



# Remote Consultation Information Mobile Phone Intelligent Display System Under Augmented Reality and Human-Computer Interaction

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**Abstract.** The current mobile phone intelligent display system lacks the matching operation of display mode before the display driving operation, which leads to the large average variance of display results. Therefore, this research designs a new intelligent display system of remote consultation information based on augmented reality and human-computer interaction technology. The research and design is mainly for software design. Firstly, two-dimensional display matching algorithm is applied to complete the matching operation of display mode. At the same time, Linux is used as the system framework to be compatible with different modules. In the system, augmented reality and UI human-computer interaction module are established to increase the system functions. GPRS technology is used as the carrier in remote transmission. Finally, a new display driven algorithm is designed. In order to verify the feasibility of the intelligent display system on mobile phone, a comparative experiment was designed to display the remote consultation information, and the power consumption and mean square deviation of different systems were analyzed. The experimental results show that the power consumption and mean square deviation of the system are low, which fully proves the feasibility of the system.

**Keywords:** GPRS technology · Augmented reality · Display drive · Human-computer interaction · Consultation information · Mobile phone display

## 1 Introduction

The rapid development of electronic technology, computer technology and communication technology has brought convenience to people's life and created new opportunities for the development of medical system [1–3]. The proposal of telemedicine improves the efficiency of medical resources, and mobile phone can be used as one of the ports of telemedicine. At the same time, it has a wide range of applications and has a high prospect.

The mobile phone display terminal has higher requirements for image clarity. However, the image quality of the current mobile phone display system is difficult to meet the requirements, and there are still major limitations [4, 5]. In the early display system, the

single-chip microcomputer was usually used as the control chip of the display system at home and abroad, and the ARM embedded microprocessor was used as the control chip of the display system in the later period. The application of micro-processing technology has significantly improved the display quality of the display system, and can also realize more complex display driving operations. Therefore, the researchers used the CPLD algorithm for display drive calculations. However, as far as current research is concerned, researchers lack relevant considerations for display mode matching, which affects the results of driving calculations, and there is still room for improvement in image quality [6, 7].

Under the above background, this research designs a new remote consultation information mobile intelligent display system with the support of augmented reality and human-computer interaction technology, and verifies the application advantages of low power consumption and average variance through simulation experiments, which can enhance the effect of remote consultation information mobile intelligent display.

## 2 System Design

As this system is an intelligent display system applied to mobile phone, the software design is focused on.

### 2.1 Display Pattern Matching Algorithm

In the core calculation of the system in this paper, a two-dimensional display matching algorithm with a wide range of application scenarios is designed to perform matching operations on remote consultation displays under different conditions. First, the string is formalized. A string is defined as a sequence of characters on a limited character set. Suppose there are two strings  $T$  and  $P$ , the length of the string  $T$  is  $n$ , the length of the string  $P$  is  $m$ , where  $m \leq n$ , the string  $T$  is called the string to be matched or the text string, and the matched string  $P$  is called a pattern string. If  $0 \leq k \leq n - m$ , the string should meet the following conditions:

$$T[k \dots k + m] = P[0 \dots m - 1] \quad (1)$$

When the formula (1) is satisfied, the pattern string  $P$  is said to have an exact match in text  $T$ . the exact matching position is  $k$ . in a long string, a shorter string is found. In depth matching, BF algorithm is used to compare the first character  $T[1]$  and  $P[1]$  in text string  $T$  and pattern string  $P$ . If they are exactly the same, continue to compare the second characters  $T[2]$  and  $P[2]$  in the text string  $T$  and pattern string  $P$  until  $T[M]$  and  $P[M]$  are matched. In the case of mismatching, the characters in the text string  $T$  are moved and compared with the pattern string  $P$  until the matching result is obtained. At the same time,  $T[k + 1 \dots k + M] = P[1 \dots M]$  is satisfied. If the above formula is satisfied, the matching is successful, otherwise it is the matching failure. The two-dimensional display string is obtained by matching algorithm.

