TOWARDS A MULTI-SOURCE RECORD KEEPING SYSTEM FOR AGRICULTURAL PRODUCT TRACEABILITY

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ABSTRACT

Agricultural production record keeping is the basis of traceability system. To resolve the problem including single method of information acquisition, weak ability of real-time monitoring and low credibility of history information in agricultural production process, the multi-source record keeping system was designed. The system consisted of the following components: I） Sensing equipments. Based on ZigBee and video processing technology, the system could realize remote monitoring of crop temperature, relative humidity, light intensity, and dynamic process. II) Transmission technology. The system supports transmission techniques of text, images, video information using 3G module. Also the H.264-based video compression hardware platform and software architecture was built. III) Server. The environmental and compressed video information was eventually transmitted to the server for agricultural product traceability. We tested the whole system in the greenhouses. Tested results showed that the multi-source record keeping system had the ability of accurate acquisition and smooth transmission, and provided strong support for traceability system.

Key words: wireless sensor network, record keeping, traceability system, video processing, remote control

INTRODUCTION

Traceability has been a popular study point in many countries in the last few years. Many traceability information systems were developed in order to record agricultural activities. Record keeping was the basis of traceability system. These systems varied in complexity from simple paper recording systems to complex computer-based information technology. The reliability and effectiveness of the traceability systems depended on the degree of accuracy and efficiency of recording. And some record keeping systems based on PDA were researched widely, in China Li et al (2009) developed a PDA-based record-keeping and decision-support system (PRDS) for traceability in cucumber production and similar systems could be found in other countries*(*Otuka and Yamanaka, 2003*).*

However, the traceability systems are doubted for the weak ability of real-time monitoring and low credibility of history information in agricultural production. The development of wireless sensor network (WSN) and video technology offers great opportunities to advance the agri-food traceability(Huircán,et al, 2010). WSN have been widely used in agricultural environment data monitoring for its low cost and easy deployment (López Riquelmea et al, 2009; Matese et al,2009; Sudha et al,2011). Soil-moisture, salinity or pH could be measured by the sensors in wide area. Video monitoring of scattered crop areas helps to save human resources, and also provides functions as monitoring of the pests and diseases (Shimu, et al, 2011)**.** The video files with the data coming from sensors are a challenge that may cause frame collision and losses, because usually the video files are too large for the communication rate (250kps). Thus we presented the multi-source record keeping system based on ZigBee and video processing technology, realizing remote monitoring of temperature, relative humidity, light intensity, and dynamic process. And then we integrated 3G module to support transmission techniques of text, images and video information. Also the H.264-based video compression hardware platform and software architecture was built for agricultural product traceability.

The entire system is described in the remaining part of this paper which is organized as follows. Section 2 introduces the framework of the system. Section 3 presents the hardware implementation details. Later, the software implementation of the multi-source record-keeping system was explained in section 4. Section 5 shows and discuses the results obtained in the experiments. The conclusion and future directions of this study is outlined in section 6.

FRAMEWORK OF THE MULTI-SOURCE RECORD-KEEPING SYSTEM

This paper designed multimedia information acquisition and compressed system based on former studies (Garcia-Sanchez et al, 2011; Sempere-Payá and Santonja-Climent, 2011; Han et al, 2008) and the characteristics of agricultural environment. The system architecture is shown in Fig. 1.

