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An Efficient Adaptive Switching Median Filter Architecture for Removal of Impulse Noise in Images

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Abstract— The median filter performs well as long as the spatial density of the impulse noise is not large. However the adaptive switching median filtering can handle impulse noise with probabilities even larger than these. An additional benefit of the adaptive switching median filter is that it seeks to preserve edges while smoothing nonimpulse noise. Considering the high level of noise, the adaptive algorithm performs quite well. The choice of maximum allowed window size depends on the application. In which it compares each pixel with surrounding neighbour pixels. If a pixel is different from neighbourhood is labelled as impulse noise. those noise pixels are replaced by median pixel value. Such that edges are preserved and it smoothens the other noises also.

Keywords— median filter; impulse noise; adaptive switching; median pixel; window level.

I. INTRODUCTION

In the process of image acquisition and transmission over the channel, the images are frequently influenced by some external environment and corrupted with impulses. The fixed valued impulse noise corrupts the true intensity value in random position with corruptive values in the extreme ranges, ie ‘0’ (pepper) and ‘255’ (salt) called as salt and pepper noise. Another type of impulse noise is random valued impulse noise which affects the true intensity value with corruptive values in the range [0, 255], which is also the dynamic range of the image. The objective of filtering is to restore the original image from the noise corrupted image. Generally, linear filters can remove the impulse noise, but it blurs the image. Hence the best known nonlinear filter namely standard median filter (SMF) is widely used due to its simplicity and computational efficiency. But it exhibits blurring effect for larger window size and less noise suppression for smaller window size, at higher noise density. The weighted median filter (WMF) , center weighted median filter (CWMF) and adaptive centre weighted median filter (ACWMF) are proposed to improve the performance of the standard median filter by giving more weight to some selected pixels in the filtering window. However, most of the median based filters are applied to all the pixels in the noisy image which affects both noise and noise free pixel intensity which leads to blurring of an output image. Hence, many filtering algorithms with a switching strategy which discriminates the corrupted pixels and uncorrupted pixels namely, tristate median filter (TMF), advanced impulse detection based on pixel wise median of absolute deviation (PWMAD) and new decision based algorithm (DBA) are proposed. In TMF, the corrupted pixel is replaced by either the median value or the center weighted median value based on the threshold value and noise free pixels are left unaltered. But it performs well for the images corrupted with slightly higher impulse noise ranges to 50% only. The DBA used 3 x3 fixed window for detection and filtering process. If the processing pixel is either ‘0’ or ‘255’, then it is replaced with a median value of local neighbourhood pixels in the 3 x3 sliding window, otherwise retained. At higher noise level all the pixels in the selected window are corrupted, and the median value may also be a noisy value. In that case, the left neighbourhood pixel is used to replace the corrupted center pixel which produces the streaking effect. Also the edges are not recovered satisfactorily, since the local feature in filtering window is not taking into account. To overcome the above drawback, adaptive recursive weighted median filter (ARWMF) and robust estimation based filter (REBF) are proposed. The ARWMF used median controlled algorithm for weight calculation to achieve a high degree of noise suppression and edge preservation. The REBF used an influence function based on the local estimate of image standard deviation to calculate the estimated value of corrupted pixel which gives better restoration results. The decision based unsymmetrical trimmed median filter (DBUTMF) proposed in uses the trimmed median value to replace the noisy pixel. At higher noise level if the selected window contains all the pixels as noisy pixels, then the trimmed median value cannot be obtained. In addition to that, DBUTMF does not provide better restoration results. When the noise level is more than 60%.

