Design and Realization of Home Remote Monitoring System based on Android Client

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***Abstract* — According to the demand the smart home market of Internet of things, this paper introduced a way of the design and realization of home remote monitoring system based on android client. Family environment is monitored by Wireless passive infrared moving detector. Family environment images are collected by the camera. Family environment data is transferred to android client, and it is realized that home scene is real-time remote monitored by the android client. The measurement result showed that the system works well with stable performance, and it has a promising future in market.**

Keywords – android; remote monitor; smart home; mjpeg algorithm

I. INTRODUCTION

With more people accepting the concept of IOT ,the boom of wireless sensor network technology which causes the fade of the traditional analog video monitoring system ,it is important for people in the field of security monitoring to design a IOT camera which combines IOT technology and extends the webcam .Aimed at the features of smart family environment where the IOT is applied typically and combined with 802.15.4e wireless sensor network and the superiority of the 3G Android phone technology ,this paper comes up with the IOT camera which combines ARM processor ,built-in Linux operation system and wireless sensor network .Considering the limitation of the traditional webcam ,only by remote webpage can people reach the access to the monitoring video ,we designed a Android client software by which people can watch the video at any time and everywhere.

II. SYSTEM COMPOSITION AND NETWORK ARCHITECTURE

The hardware of the camera consists of a S3C2440A microchip as the core processor built on ARM9 frame ,64M SDRAM ,256M NAND FLASH ,DM9000 Ethernet MAC controlling microchips ,USB controller and core circuit comprising power supply circuit and peripheral interfaces .The dominant frequency of the core processor is 400MHz meeting the performance requirements of compressing MJPEG video stream to the resolution 320*240 and 25FPS .The system composition is displayed in Fig.1.

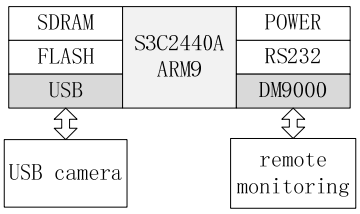

Fig.1 The Diagram of System Hardware

Security strategy is the primary element embodying intelligence of the smart family and also the major function of remote monitoring camera .The security strategy of our design is working out a wireless passive infrared moving detector based on the wireless gateway of 802.15.4e protocol stack and the sensor module based on CC2530 wireless microcontroller made by TI company .The detector detects alarm and sends the alarm messages to the gateway after sensing the infrared ray with particular wavelength emitted by human body .The gateway forwards the received data frames to the webcam through TCP/IP network .After receiving infrared alarm data frames ,the camera judges the alarm messages from window magnetism alarms and door magnetism alarms in the family environment and then analyses video frames with moving objects detection algorithms to reduce wrong alarms caused by cats ,dogs and other mammal pets .At last the camera determines whether there is invasion or something abnormal happening and stores the alarm image record on a storage card in case of using someday .Users can access the camera through Android client ,3G notepad or web browsers on PC .The network topological diagram of the system is displayed in Fig. 2[1]-[3].

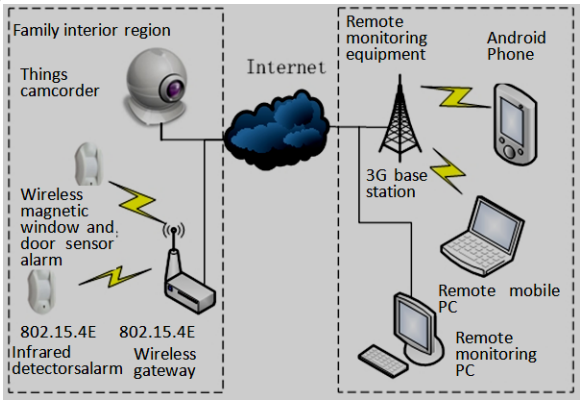

Fig. 2 The Diagram of System Network

III. THE DESIGN OF THE WEBCAM SOFTWARE

To build the Linux system environment which is essential to run the webcam software ,we transplant boot

loader ,trim the Linux 2.6.32 core ,load the Linux UVC (USB video device class) driver and other related drivers ,write the complied Linux system image file in the NAND FLASH of the ARM board and ,at last ,set the system boot address for boot loader.

A. *Design of Software Architecture*

The design of the IOT camera must meet the following requirements : 1) real-time vide monitoring .2) allow more than one clients to have access .3) image recognition algorithm or reserved interfaces .4) function modulation meeting the expansibility for further development .So we adopt multithread architecture ,interlock mechanism and the idea of modulation to design program .The main flowchart of the camera software is displayed in Fig. 3.

