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Using dual channel CMOS sensor and moving image stabilization algorithm to design image recognition and tracking system

Ting Liu

College of Information Science and Technology, Zhengzhou Normal University, Henan Zhengzhou, China

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ABSTRACT

Image recognition and tracking system is the function of the surveillance cameras and camera tracking automatic tracking / shooting. The function of binocular vision includes dual CMOS synchronous motion control, dual channel video acquisition, feature extraction, image matching, object location, depth calculation. AVI video stream directly is processed by image stabilization algorithm, the image sequence stabilization to PC monitor display, then only need to PC machine can obtain stable video stream. The paper presents using dual channel CMOS image sensor and moving image stabilization algorithm to design image recognition and tracking system. Evaluation methods of general to stabilization results were evaluated, and the experimental results show that the algorithm is effective.

Keywords: Dual channel CMOS, Image stabilization, Image recognition, Image tracking.

INTRODUCTION

Positioning, matching model for target tracking, using image recognition is one of important methods often used image recognition system. The realization process of the matching model is the different video sources or a video source at different time, different imaging conditions, access to the same thing in the two images in space on the registration, or according to the known patterns in another image search the corresponding mode. Image matching is the most extensive application of template matching method, the basic idea is: two images of matching can be summed up as the two one of the correlations metric.

Methods from human perception of object simulation, with the same performance, fixed relative positions of two CCD (Charge Coupled Device) two image cameras to capture the same scene, using triangulation, depth perception to obtain 3D information of the object; this is called binocular vision [1]. Binocular vision includes dual CCD synchronous motion control, dual channel video acquisition, feature extraction, image matching, object location, depth calculation.

Global motion is obtained by the superposition of two parts of subjective motion and jitter. In order to remove jitter in preserving the subjective motion, the need for jitter components were separated and subjective motion. In recent years, many researchers think, jitter has high frequency characteristics, characteristics and subjective movement has a slow smooth, can be subjective motion parameters obtained by low pass filtering method, and then obtain the required to remove jitter components.

Surveillance camera system based on analog tape to complete this work will inevitably increase the cost and size of the whole system. In addition, the video is based on analog TV format recording, want to go to PC to do further analysis is very troublesome, often increases the driving piece of software PCI video capture card and the corresponding need. In the CMOS imaging sensor system is new, digital control chip integrated with a universal digital storage media interface; the memory card has the advantages of small volume and low price. If the digital

control chip integrates powerful image compression encoder, file storage capacity can be reduced further. Video clips recorded for TV replays, or through the extensive use of the card reader is transferred to the PC analysis or backup.

Image recognition and tracking system for each surveillance video source, there are image recognition program specific to particular recognition, marking out the relevant information. All image recognition program gives relevant information through comprehensive analysis of controlling program, the actual control, scheduling requirements are, Pan & Tilt directly control the corresponding. The paper presents using dual channel CMOS image sensor and moving image stabilization algorithm to design image recognition and tracking system.

2. Research of Dual Channel CCD and CMOS Image Sensor

CMOS image sensor is manufactured in standard DRAM bare chip, has the characteristics of reasonable cost, convenient production. In addition, DRAM manufacturing process itself has a low leakage current, to achieve low noise operation, to get a clear, sharp image quality. CMOS image sensor integrates several camera functions in a die, reduces the number of chips, improved reliability, simplified the miniaturization process, and reduce the total cost.

The problem of binocular vision in two real time video acquisition channel switching work coordination. Aiming at this problem, the DM642 EVM system based on board, composed of DM642 two capture video port, two piece of SAA7115 video decoding chip and two CCD cameras consisting of both independent and interrelated dual channel video acquisition system hardware and working principle are analyzed, and the software in this system realized the free switch dual channel real-time video acquisition two acquisition channels control.

CCD video signal processing circuit with CCD video signal processing chip XRD4460 as the core component, complete CCD video signal amplification, noise processing and digital, and the use of CPLD (programmable logic device) technology to complete the whole logic control circuits, with first in first out (FIFO) memory as a cache for storing data, AD conversion after the data, which has the USB interface chip micro controller, the CCD data into the computer through the USB interface.

TMS320DM642 based on the EVM development board, the composition and working principle of dual channel video acquisition system composed of DSP chip, the first high speed video A/D chip and two CCD camera is composed of hardware are analyzed; and then gives the dual channel video acquisition in two video acquisition channel free switching control design; finally, discusses in detail the system function software implementation and experimental results, as is shown by equation1.

$$V(f,t)=\int_{-\infty}^{\infty} C_c(\tau,t)e^{-jft}d\tau \tag{1}$$

The CCD sensor has better sensitivity, resolution, noise control, CMOS sensor, CMOS sensor has the advantages of low cost, low power consumption, and highly integrated features [2]. However, with the CCD and CMOS advances in sensor technology, a narrowing of the situation, the difference between them for example, the CCD sensor has been in power for improvement, to apply to the mobile communication market (this aspect of the industry representative for Sanyo); CMOS sensor is improved in resolution and sensitivity of the deficiencies, to apply to more the high-end image products.

