INFORMATION SECURITY DISPLAY SYSTEM ON ANDROID DEVICE

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ABSTRACT

With the arrival of the information era, there is ever increasing amount of secret information that need to be protected. This paper introduces an information security display system based on spatial psychovisual modulation (SPVM) on the android mobile platform. SPVM is a new paradigm of information display technology which is conceived as an interplay of signal processing, optoeletronics and psychophysics. Nowadays modern displays support very high pixel density. Meanwhile the human visual system (HVS) cannot distinguish image signals with spatial frequency above a certain threshold. Therefore, it is now possible for us to devise a type of information security display using the mismatch between resolutions of modern displays and HVS. In this system, there are two kinds of viewers, those authorized viewers with the viewing devices can see the secret information while those unauthorized viewers without the viewing devices only see disguise images. Thus, people can see different contents on the same display through different viewing devices. What is more, the development of stereoscopic display technologies has made lots of polarization based spatial multiplexing type of display devices available. So we choose the polarization based stereoscopic screen as the display in this information security display system. The information security display system, as a proof-of-concept and concrete implementation of the SPVM, attains remarkable performance in our experiments.

Index Terms— Spatial psychovisual modulation(SPVM), information security display, human visual system (HVS), display technology

1. INTRODUCTION

This paper presents an information security display system based on spatial psychovisual modulation (SPVM) [1] on the android mobile platform. Recently a new paradigm of information display, temporal psychovisual modulation (TPVM) [2] [3] was proposed, it utilizes the psychovisual redundancy in temporal domain of the modern optoelectronic displays. In TPVM, the display emit a set of atom frames which are amplitude modulated by liquid crystal (LC) glasses. LC glasses

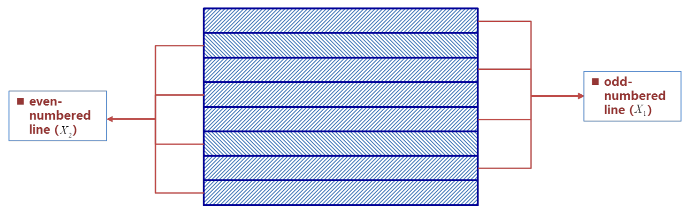

Fig. 1. The mechanism of the information security display system.

can control how much amount of light passing through. However, For most of people, flicker fusion frequency is about 60 Hz [4], so human visual system cannot resolve temporally rapidly changing signals beyond flicker fusion frequency. Before the atom frames entering the human visual system , they will be weighted by LC shutter based viewing devices that are synchronized with the display.

SPVM extends the idea of TPVM to spatial domain. Nowadays the mainstream display devices have very high pixel density that is far beyond the resolution of the human visual system. The current LCD screen usually provides High Definition resolution of 1920*1080. However the resolution limit of human eyes is about 300 PPI under normal viewing conditions. So there are lots of redundancy can be used. In this paper, we built the information security display system on passive stereoscopic display devices based on interlaced polarization by proposing the idea of SPVM to exploit the spatial redundancy of the screen. For such a stereoscopic display device, odd and even scan lines of the device are polarized in different directions. Using a pair of glasses with left and right eye matched to different polarization directions, the viewer can see the 3D illusion. The PPI of this type of screen is usually very high that the HVS cannot discriminate the mismatch between the left and right eye image. This type of display device makes it possible to broadcast a pair of frames simultaneously on the screen in odd and even lines. We use a pair of glasses with both eyes in the same polarization direction. We denote the view through this polarization glasses as glasses-aided view and the one watched directly from the screen as the normal view. Supposing a pair of images X_1 and X_2 are displayed in the odd and even lines simultaneous-