## 2.2 Linux System Framework

In order to achieve multi-functional compatibility, the system framework adopts the embedded Linux system framework. This support module has many, at the same time the system compatibility is better, the running speed is high and has the good network performance [8]. Support for more processors, such as some mainframes and embedded systems, while improving the support for existing processors. The use of a preemptive kernel greatly improves the response speed of interactive operations. According to the embedded framework, the partition information of Nand Flash needs to be set up to facilitate the initialization of the system at startup. The Nand Flash partition setting code is shown in Fig. 1.

```
static struct mtd_partition smdk_default_nand_part[]={
[0]={
.name=' bootloader',
.size=SZ_128K+SZ_65K,
.offset=0,
}
[1]={
.name=" parameter",
.offset=SZ_128K+SZ_64K,
.size=SZ_64K,
}
[2]={
.name=" kernel"
.offset=SZ_128K*2,
.size+SZ_4M+(SZ_1M-SZ_128K*2)
},
},
```

Fig. 1. Code of NAND flash partition setting

After the system partition of the MTC is determined, the system partition is checked. Set S3C2410 in drivers/MTD/NAND/S3 c2410. C file\_nand\_init\_Chip -> of chip() function ecc.mode = NAND\_ECC\_Soft to NAND\_ECC\_None. The reason is that using mtdecc function in yaffs file system can easily cause the system to read wrong data.

## 2.3 Augmented Reality Driven Development

Drivers of different functions can be developed directly in the embedded Linux system [9]. During development, the automatic configuration and initialization subroutines must be executed first, which is responsible for detecting whether the hardware device to be driven exists and whether it can work normally [10]. If the device is normal, initialize the device and its related state. This part of the driver is only called once during initialization. Secondly, it serves the subroutine requested by I/O, which is also called the upper part of the driver. This part of the call is the result of a system call. When this part of the program is executed, the system still thinks that it belongs to the same process as the process that called sleep(), but changed from the user mode to the core mode, so functions related to

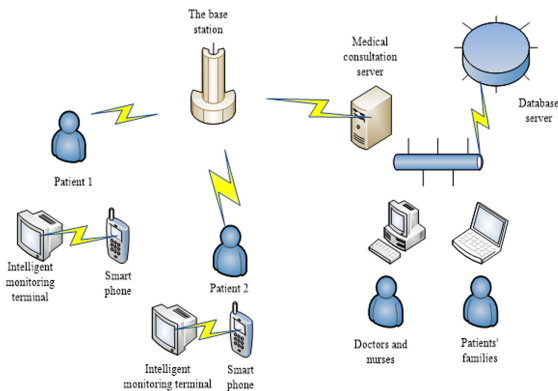
the process operating environment can be called in it. Then implement interrupt operation to the subroutine.

In the Linux framework, the interrupt service subroutine of the device driver is not invoked directly from the interrupt vector table. Instead, the hardware interrupt is received by the Linux framework, and the interrupt service subroutine is called by the system. Interrupt process can be generated in any process to run the program, so when the interrupt service program is called, it can not rely on the state of any process, and can not call any function related to the process running environment.

Use Linux framework to replant the open source visual processing library OpenCV to realize augmented reality. OpenCV provides basic structures such as arrays, sequences, matrices, trees, etc., as well as many advanced mathematical calculation functions such as differential equation solving, Fourier analysis, integral operations, special functions, as well as various image processing operations and target tracking, camera calibration, three-dimensional Reconstruction and other advanced vision functions. Use armv41-tools-2.95.2 cross-compiler to compile OpenCV during transplantation, and modify the source code according to C99 until the compilation is completed.

## 2.4 Remote Consultation Information Transmission

In the remote consultation information display system designed in this paper, GPRS technology is used as the carrier to improve the quality of information transmission. The structure of information received by mobile phone in this system is shown in Fig. 2.