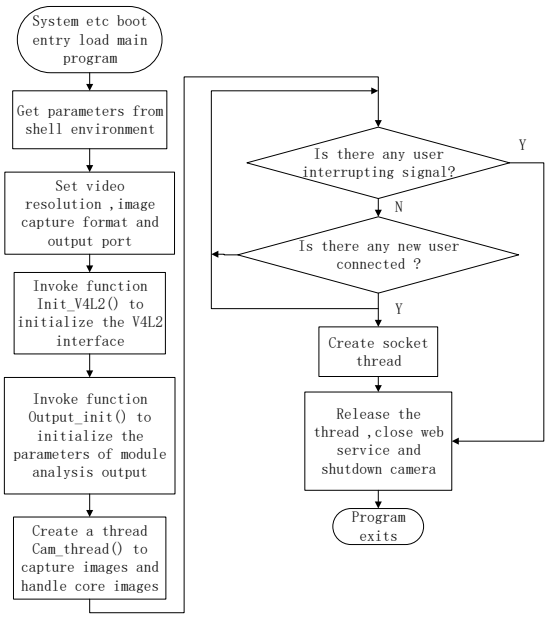

Fig. 3 The Main Flowchart of Program

The main realizations include:

1) Initialize Linux V4LZ interface ,initialize Struts according to the V4LZ standard structure including struct v4l2_capability cap , struct v4l2_format fmt , struct v4l2_buffer buf ,struct v4l2_requestbuffers rb and struct v4l2_streamparm setfps and then deliver video equipment name ,video width ,video height ,frame rate ,video format and capture method to the function init_videoIn(struct vdIn *vd, char *device, int width, int height, int fps, int format, int grabmethod) to complete the initialization .Use the YUYV capture module and analyze YUYV original image data directly when handle the image recognition algorithm late.

2) Create core thread to handle images .The thread realize the following operations : ①UVC equipment single frame capture ,the function uvcGrab(struct vdIn *vd) copies the single frame YUYV original image to internal memory through reading data with efficient mmap internal memory mapping method .②JPEG core algorithms.

3) Create socket interface .We must use socket service thread to allow more than one users to connect webcam at the same time .A new thread will be created correspondingly upon a new user connecting the camera to realize synchronous monitor on different clients.

4) Establish webpages based on the browser access method .The resource of built-in equipment is limited .The lightweight webserver includes Boa ,Httpd ,Thttpd and so on .We use source-opening Boa for design ,cross-compile the original code of Boa ,configure boa.conf file ,configure system etc to start shell automatically and put it into the Boa program ,and last put the written HTML page file into the matching WWW directory .Only this way can the camera work normally.

B. *MJPEG Compression Algorithm and Its Realization*

MJPEG (Motion Joint Photographic Experts Group) ,a kind of video encoding format ,takes the motion video sequence as sequential still images and handles it .This compression method completely compress each frame separately ,and the editor can store any single frame randomly during the compression process ,which can carry out accurate frame-edition .Although the compression is lower than inter-frame compression algorithms such as H264，MJPEG has its own edge —whit lower requirement for processor performance and no need of a special codec circuit or auxiliary DSP processor it can be realized .MJPEG has a cost advantage and there is no too much high performance requirement for a remote Android phone's video decoder .MJPEG's dingle frame compression algorithm is JPEG (Joint Photographic Experts Group). The eye contains 180 million columnar cells sensitive to brightness and 8 million cone cells sensitive to color .Since the number of the columnar cells is much greater than cone cells' ,eyes are much more sensitive to brightness than that of color .The visual physiological characteristics of human eyes determines the different sensitivity to different frequency components which form an image .JPEG is a loss-causing compression but the lost part can't be recognized by human eyes .The feature that eyes are insensible to the high frequency information section of the color space can helps us to save much data to be dealt .The process using JPEG algorithm to code a single frame of image data consists of two parts :

1) Removing redundant information on the visual ,that is spatial redundancy.

2) Removing the redundant information of the data itself ,that is structural redundancy.

JPEG encoding process mainly includes :DCT ,zigzag encoding ,qualification ,RLE encoding ,paradigm Huffman coding and DC (Direct-current component) coding[4]-[6] .The flowchart of JPEG encoding is displayed in Fig. 4.

