Table Average Illusion Halftoning Technique

[1]Manish Kashyap, [2]Purvee Kashyap
[1]Department of Electronics and Communication, JIIT NOIDA, U.P.
[2]Department of Computer Science and Engineering, ITM University, Gwalior, M.P
[1]manishkashyap.jiit@gmail.com, [2]purveekashyap@gmail.com

***Abstract*— Halftoning is the technique of representing a wide range of colors by using a relatively small color palette, which is very useful for reproducing images on various display devices or printers as they usually have very low (two for black and white printers) colors in their color palette. Various techniques have been suggested to achieve this in the past. This paper deals with one such hybrid (AM-FM) technique made by combining the best of 'AVERAGE ILLUSION[1]' and 'TABLE HALFTONING' and is named as 'TABLE AVERAGE ILLUSION' (TAIH Technique)**

Keywords- Table Average Illusion, Digital Halftoning, Table Halftoning, Average illusion, Image processing.

I. INTRODUCTION

Digital Halftoning for image processing mainly refers to printing or image reproducing devices which have a limited amount of colors and they are supposed to reproduce very large colors present in say nature.

Considering the black and white printers, only black ink is being supplied to them and by using that black ink and white paper, they are supposed to produce an illusion of complete grayscale range for printing of natural image on paper. In the proposed work, we are dealing with grayscale images only however the same work can be extended to color images also.

The main points to be considered while evaluating a particular Halftoning technique are-

1) Faithful reproduction of image details (sense preservation).
2) Low information loss.
3) Least artifact introduction.
4) Toleration to little bit of scaling in the image.
5) Fair generation of the original image by de-Halftoning the halftoned image.

Traditionally, Halftoning is done by using Amplitude modulation (AM) or Frequency modulation (FM) methods. Further, some hybrid techniques were also proposed in the past.

In AM methods, the black dots are placed on white paper in such a way (for a small, fixed, periodic region in the image) that they nearly match the average value of color (grayscale level) produced by that small region.

The small region should be selected in such a manner that that region's pixels appear to be indistinguishable to human eye.

FM techniques on the other hand operate pixel by pixel for deciding their halftone values. The disadvantage of using AM techniques is the production of periodic artifacts in the halftoned image and unwanted texture generation in some cases. FM techniques also suffer from the later disadvantage but scores over AM in most of the ways.

II. ORGANISATION OF THE REST OF THE PAPER

The rest of the paper is organized as follows- In the third section, we will discuss table Halftoning technique which is indeed one of the components of TAI. In the fourth section, the second component of TAI i.e. Average Illusion Technique is touched.

Fifth section presents TAI technique for Halftoning in detail. Section Six is dedicated to results and comparisons and section seven concludes the paper.

III. TABLE HALFONING TECHNIQUE

A. Description of the technique

This is an Amplitude modulated method for producing halftoned images. Different areas in the original image are replaced by their corresponding halftone cells by selecting an appropriate (Producing nearly same average) cell from the table.

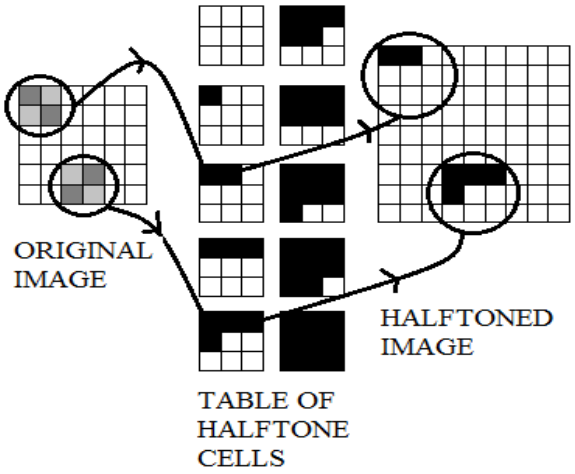

Figure 1: Table Halftoning Technique.

As shown in fig. 1, a 2x2 area in the original image, which has one of the 256 possible values for its every pixel, is replaced by a 3x3 area in the halftoned image which is essentially binary.

