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Banalization Approach for Achromatic Images

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Abstract

In this paper, we propose a new dithering method which uses random weight assignment. We use 3-by-3 window for dithering process and four coefficient values are randomly determined, where right, left-down, down, and right-down weights are determined accordingly. The sum of all weights is one. Block diagram and the pseudo code are provided. Experiments were conducted on two natural and two artificial images. Simulation results show that the proposed approach gives the best visual quality among all result images.

Keywords: *Random process, threshold, dithering, weight*

1. Introduction

The dithering is a calculatedly generated fashion of electrical signal that is employed to randomize quantization error [1-3]. The dithering method can generate particular patterns such as luminance banding. In general, color image is converted into gray image, and the density of black dots comes near the intermediate gray level in an original one [4]. In addition, dithering method is used in newspaper where black dots are only used.

Dithering is also employed in computer graphics to generate the delusion of gray (or color) depth in an image where colors in a palette are limited [5-8]. This process is called as color quantization. In other words, if a particular color does not exist, the wanted color is estimated and generated by a color dispersion of pixels from the available colors in a palette. The human eyes sense the dispersion as a combination of the colors [9]. However, reduced color depth may cause consequential subjective side effects [10-12].

There have been many algorithms which were generated to fulfill dithering process. The main goal of these methods is to give minimized subjective side effects through a dithering process. They can be classified as:

Thresholding method (TM): a given pixel is examined with a fixed threshold level

Random dithering method (RDM): a given pixel is examined with a random threshold level

Patterning dithering method (PDM): a fixed pattern is placed in a given image

Ordered dithering method (ODM): The dither matrix is used. This matrix is used for a pixel in an image ad generated pattern at the corresponding position

This paper is organized as follows. Section 2 explains the proposed dithering method. Sections 3 and 4 describe experimental results and conclusion remarks.

2. Proposed Method

The Floyd-Steinberg dithering method is the most popular approach. This technique create classical pattern, which is based on error diffusion. The error diffusion method is easy to generate by a rule. One can compute the difference between the given value

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and the real value, then any value with positive number are given as 1, otherwise are given as 0. Here, the error diffusion only affects those pictures which are not process yet. When one processes the later pixels which subsequently come, then one adds the diffused errors calculated from the previous pixels, and makes a binary image (or images with certain number of levels).

This process can be applied into binary image on black-and-white display. Then the operation is straightforward thresholding process. In color image, one can apply above process into red, green and blue components. The coefficients of error diffusion is determined as,

$$\begin{matrix} N/A & N/A & N/A \\ N/A & x & 7/16 \\ 3/16 & 5/16 & 1/16 \end{matrix} \tag{1}$$

Where the coefficients are introduced by Floyd and Steinberg.

The symbol 'x' strands for the pixel presently scanning, and the other numbers are coefficients or weights which stand for the ratio of the diffused error to the pixel in the present location. Note that the sum of all coefficients is 1. When a coefficient is 'y', the neighbor pixel achieves 'y' of the diffused error. Under the raster scan condition, 0.4375 of error is added to the right pixel, 0.1875of error is added to the left-down pixel, 0.3125 of error is added to the down pixel, and 0.0625 of error is added to the right-down pixel.

The process of error diffusion can be improved by modifying the weights (coefficients). For instance, one can modify weights of errors of neighbor pixels. Note that the sum of total weights is 1 and the scanning direction is left to right, and top to bottom with raster scan. The determined pattern is selected cautiously. Then, a checkerboard pattern is produced in a field, and the average intensity value is 128.

In our system, four coefficient values are determined: *a*, *b*, *c*, and *d*.

$$\begin{matrix} N/A & N/A & N/A \\ N/A & x & a \\ b & c & d \end{matrix} \tag{2}$$

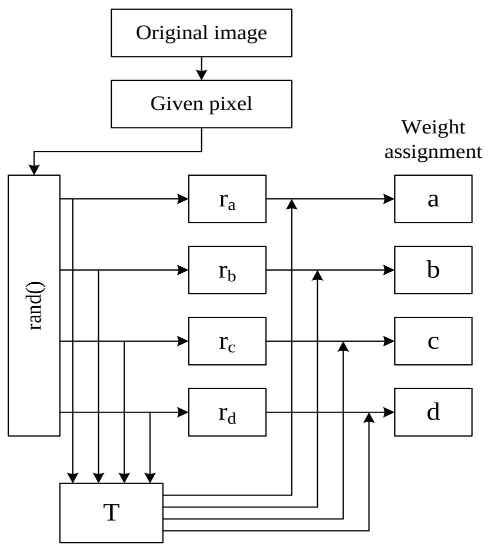


Figure 1. Block Diagram of the Proposed Method

We produce four random values, r_a, r_b, r_c, and r_d by using command *rand*(). Parameters *a*, *b*, *c*, and *d* are determined as

