An Efficient QR-code Authentication Protocol using Visual Cryptography for Securing Ubiquitous Multimedia Communications

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Abstract

Background: Now a day, data communication plays a vital role in day-to-day life. There is a strong desire to develop and implement more secure authentication protocol to protect secret information against security threats. Method: The paper proposes a Quick Response (QR) code Authentication Protocol (QRAP) using Visual Cryptography. Visual Cryptography (VC) is a model of cryptography split the secret into share images, which prevents the secret image from being altered by using the concepts of the cipher and can reconstruct the secret image by stacking the legitimate share images. Findings: The passwords for authentication are encoded as QR-codes and later encrypted into colour share images. Thus, the colour share images by itself convey no information, but when the shares are combined, the secret password can be revealed. The necessary is that the user needs to handle a device containing a QR-code reader, most probably a Smartphone. The experimental result shows that the proposed QRAP scheme provides secure data communication with less computational complexity. Applications/Improvement: This research work can give a way for providing authentication to all services which are related to electronic devices.

Keywords: QR Codes, Security, Visual Cryptography, Visual Secret Sharing

1. Introduction

Recent Internet technology ranges from low-speed applications to high-speed multimedia applications. Naor and Shamir scheme describes the principles of Visual Secret Sharing (VSS) to generate two shares by the perfect combination of black and white pixels according to the secret image. K out of N Visual Cryptography schemes but unable to get any secret information by stacking a less number of favorable shares. Multi-secret scheme is to share more than one secret image in two random shadows. Image Size Invariant Visual Cryptography scheme minimized the size of share images, by invariant visual secret sharing scheme. Young-Chang scheme describes that different cover images can be used for hiding secret images and has focused on the image quality of the share images. Visual protection scheme concentrated on the verification of encryption scheme of content protection and the techniques were proposed for handheld devices based on video coding but failed to work on authentication during transmission of videos. Optimal Contrast Grayscale Visual Cryptography Scheme satisfied user requirements and proposed a technique to use a minimum number of shares, it was given only for grayscale images and half-tone images and not for colour images. A Lossless Tagged Visual Cryptography Scheme uses k-1 specific shares and embedding tag images to improve the contrast of our proposed QRAP Will focus on improving better contrast for the colour images and thereby increase the quality of the colour image. The method called binocular VCS for secure data transmission, and it provided an optimization...
model for the improvement of quality \(^9\). The Novel Visual Cryptography without pixel expansion scheme focused only on the improvement of the quality of halftone images by the technique called extended VC, did not focus on the colour images \(^{10}\). The schemes \(^5\) – \(^9\) are applied to grayscale and colour images, which uses to carry out the work of generating shares with higher efficiency.

2. Materials and Methods

The proposed work focuses on making improvement in the authentication ability using VC. The QRAP proposes an introduced system of sharing the QR images for authentication using Visual Cryptography. The basic idea is to authenticate between two devices, and the proposed method describes three phases. First, share generation phase, each connecting device creates the QR secret image which is same as of the original, cover images and creates the share images. Second is the Service Request Phase. In this, one device sends the service request to the other device. Another device accepts the request and both devices exchange their share images to each other. Finally, confirmation phase, which reveals the secret QR image from the two share images that say, from the one share it already has and the one received from the other device by using XOR operation and checks with the secret image. Figure 1 shows a complete illustration of QRAP protocol.

![Figure 1. Block diagram of QRAP protocol.](image-url)
2.1 Share Construction Phase

**Input:** The secret QR colour image I and cover image CI1, CI2.

**Output:** Shares generated S1, S2.

Step 1: Consider secret QR colour image (I) and multi-channel (colour) image as the cover up images CI1 and CI2; then,

\[ [I] \rightarrow RGB \rightarrow I^R, I^G, I^B \]
\[ [CI_1] \rightarrow RGB \rightarrow CI_1^R, CI_1^G, CI_1^B \]
\[ [CI_2] \rightarrow RGB \rightarrow CI_2^R, CI_2^G, CI_2^B \]

\[ I, CI_1, CI_2 \in \{0,1,2,3, \ldots, 255\} \]

Step 2: Construct a half-tone image (HI) by applying the error diffusion technique on the secret QR colour image;

\[ I^*, I^G, I^B \rightarrow ED \rightarrow HI^R, HI^G, HI^B \]

Step 3. Construct the shares S1 and S2 from HI by using SHARE_GEN algorithm; now, S1 and S2 shares will have the pixel expansion of three and assures that the secret information can be restored completely after stacking from the shares. Shares are delivered to the receiver.

**Algorithm 1: Shares Generation**

For specified matrix CI1, CI2 and HI of size (m x n).

Then shares S1 and S2 be empty (unfilled) as size of m x 3n.