The selection of halftone cell is made by choosing one cell from the table of halftone cells having the closest average value to the original 2x2 cell.

B. Results of Table Halftoning

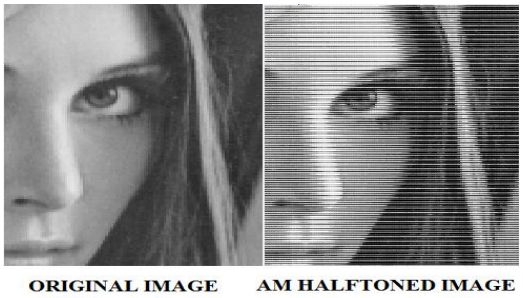

Figure 2: Table Halftoning results

As clear from figure 2, the halftoned image contains artifacts (Undesired horizontal lining) which are due to the shape of AM halftone cells. However these artifacts can be reduced if the size of halftone cells is very small say 2x2.

But then the total grey levels available in the table of halftoned cells will be reduced. So, a proper trade off is to be made between the two.

IV. AVERAGE ILLUSION (AI) TECHNIQUE

A. Description of the technique

AI Technique can be thought of as an advanced version of Thresholding. In Thresholding, if the value of a particular pixel in original image is above some predefined threshold, it is given a value of 255 (white) else 0 (Black). The threshold is usually midpoint of 0 and 255. The results of Thresholding are poor as there is a lot of error due to loss of information at every pixel after Thresholding.

AI on the other hand works on the basic assumption that in a halftoned image, the illusion of grey level which is produced by a particular pixel is not due to that pixel alone but is a result of small neighborhood of it providing highest weightage to the pixel under consideration.

The mechanism of estimating a 0 (Black) or 255 (White) value for every pixel in AI technique is shown in figure 3. The pixels are processed in left to right and top to down order. The halftoned image shown in figure 3 is not completely processed.

The pixel filled with red color is under processing and to estimate its value a small neighborhood of 3x3 is considered. This 3x3 neighborhood is multiplied to filter shown in element by element manner keeping the value of pixel under processing as unknown. Then the sum of every element of the resulting array so formed is taken (it contains a variable).

Now we substitute a value 0 or 255 in variable and obtain two results. The result whose value is closer to actual pixel's value in the original image is said to have minimum energy loss.

The value of the variable in that particular case is selected as the final value of the pixel under processing.

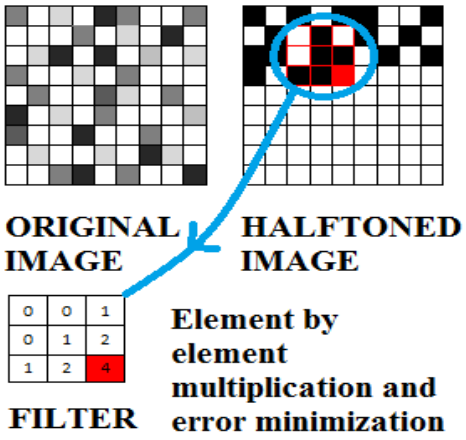

Figure 3: Average Illusion Technique

As it's clearly visible that to obtain a pixel's value for halftoned image, some pre processed pixels are required, hence to start with, the halftoned image is padded with zeros of suitable dimensions. Also there can be various forms of filter used.

By using AI, error due to quantization to only two levels will be minimized as neighborhood plays an important role in producing the illusion of grey level for a pixel in the halftoned image.

B. Results of AI

Figure 4: Average Illusion Technique

As clear from figure 4 that there is no artifact introduction in the halftoned image and the results are better as compared to Table Halftoning or Thresholding. AI works on a wide variety of images and provides quick and better results as compared to some of the best known techniques like error diffusion and its various forms.

V. TABLE AVERAGE ILLUSION TECHNIQUE

A. Description of the proposed work (TAIH technique)

This technique combines the best of AI and Table Halftoning i.e. a region of original image will be replaced by its halftone equivalent (as in table Halftoning) but replacement will be done by considering the

neighborhood in the halftoned image (as in AI). In AI, by considering the neighborhood, we guess only two levels for the pixel under processing, but due to the introduction of table Halftoning in it, after considering the neighborhood, guessing levels are increased from 2 to 5 (for 2x2 halftone cell), to 10 (for 3x3 halftone cell), so the quantization levels increase. Figure 5 will illustrate the procedure.

