ABSTRACT

Digital image processing algorithms play a very vital role in all the fields of science, engineering and technology. Performance of algorithms basically relies on the quality of input image supplied to that algorithm. If the quality of the input image is good then the quality of output will also be good; otherwise we will get low quality outputs. Efficiency of all image processing algorithms is directly proportional to the quality of input images. Hence, image quality enhancement or image de-noising techniques for images corrupted by various types of noises are one of the most important issues in digital image processing. In digital image processing, impulse noise is considered to be the most frequently occurring noise in images. Impulse noise is one which may corrupt the images during their acquisition or transmission or storage. The high or low impulse levels produced in impulse noise creates small dots or patches on the image. Impulse noise is broadly classified into two types: fixed valued Salt and Pepper Impulse Noise (SPIN) and Random Valued Impulse Noise (RVIN). Several algorithms are proposed to remove impulse noise in the images. Some algorithms provide good results in low noise conditions and weak results in high noise conditions and vice versa. Further, some algorithms are not well-suited for real world applications to remove noise since they use prior knowledge of the noise that is not available in real world scenarios.

In this research work, an attempt is made to enhance performance of impulse noise reduction techniques for both fixed SPIN and variable RVIN impulse noise. The first type, the SPIN method assumes minimum or maximum values of noise while the second one, the RVIN method assumes a noise value between minimum and maximum values of noise. The primary goal of this research is to design efficient de-noising algorithms for images corrupted by most frequently occurring impulse noise, which produces consistent outputs in both low and high noise conditions for both SPIN and RVIN noise.

Motivation

Impulse noise filters are classified into two main groups: linear filters and non-linear filters. Linear filter performs filtering without detection of noise, whereas non-linear filters apply detection mechanisms. The non-linear filters are superior to linear filters in terms of noise rejection as well as retention of edges in restored images. All algorithms work well in low noise conditions below 50% but as soon as noise level increases beyond
50% restoration becomes a difficult process. Only few algorithms are specially designed for high noise conditions but they are not effective to handle low noise. Compared to SPIN, handling RVIN is difficult and only few solutions are proposed in the literature with very low noise of less than 40%. In our research work, an attempt is made to design efficient impulse noise reduction techniques which handle both low and high noises effectively and produces consistent results. Also, an attempt is made to provide solutions for both types of impulse noise, namely, SPIN and RVIN.

**Literature Review**

In literature, many value estimation techniques for corrupted pixels are available and mean and median filters are the most popularly used techniques. In the mean filter, average value of neighboring pixels of a scanning window is used as an estimated value of target pixel whereas in the median filter neighboring pixel values are sorted in order and then the median value is used as the target pixel value. Mean filter is effective in minimizing the mean square error value of estimation while median filter algorithm produces good visibility in the restored image. Several improved versions of mean and median algorithms are proposed by adding new features like weight and trimming to the existing algorithms. In non-linear filters, certain criteria are used for separating or identifying corrupted pixels from uncorrupted pixels and only corrupted pixels are restored. Few widely used criteria are: (i) global and local threshold, (ii) calculation for separation of corrupted pixels from uncorrupted pixels, (iii) adaptive median value calculation for accurate restoration or replacement pixel value calculation, (iv) weight based restoration for combining or considering the effect of more than one affecting features of noise replacement, (v) progressive or iterative replacement to improve the accuracy of algorithm by repetitive identification and replacement of corrupted pixels, (vi) two or multiphase algorithms in which distinct unrelated stages to avoid propagation of noise signal by calculating exactly corrupted and uncorrupted pixels and considering the only uncorrupted pixels for restoration value calculation is used, and (vii) switching techniques to combine more than one existing filter to use different efficient filters in different corrupted conditions because no single filter best fits for all noise Percentage. Some algorithms are good for low noise while some are good for high noise. Soft computing techniques such as fuzzy, neural, edge preserving and decision based
techniques for enhancement of efficiency of algorithms are also used; these algorithms produce good visibility in the restored images.

**Methodology**

We used a combination of theoretical and experimental studies to carry out our research whose primary objectives were: (i) to work towards deriving better image statistics for identifying corrupted pixels and the replacement values for corrupted pixels; this is crucial because performance of an algorithm directly depends on how effectively or correctly the algorithm identifies the corrupted pixels and how accurate the replacement value that is used for replacing the identified corrupted pixels is, (ii) to work towards the decreased computational complexity and increased speed of the algorithm so that it can be used in real-time video processing applications, and (iii) to work towards identification of different types of impulse noise, and the solutions for these impulse noise types.

**Results Obtained**

Our research helped in designing highly efficient algorithms to reduce both fixed valued and random valued impulse noise for gray scale images. The proposed algorithms are tested and compared with existing algorithms. Our experimental results show that proposed algorithms are highly efficient to remove impulse noise and produces better output compared to the ones reported in the literature.

**Contributions**

This research work has resulted in six publications as mentioned in the List of Publications. Our publications received citations in various refereed international journals.