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II. IMAGE FILTERING

Adaptive median filtering is a powerful instrument used in image processing. The traditional median filtering algorithm, without any modifications gives good results. There are many variations to the classical algorithm, aimed at reducing computational cost or to achieve additional properties. Median filters are used mainly to remove salt-and pepper noise. Doing this, they preserve edges in the image (preserve their location and do not affect their steepness, unlike Gaussian filters), but unfortunately median filtering may destroy small features in the image. A way to avoid it is to apply center-weighted median filtering instead of a plain median, but the drawback of this solution is the deterioration of the filter's ability to suppress impulse noise.Common drawback of various kinds of the median filtering is their computational cost. Computing a two-dimensional median for a *N x N* window, requires sorting of *N x N* elements for every image pixel and choosing the median value for the output. After the sorting, each queue element is assigned a value called a rank, specifying its position in the queue as a result of sorting. Therefore, using median filtering in any real-time vision system requires a significant computational power. One way parallel. Moreover, programmable logic creates the to speed up the computations is to implement the algorithm in hardware, e.g. with the help of FPGA circuits. The rationale behind this is to use the FPGA's inherent ability to execute operations in possibility to tailor the implementation to the user's needs. All this results in a significant speedup over the software implementations by using sequential processors. One drawback of hardware-based algorithm development is the complexity of the design process as implementing algorithmically complex operations is very difficult. Median filtering, like many other low-level image processing algorithms is fairly simple - the main problem in this case is the amount of, low-pass filtering method, which you use to remove "speckle" noise data to handle. Median filtering is a non-linear, low-pass filtering method, which you use to remove "speckle" noise from an image processing system. The rank order filter is a Median filtering is a non-linear from an image. A median filter can outperform linear, low-pass filters on this type of noisy image because it can potentially remove all the noise without affecting the "clean" pixels. Median filters remove isolated pixels, whether they are bright or dark.Prior to any hardware design, the software versions of the algorithms are created in MATLAB. Using MATLAB procedural routines to operate on images represented as matrix data, these software algorithms were designed to resemble the hardware algorithms as closely as possible. While a hardware system and a matrix-manipulating software programme are fundamentally different, they can produce identical results, provided that care is taken in development. This approach was taken because it speeds understanding of the algorithm design. In addition, this approach facilitates comparison of the software and synthesized hardware algorithm outputs. This project is focused on developing hardware implementations of image processing algorithm for use in an FPGA-based image particularly common algorithm in image processing systems. For every pixel in an image, the window of neighbouring pixels is found. Then the pixel values are sorted in ascending, or rank, order. Next, the pixel in the output image corresponding to the origin pixel in the input image is replaced with the value specified by the filter order. The VHDL code can be simulated to verify its functionality. value of that pixel in the filtered image will be the median value of the pixels in that window. If, however, the center pixel is not an impulse, then the value of the center pixel is retained in the filtered image. Thus, unless the pixel being considered is an impulse, the gray-scale value of the pixel in the filtered image is the same as that of the input image.

III. LITERATURE REVIEW AND EXISTING SYSTEM

In 1979 Thomas S.Huang, George J.Yang and Gregory Y.Tang proposed a paper on fast algorithm for two-dimensional median filtering. It is based on storing and updating the gray level histogram of the picture elements in the window. The algorithm is much faster than conventional sorting methods. For a window size of m X n, the computer time required is O(n). In doing median filtering, w e are computing running medians. In 1991, Sung-Jea KO and Yong Hoon **Lee** proposed a paper on the center weighted median filter, which is a weighted median filter giving more weight only to the central value of each window, is studied. This filter can preserve image details while suppressing additive white and/or impulsive-type noise. The statistical properties of the CWM filter are analyzed. It is shown that the CWM filter can outperform the median filter. Some relationships between CWM and other median-type filters, such as the Winsor zing smoother and the multistage median filter, are derived. In an attempt to improve the performance of *CWM* filters, an adaptive CWM (ACWM) filter having a space varying central weight is proposed. In 2008,Hancheng Yu, Li Zhao, and Haixian Wang present an efficient algorithm for the removal of random-valued impulse noise from a corrupted image by using a reference image. The proposed method uses a statistic of rank-ordered relative differences to identify pixels which are likely to be corrupted by impulse noise.

