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Restoration of Lost Pixels Using Generalized Octagonal Fuzzy Numbers

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ABSTRACT

There are many methods that are used to restore the lost pixel in a digital image. The use of fuzzy numbers gives a simple method for restoring the lost pixels in a digital image. In this paper we use generalized octagonal fuzzy numbers obtained from the neighboring pixels of the lost pixel to restore it.

Keywords: lost pixel restoration, octagonal fuzzy numbers

INTRODUCTION

Application of Fuzzy numbers has dominated the research world owing to the ease, versatility and reliability of such numbers. They provide a simple means by which certain unknown but predictable quantities can be constructed based on them. When uncertainty is the issue, fuzzy numbers give a method by which the required number can be guessed to certain degree of certainty. Fuzzy numbers are not single numbers, but are rather a collection of numbers which have a 'look alike' behavior to a certain number to a certain degree of similarity. Depending upon how many numbers make up a fuzzy number, they are categorized as triangular fuzzy numbers, trapezoidal fuzzy numbers, pentagonal fuzzy numbers, hexagonal fuzzy numbers and so on. Each of these numbers can be used to construct a single number by a process called defuzzification. Initially the fuzzy numbers can be generated using a process called fuzzification. This pair of processes, the fuzzification – defuzzification is at the center of all application that use fuzzy numbers. Many researchers have successfully used fuzzy numbers in several application domains and addressed the problem of uncertainty [3, 6].

The recent development of digital technology has enabled the images to be captured and stored with ease and in little space without compromising on the visible quality to the human eye. However, owing to the way the images are processed in the digital form renders the image lose quality and sometimes parts of the image itself. These problems have been addressed by researchers who have designed several algorithms to retrieve the important aspects of the image so that the appeal to the viewer's eyes is not compromised. Amongst the many works done by the researchers are the following [2, 8]. Lost pixel restoration is being attempted by many researchers and have suggested many useful and workable methods. To name a few, we have [4, 9].

RESTORATION OF LOST PIXELS USING GENERALIZED OCTAGONAL FUZZY NUMBERS

We use generalized octagonal fuzzy numbers to retrieve the lost pixel. Octagonal fuzzy numbers have been used widely in several applications [5, 1]. This method is suitable when the lost pixel is at the center of the 5×5 sub-matrix of the pixel value matrix associated with the digital image. Assume that the 5×5 sub-matrix with the lost pixel at its center is as follows. In this method, we try to restore the lost pixel value using the pixel values in its neighboring pixels.

a_{11}	a_{12}	a_{13}	a_{14}	a_{15}
a_{21}	a_{22}	a_{23}	a_{24}	a_{25}
a_{31}	a_{32}	X	a_{34}	a_{35}
a_{41}	a_{42}	a_{43}	a_{44}	a_{45}
a_{51}	a_{52}	a_{53}	a_{54}	a_{55}

Table 1

To restore the lost pixel, we consider the following generalized octagonal fuzzy numbers namely,

$(a_{22}, a_{23}, a_{24}, a_{32}, a_{34}, a_{42}, a_{43}, a_{44})$,
$(a_{12}, a_{13}, a_{14}, a_{21}, a_{22}, a_{23}, a_{24}, a_{25})$,
$(a_{21}, a_{31}, a_{41}, a_{12}, a_{22}, a_{32}, a_{42}, a_{52})$,
$(a_{25}, a_{35}, a_{45}, a_{14}, a_{24}, a_{34}, a_{44}, a_{54})$ and
$(a_{52}, a_{52}, a_{53}, a_{54}, a_{55}, a_{42}, a_{43}, a_{44})$.

Considering these sets after ordering as $\tilde{A}, \tilde{B}, \tilde{C}, \tilde{D}$, and $\tilde{E}$, with respective weights 1, 0.5, 0.5, 0.5 and 0.5, we rank these generalized octagonal fuzzy numbers following the ranking method given in [7].The maximum rank determines the fuzzy set which is the most associated with the lost pixel. Select this set as the one that most represents *X*. By Defuzzifying the selected set using simple average and finding the value of the floor of this value, we get the lost pixel value.

The following illustration attempts to demonstrate the method discussed above for the restoration of lost pixels in a digital image.

Illustration 1
We shall demonstrate this with an example. Consider the following portion of a digital image, with a lost pixel *X*, which has to be restored.

131	138	140	136	110	141	150	149	132	155	140	142
129	145	152	142	130	139	145	155	138	144	148	150
138	156	159	144	137	138	143	152	155	150	160	162
130	152	175	***X***	132	151	142	154	158	161	165	168
140	162	180	149	162	140	145	158	160	166	172	175
156	170	175	162	182	165	169	168	170	160	159	172
163	176	185	180	196	171	177	184	187	166	179	188
186	188	182	200	208	182	189	202	190	175	182	203
199	192	201	208	213	195	199	198	186	189	186	198
200	198	192	217	221	208	204	203	200	198	189	207
205	211	204	221	228	217	210	214	211	205	197	218
216	224	212	231	238	228	217	216	213	217	209	216

The 5×5 sub-matrix with *X* at its center is given below.

145	152	142	130	139
156	159	144	137	138
152	175	***X***	132	151
162	180	149	162	140
170	175	162	182	165

We consider the fuzzy sets (159, 144, 137, 132, 162, 149, 180, 175), (152, 142, 130, 156, 159, 144, 137, 138),(156, 152, 162, 152, 159, 175, 189, 175),(138, 151, 140, 130, 137, 132, 162, 182) and (175, 162, 182, 162, 180, 149, 162, 140).

Upon ordering, the sets are $\tilde{A}$= (132, 137, 144, 149,159, 162, 175, 180), $\tilde{B}$ = (130, 137, 138, 142, 144,152, 156, 159), $\tilde{C}$ = (152, 152,156, 159,162, 175, 175, 189), $\tilde{D}$ = (130, 132, 137, 138, 140, 151, 162, 182) and $\tilde{E}$ = (140, 149, 162,162, 162, 175, 180, 182). The corresponding generalized octagonal fuzzy sets are, (132, 137, 144, 149,159, 162, 175, 180; 1), (130, 137, 138, 142, 144, 152, 156, 159; 1), (152, 152, 156, 159, 162, 175, 175, 189; 1), (130, 132, 137, 138, 140, 151, 162, 182; 1) and (140, 149, 162,162, 162, 175, 180, 182; 1).

Now, using the ranking method suggested in [7], we get, $R(\tilde{A})$ =154.4286 = 154, $R(\tilde{B})$ =⌊144.5357⌋ = 144, $R(\tilde{C})$ =⌊164⌋ = 164, $R(\tilde{D})$ =⌊144.5714⌋ = 144, $R(\tilde{E})$ =⌊164.25⌋ = 164. While the rank of the generalized fuzzy sets $\tilde{C}$ and $\tilde{E}$ are equal, they are equal only upon taking the floor values. However, $R(\tilde{E})$ is the highest amongst all the ranks. Hence, $\tilde{E}$ is the fuzzy set most associated with the lost pixel *X*. Defuzzifying, using the simple average, the most likely value of *X* is 164.

CONCLUSION

The above suggested method gives a better approximation of the lost pixel compared to the restoration method that uses the generalized trapezoidal fuzzy numbers. It is apparent that, more the number of values used for restoration, better will be the approximate value of the lost pixel value.

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