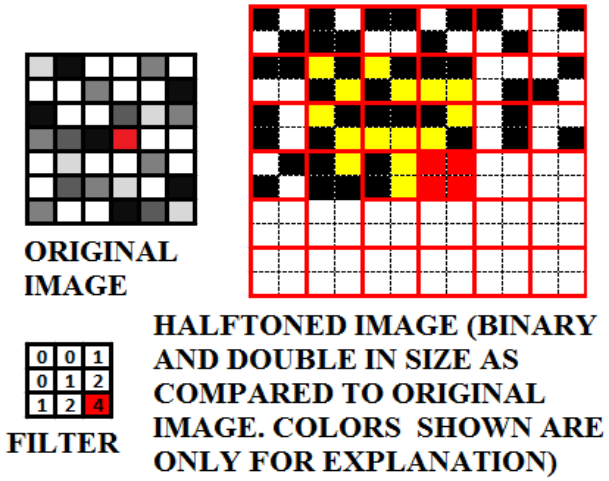

Figure 5: TAIH Technique

In Figure 5 three images are shown- Original image, Filter and Halftoned image. The size of halftoned image is double as that of original image. Every pixel in original image is replaced by a 2x2 sized region in the halftoned image (this size is under user control, for e.g. a 2x2 region in original image can be replaced by a 3x3 region in the halftoned image). Pixel shown in red color is under processing. Now, if this replacement were for table Halftoning alone, a 2x2 region matching nearly in average with the value of that pixel would have been selected. For AI, considering the filter, this replacement could have been done by considering the neighborhood in yellow color. For the proposed technique however, this replacement will be done by combining both i.e. first by considering neighborhood in the halftoned image, an expected value for replacement in 2x2 region will be found. Then a value matching nearly in average will be selected by table Halftoning technique.

B. Results of TAIH Technique

Figure 6: TAIH Technique.

Results demonstrate that halftoned image is highly close to original image with no loss of details and no artifacts.

VI. RESULTS AND COMPARISIONS

This section presents results of Halftoning by using TAIH technique and comparisons with various well known techniques for Halftoning [3],[4],[5],[6],[7],[8] like error diffusion, Floyd's Halftoning, Jarvis's Halftoning, Average Illusion.