From the analysis of human vision theory, only the processing speed of image processing system up to more than 25 frames per second to achieve real-time performance, which requires the real-time image processing system, must perform processing on an image in 40ms, in order to ensure the real-time image processing. And the powerful functions of DM642 system, the DM642 development board EVM real-time image processing can be very good to meet the real-time requirement.

$$X(m+1)=\Phi(m)x(m,M)+\overline{w}(m) \tag{2}$$

According to the working principle of CIS sensor, the output signal is the voltage signal and serial output. Therefore, the image processing system in this paper includes microprocessor, CPLD module, CIS interface, the sensor signal differential amplifier circuit, image signal A/D converter, double buffer memory interface and so on, so as to realize the acquisition and processing of the image.

Relevant settings for DM642 video capture function is captured on video completion ports in the register, combined with the specific requirements of the dual channel video acquisition system, system to capture port register on the

DM642 chip video configuration mainly has: the dual channel video acquisition; 8 BT.656 video capture mode; do not enable external synchronization mode; enable the EAV/SAV line field synchronous mode; set the parity field size is 720*288; the use of level (column) counter (HCOUNT=0 - 719) and vertical (row) counter (VCOUNT=1 - 288) set the image acquisition parity field window size.

Image sampling, photoelectric sensor output electronic signal proportional to the image gray value is analog, therefore, must turn it into a digital signal, can be input to the computer for data processing. The actual output image information is transformed into digital analog conversion discrete process is called quantization. Using uniform quantization technique is to combine Vp and Vd difference between Vp-Vd interval and K grades, usually the quantization level of K=2m, if you use 8 bit A/D converter, m=8, K=256.

CMOS image sensor to meet the design requirements of the system. Tracking controller using a network of cameras, with small power consumption, and it is low cost, single power driven, and easy realization of system on chip integration [3]. The window can be arranged according to the characteristics of the actual needs of the effective image data window size, thus avoiding the invalid data collection, reducing storage space. Because the sun is very strong, so in the image acquisition, camera needs to add bud membrane filter. Experiments show that with two layers of filter, the image effect is better, as is shown by figure1.

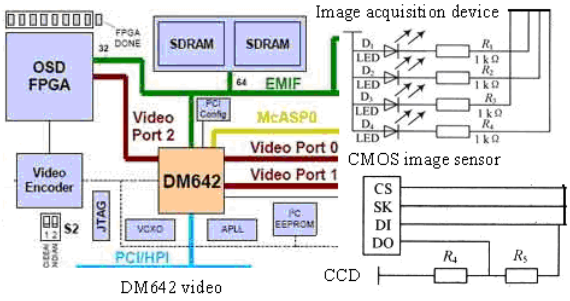

Fig. 1. Development of Dual Channel CCD and CMOS Image Sensor

Image acquisition device with dual channel video acquisition system is a CCD camera, an analog video signal is not its output directly by the DM642 processing, therefore, the SAA7115 video decoder chip system using Philips complete digital image. The SAA7115 chip is a multi standard video decoder, the analog-to-digital conversion, many complex functions of automatic clamp, clock generation, and multi standard decoder is integrated on a chip, provides great convenience for real-time image acquisition system.

CMOS image sensor has many particular board level characteristics; internal design helps to carry out image sensor, high speed camera demand similar consumer electronics applications. The relevant properties are required to provide customers, mainly for the custom design. High speed image sensor: the image sensor will feature the most common image sensor and image sensor is combined, can be suitable for various application of camera.

The SAA7115 chip has many functions for the users to choose, the selected function can be accomplished by the chip register settings. Combined with the specific requirements of this chapter, the system configuration of the SAA7115 chip as follows: set the video input format for the PAL; video output format settings for 8-bit chip BT.656 data stream; enable BT.656 synchronization (even if the timing reference code EAV/SAV); chip enable I-port (Image port) output port. DM642 and SAA7115 chips have special I2C bus interface, DM642 completed the initialization of SAA7115 through the I2C bus, the specific operation on the SAA7115 package chip system to the driver.

