INFORMATION SECURITY DISPLAY SYSTEM ON ANDROID DEVICE

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ABSTRACT

With the development of the modern technology, there is increasing a lot of important secret information to be protected. In this paper, an information security display system based on spatial psychovisual modulation (SPVM) is introduced on the android mobile platform. SPVM is a new way 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 the image signals with spatial frequency more than a certain threshold. By this idea, we can design a new information security display system by utilizing the inconformity between HVS and the modern displays' resolutions. In this system, two types of viewers are defined, the first viewers wearing a pair of polarized glasses are authorized to see the secret information, however the second unauthorized naked-eye viewers without glasses can only see the disguise images. Thus, the different contents on the same display can be seen through different viewing devices. What is more, the increasing stereoscopic display technologies drive amounts of polarization based spatial multiplexing 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 guidance and concrete implementation of SPVM, attains remarkable performance in our experiments.

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

1. INTRODUCTION

We in this paper present an information security display system based on spatial psychovisual modulation (SPVM) [1] on the android mobile platform. Recently a new way of information display technology, Temporal Psychovisual Modulation (TPVM) [2] [3] has been 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 synchronized active liquid crystal (LC) glasses, which can control how much amount of light passing through. However, it has been acknowledgeable that the flicker fusion frequency for most people is approximately 60 Hz [4], so the temporally rapidly changing signals can not be resolved successfully by human visual system (HVS) when the signals are beyond the flicker fusion frequency. Before the atom frames entering the human visual system, they will be weighted by LC shutter based on the viewing screen.

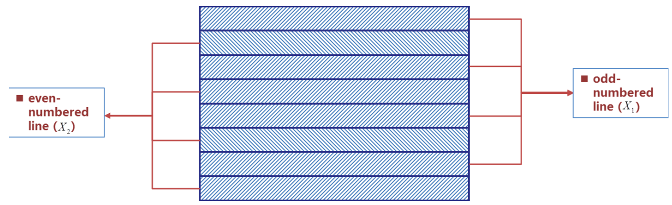

Fig. 1. The mechanism of the information security display system.

Nowadays, modern display has very high pixel density [5] (e.g., Sony Xperia Z5 Premium is 801.06 ppi), which is far beyond the limit that HVS can resolve. Human eyes without aided generally is difficult to differentiate detail beyond 300 ppi. Moreover, generally people view the display screen in a farther distance than the idea condition. So a high pixel density display has psychovisual redundancy in spatial domain that also can be explored to generate different visual views for different viewers concurrently.

The idea of TPVM can be extended to the spatial domain and get the SPVM. Currently the pixel density of the mainstream display screens is so high [5] (e.g., Sony Xperia Z5 Premium is 801.06 ppi), which is far beyond the limit that HVS can resolve. The current LCD screen usually provides High Definition resolution of 1920*1080. However under the condition of normal viewing, human eyes without aided generally is difficult to differentiate detail beyond 300 Pixel Per Inch (PPI). Moreover, a high pixel density display has psychovisual redundancy in spatial domain that also can be explored to generate different visual views for different viewers concurrently. In this paper, the information security display system is designed on the passive stereoscopic display devices, which is based on the interlaced polarization by utilizing the spatial redundancy of display screen. For such a stereoscopic

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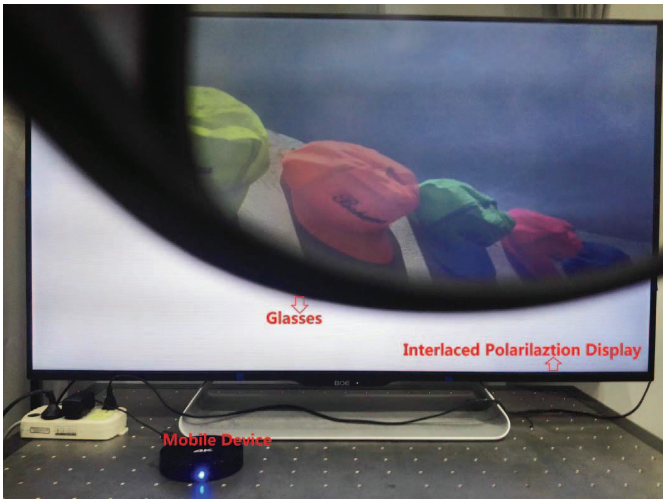