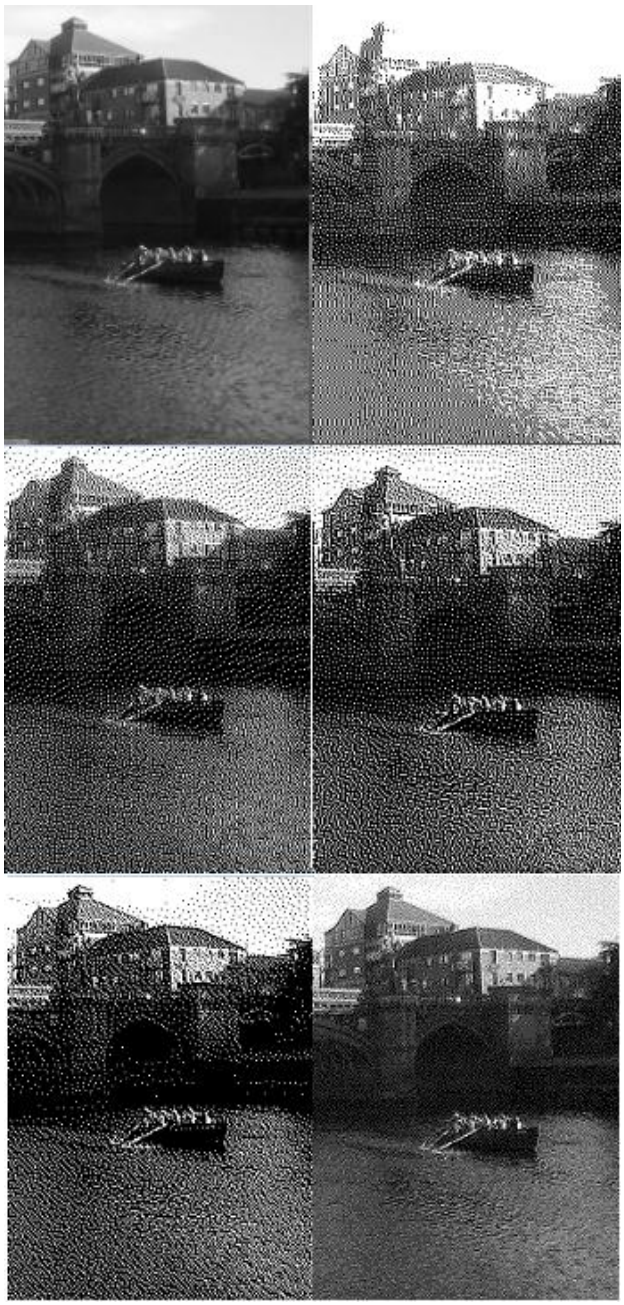

Figure 7: (Original image, Error Diffusion [2], Floyd's technique, Jarvis's Technique, AI, TAIH-in that order from left to right, top to bottom)

