PSNR can be easily derived from mean-squared error (MSE) as follows:

$$PSNR = 10\log_{10}\frac{I_{MAX}^2}{MSE} \tag{11}$$

where $I_{MAX} = 255$, as the maximum possible value of a pixel in the gray scale images or a color in the color images is 255. PSNR is measured in decibels (dB). MSE between two images i(x,y) and g(x,y) is defined as

$$MSE = \frac{1}{R \times C \times L}\sum_{i=1}^{R}\sum_{j=1}^{C}\sum_{k=1}^{L}(I_{i,j,k} - G_{i,j,k}|)^2. \tag{12}$$

where $I_{i,j,k}$ is original image pixels and $G_{i,j,k}$ is generated image pixels. The higher the PSNR, the better the quality of image is expected. PSNR has shown poor performance compared to other quality metrics when it comes to estimating the quality of images perceived by humans.

SSIM [23] measures the similarity between two images based on structural information changes in images and generates SSIM map. Bright region in SSIM map indicates similarity, while dark region indicates distortion or degradation. The SSIM index between two windows x and y y of common size $N \times N$ is calculated as:

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x{}^2 + \mu_y{}^2 + c_1)(\sigma_x{}^2 + \sigma_y{}^2 + c_2)} \tag{13}$$

where μ_x = average of x, μ_y = average of y, $\sigma_x{}^2$ = variance of x, $\sigma_y{}^2$ = variance of y, σ_{xy} = covariance of x and y and $c_1 = (k_1L)^2, c_2 = (k_2L)^2$, two variables to stabilize the division with weak denominator.

Most-apparent distortion (MAD) [24] models two HVS strategies, namely distortion-based strategy and appearance-based strategy, to determine the quality of images. The combination of these two strategies better predicts the subjective ratings of image quality. MAD yields two quality scores namely visibility-weighted error and the differences in log gabor sub-bands statistics. The average values of PSNR, SSIM and MAD for the generated QR codes are presented in Table 3.

Table 3: Evaluation of proposed method using quality metrices.

Images	Quality Metrices		
	PSNR	SSIM	MAD
Einstein	21.83	0.73	123.79
Lenna	18.75	0.91	143.16
Beetle	11.87	0.64	189.83
BMW	12.60	0.68	175.78
Kumu	16.34	0.82	150.12

4.3 Visual Quality of Image Blending

To evaluate the visual appearance of the generated QR code, first, a scoring system is designed. There are five levels in the scoring system including disastrous, poor, moderate, excellent and divine corresponding to the levels ranging from 1 to 5 as shown in Table 4. Then, fifty students (30 male students and 20 female students) of our department from different semesters who are not engaged in this work were invited to give their assessment about the visual quality of the QR codes generated from Visualead [14], Halftone [16] and proposed method . The QR codes generated using proposed algorithm, [14] and [16] are presented for comparison in Figure 8. The participants were asked to evaluate the generated QR codes about the attractiveness, clearness and visual similarity with the reference images. The subjective evaluations of the