**Fig. 2.** Smart phone consultation information transmission architecture

In the transmission architecture, firstly, the patient data collected by the relevant intelligent monitoring equipment is used for transmission, including other forms of patient medical information. The data is transmitted to the base station, processed by the database server, and then sent to the mobile phone. After the above display data matching operation, the relevant display data is obtained.

## 2.5 UI Human-Computer Interaction Establishment

The design of mobile phone UI is relatively simple than that of computer, but it is an extension tool of computer Internet. Conceptually speaking, multi-channel interaction mode refers to the combination of two or more input and output modes, such as voice and video. Sometimes, due to the low input efficiency, the cognitive load of users will be increased during the operation. Therefore, the multi-channel interaction mode of handheld devices can improve the efficiency and naturalness of interaction.

For different types of interfaces, the usability elements are different, and the interaction characteristics are also different. For example, there are two significant differences between the physical user interface and the sound user interface, real and virtual. The combination of the two achieves effective integration and makes the interface of mobile phone products more usable. The interface design of the machine product needs to consider the product interface related to its use, and there should be no interactive “fault” phenomenon, which fundamentally solves the technical and operational obstacles of the product. The research on the usability of multi-channel user interface is to take the user as the core and pursue the natural interface of “human-machine harmony”.

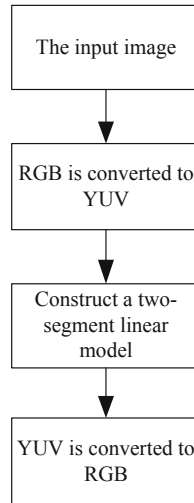
Multi channel user interface has the following basic characteristics: first, multiple sensory and effect channels; second, three-dimensional and directly manipulated interface; third, allowing imprecise interaction; fourth, mutual bidirectional interface; fifth, the implicit interaction. Therefore, it is necessary to ensure that the user interface can be changed at any time, so that the interaction channel is more diversified. Therefore, the development of multi-channel interface technology will improve the efficiency and naturalness of human-computer interaction to a certain extent.

The update of interactive technology and mobile phone interface technology has caused changes in the shape of the mobile phone interface, which cannot be changed if only the increase of mobile phone functions. As digital and networked homes become a reality, mobile phones enter people’s living and working spaces in small and invisible forms. Driven by information technology, mobile phone products will be able to communicate better wirelessly, and interface systems will also The realization of multi-channel and multimedia intelligence and efficiency will further promote communication and exchange between people.

## 2.6 High Quality Display Driver Algorithm

The display-driven algorithm flow used in this article is shown in Fig. 3.

First, the input image transmitted by remote information is converted from the actual RGB space to the YUV space, where  $Y$  represents brightness information, and  $U$  and  $V$  represent color information. Then calculate the average brightness  $Y_{av}$  and the maximum brightness  $Y_{max}$ . The key of this algorithm is to calculate the key two straight lines, and generate a new brightness component  $Y'$  according to the model. Finally, the YUV space is converted to the RGB space to obtain the processed image.



**Fig. 3.** Algorithm flow chart

Because the power consumption is limited by using two linear operations, only one operation is needed, and the complexity of hardware is reduced. The processing speed is improved, which makes the algorithm suitable for real-time scene processing. In this algorithm, the high brightness part of the image details are processed to limit the power consumption, and the low brightness part is reserved. Therefore, the visual effect of the image is improved while the power consumption is limited. In YUV space, luminance component and chroma component are separated. Therefore, there is no mutual confusion and influence between brightness and chroma. In the process of low-power image processing, the brightness information should and should only be changed, and the chroma information should not be changed. On the other hand, the power consumption can be reduced by processing y channel. The YUV space converted by RGB is as follows:

$$\begin{cases} Y = 0.257R + 0.504G + 0.098B + 16 \\ U = -0.148R - 0.291G + 0.439B + 128 \\ V = 0.439 - 0.368G - 0.071B + 128 \end{cases} \quad (2)$$

