Based on DSP and ARM Independent Binuclear Structure River Sediment Image System Design and Realization

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Abstract—One kind based on embedded Internet, uses DSP and the ARM independent binuclear structure river sediment image system. In the video frequency track, uses Kalman filter algorithm which has the forecast function, designed one kind advanced version PID controller which has the robust, compress code by the DSP system to the information, then transmit the image coding to the ARM system, the ARM system the pack the compression code through the network protocol stack, then transmission through gateway according to demand. This system can record river sediment flow situation, image information and correlation environmental information synchronizations and so on in real-time, and can saved and preserved.

Index Terms—river sediment image system; video transmission; ARM; DSP; Kalman filter.

I.  INTRODUCTION

In image detect river segment researches of Mountain Rivers, How to transmit signals and get data correct is a vital problem, it is also a key problem to influence the collection, transmission, processing and predict intelligently of water resources. The river sediment image data system, based on DSP and ARM independent dual-core structure, as a new type digital hydrology facilities, provide a convenience for online detect river hydrology data.

II. SYSTEM HARDWARE DESIGN

Based on DSP and ARM independent binuclear structure river sediment image system, on the basis of analyzes the Kalman filter, uses Kalman filter algorithm which has the forecast function, designed one kind improved type PID controller which has the robust. This system can record image information of river sediment image and other relevant environmental information synchronous and in real-time, and the video information through the embedded system connected to the Internet, real-time recorded the information of detected object through Internet to the terminal. It can be saved and preserved to provide the user to use as necessary.

A. Control System Design

According to the design request, this system designed as embedded audio/video control system based on DSP and ARM independent binuclear structure. The main processor used ARM9 S3C2410, S3C2410 uses the ARM920T nucleus, the interior had entire performance MMU, integrated 64MBYTE SDRAM and 64MBYTE NAND Flash, 10MByte Ethernet interface and so on, possess high performance, low power consumption, diverse interface and small size so on fine characteristic. DSP uses TMS320C6202B as the video acquisition and compression processor, this kind of DSP chip specifically designed for image/video application, process complete external interface, can conveniently expand external memory and so on peripheral. The entire hardware system overall diagram as shown in Figure 1.

B. Telecontrol Design

With the development of computer technology and embedded technical, embedded Internet technology enable field apparatus equipped with the IP sensor (Internet Protocol Sensor)have the Ethernet interface, then the data can transmit to the sensor and actuator directly. Tele control sketch map as shown in Figure 2.

Figure 1. System Functional Diagram.
video acquisition and compression processor. It can realize the high-speed parallel pipelining, real-time image processing in a great deal of potential, some disposition of peripheries can be an independent image compression terminal. The video control consists of video input, CPLD control, DSP coding three parts. The video input part mainly is transform the simulated video signal inputs from the CCD camera into the digital signal, then storage the data to dedicated video FIFO according to the time sequencing requirements, waiting for the DSP processing[3]. The core of CPLD control section is EPM7128AETC100 comes from Altera Corporation, mainly completes video time sequencing control function between AD and FIFO, FIFO and DSP, DSP and ARM. The DSP unit mainly undertakes processing and the compressing the digital video flows gathers from FIFO.

### A. Video Tracking Algorithm

In this system, target tracking algorithm the most important issue is the timely and adaptivity, the tracking algorithm must have very strong robustness, and must have the ability to forecast the target trajectory [6]. Kalman filter need not consider so many past input signals, in each recursive computation, when designed only need consider the previous input signal, namely thought the signal present condition only relies on former, rather than rely on the former. So does not need to observe all the passes value, this character is advantageous for the computer to the signal real-time processing. The motion state equation and measurement equation of the Kalman filter to the object are as follows:

\[ x(k) = \phi(k) x(k-1) + \Gamma(k-1) u(k-1), (k \geq 1) \]  

\[ z(k) = c(k) x(k) + \nu(k) \]  

Variable w, v respectively is the dynamic noise and the measurement noise. This Kalman filter practical application difficulties lie to a lot of real-time calculation, it is difficult to obtain precise system equation of state. Make certain suppositions to the movement of system state variables, in this foundation according to the system information to estimate the state, need not know the equation of system state, moreover the calculation process is extremely simple, solved this problem preferable. In order to add control items in the Kalman filter, the evolution of the formula (1),(2) is:

\[ x(k) = Y(k-1) + tsY'(k-1) + 0.5s^2Y''(k-1) + \omega(z(k) - Y(k)) \]  

\[ Y'(k) = Y'(k-1) + tsY''(k-1) + \beta(z(k) - Y(k)) \]  

\[ Y''(k) = Y''(k-1) + Y(z(k) - Y(k)) + \theta(u(k) - u(k-1)) \]  