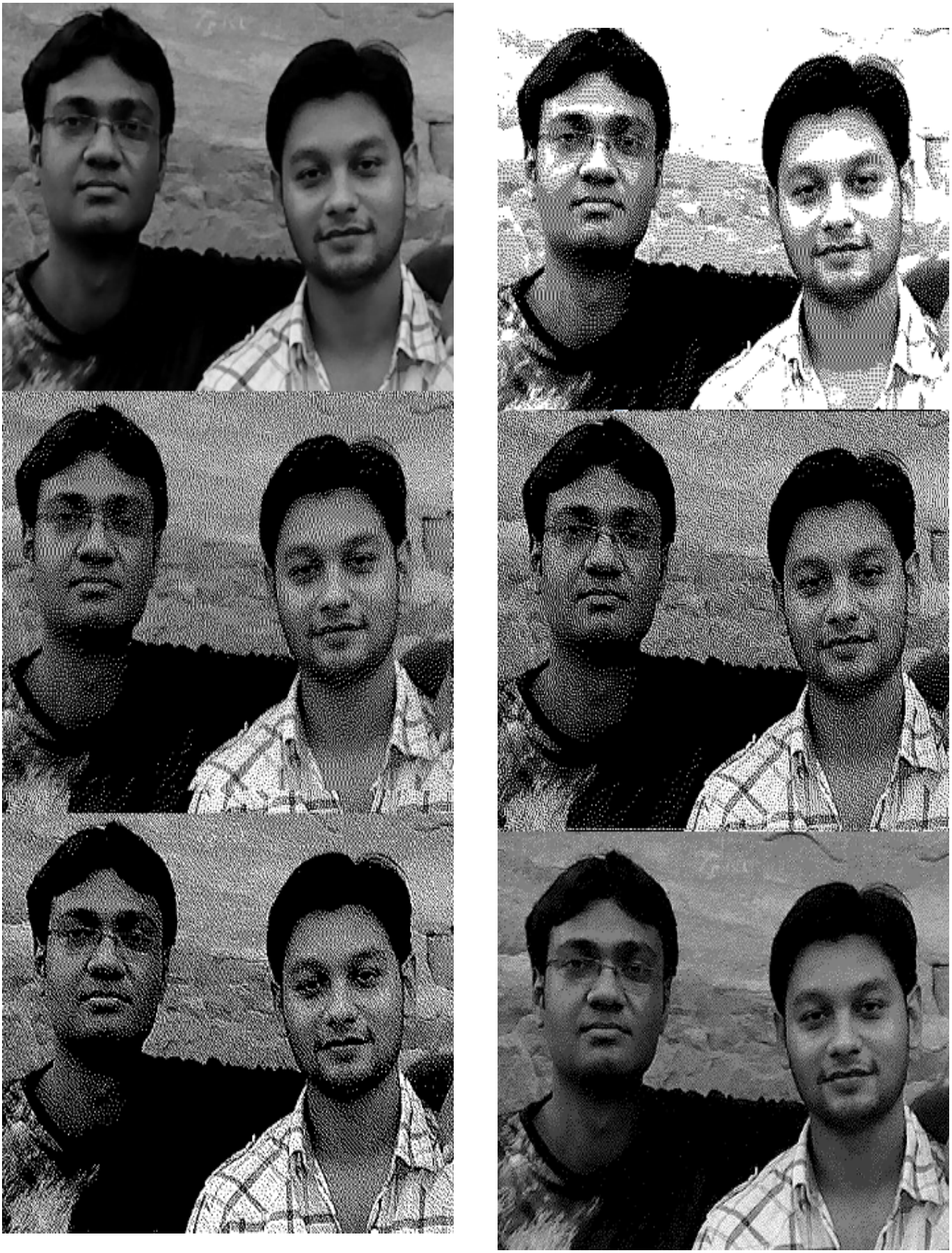

Figure 8: (Original image, Error Diffusion, Floyd's technique[4], Jarvis's Technique[3], AI, TAIH-in that order from left to right, top to bottom)

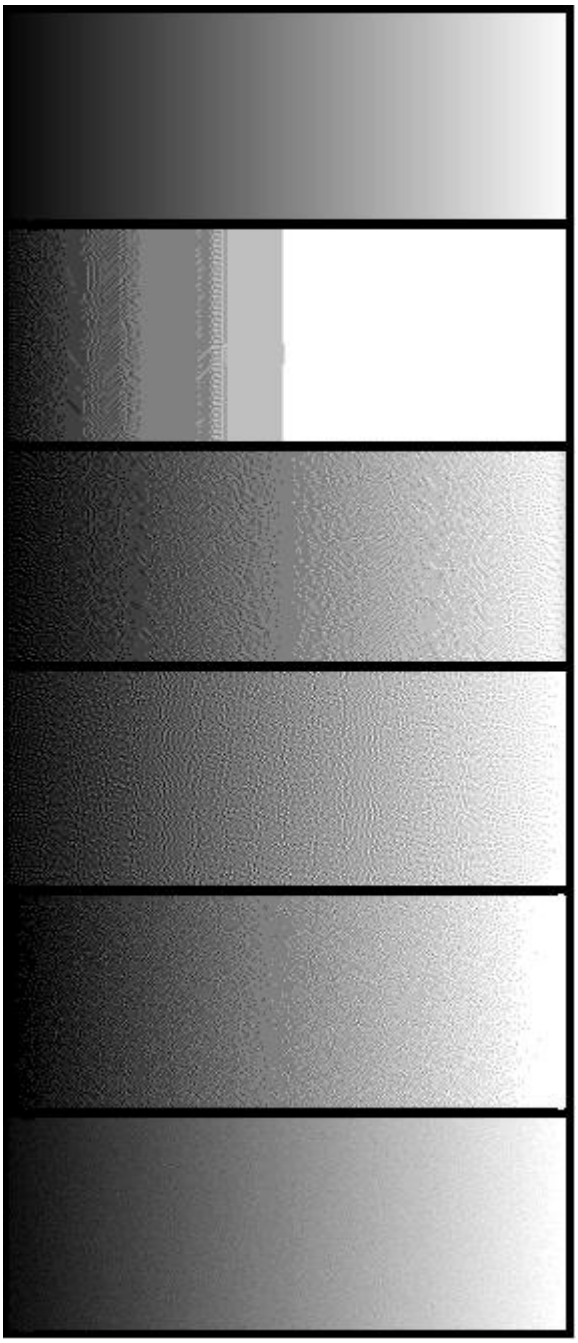

Figure 9: REPRODUCTION OF GRAYSCALE RANGE (Original image, Error Diffusion, Floyd's technique, Jarvis's Technique, AI, TAIH-in that order from top to bottom)

VII. CONCLUSION

TAIH Technique is a good approach for Halftoning which satisfies all five conditions mentioned in section I in this paper.

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