In a CMOS image sensor, the signal is the result of surface channel to silicon; in LBCAST, the signal transmission is through the internal channel, so the noise reduced almost to the previous level of 1/3, while the dark current is very small, can effectively inhibit the dark noise [4]. On the other hand, dual channel pixel signals at the same time extraction, can achieve high-speed processing. In the structure, wiring structure LBCAST camera pixel is less than CMOS a metal layer, and the wiring density is relatively low, the interlayer connection hole is relatively small. It has the advantages of simple structure, low manufacturing faults, high rate of finished products.

$$F(\theta)=\sum_{n=0}^{N-1}A_k e^{j(\kappa nd\sin\theta+n\alpha)} \tag{3}$$

Dual channel video acquisition system core processing device based on TMS320DM642 DSP chip, two capture video port two SAA7115 video decoder chip and the use of DM642 (VP0 and VP1) composed of dual channel video acquisition system are independent and interrelated, the dual channel real-time input image.

The core of the circuit is CPLD, uses the EPM7128SLC8415 chip of ALTERA company MAX7000S series of. It generates control signals, but also simulated a gray-scale image data source. 62MHz crystal is used to generate the required CPLD clock. DSC90C031 used to convert the image signals and control signals generated by CPLD (TTL signal) is transformed into LVDS signal, and outputs. The output signal of the 8 bit image can produce a channel every two pieces, a total of 4 channels, ninth are used to convert the control signal and output.

$$d_i(X) = \left[(X-\mu_i)\sum_i^{-1}(X-\mu_i)^T\right]^{1/2} = \left[\sum_{j=1}^{n}\frac{(x_j-\mu_j)^2}{\sigma_{ij}^2}\right]^{1/2}, \quad i=1,2,\cdots,m \tag{4}$$

CMOS active pixel technology, ultra low power MT9V011 image sensor Meguiar's fusion of the VGA resolution and the standard charge coupled device (CCD) are a lot of advantages not available. It can be up to 30fps frame and high quality output progressive scan image, and battery life than the CCD competitive products is greatly prolonged, making it an ideal choice for mobile phone, palmtop computer and PC USB camera.

The DM642 has 3 dedicated flexible configurable video ports: VP0, VP1 and VP2. Each video port are made of channel A and channel B. Video port with its own for temporary capture video data, 5120 bytes of FIFO (First in first out), each channel occupies 2560 bytes. Video port FIFO for a 64 bit width, capture data written into the FIFO before being packed into 64 bits. Video port mode to capture and it is display and TSI (Transport Stream Interface). Capture video port 9 acquisition mode, the two video port in this system are working in the single channel 8 bit YCbCr4:2:2 format BT.656 acquisition mode (Cb, Y and Cr respectively represent the image brightness blue, and the red component information), each capturing video port can only use the port channel A.

Register allocation module is used to register the 12 internal configuration of CMOS image sensor, to provide the necessary sensor working parameters and mode. Among them, parameter time, integral integral (single slope or multi slope), SS sequence generator X sequence generator clock interval, the clock interval, sub sampling mode, the window position and size etc.. Shutter module is used for generating control signals required for sensor, signal control is given according to different shutter required [5]. In the design of synchronous shutter, the monoclinic rate integral, this design based on the multiple slope integration is easy to realize.

3. Design of Moving Image Stabilization Algorithm

Feature matching based algorithm has reduced the amount of computing and advantages of treatment of rotary motion; in recent years has been the attention of researchers. But the use of feature matching method will face a serious problem: the real scene, the external environment is often very complex, moving objects; shake the branches and leaves, and the outside light mutation, foreign body in the field will adversely affect the estimation of global motion parameters.

About image stabilization in motion estimation problem, researchers proposed many algorithms, feature matching motion estimation method is widely concerned by researchers because of has the advantages of small computation amount and can handle rotation motion based on the. Feature matching motion estimation method is difficult to improve the robustness of feature selection and matching algorithm accuracy and algorithm in the complex environment based on the basic principle and algorithm process, in this paper the feature window matching algorithm, and then discuss the feature detection and feature matching these two important modules.

$$\frac{\partial^2\phi}{\partial x^2}+\frac{\partial^2\phi}{\partial y^2}+f(x,y)\phi=q(x,y) \tag{5}$$

Motion compensation is based on the jitter parameter reconstruction of video image motion estimation and motion get smooth, rebuilds one exists only camera subjective motion stability of video sequences. In the complete motion smoothness, can according to the dither motion parameters, for each frame of video image in the video sequence is corrected transform, obtained preliminary stability. At the same time, according to the pixel correlation among neighboring frames of image stabilization, the "empty" regional mosaic, finally obtains the high quality video

output.