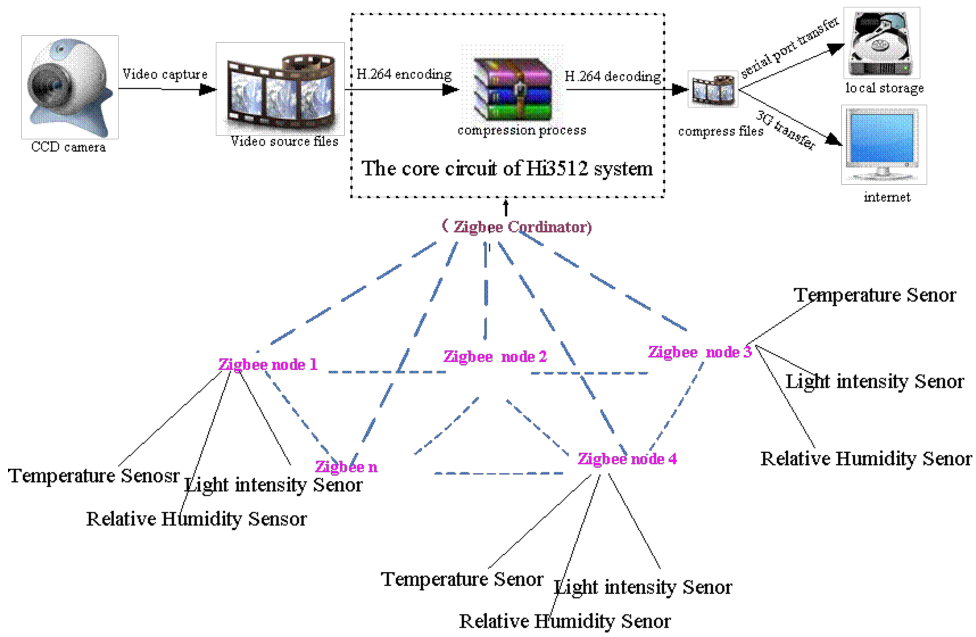

Fig. 1 The system architecture of multi-source record keeping system for agricultural product traceability (MSRK)

The MSRK system architecture design took into account the information path went from the crop to the Farmers' Cooperative and then to the particular farmer/user. The user interacted with the system and modified the monitoring and video surveillance parameters. To this end, we devise diverse nodes which incorporate appropriate sensors together with wireless communication modules. The resulting devices are able to acquire data from different sensors of crop temperature, relative humidity, light intensity, etc. In addition, motion detection (PIR Passive Infrared Sensor) and identification (camera) sensors were in charge of the video-surveillance for the crop security. Data coming from all sensors were transmitted by the communications module to a common device as Gateway placed in the crop. It was responsible for delivering the information to the Farmers' Cooperative. Finally, the Cooperative provided each farmer the information of their crops in real-time. The farmer could receive the information via Internet, in a PDA or mobile handset.

THE MSRK **SYSTEM HARDWARE DESIGN**

The hardware platform core chip was Hi3511, which was developed by Hisilicon Company and integrated ARM926EJ-S embedded processor and H.264 hardware encoder. The chip can achieve video quality and high compression. The video capture boards consisited of ADV7179 video encoding module developed by Analog Devices company and TW2815 decoding module developed by Taiwan Techwell company, as well as other supporting modules (Fig. 2).

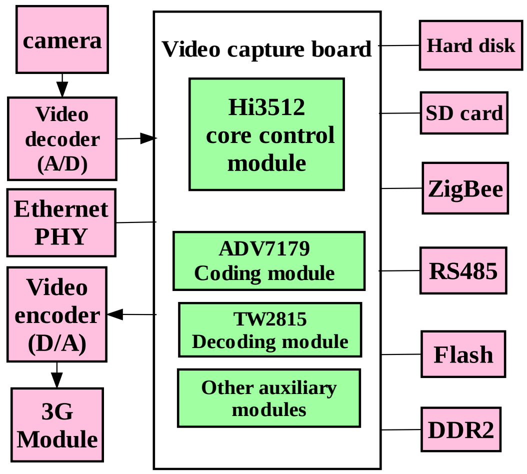

Fig.2 system hardware structure diagram

Agricultural production monitoring process was realized by capturing motion video data through external camera, Firstly，A/D transformation was conducted in ADV7179 chip; secondly, H.264 video were compressed on Hi3512 chip; Thirdly, D/A transformation was done in TW2815. Finally, video signal was output to local storage or sent to monitoring center through 3G module.

Video encoding process

Video Coding is a very important process in keeping video signal not distorted. ADV7179 has good resolution, fast conversion speed and small quantization error and so on. After circuit preceding decoupling filter, video analog signal was received from video input interface and went into the ADV7179 encoder chip through DAC_A of ADV7179 chip, and started video signal A/D transformation into ADV7179 chip. The principle figure of video signal coding and peripheral circuit was shown is Fig 3. The processed digital signal was connected to VODAT0-VODAT7 through P0-P7.