Fig. 2. Setup of the information security display system.

display device, the polarized directions are different on even and odd rows of the display device. The viewers can perceive the 3D depth with the help of a pair of stereo glasses to match the left and right eyes of people to different polarization directions. The pixel density of the kind of screen is usually too high to distinguish the mismatch between the right-eye image and left-eye image for the HVS. Therefor it is possible for the kind of display to emit concurrently a pair of frames in odd and even lines of the screen. Supposing a couple of frames X_1 and X_2 are respectively displayed in the odd and even rows simultaneously. Here we define the view seen by the viewers wearing the polarized glasses as the *personal view* and the view seen for naked-eye viewers not wearing glasses as the *shared view*. Firstly we matched the polarized glasses to the odd rows of the screen, and we can see the *personal view* X_1. If not wearing the polarized glasses, we can see the *shared 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 and the privacy filter of 3M company, the previous one is actually a simultaneously screen sharing approach for the viewers wearing the polarization glasses matched respectively to odd rows and even rows of the viewing screen. Nevertheless, the naive screen sharing technique exists a fatal flaw, that is the naked-eye viewers not wearing glasses cannot see a semantically meaningful image. The latter one is to utilize a privacy filter, which is a micro-louvre that reduces the visibility angles to fence spectators. All these solutions based on the limitation of viewing angle still cannot prevent peeking from behind [1]. Compared with the above solutions, the information security display system we proposed provides the better performance to protect the secret information [6] [7].

However, SPVM has just right solved the above drawbacks of information hiding system. We can take a concrete example here, we have denoted the image X_1 as the *personal*

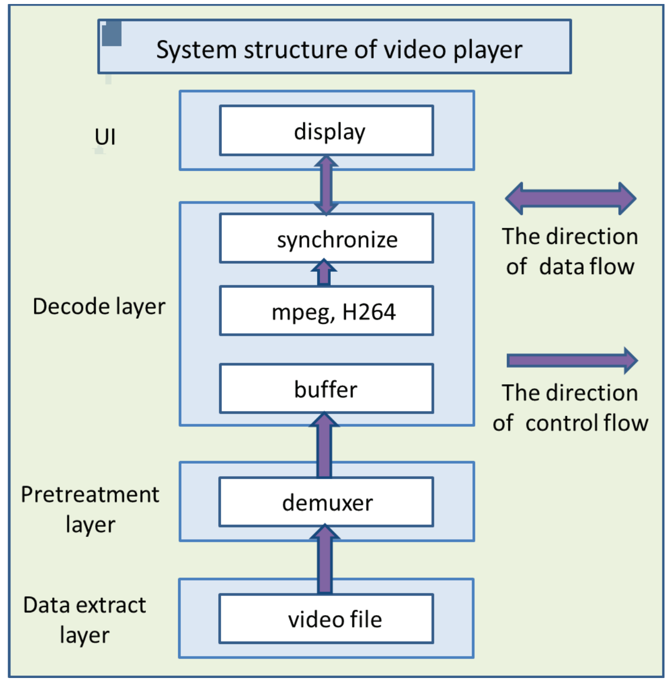

Fig. 3. The framework of the proposed system.

(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.

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

view to present the secret inforamtion. We denote the MAX_b as the brightest pixel of all the possible pixels. And the image X_2 are denoted as the compensated image to cancel out the frame X_1 in the *shared view*. Therefore, the image X_2 is the negative of the image X_1 and can written as $X_2 = MAX_b - X_1$. Further we can get the *shared view* $Y = X_1 + X_2 = X_1 + MAX_b - X_1 = MAX_b$, with the MAX_b is a constant. In this way, the viewers not wearing polarized glasses would perceive a gray image Y and the secret information is invisible for them . Meanwhile the naked-eye viewers wearing polarized glasses can perceive the hiding information using the glasses matched to the polarization type of X_1. The rest of the paper is organized as follows: Section 2 details the design and implementation of our system. Section 3 introduces the system test and result analysis, and we finally conclude this paper in Section 4.

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 our information display application utilized an ordinary stereoscopic polarization screen. For such a display device, the polarized directions of the even row and odd row are different, so that the hidden information can be seen by the authorized viewers with the polarized glasses.

