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Research and Design of MW-SVM Image Enhancement Algorithm in Embedded Network Video Monitor System

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Abstract: With the demand of image quality, a novel algorithm named MW-SVM is proposed for the enhancement of digital images based on mathematical morphology, watershed algorithm and SVM to remove noises and increase articulation. The MW-SVM algorithm is adopted in embedded network video monitor system to improve video image quality. Firstly, the principle of MW-SVM algorithm and the structure of network video system are introduced briefly. Then, the system hardware structure, software structure and working principle are analyzed. Finally, the typical test parameters, including PSNR, MSE and ISNR, show that this system is reliable, stable and extensible. It will have meaningful practical value in embedded system development.

Key words: Image enhancement, video monitoring, embedded system, MW-SVM, wireless communication

INTRODUCTION

With the development of Internet and embedded technology, researchers pay more attention to the embedded video monitoring system. Normally, computers are the center of the video monitoring system. But they are idle for many resources. Meanwhile, much video monitoring system has hardly image processing function. So, these resources of the computer can be good used in advanced application such as image enhancement and recognition (Gonzales *et al*., 2009).

For the high quality monitor system, this research designs the reliable and smart monitoring system on embedded devices for local area security. In foundation level, the monitor host is based on S3C6410 hardware platform and embedded Linux software platform. In upper level, the algorithm for image enhancement not only decreases image noise effectively, but also improves image quality.

ANALYSIS OF IMAGE ENHANCEMENT ALGORITHMS

Digital images are often corrupted by noises during acquisition, transmission and storage processes. Such noises will severely affect image processing such as image segmentation, edge detection and object recognition. Therefore, many well-known digital noise filters have been presented in the past years for all kinds of image processing systems, such as average filter, median filter, Wiener filter, discrete Fourier transform, discrete cosine transform, discrete wavelet transform and so on (Liu and Yan, 2011).

As a famous method, the FFT algorithm is well suited for analysis stationary signal where frequencies have infinite coherence time. But this method fails to exactly determine when a particular frequency component occurred. Then a short time FT with a fixed sized window was proposed by Gabor to overcome the problems of FT. But it does not describe local changes in frequency content which prompted the use of Wavelet transform for the purpose of signal analysis. Figure 1 shows wavelet transform enhancement framework. The WT offers a multi scale and time frequency localized image representation.

Though, it has many encouraging results, recent studies turn up their own weaknesses. The main drawback is the limited ability in capturing directional information (Gonzales *et al*., 2009).

A block in denoising is that particular pixels in images would be clear up as well as noisy pixels. So, an integrated algorithm is raised in this research.

THE PRINCIPLE OF MW-SVM ENHANCEMENT ALGORITHM

From above analysis, Wavelet transform cannot capture smoothness along contours satisfactorily. Mathematical morphology is well known in the recently developed with its superior capability in representing curvature details (Chen *et al*., 2011).

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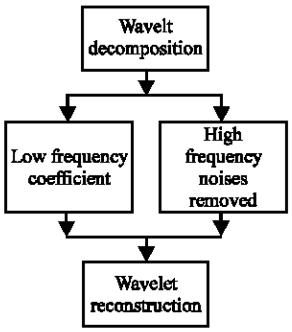

Fig. 1: The image enhancement framework based on wavelet transform

Mathematical morphology: Two basic operations morphological are erosion and dilation. Other morphological transforms can be composed from the two operations. Morphological transforms can separate intricate image from undesirable parts and decompose complex shapes into more meaningful forms.

Watershed of image enhancement: Watershed algorithm is a region-based segmentation techniques. The idea of watershed algorithm is from geography. It sees every object of image as a separate part and requested there must have one tag at least in the each object or seed points. The objects can use watershed algorithm to transform and develop regional growth after maker.

SVM denoising: Recently rapid development of Support Vector Machine (SVM) in statistical learning theory, encourages researchers actively focus on applying SVM to various research fields (Bao and Sun, 2008). SVM takes on great potential performance as is appeared in many previous applications. In this research LS-SVM has been studied for eliminating noises in digital image (Suykens and Vandewalle, 1999; Grinblat *et al*., 2011).