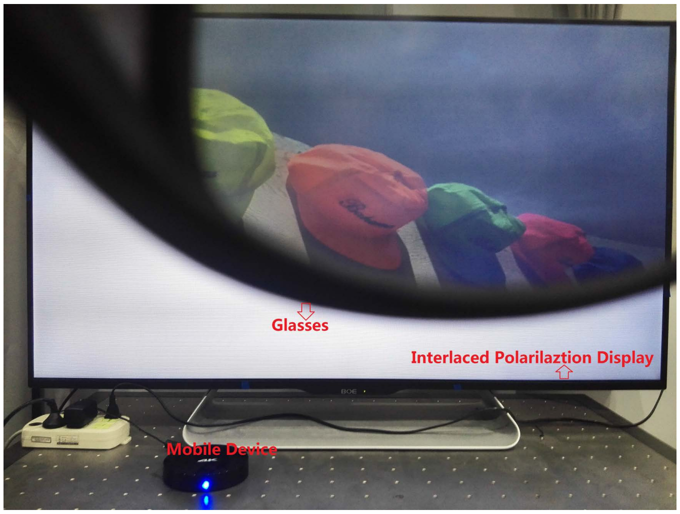

Fig. 2. Setup of the information security display system.

ly. Using a pair of glasses matched to the odd lines, we can see glasses-aided view X_1. With naked eyes, we see normal view $Y = X_1 + X_2$. The mechanism behind the information security display system is shown in Fig. 1.

Comparing to the LG's "Dual Play" system which using interlaced polarization to display two images [7] and the 3M's privacy filter [8], the previous one is actually a simultaneously screen sharing method for people with two kinds of polarization glasses matched to odd and even lines of the screen respectively. However, with this naive screen sharing technique, people without the polarization glasses can only get a meaningless view combining two views X_1 and X_2. The latter privacy filter limits the light emitted from the screen into a small angle. This viewing angle limitation type of solution might be sufficient for some daily usage, but it cannot prevent shoulder surfing from the back of the user [9]. Clearly, the proposed information security display solution offers better protection for the secret information [5] [6].

However, SPVM has just right solved the above drawbacks of information hiding system. For example, we can let frame X_1 be the secret message, then make another cover frame X_2 to cancel out X_1 in the normal view. In this way, the unauthorized viewers can only see a blank screen or some disguise image Y instead of the secret information. Meanwhile the authorized viewers can access the secret message by glasses matched to the polarization type of X_1. For example, to set the normal view a blank grey screen, we can set X_2 as the complement of X_1, i.e., X_2 = C $-$ X_1 with C is a constant. In that way, the normal view is simply $X_1 + X_2 = X_1 + C$ - $X_1 = C$. We can also choose X_2 properly and let the normal view be a meaningful disguise to confuse the bystanders. The remainder of this paper is organized as follows: Section 2 details the design and implement of the system. Section 3 introduces the system test and result analysis, and we finally conclude this paper in Section 4.

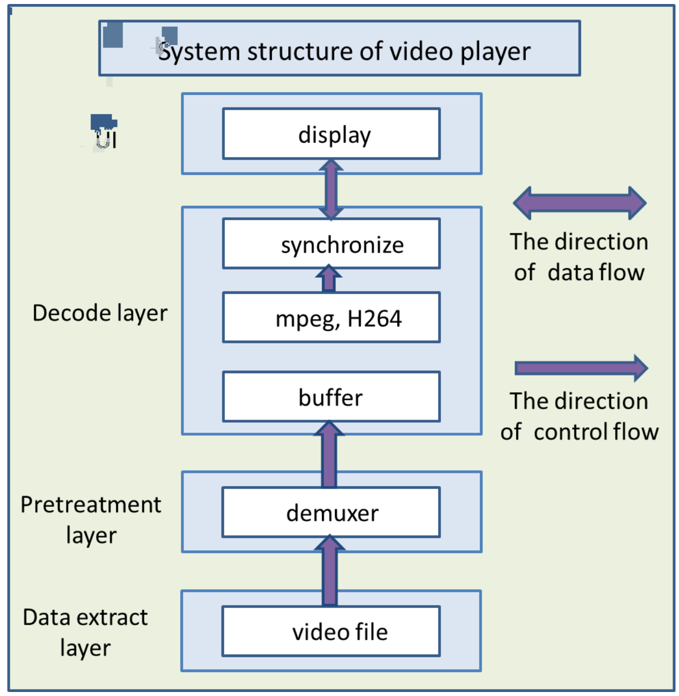

Fig. 3. The framework of the proposed system.