$$\lambda = \frac{r_\lambda}{r_a + r_b + r_c + r_d}, \tag{3}$$

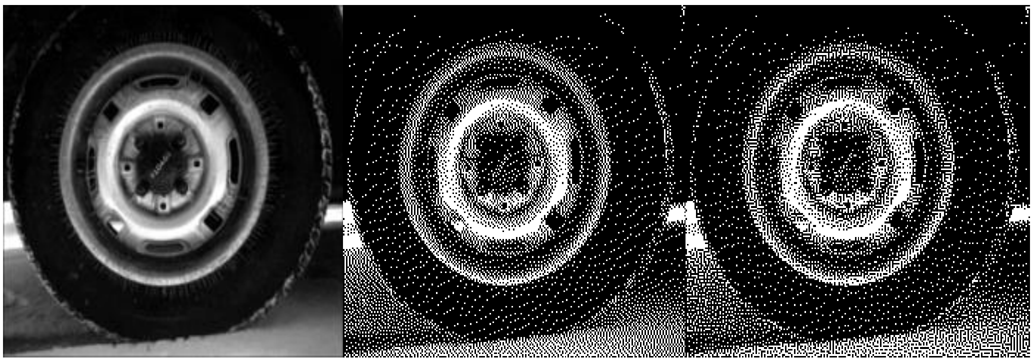
Where $\lambda \in \{a,b,c,d\}$, and r_λ is calculated with *rand*().

This process is explained with pseudocode:

```
for each row number R from top to down
  for each column number C from left to right
    originalpixel = p[C][R]
    revisedpixel  = find_closest_palette_color(originalpixel)
    p[C][R] = revisedpixel
    qe = originalpixel – revisedpixel
    ra = rand();  rb = rand();  rc = rand();  rd = rand(); T = ra+ rb+ rc+ rd
    a = ra/(T), b = rb/(T), c = rc/(T), d = rd/(T)
    p[C+1][R] = p[C+1][R] + qe × a
    p[C-1][R+1] = p[C-1][R+1] + qe × b
    p[C][R+1] = p[C][R+1] + qe × c
    p[C+1][R+1] = p[C+1][R+1] + qe × d
```

Where p and qe are pixel and quantization error.

The flowchart of the proposed method is show in Figure 1. Figures 2 and 3 show examples of Floyd-Steinberg dithering and its original images.



(a) (b) (c)

Figure 2. (a) Original 'Tire' Image, (b) Floyd-Steinberg Dithering Processed, and (c) Proposed Method

(a) (b) (c)

Figure 3. (a) Original 'Cameraman' Image, (b) Floyd-Steinberg Dithering Processed, and (c) Proposed Method

As can be seen in Figure 2 and 3, dithering processes reduce grey quantization. However, observers still sense the quite the same image.

To compare the performance of the proposed method we introduce several methods. For fixed threshold method for example, the output pixel is determined to be black or white depends on the intensity of the input pixel,