SYSTEM STRUCTURE

Architecture of video monitor system: A type of video monitor system has been designed to safety location based on ARM architecture. S3C6410 would be preferred for the features and cost reason. Processor ARM is a kind of 16/32 bit embedded RISC microprocessor which could extend and integrate easily. It widely used in consumer electronic and wireless products for the notable ability of low power consumption and multifunction data processing.

Figure 2 shows the architecture of the video monitoring system. The video monitor is composed of the following parts: camera module, audio module, SDRAM, NAND flash, Wi-Fi communication module and the administrative terminal unit in PC.

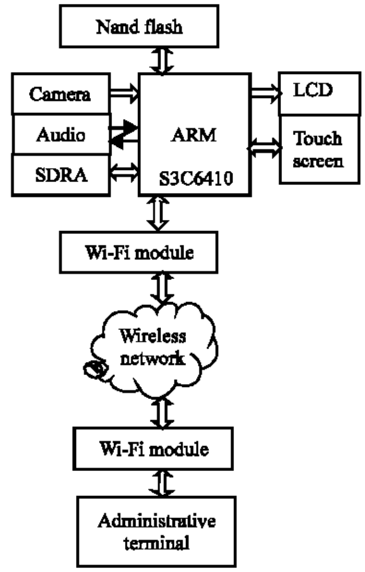

Fig. 2: Architecture of video monitor system

Monitoring terminal: The kernel unit of the monitor terminal is 32 bit S3C6410 produced by Samsung Ltd. Co., its main frequency is 533 MHz/667 MHz, including SIMD (Single Instruction Multiple Data) for media processing, with the NAND flash and SDRAM as its memory chip. A 4G TF card is ready-for-use as auxiliary memory. The output image data format can be 8 bit RGB/YCbCr or 10 bit raw RGB. Camera Omni Vision's OV9650 incorporates a 10 bit A/D converter. Touch screen and LCD are adopted as good man-machine interactive interface.

The main task of monitoring terminal is capturing the video image data through USB camera device, encoding the video data, storing the encoded data and transferring them through wireless Wi-Fi.

Wireless communication module: As a popular communication method, Wi-Fi technique is accepted in the communication module. The module consists of wireless card TL-WN321G, Ralink's chip RT73 as its core and USB interface manufacture by TP-link.

The communication module must build network fast and transmit the encoded image and audio data through Mini USB interface instantly. In the ground, the communication unit can download the data directly.

Software design of monitoring system: There are 3 steps to obtain video image: firstly, load devices drivers to

Linux kernel on the bottom; secondly, compile image acquisition applications on the top to get image data; finally, transmission image data through wireless communication units.

Linux 2 is adopted as software platform in the system. After loading the driver of CMOS camera OV9650 and other relative equipment drivers, image acquisition applications on V4L2 (Video for Linux Two) is compiled. To reduce power consumption, double frame buffer is adopted.

Before compiling the monitor procedure, devices drivers should be loaded at first.

With the kernel starts, if there is the same indication as follows, it shows that the driver of OV9650 has been loaded:

- [CAM] OV9650 init reg start
- [CAM] OV9650 init reg end

After system starts, it can automatically identify OV9650.

As a range of interface functions which can be called for video devices applications provided by Linux, V4L has two shortages in the extensibility and flexibility. A set of APIs and data structure is redesigned called V4L2. V4L2 has two-tier driver architecture. The upper is videodev module, the lower is V4L2 driver. Figure 3 shows the flow chart of image acquisition based on V4L2.

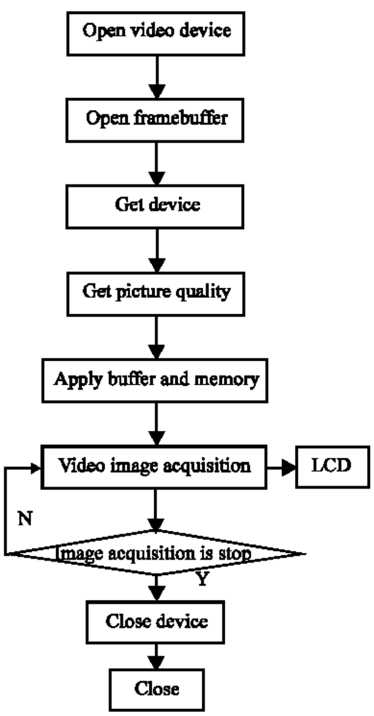

Fig. 3: Flow chart of image acquisition

EXPERIMENT RESULTS

MW-SVM algorithm's enhancement effect in image is evaluated by objective standard and subjective standard.