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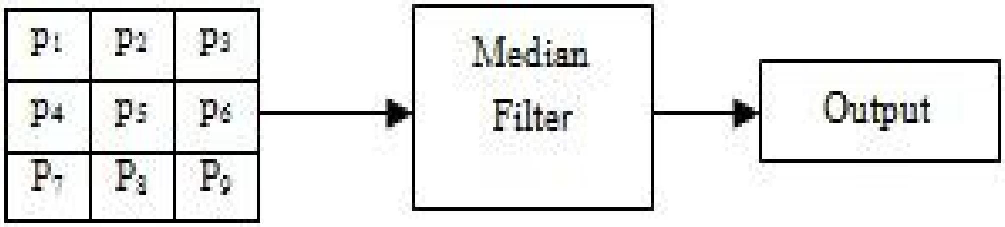

Figure 1 Block Diagram of Median Filter

A. Architecture design of adaptive median filter

The proposed architectures are designed in pipeline manner to minimize computational time. Parallel processing has also been done for process acceleration. A 3x3 or 5x5 pixel image neighbourhood can be selected for computation of the filter output. The design of the adaptive median filter consists of five different operational stages which are described in the following paragraphs. The hardware structure of adaptive median filter and the computation procedure are illustrated in the following subsections the design and functional characteristics of previously mentioned stages are described in detail

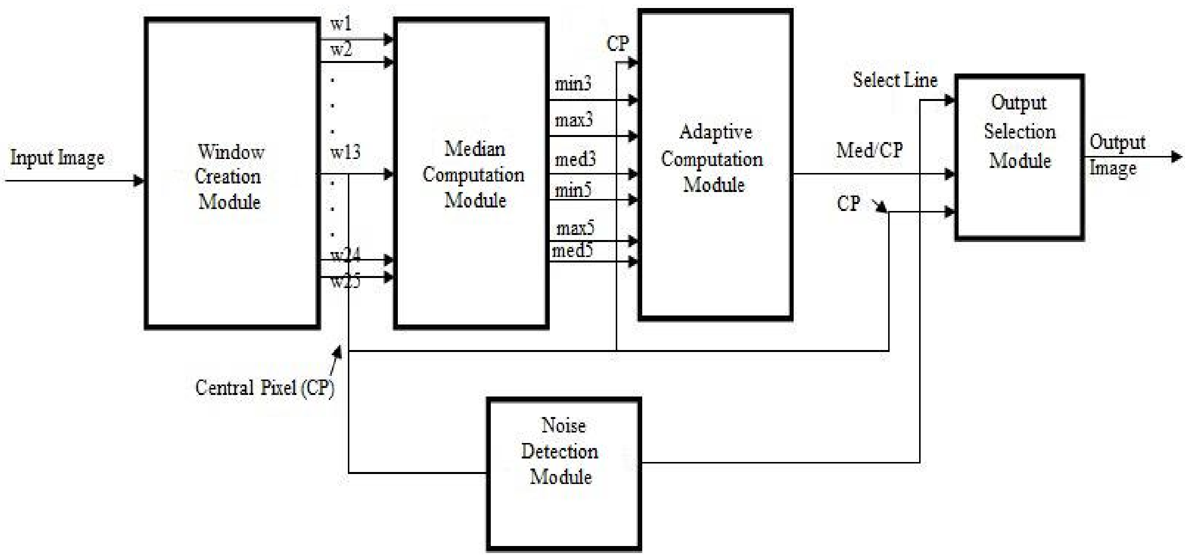

Figure 2 Hardware Design of Adaptive Median Filter

Our main goal is efficiently removing the fixed-valued impulse noise from the corrupted image which is presented in this paper. The pixel values of the input image are imported into this module serially for computation of moving window. In order to obtain the n x n window, a set of dual port Delay Blocks are used to generate the row of the window. For generation of this window, n number of delay blocks is required in which the first block zero latency and the other takes latency one.