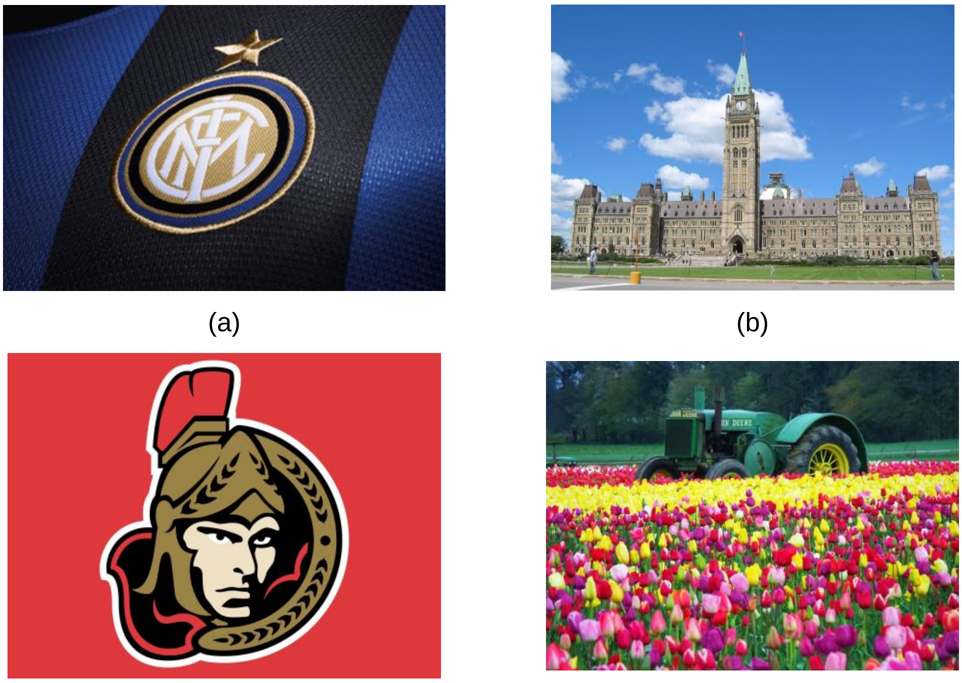
$$\text{output} = \begin{cases} \text{white} & \text{input pixel is bigger than the fixed threshold} \\ \text{black} & \text{input pixel is smaller than the fixed threshold} \end{cases} \tag{4}$$

For random threshold method, threshold value is not fixed, but randomly determined. It is known that the dithering results especially well on less complicated images. For ordered threshold method, particular matrix (M) is determined to threshold corresponding pixels. We used following matrix in the comparison.

$$M = \frac{1}{630}\begin{bmatrix} 34 & 29 & 17 & 21 & 30 & 35 \\ 28 & 14 & 9 & 16 & 20 & 31 \\ 13 & 8 & 4 & 5 & 15 & 19 \\ 12 & 3 & 0 & 1 & 10 & 18 \\ 27 & 7 & 2 & 6 & 23 & 24 \\ 33 & 26 & 11 & 22 & 25 & 32 \end{bmatrix} \tag{5}$$

3. Experimental Results

We conducted simulations to assess the visual performance of the proposed method with conventional ones. We collected four test images as shown in Figure 4. They are Inter, Parliament hill, Senators, and Tulip. Inter and Senators are artificial images and Parliament hill and Tulip are natural images taken by camera. All images are color images with three color channels, and these images are converted into gray images by using rgb2gray command in Matlab. The visual performance comparison is conducted, where four benchmarks are employed: fixed threshold method, ordered threshold method, Floyd-Steinberg method, and Stucki method.

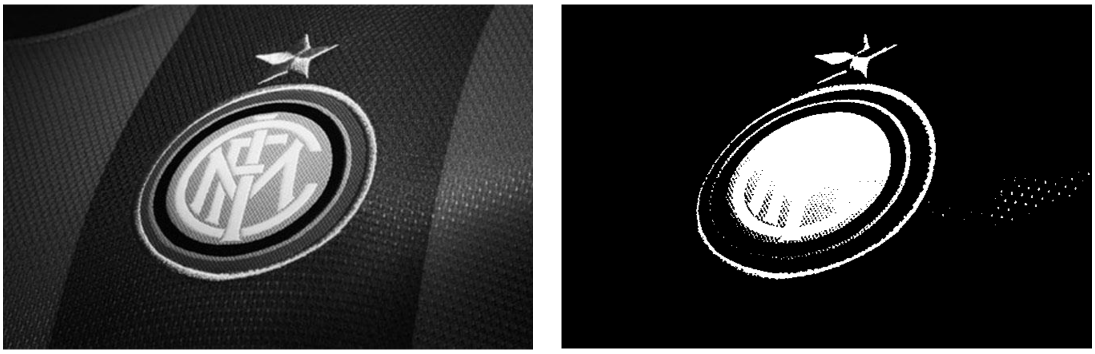


(a) (b)