When the input video stream for the computer itself is stored in AVI format file, image stabilization algorithm for AVI video stream processing, the image sequence after stable to PC monitor display, then only need to PC machine can obtain stable video stream; in the real-time video stream image stabilization processing, will need to pick-up the installation of equipment and computer image acquisition card is connected, the video signal captured by camera equipment into the image acquisition card. In the image acquisition card by the A/D converter to convert analog video signal to digital image can be processed by the computer, and then the design of image stabilization algorithm for digital image sequence processing.

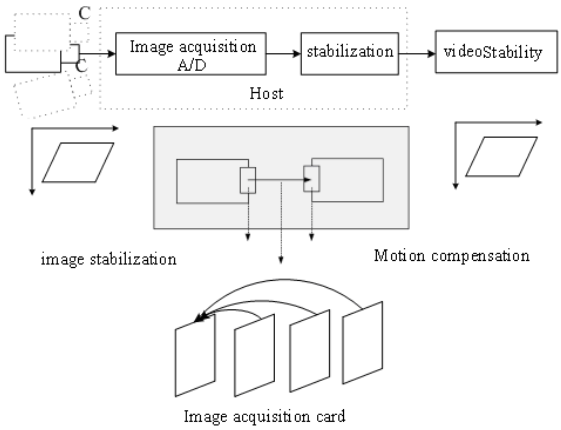

Fig. 2. Design of Moving Image Stabilization Algorithm

This method first uses high precision gyro sensor, obtain the motion parameters between frames, and then using the digital image processing technology for image motion compensation, to eliminate adverse effects of motion vector jitter on the video image, obtains the stable video output [6]. For example, Oshima is a kind of household electronic camera stabilization system is designed using the technique. This method is easy to implement, but its accuracy depends on the high precision gyroscope to achieve, so the sensor's precision is high; on the other hand, due to the amount of exercise detected must be converted to image motion parameters between frames, needs many parameters known device, such as a camera lens focal length value.

In this context, matching when the external light mutation will cause the characteristic distance increases suddenly, and it is causing loss of effective feature. In this paper, combined with the uniformity of brightness transform, the algorithm is improved, which is adaptive to brightness. In the algorithm, because the image smaller contain every character, usually approximation assumes that the characteristic of the regional pixel brightness variation with unity, the overall brightness information which can be use in the adjacent frames describe the brightness change pixel points within it.

Image acquisition card can flow into the video camera 2 dimensional image array. Each pixel quantization is an integer between 0-255, and stored in the storage space for processing. In the experiment, M404T image acquisition card. M404T image acquisition card is a collection of standard and non-standard, monochromatic /RGB analog / digital video signal collecting card. Analog color / black and white video signal acquisition criteria, and strong function expansion properties are integrated into the collection card.

Automatic detection in the first frame in the video sequence and select a group of characteristic window, need to match these feature windows in subsequent frames [7]. The basic principle is to search the similarity matching for the two images in the image sequence, the feature of the two images are matched. Due to the complexity of using color image will improve the algorithm, and the precision of matching also no obvious improvement, therefore, for the sake of simplicity, in the feature matching we use eight bit grayscale image. Considering the time interval of adjacent frames of video is very short, but that the gray adjacent frame the public part of the value remains unchanged.

Jitter detection algorithm based on single feature, but did not consider the first problem in the algorithm, so the feature matching robustness. The paper uses the residual image feature validation, support from trusted characteristics based on reflection model to reduce the brightness changes small feature window matching loss in features, and improve the robustness of feature matching. As can be seen, these studies only for jitter detection or feature matching a particular aspect of the robustness of the algorithm are studied in the. For the two aspects of the

problem are processing algorithms are rarely see.

$$V_j = V_{j-1} \oplus W_{j-1}, \quad \forall j \in Z \tag{6}$$

In the ideal case, if the camera just happened to random jitter removal, the adjacent stable after the two frame image should be fully coincide. And the existence of normal scanning motion or video stream in moving foreground objects in the camera, even removing jitter, between two adjacent frames is still not completely coincident. But no matter what kind of situation, in compensation for random movement, the image sequence obtained stability will be improved; the adjacent frame coincidence degree becomes higher. At the same time, due to noise, the estimation error and movement pattern is not precise reason also makes the coincidence degree is not 1. In order to more accurately measure algorithm, proposed algorithm to evaluate the algorithm accuracy.

4. Using Dual Channel CMOS Image Sensor and Moving Image Stabilization Algorithm to Design Image Recognition and Tracking System

A moment of image recognition and tracking system to monitor activity within the course of events, the comprehensive utilization of all kinds of information, combined with the analysis of the sequence of historical events, can accurately know the situation, the implementation of tracking shot, captured the key event details.