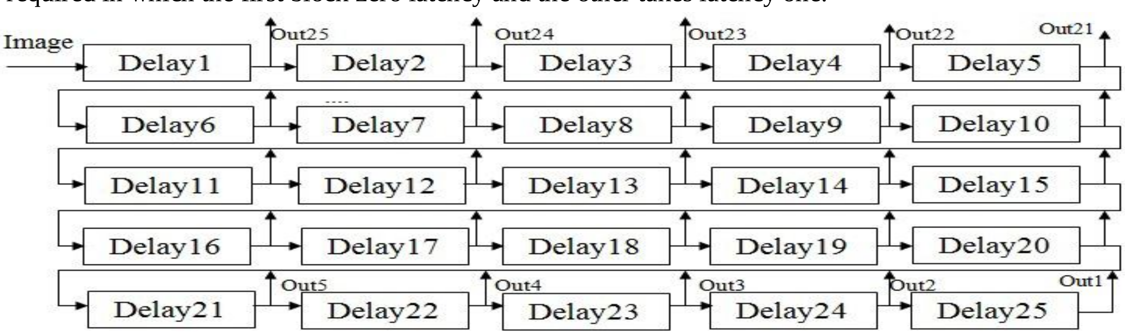

Figure 3 Window Creation Modules

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IV. PROPOSED SYSTEM

The proposed algorithm process each and every pixel in the noisy image to detect the presence of noise and filtering is applied if it is corrupted otherwise left unaltered. The fixed valued impulse noise corrupted pixels can take either maximum (Smax) or minimum (Smin) intensity values in the dynamic range [0, 255]. If the processing pixel lies within the range Smin < Xij < Smax, then it is noise free and actual value is retained. If it is identified as noisy as described in the following algorithm steps, then the median value of neighbourhood pixels is used to replace the noisy intensity value. The proposed algorithm is described in the following steps. The architecture of proposed median filter mainly consists of noise detector, sorting network and switching stage as shown in figure. Generally the images are corrupted with salt and pepper noise during the image acquisition and transmission process.

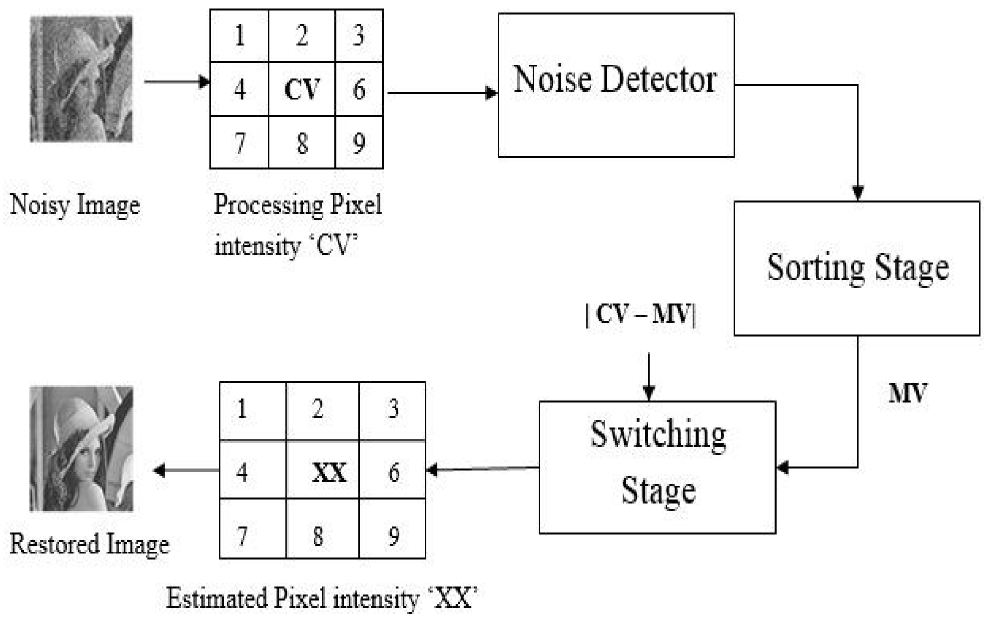

Figure 4 Block diagram of proposed median filter

Let us consider a sorting of, 9 elements in an array, where I' represents the current pixel intensity value to be sorted and 'J' represents the rest of the elements in an array.