(a) (b) (c)

Fig. 4. The comparison by different mapping methods of the pixel value and brightness inverting. (a) is the original image. (b) is the image mapped by the pixel value inverting. (c) is the one mapped by the brightness value inverting.

2. DESIGN AND IMPLEMENTATION OF THE SYSTEM

2.1. System overview

Fig. 2 shows the component of the system. The system can be run on the android mobile devices, such as the android TV. Hardware of the information security display system utilized a polarization based on stereoscopic screen made by LG. For such a display device, odd and even scan lines of the device are polarized in different directions, so that the hidden information can be seen by the authorized viewer with the viewing glasses.

As shown in Fig. 3, it is the structure of this proposed system. Compared to the other operating systems, the an-

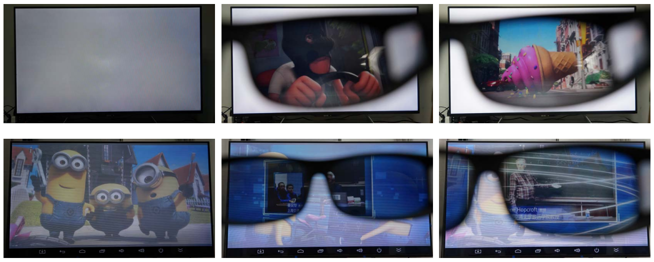

Fig. 5. Demonstration effect of the prototype information security display system. First row, a direct comparison of glass/glass-free views in video player application. Second row, the "Dual-view" by the views without glasses and the authorized viewers with the glasses.

droid system has a great advantage because of its portability and universality. The Android platform is the first integrate and open-source mobile software platform, which includes operating system, middleware, user interface and core applications. Nowadays the function of a mobile phone is powerful, playing a video on a mobile phone becomes a basic function, but the original media player in Android cannot meet people's need that is protecting their privacy, so the information security display application based on Android is needed intensively.

2.2. Design of the video player

In this system, we developed a information security display application on android mobile device based on SPVM. The system is implemented in Java language in the integrated development environment (IDE) called eclipse platform, using the android development tools (ADT) and android software development kit as the plugin.

2.2.1. Design of the framework of video player

To play video files, the video player should gather the media data first, decode the audio and video streams later, then display the data after decoding. According to the three steps, this paper designs a video player based on hiberarchy. In the three steps, video player needs to parse the coding format of the media file, decode the original data by the corresponding decode programs, put the original data to buffer queues and then display the original data after being synchronized. This video player is based on hiberarchy, which each layer completes its assignments by itself. This design reduces the application coupling. These layers from the top down are data extract layer, pretreatment layer, decode layer and the UI. The system structure and hiberarchy of the video player is shown in Fig. 3. Data extract layer is in charge of reading the media file. Pretreatment layer is to demux the media file and store the information of the media file into the buffer. Decode layer is to choose the corresponding decoder to decode audio streams

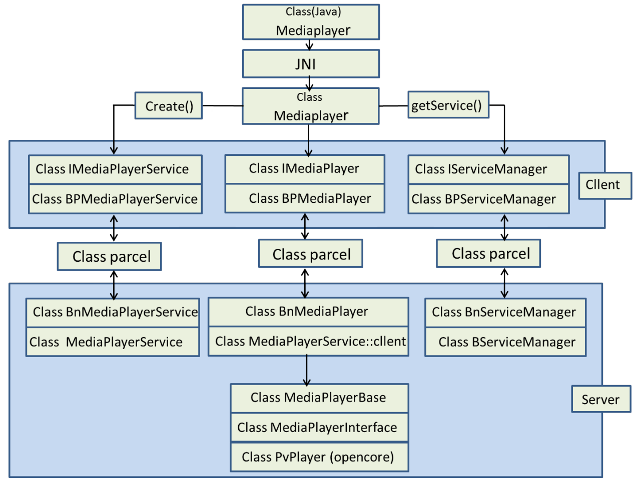

Fig. 6. MediaPlayer class hierarchy diagram of this video player.

and video streams, and then to synchronize the audio streams and the video streams. UI is for displaying the original data for users. UI provides the interface for interaction between users and video player, such as functions of play, pause, page down page up, etc.

