of Chang'an University: Natural Science Edition*, 2004, **24**(1): 92 - 95. (in Chinese)

[3] Liu Guangyao, Ye Xiuqing, Gu Weikang. 3D reconstruct based traffic flux detection algorithm[J]. *Journal of Image and Graphics*, 2003, **8**(6): 631 - 636. (in Chinese)

[4] Yu Mei, Jiang Gangyi, He Sailong. Land mark based method for vehicle detection and counting from video[J]. *Chinese Journal of Scientific Instrument*, 2002, **23**(4): 386 - 390. (in Chinese)

[5] He Tiejun, Huang Wei, Chen Lide. Development and application of digital video transmission system based on MPEG-2 [J]. *Journal of Highway and Transportation Research and Development*, 2004, **21**(11): 86 - 88. (in Chinese)

[6] ISO/IEC 13818 Information technology-generic coding of moving pictures and associated audio information[S]. 1995.

[7] Jin Hong, Zhou Yuanhua. Review of video parsing techniques for contented based video retrieval [J]. *Journal of Image and Graphics*, 2000, **4**(3): 276 − 281. (in Chinese)
[8] Yeo B L, Liu B. Rapid scene analysis on compressed video [J]. *IEEE Transactions on Circuits and Systems for Video Technology*, 1995, **5**(6): 533 − 544.
[9] Lee Seong-Whan, Kim Young-Min, Choi Sung Woo. Fast scene change detection using direct feature extraction from MPEG compressed videos [J]. *IEEE Transactions on Multimedia*, 2000, **2**(4): 240 − 254.
[10] Pei Soochang, Chou Yuzuong. Efficient MPEG compressed video analysis using macroblock type information [J]. *IEEE Transactions on Multimedia*, 1999, **1**(4): 321 − 333.
[11] Wang Zhanhui, Liu Guizhong, Liu Long, et al. A fast and accurate moving object extraction method from compressed video stream [J]. *Journal of Electronics and Information Technology*, 2004, **26**(7): 1157 − 1161. (in Chinese)
[12] Zhan Yiqiang, Qi Feihu, Liu Tianming. Fast object tracking algorithm based on MPEG-2 video sequence [J]. *Journal of Shanghai Jiaotong University*: *Natural Science Edition*, 2001, **35**(9): 1321 − 1324. (in Chinese)
[13] Huang Ruoyun, Mo Yulong. Moving objects detection from MPEG-1 video stream [J]. *Journal of Shanghai University*: *Natural Science Edition*, 2003, **9**(2): 100 − 104. (in Chinese)
[14] Chen Li, Fang Xiangzhong, Yu Songyu. Changing frame type in the compressed domain[J]. *Journal of Shanghai Jiaotong University*: *Natural Science Edition*, 2003, **37**(8): 1293 − 1296. (in Chinese)
[15] Xiao Wangxin, Zhang Xue, Huang Wei. Adaptive thresholds edge detection of traffic image [J]. *Journal of Traffic and Transportation Engineering*, 2003, **3**(4): 104 − 107. (in Chinese)
[16] Zhou Xin, Huang Xiyue. Detection and reconstruction for multi-lane line on freeway[J]. *China Journal of Highway and Transport*, 2005, **18**(2): 107 − 111. (in Chinese)

基于 MPEG 压缩域的高速公路车辆检测方法

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摘要:提出了一种从 MPEG-2 压缩数据流中提取高速公路车流量的方法. 白天根据车辆运动的特点,利用宏块的运动矢量检测车辆,并给出了运动矢量噪声的滤除算法. 夜间根据车灯的亮度高于背景区域的特点,利用图像块的 DCT 系数检测车辆的车灯,并介绍了 P 帧图像块的 DCT 系数的计算方法. 为了防止道路外物体的移动以及镜头的移动对检测造成的影响,给出了车道定位的方法以及镜头移动检测的算法. 采用此方法,白天的检测准确率可达 97.4% ,夜间的检测准确率可达 95.4% . 实验表明本检测方法是有效的.

关键词:车辆检测;压缩域;DCT 系数;运动矢量
中图分类号:TP391.41