A. Algorithm

Step 1: The value 'I' is compared with the rest of the 'J'values.
Step 2: If 'I' is less than 'J', then shift the 'I' value to the temporary register't'.
Step 3: Shift the 'J' value to 'I' register.
Step 4: Shift the value in temporary register to 'J' register.
Step 5: If 'I' is not less than 'J', then go to step 1. The inputs to the threshold detector are 8 bits of the absolute difference T(8), T(7),…T(0) and their inverted values T(8)',T(7)',…T(0)'. It detects whether the absolute difference lies within the threshold range [27-30] with a high level output, which is given to the selection line of the multiplexer. If the output of threshold detector is logic '1', then the multiplexer selects the actual pixel intensity value Xij otherwise it selects the median value already obtained. The proposed denoising algorithm is illustrated by considering a 3 x 3 window for three different cases as given below and the simulation result of VHDL implementation for the same three cases. The performance of the proposed algorithm is also evaluated quantitatively in terms of CPU time and compared with other existing algorithm for all four test images, namely Lena, Living room, Satellite and Mandril by varying noise density from 10% to 90%. The proposed filter and other existing algorithms are simulated in MATLAB on a PC equipped with 2GHZ operating speed A new switching based trimmed median filter using 3 x 3 filtering window for effective removal of high density salt and pepper noise and its VLSI architecture is proposed in this work.

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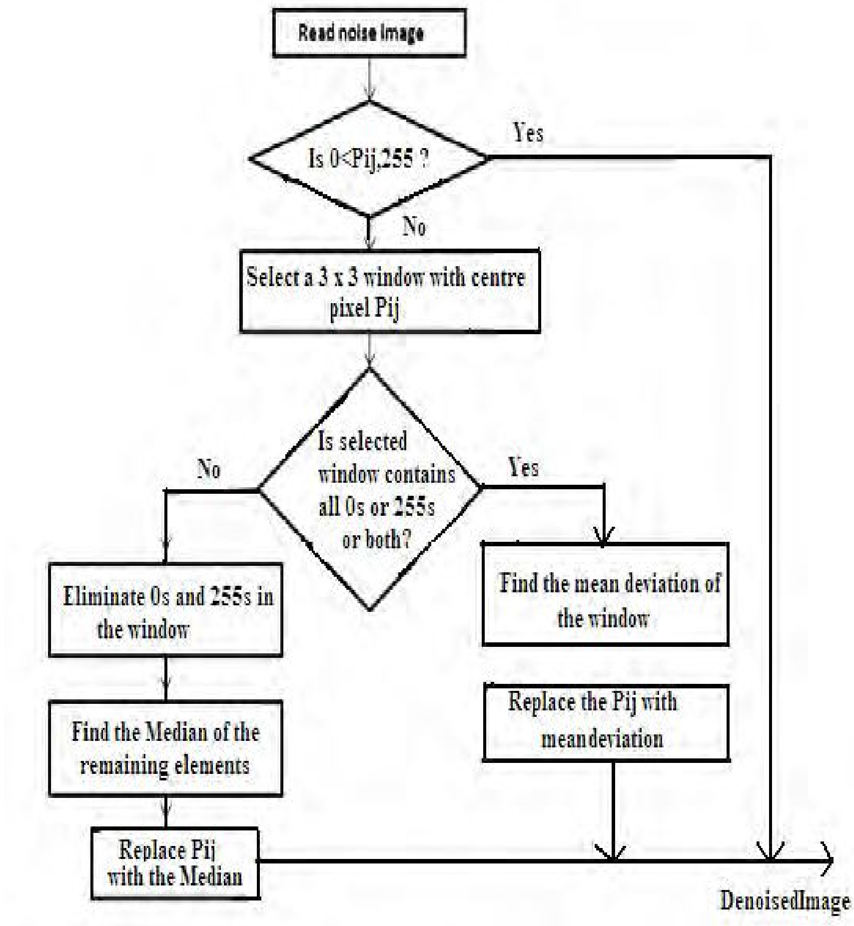

