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SmartQR: a new interactive system based on QR code for smart TV[1]

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Abstract. QR code (Quick Response code) embedded in TV content is popular nowadays, especially with smart TV. In current smart TV interactive system based on QR code, scanning is the single way for audiences to interact with TV content, which leads to high cost of action, blocking others, exposure privacy and inconvenience for the disabled. To solve these problems, we presented smartQR, by which audiences can stay in couch and obtain the QR code without scanning. SmartQR consists of two parts, mobile-end and smart-TV-end. When an audience clicks a button on the mobile device, Smart TV screenshots the image on the screen and sends it to mobile-end. After receiving the image, the mobile-end processes the image and parses the content encoded in QR code. Finally, the mobile-end makes an appropriate feedback. We conducted an evaluation experiment and found out smartQR interactive system improved user experience when interacting with smart TV by using QR code

Key words. Human-machine interaction, QR code, smart TV, user experience.

1. Introduction

The QR code is a two-dimensional (2D) matrix code introduced in 1994. With the tremendous development of mobile internet and smart phones, QR code has been ubiquitously gained wide acceptance for its convenience, error correction [1], such as posters, packages, webpages and sharing bikes. In recent years, QR code has been applied in television videos [2] and advertising [3] as an interface connecting audiences and video makers or advertisers, usually by offering a web link or a follow-us link [4] for audiences' further learning.

QR code provides audiences with unique cross-screen interaction experience, which can make sure that audiences can participate in real time. However, the current interaction pattern is not smart enough in enabling audiences a seamless

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interaction with television. One example is TV shopping, in which audiences can purchase a product by scanning the QR code on the TV screen if they see an attractive item. Audiences would have a more efficient interaction with TV content being streamed, if the smart phones can get the QR code automatically. This paper presents a new natural method for audiences to interact with the TV content through QR code. The new method is aimed to enhance user experiences by shortening time, avoiding blocking line for audiences, and helping the disabled to interact with TV content.

2. Investigation of the current interaction system

We carried out an investigation on how audiences reacted when scanning the QR code embedded in the TV content. There are mainly two kinds of QR codes by size, small ones and big ones. Given a fact that small QR codes have a much higher property of appearance, this investigation mainly focus on small QR code. Through the investigation, we find out four problems on QR code interaction with TV when audiences want to scan it as follows.

(1) High cost of action.

Compared to other scanning method (e.g. logging in WeChat on the web page or paying by Alipay), audiences must get up out of the sofa to get close to TV screen and aim the camera at the QR code. Moving forward is essential when audiences are accustomed to watch TV comfortably. Meanwhile, exclusive physical actions go against the principle of the newest Android TV OS launched by Google whose core concept is "lean back". High cost of action may reduce their willingness to scan the QR codes.

(2) Blocking

In multi-user scenario, there are two kinds of blocking, scanning blocking and watching blocking. When several users scan a QR code at the same time, the front ones inevitably block those scanning behind. For example, at a moment when the television program reaches an interactive climax, audiences will try to scan the same QR code, which we call it a blocking situation. Meanwhile, those who move close to TV block the view of those who do not scan and stay, which influence their watching badly.

(3) Privacy

Scanning QR code with a mobile device in front of others will expose their privacy to some extent. Concerning over privacy exposure, audiences may give up scanning QR code. For example, when several audiences are watching a commercial, which allows audiences learn more or buy a product by scanning a QR code embedded in the commercial, an interested audience may not scan, afraid of others knowing it.

(4) The disabled unable to be involved

For the disabled, mainly referring to the visually impaired and mobility impaired, scanning an unobvious QR code from a giant TV screen is an enormous challenge. Al-Khalifa and Hend introduced a QR code system helping the visually impaired identify objects in the environment [5]. In static scenes, the position of QR code is almost unchanged and people can keep trying until they succeed in scanning QR

code, which is impossible in TV scanning scene. The QR code showing in TV has not a fixed position but a time limit. The mobility impaired do not even think about scanning QR code. By analyzing the problems in the interaction process, we found out that the interactive action between the audiences and the TV QR code is scanning and scanning is the only way to obtain the TV QR code. The scanning behavior directly leads to the above interaction problems. In view of this conclusion, the scanning interaction is removed from the interactive system proposed in this paper.

3. Proposed interactive system

After the scene analysis in current interactive system, we improve the current TV cross-screen interactive system and propose a new one based on smart TV. The smart TV cross-screen interactive system based on QR code avoids the disadvantages and solves the problems.

3.1. System architecture

The interactive system contains mobile-end software and smart-TV-end software, which can establish a connection through local area network and communicate with Socket. The mobile-end runs as a client, and the smart TV runs as a server, so multiple mobiles can be connected to a smart TV.