2.2.2. Design of the decode layer

Decode layer is to separate decoders and the decoder choosing module. Before decoding, every format decode unit in decoders is a module, it is necessary to register all the formats which can be decoded by the module, then provide a link to connect a media format and the corresponding decode unit [10]. The main steps of the flow chat of this layer are as follows: first, we get the decodable information of audio and video streams, then choose the proper decoder to decode a frame data, finally we get the data after decode and send the data into the cache. The structure reduces the coupling of this layer and meanwhile increases its expansibility.

2.2.3. Design of the media layer

MediaPlayer is an important part of Android media framework. It is used to control the playback of Audio and Video. In this Android application, MediaPlayer can be roughly divided into two parts at run time: Client and Server. They are running in two separated processes. Binder is used to achieve Inter Process Communication (IPC). The Mediaplayerservice is a server-side implementation repository. MediaPlayer calls media playback capabilities provided by Opencore to implement video file playback. Opencore implements media file format and then outputs the media data. Opencore calls SurfaceFlinger interface to realize the display of video data. In the Android media layer, MediaPlayer class and its associated structures are shown in Fig. 6.

2.3. Implementation of the information display system

The key to information hiding of the information security display system is to get the cover image. To make the glasses-free view a blank gray screen, the normal view $Y = X_1 + X_2$ should be a constant number. For the 8-bit display device, the colors are represented by integer values range from 0 to 255. The direct way to compute X_2 is that $X_2 =$ 255-X_1. In that way, the pixel value of X_2 is also in [0, 255]. However, for an 8-bit image, the gray scale value is in [0, 255]. So X_1 and X_1 should be adjust to prevent the gray scale value overflowing. Meanwhile in practice, it is the brightness of X_1 and X_2 that are superimposed together rather than the pixel values [11]. On the other hand, for most display devices, the correlation between pixel value and brightness is not linear. Therefore, we utilize the Konica Minolta Display Color Analyzer CA-210 to measure the brightness of the BOE LE-55Z7000 monitor for each gray scale value. The brightness-pixel value correspondence is measured for red, green and blue channels independently. With those measurements, we first make a mapping table between gray scale value and brightness value. Based on the table, we find the complementary brightness values and the convert them back to the gray scale values.Fig. 4 shows the information hiding results based on gray scale values and brightness inverting respectively. Clearly, brightness based method can achieve much better result. On the interlaced screen, brightness of one pixel is deemed as the average of the two vertical adjacent pixels.

3. THE SYSTEM TEST AND RESULT ANALYSIS

As shown in Fig. 5, it illustrates the results of the information security display system. The first column of the figures show the views without LC glasses, the second and the third column present the views with the matched glasses. The first row make the view without glasses a blank and meaningless cover screen, and the viewers with the glasses can see the hidden videos. In this system, the viewers wearing different polarized glasses can see different images (called personal views). The viewers without polarized glasses can also see a semantically meaningful image (called shared view). And in this case, we design the personal view a tested video. It can be seen that both text and complicated visual contents can be effectively protected. The second row make the "Dual-view" come true, the glasses-free viewers can see the meaningful videos while the viewers can see the different hidden videos through the glasses.

4. CONCLUSION

In this paper, we make the concept of SPVM come into realization with programming on the polarization based stereoscopic screen. With this system, the authorized visitors with the glasses can see the video and images on the screen at any time while others without the polarized glasses can only see a constant gray screen. Meanwhile the system can simultaneously play two different videos, so the viewers without glasses can see the video, and the authorized viewers can see the hidden video to make the real "Dual View" come true. What's more, visitors with different polarized glasses can see different contents on the same display screen at the same time. people can experience the magic effect of the information hiding technology wherever in the indoors or outdoors. Particularly, it's so convenient for the office workers to read the important emails and documents in the public safely.

5. ACKNOWLEDGMENT

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