Figure 5 Flowchart for the proposed system

V. EXPERIMENTAL RESULTS

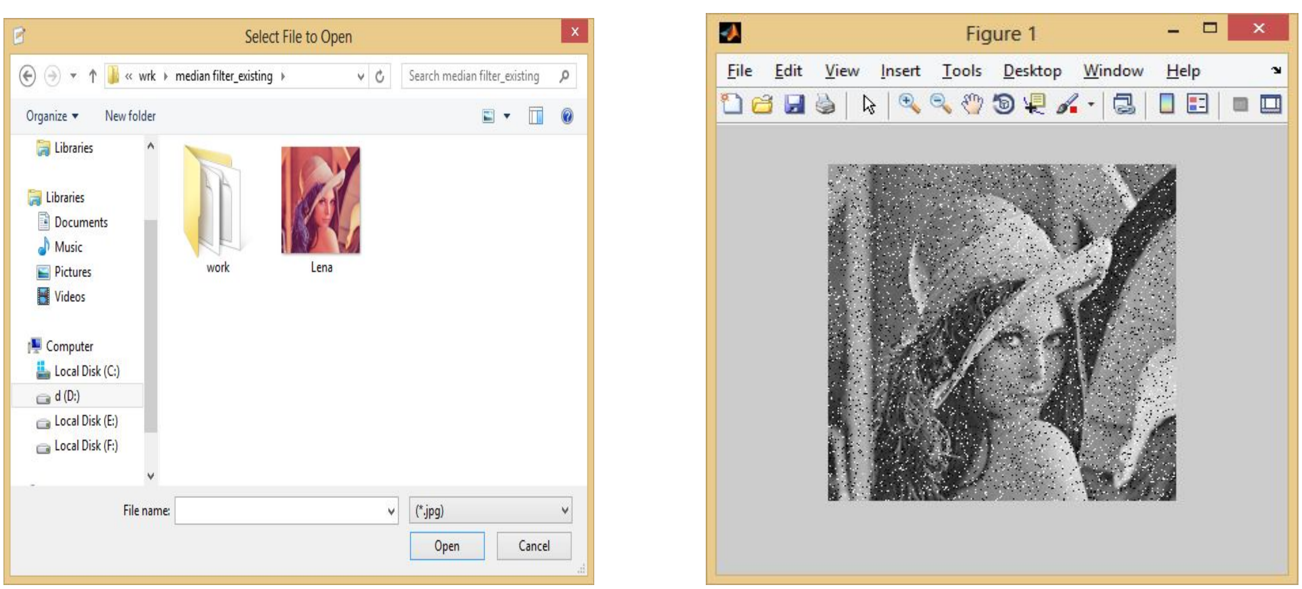

Figure 6 Mat lab iniation process to upload test data

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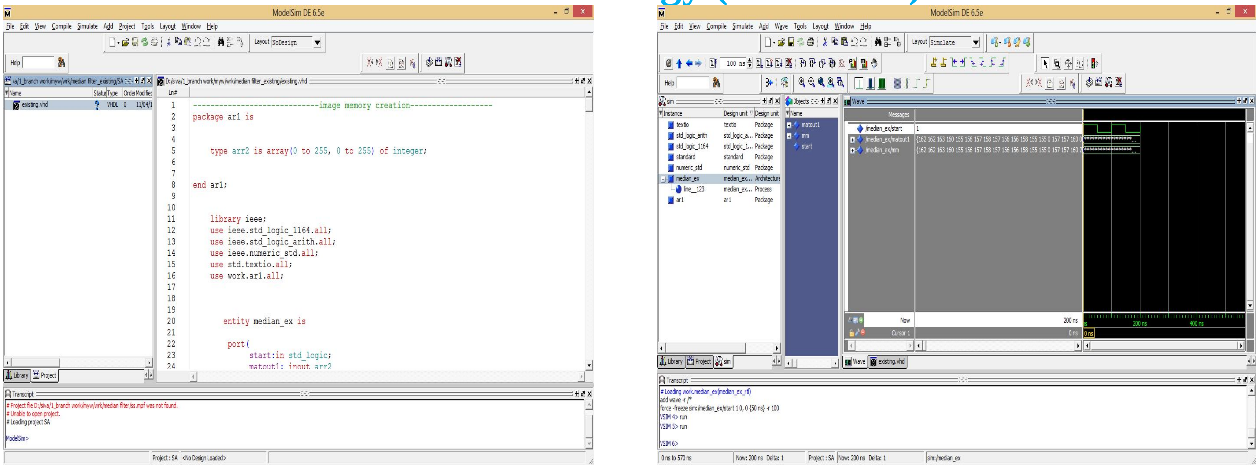