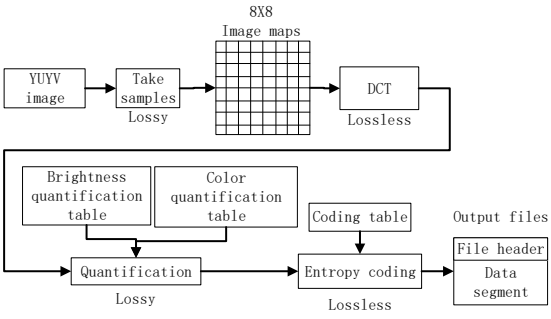

Fig. 4 JPEG Coding Flowchart

Discrete Cosine Transform is abbreviated to DCT .The DCT converts the color spaces domain of original images into frequency domain .For pixel color of the two adjacent points are very similar ,these unwanted data must be compressed by using the spectrum characteristics of image signals .The theory basis of the JPEG compression principle is that image signal spectrum lines are mostly distributed in 0~6 MHz range and the frequency spectrum lines in a image are mostly low frequency while high frequency spectral lines only appear in the image edges which take up a low percentage of a whole image or in subtle texture details .According to this character ,we distribute more bits in the low frequency spectral range that contains large amount of information but less bits in the high frequency spectral range that contains less information in order to complete the compression without the decline of quality which can be perceived by eyes.

The DCT transformation formula is :

$$F(u,v)=\frac{1}{4}C(u)C(v)[\sum_{i=0}^{7}\sum_{j=0}^{7}f(i,j)\cos\frac{(2i+1)u\pi}{16}\cos\frac{(2j+1)v\pi}{16}] \quad (1)$$

In equation (1),when u=v=0,C(u)=C(v)=1. After f（i,j） experiencing the DCT transformation, F(0,0)is the DC coefficient and other parameters are AC coefficient .After DCT transformation ,the coefficient blocks of a image concentrate on the top-left of the 8×8 matrix in which the DC coefficient is the largest .Most low frequency spectrum of the image concentrate on this district and the high frequency spectrum far away from the top-left of the matrix contains little image information .Although the transformation itself does not produce any compression effect ,the frequency coefficient after the transformation is pretty beneficial to bit-rate compression .

Quantification sing to optimize the DCT coefficients and utilize the feature that eyes are insensitive to high frequency to compress data significantly .The whole process is dividing each component with the corresponding constant in frequency domain and then getting an integer from the result after rounding .The goal of this process is to decrease the non-zero coefficients and increase the number of zero value coefficients .Quantification is a lossy operation and the main factor causing the decline of the image qualities .Because of the inconsistency of eyes' sensitivity to luminance and chromatic aberration ,we use luminance quantification tables and chrominance quantification tables respectively .AC components contain a large number of zero values and zigzag coding can produce more continuous zero values ,So we encode the quantified data with zigzag coding which is beneficial to the further run length coding.

Run length coding is an algorithm which is represented in simple according to the situation thank the same data repeated several times in a row of data .For example ,according to run length coding ,555533333999 is expressed as (5 , 4) (3 , 6) (9 ,3) .The run length coding can compress the length of data especially zero values .

Encoded data must be compressed through Huffman coding .The greatest feature of Huffman coding is to make the numbers with high frequency of occurrence less than 8 bits and make that with low frequency of occurrence greater than 8 bits ..According to the idea of information theory ,character frequency of occurrence must be different which makes substantial data compression .After the end of the data compression ,the compressed data is saved in accordance with the JPEG file format and is added with start mark Start Of Image = FFD8 ,end of file mark End Of Image = FFD9, quantification table mark Define Quantization Table = FFDB ,Huffman coding mark Ddfine Huffman Table = FFC4 ,start of frame mark Start Of Frame = FFC0 ,and other marks .At last ,the compressed data is added with picture identification information byte mark and then the JPEG frames that can be used for transmission or storage is finally formed .The MJPEG video stream is formed when the JPEG images are sent uninterruptedly through socket interfaces .