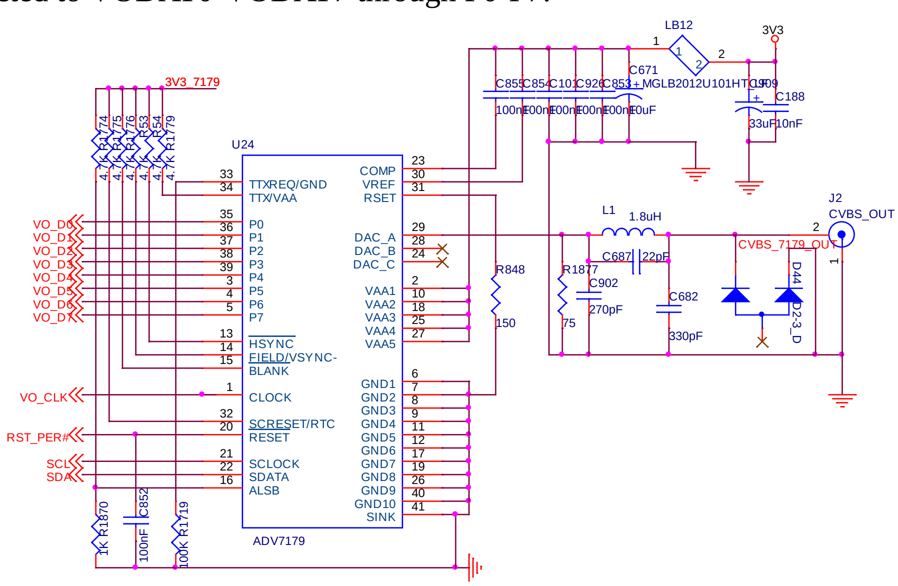

Fig.3 ADV7179 encoding principle diagram

H.264 compression process

Video compression technology has been developed over the last 20 years, and there are several different video coding methods and standards: MJPEG, H.263, MPEG-1, MPEG-2, H.264, etc (Yu and Guo, 2010). H.264 standard can implement higher compression ratio, better image quality and network affinity, lower bit stream and stronger capability of fault tolerance than other standards. It absorbs the experience gained in the previous standard-setting, and has more technical advantages compared to other compression standards. The data compression procedure is shown in Fig. 4. Its higher compression and excellent video quality reduce much communication burden for agricultural video surveillance and remote transmission.

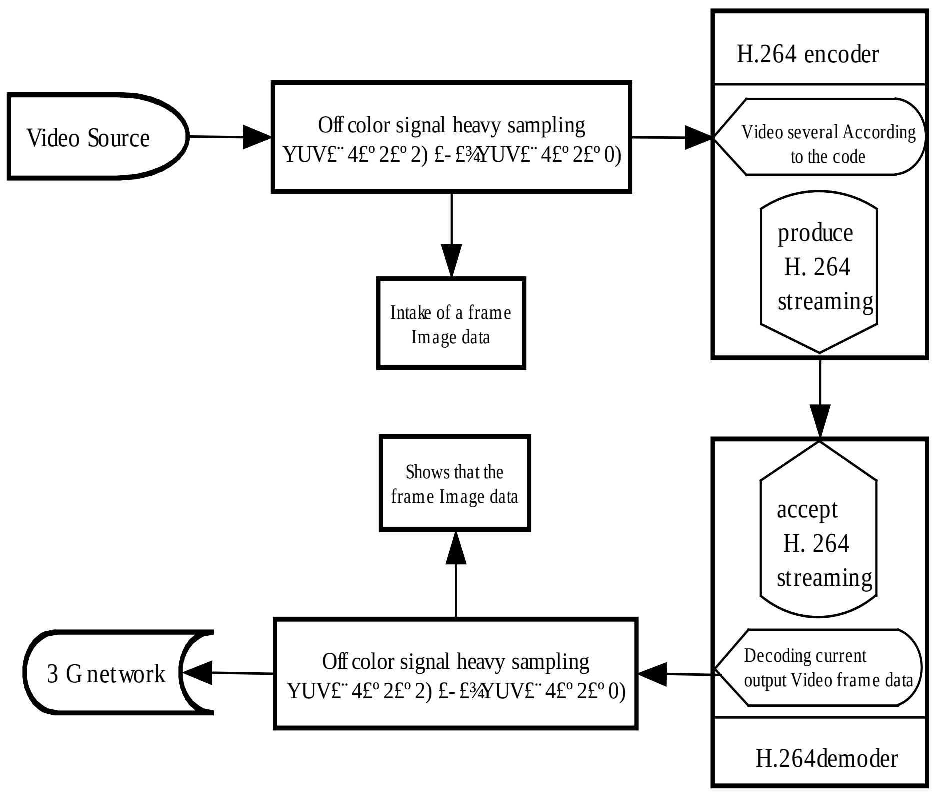

Fig.4 The flow chart of data compression in H. 264 standard

Video decoding process

After H.264 compression, Video decoding is another important task before video outputting. The system used TW2815 Decoder Chip with high resolution, converter speed and linearity to obtain continuous and distinct video. Compressed digital audio signal was output through VI1DAT0-VI1DAT7 base pin of Hi3511 chip and input through VD2_0-VD2_7 base pin of TW2815. Fig. 5 is the decoding principle. After video decoding, the recovered signal was sent by 3G or local storage.