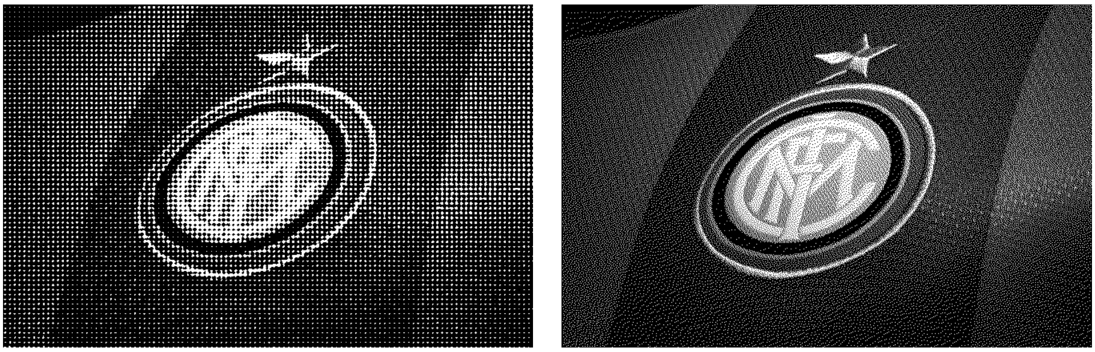
(c) (d)

Figure 4. Four Test Images: (a) Inter, (b) Parliament Hill, (c) Senators, and (d) Tulip

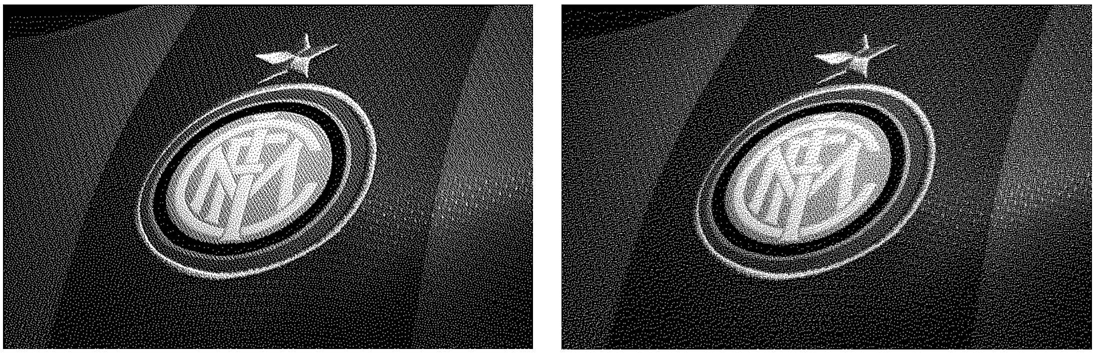
Figure 5 shows visual performance comparison results on Inter image. As we can see, logo in Figure 5(b) is not readable and center area is pretty much brighter and corners became darker. Figure 5(c) shows ordered threshold method result. The result image is more brighter than the original gray image, and dot is quite big. Figures 5(d) and 5(e) show Floyd-Steinberg method and Stucki method results. Both images provided well preserved results, however dots are connected and particular patterns are shown. Figure 5(f) shows the proposed method where the result provides randomly produced dots which are pleasant to human eyes.



(a) (b)



(c) (d)

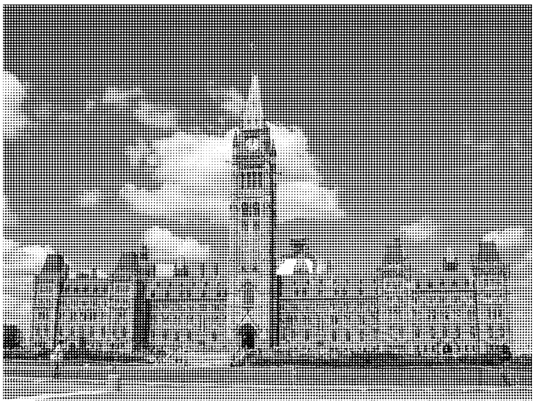


(e) (f)

Figure 5. Inter: (a) Grayscale Test Image, (b) Fixed threshold, (c) Ordered threshold, (d) Floyd-Steinberg, (e) Stucki, and (f) Proposed Method

Figure 6(a) shows gray image of Parliament hill. As can be seen in Figure 6(b), sky in the image is totally black which is not pleasant. The proposed is shown in Figure 6(f), which proves the best visual quality compared to the other images.