The mobile-end software contains order module, receiving image module, image preprocessing module, QR code detection module and feedback module. The smart TV end software contains order receiving module, screenshot module and image sending module. Figure 1 shows the system architecture.

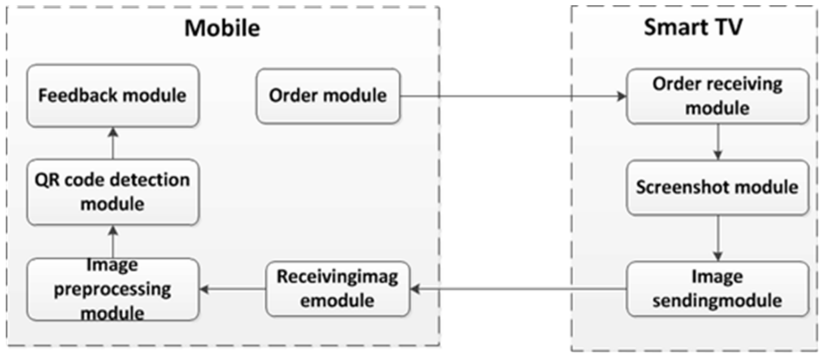

Fig. 1. System architecture of smartQR

When a user clicks the "obtain QR code" button, mobile device sends an order to smart TV. After smart TV receives the order, it will launch its screenshot module. After screenshot module gets screen image in real time, smart TV will send it to mobile device. Then receiving image module in mobile software receives the image. Image preprocessing module includes image graying, noise reduction and binary.

After the image is preprocessed, the QR code detection module will detect the QR code's location and recognize it. Finally, the feedback module shows a corresponding page according to the content encoded in QR code.

3.2. System implementation

3.2.1. Socket connection. Compared with UDP transport protocol, TCP transport protocol can guarantee the correctness of data and sequence. The smart TV interactive system based on QR code use connection oriented TCP protocol to achieve reliable transmission. When a mobile device (here we take a phone as an example) and smart TV connected to the same LAN, the phone software can use the address scanning program to discover the smart TV and obtain the IP address of the smart TV. The phone sends a request of Socket connection to smart TV. Once the smart TV receives the connection request, smart TV will add this request to the request list and open a new Socket channel. Smart TV continues to monitor the status of the connection with the phone. When the socket connection is broken, the smart TV terminates its processes associated with the phone.

3.2.2. Screenshot. Screenshot is a beneficial feature that helps users to depict whatever is on the screen and extends the scope of content people communicate with smart phones, not limited in text or saved pictures but what is on their screen. Screenshot offers a better user perceived experience [6]. The screenshot capability is available in the version of Android 4.0 and later versions.

This paper chose a proper method out of several implementations in Android system. Obtain the root layout of the current screen from Android system and define it as a view. This implementation is simple and the gotten screenshot eliminates its status bar, which is applicable to smart TV.

3.2.3. Grayscale. The image getting from the smart TV is in RGB format. Color Image has too much information for a phone to process directly, because image processing calculation amount is large. Meanwhile, QR code detection requires no color information. So, we need change the Image to grayscale which only has brightness information before processing the image. In this paper, we use the weighted average method to convert the original image to gray, calculating as follows:

$$w = 0.30 \times r + 0.59 \times g + 0.11 \times b\,, \tag{1}$$

where r, g and b are, respectively, the intensity value of the color pixel's red, green, blue component, w is the gray value of the grayscale pixel. All these values are in the range [0,255].

3.2.4. Noise reduction. Image noise will drown image features and influence the following QR code detection. It's necessary to eliminate noise. In this paper, we use the media filter method for its capability of preserving image edges.

The median filter (MF) is the most popular non-linear filter used for removing salt and pepper noise in image processing applications [7]. The principle is running

the filter window pixel by pixel and replacing each pixel with the median of pixels in the window.

3.2.5. Binarization

In this paper we use OTSU method (the Method of Maximum Classes Square Error) [8]. OTSU is an image segmentation method which selects the gray-level threshold by maximizing the between-class variance of pixel values and then extended to two-dimension by utilizing a joint histogram of pixels and its neighbor pixels.

OTSU threshold is used to determine whether a pixel is the foreground or background region. Suppose T is the segmentation threshold of foreground and background, the ratio of foreground pixels in the image is w_0, the average gray value of foreground is u_0, and the ratio of background pixels in the image is w_1, the average gray value of background is u_1. Then we can get the average gray value of the whole image u as

$$u = w_0 \times u_0 + w_1 \times u_1 \,. \tag{2}$$

and the classes square error σ^2 is

$$\sigma^2 = w_0 \times (u_0 - u)^2 + w_1 \times (u_1 - u)^2 \,. \tag{3}$$

Traverse t from minimum to maximum of gray value, when σ^2 reaches it maximum value, then T is the desired value.

