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Lost pixel restoration using Generalized Trapezoidal Fuzzy numbers

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ABSTRACT

The digital imaging has monopolized the imaging industry in recent times. One of the problems faced by the users in digital imaging is the lost pixels. Several restoration methods have been discussed in the literature by researchers in this respect. In this paper, we use generalized trapezoidal fuzzy numbers for restoration of lost pixels.

Keywords: digital images, lost pixels, trapezoidal fuzzy numbers

INTRODUCTION

Ever since the human race evolved, it has used images for passing on information for use in future. The cave paintings discovered from various sites in the world stands testimony to this fact. With the digital technology replacing the analogue variants in all the representations, digital imaging became possible and revolutionised the manner in which images are captured, stored and manipulated. The digital image is represented into rows and columns of elements called pixels. The downside in digital imaging is lost pixels[4] owing to compression of size, digital noise, image distortion etc. There have been several efforts to retrieve the images to the best possible condition by researchers. Quite many algorithms and methods to restore lost pixels have been considered [4, 6, 7]. In every restoration method of lost pixels, we use the average behaviour of the neighbouring pixels to the lost pixel. This is owing to the fact that the lost pixel cannot behave in a manner very different from the behaviour of its neighbouring pixels. In this paper, we provide a fuzzy approach to restore lost pixels using trapezoidal fuzzy numbers [3].

Fuzzy numbers are imprecise numbers which look alike but not exactly equal to a given number. Many types of fuzzy numbers are used in applications. To name a few, we have the triangular fuzzy numbers, trapezoidal fuzzy numbers, hexagonal fuzzy numbers, octagonal fuzzy numbers and the Gaussian fuzzy number. Fuzzy numbers have attracted a central role in research in recent times owing to the uncertainties prevalent in the problems in application domains and the ability of these numbers to give approximate solutions for a wide variety of problems. There are many problems that been solved using fuzzy numbers[5, 8].

PIXEL RESTORATION USING TRAPEZOIDAL FUZZY NUMBERS

We assume that the single pixel value of a lost pixel and its neighbouring pixels are available in a 3×3 matrix with the lost pixel X in the second row, second column. This 3×3 matrix is part of the digital image described using the pixel value of the pixels that make up the image. We consider the presence of a single lost pixel with the availability of all the pixels intact in its immediate neighbourhood. The case may be that all the pixels may not be intact in its neighbourhood, or the lost pixel may be the first or the last pixel in any row or column in the array of pixels that make up the image. In each of these cases, a similar handling as discussed in the following discussion will apply, with minor modifications.

In a digital image, the image is organized as rows and columns of pixel values. Typically, each pixel value is a number between 0 and 255.

Here we assume that A through H denote the pixel values of the neighbouring pixels of the pixel X. Pixel X has to be estimated using the pixel values of its neighbours. See Table 1. We use the fuzzy approach to do the same. The values A through H and X are all in the range 0 to 255.

Table 1

A	*B*	*C*
D	*X*	*E*
F	*G*	*H*

We assume that *X* is like any four of the values in the table for fuzzification. We use two sets of four values each namely (*A*, *C*, *H*, *F*) and (*B*, *EG*, *D*) both with the same weight 1. Then we find the difference of each of these values and *X*. We can normalize these values by dividing by 255 so that we obtain new sets namely (*a*, *c*, *h*, *f*) and (*b*, *e*, *g*, *d*) in the ascending order of its components. We consider these two sets to provide two generalized trapezoidal fuzzy numbers representing *X* as (*a*, *c*, *h*, *f*; 1) and (*b*, *e*, *g*, *d*; 1), assuming the weights of these sets as 1, each.We then rank these values using the ranking proposed by Y.L.P. Thorani et al., [9] from which we obtain the fuzzy set which most associated with *X*.

For defuzzification [1] we use the simple average of the four numbers in the most associated number with *X*. The average so obtained will be multiplied to obtain the raw estimate of *y* of *X*. This raw estimate may in some cases be greater than 255 owing to approximations used in division. We take the exact estimate *x* of *X* as the minimum value of *y* and 255 and then taking the floor of the resulting value.

For an example, consider the part of the image whose pixel values are given in the following 12×12 matrix.

121	128	130	126	100	131	140	139	122	145	130	132
119	135	142	132	120	129	135	145	128	134	138	140
128	146	149	134	127	128	133	142	145	140	150	152
120	142	165	-	122	141	132	144	148	151	155	158
130	152	170	139	152	130	135	148	150	156	162	165
146	160	165	152	172	155	159	158	160	150	149	162
153	166	175	170	186	161	167	174	177	156	169	178
176	178	172	190	198	172	179	192	180	165	172	193
189	182	191	198	203	185	189	188	176	179	176	188
190	188	182	207	211	198	194	193	190	188	179	197
195	201	194	211	218	207	200	204	201	195	187	208
206	214	202	221	228	218	207	216	203	207	199	206

We now have a lost pixel (call it *X*) in the fourth row and fourth column of the above part of the pixel matrix. We first consider the 3×3 matrix of pixel values with *X* in the second row and second column, given below.

149	134	127
165	*X*	122
170	139	152

To start with we consider the generalized trapezoidal fuzzy numbers (149, 127, 152, 170) and (134, 122, 139, 165). We find the differences of each of these values and *X*. Hence, we get the numbers (106, 128, 103, 85) and (121, 133, 116, 90). We then rationalize these numbers by dividing by 255. So, we obtain (0.333333, 0.403922, 0.415686, 0.501961) and (0.352941, 0.454902, 0.474510, 0.521569). From these, we get two generalized trapezoidal fuzzy numbers representing *X* namely (0.333333, 0.403922, 0.415686, 0.501961; 1) and (0.352941, 0.454902, 0.474510, 0.521569; 1).

We now use the ranking function prescribed by Y.L.P. Thorani et al. [3] to rank the two fuzzy sets as follows.
We get the rankings based on the above method suggested in [3] as $R(\tilde{A}) = 0.139068$and $R(\tilde{B}) = 0.148575$.

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Since $R(\tilde{A}) < R(\tilde{B})$, it follows that $\tilde{B}$ is more associated with *X*.
Hence, we conclude that (0.352941, 0.454902, 0.474510, 0.521569; 1)represents *X* more likely.

Defuzzifying using the simple average of the components in the generalized trapezoidal fuzzy number, we get $X = 0.450981$.

The corresponding pixel value is obtained by multiplying $X$by 255 and taking the floor.
Hence, we get $X = 115$.

CONCLUSION

`This method can be used to predict the lost pixel value from the average behaviour of its neighbours. There are several ways in which fuzzy numbers can be used to restore the lost pixels. Each of these methods will restore the lost pixel from the different sets of neighbouring pixel values. Each of these methods may provide different pixel values for the lost pixel, but will be approximately the same.

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