In formula (2),  $R$ ,  $G$ , and  $B$  represent the gray levels of the three primary color channels,  $Y$  represents the luminance component, and  $U$  and  $V$  represent the chrominance component. In the process of low-power high-quality image processing,  $Y_{av}$  is an important parameter. In order to improve the visual effect of the processed image, it is not necessary to process all the pixel units in the original image. For example, low brightness part of the image details will not lead to an increase in power consumption. If this part of image details are not processed, the visual effect of this part is maintained. Therefore, the algorithm proposed in this paper does not deal with low brightness partial pixel cells. However, the key point is to find a watershed brightness. The pixel unit with brightness lower than the brightness is not processed, and the pixel unit with brightness higher than the brightness is processed with low power consumption. If the watershed brightness is

too high, the visual effect of the processed image is good and the power consumption is reduced. Otherwise, the visual effect becomes worse and the power consumption limitation is increased. Through a lot of research,  $Y_{av}$  is selected as the watershed brightness value, as shown in the following formula:

$$Y_{av} = \frac{1}{W \times H} \sum_{i=0}^{W-1} \sum_{j=0}^{H-1} Y(i, j) \tag{3}$$

In formula (3),  $W$  represents the horizontal resolution of the image,  $H$  represents the vertical resolution,  $Y(i, j)$  represents the brightness value of the pixel unit in the  $i$  column and the  $j$  row, and  $Y_{av}$  represents the average brightness of the original image. Under the two-section straight line theory, the new brightness  $Y'$  obtained is as follows:

$$Y' = Y - Y_{offset} \tag{4}$$

In formula (4),  $Y_{offset}$  represents the intermediate value between  $Y_{av}$  and  $Y_{max}$ . The other two components  $U$  and  $V$  in YUV space remain unchanged, and YUV is transformed into RGB, The results are as follows:

$$\begin{cases} R' = 1.164(Y' - 16) + 1.596(V - 128) \\ G' = 1.164(Y' - 16) - 0.813(V - 128) - 0.391(U - 128) \\ B' = 1.164(Y' - 16) + 2.018(U - 128) \end{cases} \tag{5}$$

At this point, the design of the display drive operation of the mobile phone is completed.

### 3 Analysis of Experimental Demonstration

In order to verify the feasibility of the mobile phone intelligent display system designed in this paper, remote consultation application is added to the mobile phone used in this paper, and then the patient information in a hospital is displayed by this system, the traditional consultation information mobile phone intelligent display system based on virtual reality, and the consultation information mobile phone intelligent display system based on ZigBee Results the advantages and disadvantages of different systems were judged.

#### 3.1 Experimental Mobile Terminal

The mobile phone equipped with intelligent display system of mobile phone is selected as honor Play4t, the main screen size of the mobile phone is 6.39 in., the main screen resolution is 1560 × 720 pixels, the rear camera is 48 million pixels + 2 million pixels, the front camera is 8 million pixels, the electromagnetic capacity is 4000 MAH, the battery type is non removable battery, the number of cores of the mobile phone is 8 cores, the CPU model is hyskirin 710A, the CPU frequency is 2.0GHz, the mobile phone memory is 6GB, and the mobile phone carrying system is an droid 10.

### 3.2 Experimental Evaluation Method

In this experiment, we compare the advantages and disadvantages between this system and the traditional system mainly by comparing the power consumption and the mean square error of the display. The calculation method of power consumption  $PD$  is as follows:

$$PD = (1/N) \cdot \sum_{i=0}^W \sum_{j=0}^H [\omega_r R^2(i, j) + \omega_g G^2(i, j) + \omega_b B^2(i, j)] \quad (6)$$

In formula (6),  $N$  represents the number of displayed image pixels,  $W$  represents the horizontal resolution of the image,  $H$  represents the vertical resolution of the image,  $R(i, j)$ ,  $G(i, j)$  and  $B(i, j)$  represent the gray scale of pixel units in column  $i$  and row  $j$  in channel  $R$ ,  $G$  and  $B$  respectively, and  $\omega_r$ ,  $\omega_g$  and  $\omega_b$  represent the power consumption coefficients in each channel. The mean square error  $MSE$  is calculated as follows:

$$MSE = \frac{1}{W \times H} \sum_{i=0}^W \sum_{j=0}^H \left[ \text{sqrt}[R'(i, j) - R(i, j)]^2 + [G'(i, j) - G(i, j)]^2 + [B'(i, j) - B(i, j)]^2 \right] \quad (7)$$