Image recognition and tracking system is a new generation of image recognition and tracking system, to the environment and different application occasions, identify specific occasions can realize multiple process tracking, these activities can be teachers lecture, students speaking, writing on the blackboard. According to the site of the use of the environment, image recognition and tracking system can cover the entire environment, and can focus on the identification and tracking process.

It can and CMOS image sensor matrix is integrated on the same chip, a pixel of 310K single chip color real-time CMOS image sensor. Analog circuit design techniques that, not only the complete elimination of the fixed pattern noise generated by a circuit, and it reduces the random noise, improves the CMOS image sensor sensitivity. The sensor chip also integrates automatic white balance, automatic exposure control (electronic shutter), automatic gain control, automatic brightness control functions.

$$\begin{aligned} \mathrm{M} = \sigma_{s|a}^2 &= \mathrm{cov}(s(k) \mid a(k)) \\ &= E\{[s(k) - \mu_{s|a}]^2 \mid a(k)\} \\ &= \beta(k)^{\mathrm{T}} \Sigma_{\varepsilon(k)}^{-1} \beta(k) + \sigma_{s(k)}^{-2} \end{aligned} \tag{7}$$

The speed of the algorithm is steady as an important index algorithm, it is related to the system can achieve real-time processing of dynamic image sequence, generally by the frame rate per second of processing frames to measure. Traditional algorithm only contains two parts, motion estimation and compensation, the motion estimation module takes up a lot of processing time. In recent years, researchers in order to remove the jitter based subjective motion in the retention of the camera, motion smoothing module is added in the algorithm frame, so that the computational complexity further improve.

CMOS process has been successfully developed high frame rate (10000 frames / sec) CMOS digital pixel sensor. The performance parameters: pixel number is 352288; the chip size is 5mm 5mm; transistor number is 3800000; the readout structure for 64bit (167MHz); the maximum output data rate greater than 1.33GB/s; the maximum continuous frame rate faster than 10000 frames per second; the maximum continuous pixel rate greater than 1Gpixels/s; the pixel size is 9.4 m (H) 9.4 (m V); photoelectric detector type n MOS photoelectric gate; number of transistors per pixel is 37; the device of single pixel by photodiode, analog to digital conversion (ADC), digital memory and correlated double sampling (CDS) circuit.

Image recognition and tracking system is capable of automatically, accurately positioning of teacher / student position, and real-time tracking shot of teacher/student, teacher/student close-up picture or image viewing preset range; a clear track shoot explain the process of writing content and writing on the blackboard. Image recognition and tracking system through the surveillance cameras and camera tracking automatic tracking/shooting function. Surveillance camera is image recognition special; tracking camera field of activity, the automatic tracking movement controlled by the tracking system platform.

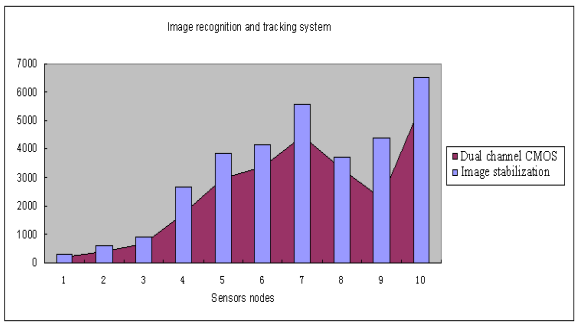

Fig. 3. Comparison design image recognition and tracking system by dual channel CMOS with moving Image stabilization

The image stabilization algorithm frame processing rate is the main module and the motion smoothing module determines the estimated by the motion, the motion estimation module also plays a role. The paper presents using Dual channel CMOS image sensor and moving Image stabilization algorithm to design image recognition and tracking system. The speed and the precision of the algorithm is often a pair of contradiction, realize high precision algorithm is often at the expense of stabilizing speed at the cost of decreased, and one-sided pursuit of speed will bring about the accuracy of the algorithm. In practical application, should be in the application requirements, as far as possible to improve the speed or accuracy.

CONCLUSION

The teacher automatic tracking using image recognition automatic tracking mode, it can automatically identify the position of teachers, and the real-time automatic control of camera tracking shot, to ensure that teachers go freely case, automatic tracking system can still accurately in real time, with the film teacher, and according to the teachers and camera distance control the camera zoom, enables the teacher to screen size always keep in the range of set value.

Image stabilizing maximum offset is capable of handling system is an important index to evaluate the performance of the system. Similar with the speed index, can handle range of the system is, the more time the motion parameters estimation module may consume. Therefore, in the design of the system and it can set some adjustable parameters in order to increase the adaptability of the system.

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