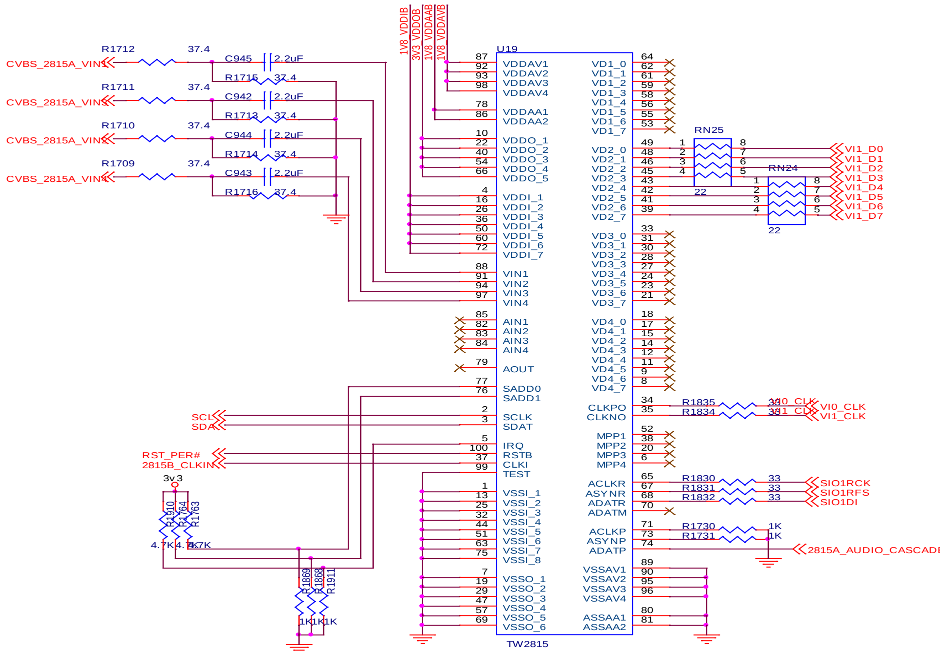

Fig.5 TW2815 decoding principle diagram

3 The MSRK System software design

3. 1 Software platform

We built the development environment using Hi3512 with embedded Linux-2.6.14 Kernel operating system. This paper used Fedora9.0 server on the PC, meanwhile, cross-compiler and SDK package were established and installed. SDK is a Linux-related application development tool and the function library is provided by Hi3512. The Bootloader uses the uboot-1.1.4 to initialize the hardware device and download the Linux kernel through the Ethernet port. Kernel (Zhu.,2010) Kennel can custom the system by making menuconfig configuration, removing redundant parts to cut the kernel, and finally making configured kernel the image file by using the mkimage tool, and then downloading Hi3512 development board RAM or Flash through the network interface

3.2 Software module structure

The System is designed using modularized software method, and the software architecture is divided into four modules from the point of function: temperature and humidity acquisition module, video-processing module, network transmission module and equipment control module. Fig. 6 describes the relationship between four modules. After the program started, the equipment control module was operated, which is main thread of the program, It read node configuration files firstly, then created command transfer thread and shifted to the state of acquiring command and handling command. Received command from internet was assigned to main thread by Command transfer thread. Main thread created the sub threads of temperature and humidity acquisition, video processing, video processing transmission and data transmission according to the commands.