In formula (7),  $R'(i, j)$ ,  $G'(i, j)$ ,  $B'(i, j)$  represents the gray levels of pixel units in the  $i$  column and  $j$  row of channels  $R$ ,  $G$ , and  $B$  in the original image. The smaller the  $MSE$ , the smaller the difference between the image displayed in the mobile phone and the image of the transmission source, and the better the visual effect.

### 3.3 Experimental Result

In the experiment, the patient's relevant diagnostic information is sent remotely and sent to the intelligent display system on the mobile phone, and the corresponding image is obtained. Figure 4 shows the ECG image of the patient obtained in this system.



Fig. 4. Patient ECG image

The image in Fig. 4 is clear and can clearly reflect the patient's ECG image information, and the feedback to the remote consultation information is more obvious. The patient's X-ray diagnosis information is shown in Fig. 5.



**Fig. 5.** X-ray images of patients

Figure 5 shows the patient’s bone and joint clearly, and Figs. 4 and 5 prove that the mobile phone intelligent display system designed in this paper can meet the display of remote consultation information. The comparison results of power consumption between this system and traditional system in displaying the same sample information are shown in Table 1.

**Table 1.** System display power consumption

Sample number	System 1 power consumption (mW)	System 2 power consumption (mW)	System 3 power consumption (mW)
Sample No.1	181.71	215.64	238.71
Sample No.2	192.15	241.33	231.51
Sample No.3	181.43	211.56	246.75
Sample No.4	182.51	246.35	244.81
Sample No.5	218.73	399.34	359.77
Sample No.6	244.59	481.21	505.33
Sample No.7	247.64	501.41	521.79
Sample No.8	241.14	511.15	504.21

In Table 1, system 1 is the intelligent display system designed in this paper, system 2 is the traditional consultation information mobile intelligent display system based on virtual reality, and system 3 is the traditional consultation information mobile intelligent display system based on ZigBee. Among the samples used, samples 1–4 are ECG images, sample 5 is X-ray examination images of patients, and samples 6–8 are MRI images of

patients. In Table 1, the smart display system in this article consumes less power under the same sample.

The mean square error values of different systems in the display are shown in Table 2.

**Table 2.** Average error of system display image

Sample number	System 1 power consumption MSE	System 2 power consumption MSE	System 3 power consumption MSE
Sample No.1	2.7	2.73	2.75
Sample No.2	2.34	2.41	2.44
Sample No.3	2.47	2.55	2.53
Sample No.4	2.48	2.49	2.52
Sample No.5	4.51	7.45	8.69
Sample No.6	6.11	10.34	12.15
Sample No.7	6.52	12.11	15.61
Sample No.8	6.66	11.58	15.74

As can be seen in Table 2, when displaying ECG images of patients, the difference of mean square error among the three systems is not big. In the subsequent display of X-ray examination and nuclear magnetic resonance imaging, the mean square error of system two and system three has great changes, and the mean square error of system one has obvious advantages over system two and system three. The experiment proves that the intelligent display system of remote consultation information mobile terminal designed in this paper is feasible.

The reason for this result is that this system uses augmented reality and human-computer interaction technology to increase the interactive functionality of the system, and uses Linux as the system framework to be compatible with different modules, and GPRS technology as the driver carrier, so as to fundamentally reduce the mean square error of the display results.

## 4 Conclusion

Based on augmented reality and human-computer interaction technology, a new mobile intelligent display system for remote consultation information is designed. Experiments show that the system reduces the power consumption of display and improves the quality of display image. However, the designed system is only used in mobile phones under Android operating system, and it does not support mobile phones with other operating systems. Future research will try to improve the compatibility of the system.

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