(a) (b)

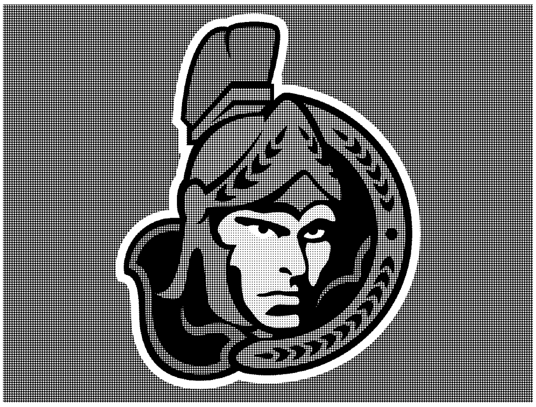



(c) (d)

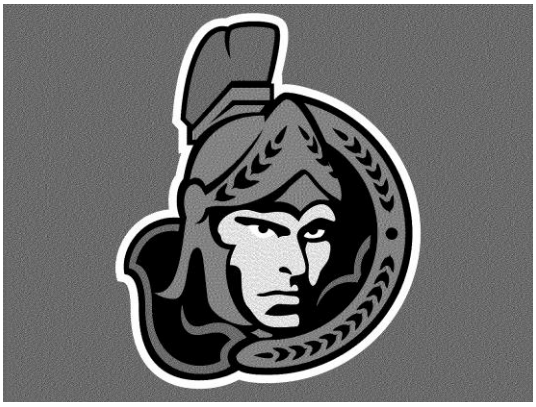

(e) (f)

Figure 6. Parliament Hill: (a) Grayscale Test Image, (b) Ixed threshold, (c) Ordered threshold, (d) Floyd-Steinberg, (e) Stucki, and (f) Proposed Method

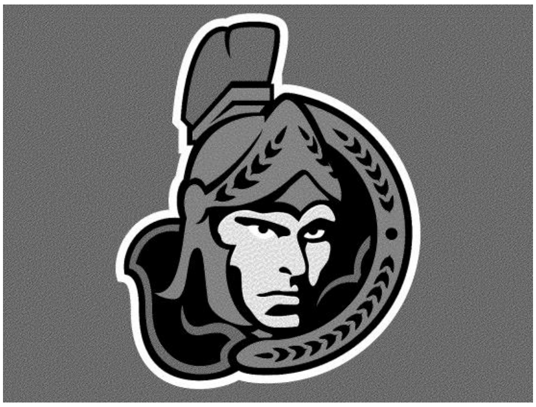

(a) (b)



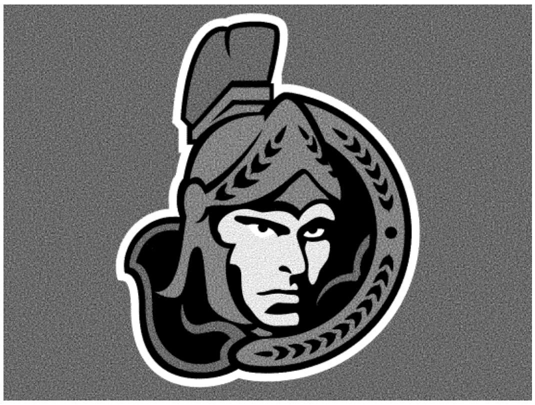
(c)



(d)



(e)

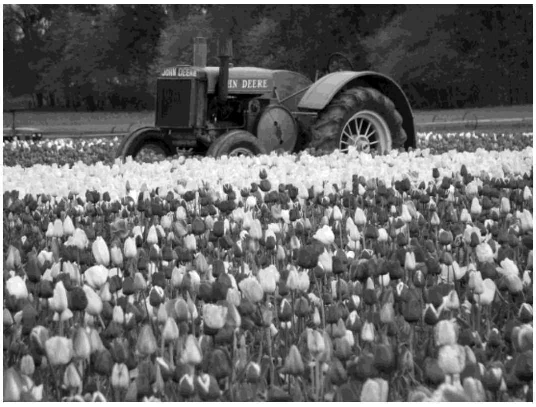


(f)

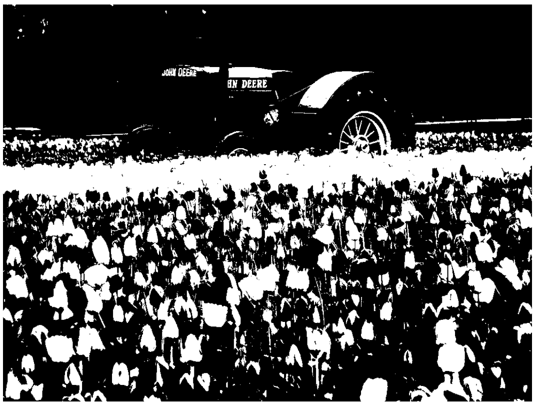
Figure 7. Senators: (a) Grayscale Test Image, (b) Fixed threshold, (c) Ordered threshold, (d) Floyd-Steinberg, (e) Stucki, and (f) Proposed Method

Figure 7(a) shows gray image of Senators, which is artificial image. It can be found that strict threshold is applied in the image; gray areas of background and the helmet are separated into black and white area. Moreover, a symbol near the chin is disappeared. It can be concluded that Figure 7(f) gives the best subjective performance.