In order to promote the efficiency of processor and reduce the overhead of switching between processes ,we integrate the compression function into a single thread .The realization of the JPEG core compression coding function MCUcode is displayed as follow :

```
uint8_t
*MCUcode(S_JPEG_ENCODER_STRUCTURE*
enc,uint32_t image_format, uint8_t * output_ptr)
    {
     DCT(enc->Y1);//DCT(Discrete Cosine Transform
function )
     quantization(enc,enc->Y1, enc->ILqt);//quantification
function ， quantified according to luminance quantification
table and stored according to zigzag arrangement
     output_ptr=huffman(enc, COMPONENT_Y, output_-
    -ptr);//Huffman coding function
     DCT(enc->Y2)……
     DCT(enc->Y3)……
     DCT(enc->Y4)……
     DCT(enc->CB);//DCT(Discrete Cosine Transform
function )
     quantization(enc,enc->CB, enc->ICqt);//quantification
function，quantified according to chrominance quantificati-
    -on table
     output_ptr=huffman(enc, COMPONENT_CB, output_-
    -ptr);//chrominance Huffman coding function
     DCT(enc->CR)……
     return output_ptr;
```

}

In the function above ,Y1 ,Y2 ,Y3 ,Y4 correspond four pixel brightness values of horizontal arrangement .CB ,CR is the horizontally arranged color value which is one unit with two pixels .

IV. The Design And Realization of Android Client

The Android system ,which occupies a large market share and is supported by a wide range of vendors ,is chosen as the development of IOT camera clients in our design .Android program is written in Java ,a fully objectoriented programming language .Usually ,a Android program is composed by several application frameworks such as Activity ,Intent ,ContentProvider ,Service and so on Activity equivalent to an interface of a running software is the most fundamental .The interface can contain different controls like Button, ImageView, TextBox, List, etc.Besides, activity is responsible for monitoring system events and for starting other activities .Intent ,which is needed for the jump between different activities ,contains two important parts action and data corresponding to the action .The common actions include MAIN ,VIEW ,PICK ,EDIT and so on while the data is represented as a URI .The Intent can also pass parameters ,which is like a chain connecting activities .The chain is displayed in Fig. (5).

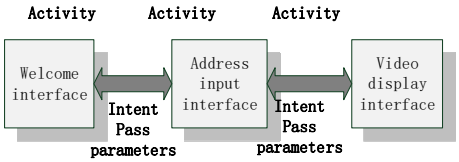

Fig. 5 Activity Diagram

The video stream cannot be parsed without the data from web first .The realization method is as following :

```
public static VideoInputStream read(String url) {
    HttpResponse res;
   DefaultHttpClient                    httpclient=new
DefaultHttpClient();
//http client
     try {
    resource=httpclient.execute(new HttpGet(URI.creat-
-e(url)));
        return
new VideoInputStream(resource.getEntity().getContent-
-());//get message content from the response entity
        } ……
}
```

Divide the received data streams according to the JPEG standard file header . The realization method is as following :

```
public Bitmap readFrame() throws IOException {
   mark(FRAME_MAX_LENGTH);//call          function
mark() to set markers in data streams
    int headerLength=getStart(this, START_MARKER);
//measure the length of the file header
    reset();//function reset() is to reset data streams and
point at the last position
    byte[] header = new byte[headerLength];
    readFully(header);
    try {
      ContentLength = countContentLength(header);
//measure the length of the data content
    } catch (NumberFormatException nfe) {
      ContentLength = getEnd(this, END_MARKER);
    }
    reset();
byte[] frameData = new byte[ContentLength];//access
the data of frame bytes
     skipBytes(headerLength);//skip header bytes
     readFully(frameData);
     return BitmapFactory.decodeStream(new ByteArray-
InputStream(frameData));
}
```

Note that the statement <uses-permission android:name--="android.permission.INTERNET"></usespermission> must be added into the file AndroidManifest.xml .which means that the program has full access permission to the Internet .After receiving each frame of data ,extend class view.SurfaceView and class graphics.Canva supplied by Android SDK and then display the received complete frame images in the queue order onto the window frame classes .For human eyes ,there will be video effect when the frame rate exceeds 5fps and film fluency when 25fps .After testing sentinel surveillances ,we set 10fps as the feasible parameter considering broadband costs and that setting the parameter to 5fps can meet the primary requirements .Store the compiled application in phone storage card and then install it ,at last the application will work .

V. Conclusion

This paper introduces the design of IOT camera software architecture and MJPEG algorithm and ,besides ,combines wireless sensor technology and Android mobile technology ,which realize the IOT camera system used for remote monitoring which is aimed at the smart family environment .And the test shows that the system works well with good prospects to be applied and reference values.

Acknowledgement

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