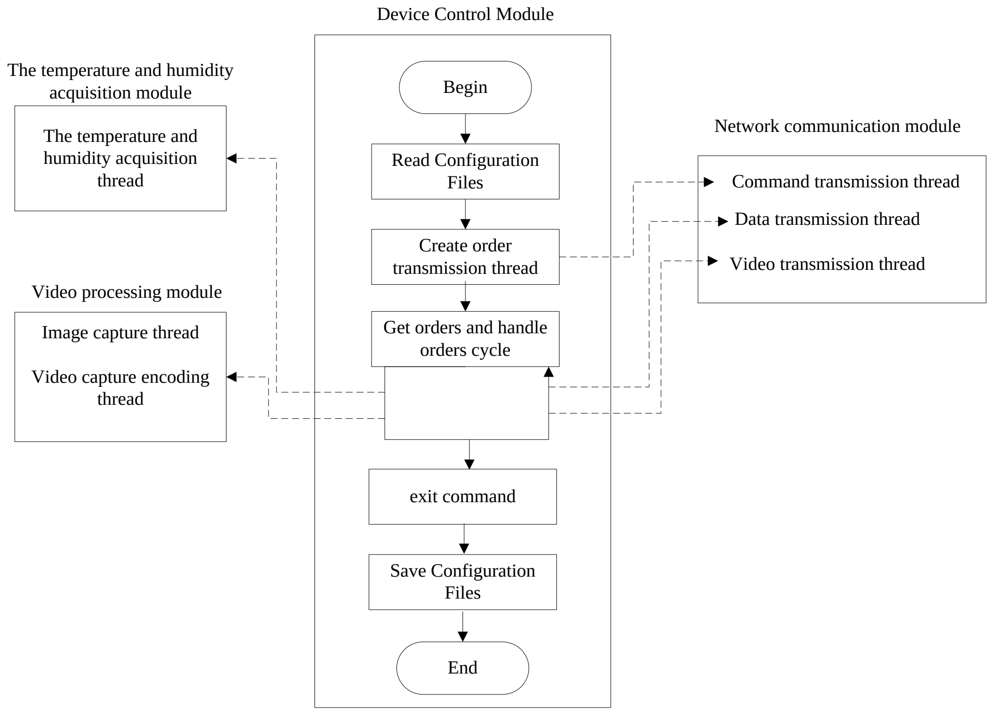

Fig.6 Application Module Diagram

(1) Temperature and humidity acquisition module: it was in charge of collecting crop temperature, relative humidity, light intensity,, collected information is transferred in the form of text by zigbee protocol

(2) Video-processing module: It was responsible for collection and compression encoding of video. This module was implemented using v41 of Linux, V41 is a video and audio interface specification provided by Linux, which is essential to all driver development of video and audio equipment. Video compression encoding had the functions of motion estimation or motion compensation, DCT/IDCT transform, quantization or Inverse quantization and loop file etc. as stipulated in H.264 Protocol Standard(Bi,2008)**.**

(3) Network transmission module: It was used to transfer control command, video, temperature and humidity between multimedia sensor nodes and gathering nodes. It could also be used to implement all functions between the application software and gathering nodes. This module was implemented by RTP / RTCP transport protocol (Schulzrinne and Casner, 2003)**.** RTP protocol was for transmission of video data, and RTCP protocol was for transmission of control data.

(4) Equipment control module: when users wanted to monitor multimedia information, they could press several buttons of client environment monitoring program to control work mode of multimedia sensor nodes, such as start/stop video collection. This function was implemented through sending point control command.

EXPERIMENTS AND APPLICATION

This system was applied to the greenhouses of Beijing Research Center for information Technology in Agriculture. Fig. 7 is two-way video remote monitoring picture. One way was to collect the tomato video in static way without wind or with slightly wind, another was to collect the tomato video in movement way with strong wind . The monitoring center could control camera rotated 360°to collect video and Snapshot. Format of Video collection and encoding test was 352*288 resolution, and 25 frames per second. The encoded H.264 streaming saved files, and then compared with theoretical value before encoding.

a. The static way video

b. The static way video under rotation

c. The movement way video

d. The movement video under rotation

Fig. 7 Two way video of remote monitoring greenhouse tomatoes

The test results was shown in Table 1. The theoretical value before encoding was calculated in the format of YUV4:2:0. For example, the theoretical value of 260 frames video before compressing should be: $260 \times 352 \times 288 \times 3 / 2 = 38610$kb. According to Table 1, the compression ratio differed slightly under different scenes. The mean value of video encoding compression ratio was about 145:1, and average code rate was about 208.18kb/s.

Table 1 H.264 encoding performance under different scenarios

Video scene	Frame number	Before compression, the theoretical value	Compressed value	Compress Ratio	Average bit rate
Basic static	260f	38610kb	249kb	155:1	192.72kb/s
Movement	260f	38610kb	333kb	135:1	223.64kb/s

CONCLUSIONS

The successful application of IT in agricultural production provides a new idea to agricultural monitoring and traceability area. The combination of wireless multimedia sensor networks and H.264 video compression technology provides a much wider development space for the agricultural intelligent monitoring. This paper designed an agricultural production whole process video surveillance system, including video acquisition, video compression, video transmission, visual display, real-time feedback especially video compress ratio analysis. A large number of experiments would be carried out in the further studies to further validate and improve the robustness and stability of the system. Wireless multimedia sensor networks applied in agricultural production data acquisition system may change the traditional production modes, improve the quality of agricultural products and capability for defense against natural disasters, and enhance consumers' confidence of food safety. In summary, agricultural production record acquisition with comprehensive monitoring and stable transmission will achieve the multi-aspect traceability of agricultural production.

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