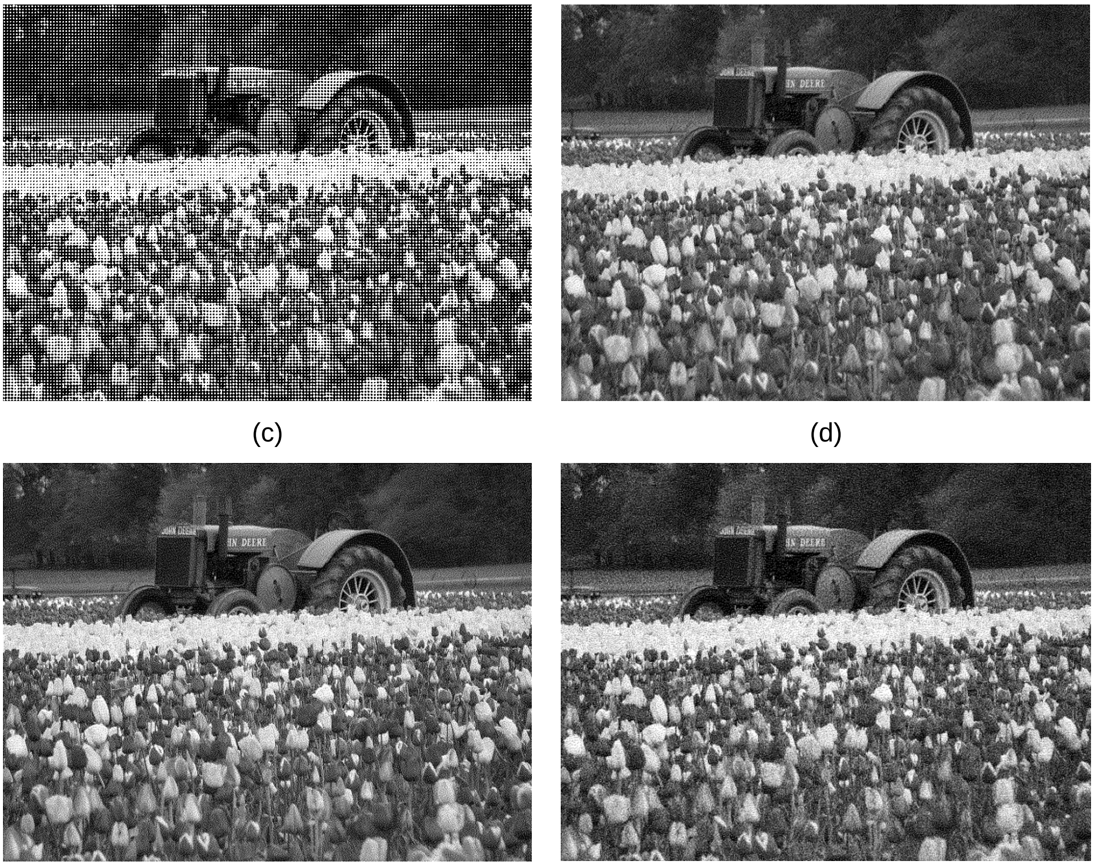
Figure 8(a) shows gray image of Tulip, a natural image. It can be concluded that Figure 8(f) gives the best subjective performance.



(a)



(b)



(c) (d)

(e) (f)

Figure 8. Tulip: (a) Grayscale Test Image, (b) Fixed threshold, (c) Ordered threshold, (d) Floyd-Steinberg, (e) Stucki, and (f) Proposed Method

4. Conclusion

This paper presented a new dithering approach where all intensity is 0 and 1. Four weights located in the right, down, downleft and downright from the center pixel are obtained and calculated based on random process, and the sum of four weights is one. Flowchart and the pseudo code were presented. Experimental results show that the presented method achieved the best visual quality among all result images.

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