The system designs into discrete forms of controls. Applies the approximate method to transform formula (3) into continual form state-space matrix equation:

\[
\begin{bmatrix}
Y_1 \\
Y_2 \\
Y_3
\end{bmatrix} =
\begin{bmatrix}
-\alpha & 1 & 0.5ts \\
-\beta & 0 & 1 \\
-\gamma & 0 & 0
\end{bmatrix}
\begin{bmatrix}
Y_1 \\
Y_2 \\
Y_3
\end{bmatrix} +
\begin{bmatrix}
\alpha \\
\beta \\
\gamma
\end{bmatrix}
\begin{bmatrix}
Z \\
U
\end{bmatrix}
\]  

\[
\begin{bmatrix}
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\]  

In the formula: \( Y_1=Y, Y_2=Y', Y_3=Y'' \); ts: sampling time; in (4) and (5), \( \alpha, \beta, \gamma, \theta \) respectively is \( 1/ts, (1/ts)^2 \), \( (1/ts)^3, 1/t \) times of \( \alpha, \beta, \gamma, \theta \) in the formula (3).U': is the change rate of input control, \( \theta \) is the most appropriate choice of parameters for the optimal control system. Select filter parameter \( \alpha, \beta, \gamma, \theta \), suitably, then we can apply \( Y_1, Y_2, Y_3 \) to estimate the system position \( y \), speed \( y' \) and acceleration \( y'' \), without the need to know the system mathematical model.

### B. PID Controller

A cording to above algorithm, the robust PID controller designed as shown in Figure 3.

In this system, target tracking algorithm the most important issue is the timely and adaptivity, the tracking algorithm must have very strong robustness, and must have the ability to forecast the target trajectory [6]. Kalman filter need not consider so many past input signals, in each recursive computation, when designed only need consider the previous input signal, namely thought the signal present condition only relies on former, rather than rely on the former. So does not need to observe all the passes value, this character is advantageous for the computer to the signal real-time processing. The motion state equation and measurement equation of the Kalman filter to the object are as follows:

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\begin{bmatrix}
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### IV. SYSTEM SOFTWARE DESIGN

The system first carries on digitized processing to the audio/video simulated signal which obtains from river...
sediment image, then coding before being presented ARM. ARM system packs the code through the network protocol stack, and then transmits on demand.

The system software program mainly composed by the initializer of TMS320C6202B, video FIFO initialize procedures; audio/video compression procedures, embedded operating system and network protocol stack transplant.

This system is actually a real-time embedded systems system, has high requirement to the delay and delay jitter, in particular the synchronized voice and video transmission process. Therefore, must have to consider timeliness to the procedure establishment.

On the other hand, apart from the use of processors to achieve full functionality, in the system software design, it is also necessary to manage memory, peripheral and other resources. At the same time must process concurrent operation between the multitask and the coordination between different tasks. In order to guarantee the reliability and stability of the system, software design must use real-time multitask operating system.

We have carried on the comparison to VxWorks, µC/OS- II etc. operating systems, As µC/OS- II is a open-source operating system and is a preemptive multitask microkernel RTOS, its code structure is clear, perspicuity, detailed notes, organizations ordinance, good probability, can be cutting, may solidify, preemptive nuclear, most can manage 64 tasks. Has good timeliness, meet the requirement of audio/video transmission delay and delay jitters, therefore uses µC/OS-operating system II.

V. CONCLUSION

The innovation of the system: one is unifies DSP and ARM, constitutes embedded network video acquisition and compression system based on independent binuclear structure. Two, uses Kalman filter which has the forecast function, enable the system very robust. In the course of the study, we found that high-performance DSP has a good function to realize video acquisition and compression, but cannot support various network protocol effectively; while 32-bit microprocessor which run embedded operating system can effectively support a variety of network protocols, but in dealing with some larger computing image compression algorithms, operational capacity lags behind.

This system organically integrates advanced embedded technology, video technology and network technology, applied to river sediment image system successfully. It has high automatization and integration; smallest data quantity, fastest transmission, advantageous to network transmission and saves storage space; simple, convenient use and so on characteristics. This kind of river sediment image system based on DSP and ARM independent binuclear structure has provided one advanced hydrology detective means.

REFERENCES