The metrics for filtering performance include Peak Signal Noise Ratio (PSNR), SNR Improvement Factor F_{SNR}, Mean Square Error (MSE), Improvement in SNR (ISNR) and Identified Noise Rate ξ. Those are defined as:

$$PSNR = 10\lg\left\{\frac{\{\max[\max(I(i,j)),\max(\hat{I}(i,j))]\}^2}{MSE}\right\} \tag{1}$$

$$F_{SNR} = -20\lg\left[\frac{\sum_{y=0}^{N-1}\sum_{x=0}^{M-1}|\hat{I}(x,y)-I(x,y)|}{\sum_{y=0}^{N-1}\sum_{x=0}^{M-1}|I(x,y)-\tilde{I}(x,y)|}\right] \tag{2}$$

$$MSE = \frac{1}{M\times N}\times\sum_{j=1}^{M}\sum_{i=1}^{N}[I(i,j)-\hat{I}(i,j)]^2 \tag{3}$$

$$ISNR = 10\lg\left\{\frac{\sum_{j=1}^{M}\sum_{i=1}^{N}[I(i,j)-\tilde{I}(i,j)]^2}{\sum_{j=1}^{M}\sum_{i=1}^{N}[I(i,j)-\hat{I}(i,j)]^2}\right\} \tag{4}$$

$$\xi(\%) = \frac{card(N_{noise})}{card(N)}\times 100\% \tag{5}$$

where, $I(i, j)$ is the original image, $\tilde{I}(i, j)$ is the degraded image, $\hat{I}(i, j)$ is the restored image, card (N) is the total number of noises, card (N_{noise}) is the number of identified noise and ξ is the identified noise rate.

256×256 pix images including pepper and salt noise and Gauss noise are checked to verify the quality of image enhancement algorithm MW-SVM.

As shown in Table 1-4, σ means variance of Gauss noise, P is occurrence probability of pepper and salt noises. The subjective visual effect of the MW-SVM algorithm is superior to the images filtered by other widely used algorithms. In Table 1, it can be seen that the greater occurrence probability (P), the better filtering effect, but variance of Gauss noise (σ) has hardly influence in the

Table 1: Noise filtering evaluation data

σ	P	F_{SNR}	σ	P	F_{SNR}
0.005	0.1	22.6372	0.02	0.1	23.8372
	0.2	28.1243		0.2	26.7253
	0.3	29.8934		0.3	26.9314
0.01	0.1	23.5392	0.04	0.1	24.1632
	0.2	27.1593		0.2	25.4123
	0.3	28.5946		0.3	29.9384

Table 2: PSNR value of different methods in denoising different noises

Noise type	Average filter	Median filter	Wiener filter	MW-SVM method
Salt and pepper	24.7630	25.5322	24.7559	30.6247
Random	25.7864	25.0977	26.7946	28.6853
Gaussian	25.1157	24.2940	26.0765	28.1254

Table 3: MSE value of different methods in denoising different noises

Noise type	Average filter	Median filter	Wiener filter	MW-SVM method
Salt and pepper	0.0042	0.0030	0.0047	0.0029
Random	0.0027	0.0035	0.0023	0.0021
Gaussian	0.0031	0.0045	0.0028	0.0027

Table 4: NAE value of different methods in denoising different noises

Noise type	Average filter	Median filter	Wiener filter	MW-SVM method
Salt and pepper	0.0768	0.0543	0.0758	0.0071
Random	0.0674	0.0697	0.0683	0.0653
Gaussian	0.0786	0.0703	0.0704	0.0689

algorithm. In Table 2, it can be seen that PSNR value of MW-SVM is greater than other methods in denoising different noise. In Table 3, it can be seen that MSE value of MW-SVM is less than other methods. In Table 4, it can be seen that NAE value of MW-SVM is less than other methods.

CONCLUSION

MW-SVM algorithm was proposed for the enhancement of digital images in this study. To remove noises and increase articulation, MW-SVM was based on mathematical morphology, Support Vector Machines and watershed algorithm. This study designed the network system structure, analyzed system hardware structure, software structure and working principle. This algorithm could be adopted in embedded network video monitor system. It will have meaningful practical value in embedded system development.

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