**function SHARE_GEN** (HI, CI1, CI2)

\[ I^R, I^S, I^B \rightarrow 1 \]
\[ CI_1^R, CI_1^G, CI_1^B \rightarrow CI_1 \]
\[ CI_2^R, CI_2^G, CI_2^B \rightarrow CI_2 \]
\[ S_1^R, S_2^R \leftarrow ISHARE (I^R, CI_1^R, CI_2^R) \]
\[ S_1^G, S_2^G \leftarrow ISHARE (I^G, CI_1^G, CI_2^G) \]
\[ S_1^B, S_2^B \leftarrow ISHARE (I^B, CI_1^B, CI_2^B) \]

**end function**

**2.2 Revealing Phase**

**Step 1.** Let the share images S1, S2.

**Step 2.** The share images SH1 and SH2 can be derived from S1, S2 using REVEAL_PHASE algorithm. Now, shares have the pixel expansion of 3 as of I.

**Step 3.** To generate the reconstructed half-tone Image HI', digitally stacking the share images S1 and S2 by XOR operation.

**Step 4.** The inverse halftoning technique applied to HI' to generate the reconstructed secret Image RI; HI extracted during the revealing phase could be either original image or noise-like image based on whether the received images are original or fake one. Let d be the difference between I and RI, i.e., d = I - RI. If d is equal to zero, it shows RI is completely restored from HI' by inverse half-toning technique.

**Algorithm 2: Revealing Secret Image**

For given matrices S1, S2 of size (m x n).

Let shares SH1 and SH2 be empty as size of m x n/3.

**procedure REVEAL_PHASE** (S1, S2) S1^R, S1^G, S1^B \leftarrow S_1 \ S2^R, S2^G, S2^B \leftarrow S_2

RI^R \leftarrow REVEAL_IMAGE(S1^R, S2^R)
RI^G \leftarrow REVEAL_IMAGE(S1^G, S2^G)
RI^B \leftarrow REVEAL_IMAGE(S1^B, S2^B)

**function** [SH1, SH2] \leftarrow RIMAGE(S1, S2)

for i = 1 to m do
for j = 1 to n do
R1 = S1(i,j) + S2(i,j)
R2 = S1(i,j) - S2(i,j)
end if

end function
SH\_1i,(2\*j-1)=255
SH\_1i,(2\*j)=0
SH\_2i,(2\*j-1)=255
SH\_2i,(2\*j)=0
else if(R1==-1 and R2==-1)
SH\_1i,(2\*j-1)=0
SH\_1i,(2\*j)=255
SH\_2i,(2\*j-1)=0
SH\_2i,(2\*j)=255
else if(R1==1 and R2==-1)
SH\_1i,(2\*j-1)=255
SH\_1i,(2\*j)=0
SH\_2i,(2\*j-1)=0
SH\_2i,(2\*j)=255
else if(R1==-1 and R2==1)
SH\_1i,(2\*j-1)=0
SH\_1i,(2\*j)=255
SH\_2i,(2\*j-1)=255
SH\_2i,(2\*j)=0
end for
end for
RI ← BITXOR(SH\_1, SH\_2)
return RI
end function
RI ← RI\_P, RI\_G, RI\_B
end procedure

3. Experimental Results

Experimental results demonstrate on three objectives. First, the robustness of the algorithm; secondly, construct the original secret image with high quality and lastly, less computational time. The proposed QRAP allows no limitation on the size of the secret images. The set of QR test images and data are shown in Figure 2 illustrates that QAP can perform well on colour images.
The performance of the proposed method listed in this paper is tested by coding and running the algorithm in MATLAB 7.10 Tool. The image quality measures such as Normalized Correlation (NC) and Peak Signal to Noise Ratio (PSNR) are evaluated between reconstructed images as well as original secret images using following equations:

**Peak Signal to Noise Ratio (PSNR):** It is defined as the maximum possible power of a signal to the power of corrupting noise that affects the fidelity of its representation. PSNR is expressed regarding the logarithmic decibel is given by,

$$PSNR = 10 \log \left( \frac{2^n - 1}{MSE} \right)$$

**Normalized Correlation (NC):** It measures the similarity between the original image and reconstructed image.

$$NC = \frac{\sum_{i=1}^{M} \sum_{j=1}^{N} (I(i, j)I'(i, j))}{\sum_{i=1}^{M} \sum_{j=1}^{N} (I(i, j))^2}$$

where, $I(i, j)$ is original image and $I'(i, j)$ is decrypted image, $M$ is height and $N$ is width of the image.

Figure 3(a), (b), (c), (d), (e) and (f) shows QR1 secret image, Lena, and Baboon which are cover images, Share1, Share2 and reconstructed QR1 secret image. Table 1 depicts the performance analysis between original images and reconstructed images. The graph of the various reconstructed quality measures for the QR image is shown in Figure 4. The PSNR values range from 30.23 to 32.52 dB. From the result of PSNR and NC values, the quality of the reconstructed QR image is maintained as the original secret image. Table 2 shows the time was taken to run the algorithm for different images.
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4. Conclusion

Proposed QRAP protocol gives a new way for authentication by using QR code colour images. The proposed protocol adds a layer of security in authentication. Visual cryptography methodology increases the level of security. Many advanced applications, where there are demands for high-level security in an efficient manner can use the proposed QRAP protocol.

5. References

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