3.3. QR code detection

Every QR code composes black and white, including coding regions and many function graphic. There are three finder patterns in the upper-left, upper-right, bottom-left corner. Each finder pattern consists of three black and white concentric squares. The outermost square size has 7×7 modules, the middle square 5×5 modules and the innermost square 3×3 modules. Finder pattern (see Fig. 2) can keep the ratio maintained at 1:1:3:1:1 from all directions. This ratio does not vary with the size of the QR code or rotation angle. Considering the composition of QR code structure, the probability that an image with such a proportional feature appears at other locations is impossible.

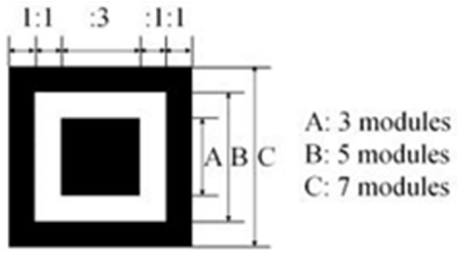

Fig. 2. The structure of finder pattern

4. Interactive process and evaluation experiment

The smart TV cross-screen interactive system based on QR code contains both mobile-end and smart-TV-end. The mobile-end interacts with users directly. The UI (user interface) in mobile software mainly has a button which allows users to obtain the QR code showing on the smart TV screen, while the software running in smart TV has not any UI pages for all its servers run in the background. The interactive process of smartQR is depicted in Fig. 3.

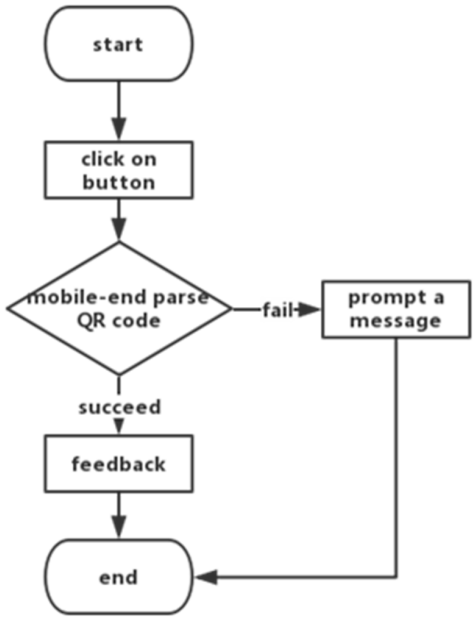

Fig. 3. Interactive process of smartQR

A user sends an order of obtaining QR code by clicking on the button on the phone. When the phone has the access to the QR code, it will make an appropriate feedback. For example, when the phone parses a QR code and gets a text, it just shows the text, if it gets a network link, it will launch a browser open the link. While the phone failed to obtain or parse a QR code, it will prompt the user with a message in the form of Toast.

We recruited 10 users (3 females, 1 visually impaired and 1 behavior impaired), aged between 20 and 40 years (mean=25). Participates were required to watch a video with 10 QR codes embedded randomly and use two different method to obtain the QR codes respectively. One is the current scanning system, here we used a QR code scanner software as a representative, the other is the proposed interactive system. 9 out of 10 have scanning QR code experience with a smart phone.

We recorded everyone's operating data. The average completion time of each participant is shown in Table 1. Overall, using the smartQR interactive system,

participants need less time to interact with TV content (mean = 0.44 seconds compared to 6.55 seconds using scanning interactive system on average). Furthermore, participants had a higher success rate (mean=51 % compared to 89 % with scanning interactive system).

Table 1. Comparison of average completion time between current interactive system and smartQR

	1	2	3	4	5	6	7	8	9	10
Current	5.39	7.02	5.82	6.47	6.29	4.91	5.72	6.29	17.64	10
SmartQR	0.42	0.47	0.44	0.44	0.43	0.46	0.46	0.43	0.45	0.44

Among them, number 9 is visually impaired and number 10 is mobility impaired. From their data comparison, we learned smartQR interactive system can improve the visually impaired performance and make the mobility impaired like normal one. In the following multi-user experiment, result was also desired. There is no blocking in smartQR interactive system.

Finally, all these participants were asked to complete a questionnaire with 5-point Likert-scale questions and debrief their thoughts.

5. Conclusion

In this paper, we presented smartQR, a new interactive system for smart TV based on QR code. After analyzing the shortages of the current interactive system based on QR code, smartQR eliminates the scanning procedure. We evaluated smartQR with 10 users and found that, compared with the current cross-screen interactive system based on QR code, smartQR offered better user experience in four ways, such as cost of action, blocking, privacy and inconvenience for the disabled people.

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