As shown in Fig. 3, it is the structure of this proposed system. Compared to the other operating systems, the android system has a great advantage because of its portability and universality. The Android platform consists of operating system, middleware, user interface and core applications, which is the first integrate mobile software platform. Nowadays the mobile phone has powerful functions, which one of the most popular of them is the playback of video, however the original media player cannot satisfy our 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 software development kit and android development tools (ADT) as the plugin.

2.2.1. *Design of the framework of video player*

To order to play the media files, the video player should do three steps, that is, collect the necessary media datum, decode the audio and video streams and show the decoded datum on the screen. In this way, we design a video media player based

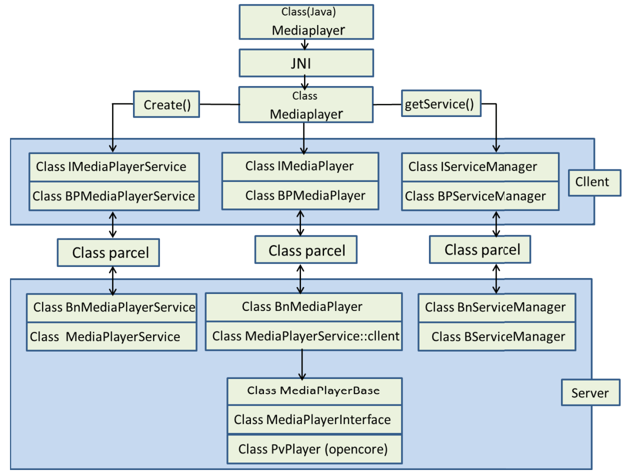

Fig. 6. MediaPlayer class hierarchy diagram of this video player.

on the kind of hiberarchy, which each layer finishes its respectively tasks. The layers from the down top are respectively the UI, the decode layer, pretreatment layer and the data extract layer. The system structure and hiberarchy of the video player is shown in Fig. 3. In this system, data extract layer is responsible for reading the video files. Pretreatment layer is to demux the media file and store the information of the media file into the buffer. The audio and video streams are decoded by the decode layer is to choose the corresponding decoder. The user interface is for displaying the above generated data. What is more, UI provides the interface for interaction between users and video player.

2.2.2. *Design of the decode layer*

The decode layer is used to part the decoder choosing module and the decoders. Before decoding, every format decode unit in decoders is a module. Therefore it is necessary for registering the formats that decoded by the module and then it will also provide a specific link to connect the corresponding decode unit [8] and the media format. The main steps of the flow chat of this layer are as follows: first, we get the decodable information of audio streams 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.

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 is make up of the Client and the Server when it runs. Meanwhile they usually are running in two uncrossed processes. The 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. In the Android media layer, as shown in Fig. 6, it has presented the abovementioned MediaPlayer class and its associated structures.

2.3. Implementation of the information display system

The core to realize the information hiding of our information security display system is to generate a compensated image to cancel out the X_1. In this system, in order to make the *shared view* a total gray image, the *shared view* $Y = X_1 + X_2$ should be set to a constant value. For an 8-bit display device, all the possible brightness value are within the range from 0 to 255. Therefore the straightforward way to compute X_2 is that $X_2 = 255$-X_1. As similar before, all the possible pixel values of X_2 are also in [0, 255]. Nevertheless, the gray scale value is also in [0, 255] of an 8-bit image. So we should adjust X_1 and X_1 to prevent the gray scale value overflowing. Meanwhile, it should be pointed out that in this system the brightness of image X_1 and image X_2 are superimposed together instead of the pixel values because the correlation between brightness values and the pixel values are nonlinear for most display devices. Therefore, we utilize a device to measure the brightness values of the viewing screen for each gray scale value. What is more, the correspondence between the brightness values and the gray pixel values is measured respectively for red, green and blue channels. With those measurements, a mapping table has been made in the process of implementation between brightness values and gray scale values. We will find the complementary brightness values and the mapped them back again to the gray scale values based on the above mapping table.Fig. 4 shows the performance of the information hiding effect based on the gray scale values and brightness values respectively. By observing this figure, we can get the conclusion that the we can achieve a better performance by using the curve of the brightness and gray values mapping approach.

3. THE SYSTEM TEST AND RESULT ANALYSIS

As shown in Fig. 5, it illustrates the performance of our information security display application. 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*). In this way, we have designed the *personal view* a tested video. Experimental results show that most complicated visual contents, e.g. figures and characters, can be effectively protected in our system. The second row makes 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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