Figure 7 Matlab coding and simulation process

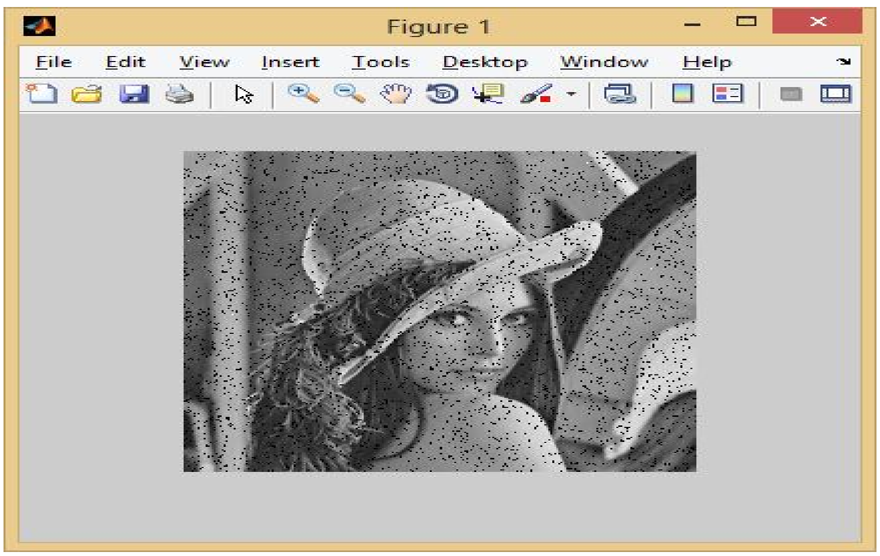

Figure 8 existing method output

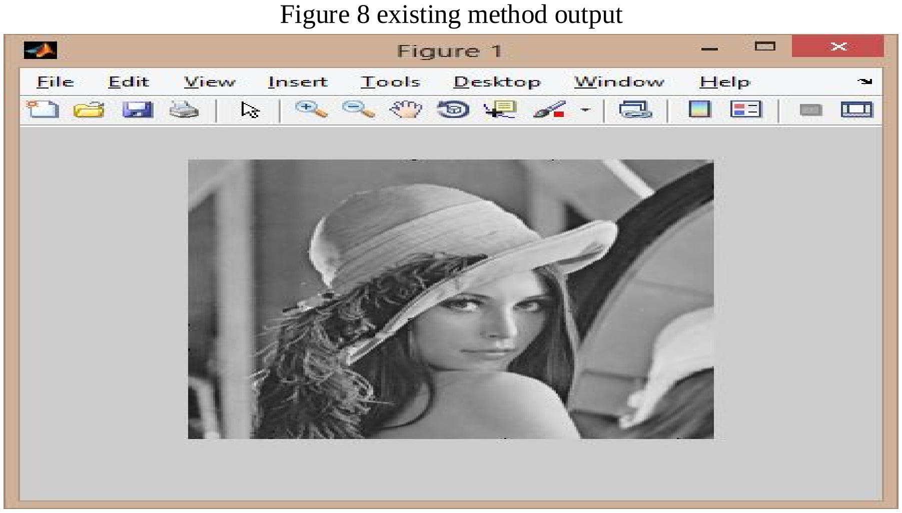

Figure 9 proposed method output

VI. CONCLUSIONS

A new switching based adaptive median filter using 3 x 3 filtering window for effective removal of high density salt and pepper noise and its VLSI architecture is proposed in this work. The image degradation caused from undetected noisy pixels is prevented due to the better noise detection capability of the proposed algorithm. The experimental results in terms of qualitative and quantitative metrics of proposed algorithm and other state of art technique are compared and better performance of proposed filter is demonstrated. In addition to that, VLSI architecture of the proposed filtering algorithm is also implemented and performance in terms of logic element, delay and power delay product is compared with other existing algorithms which clearly show the simplicity of the porposed architecture.

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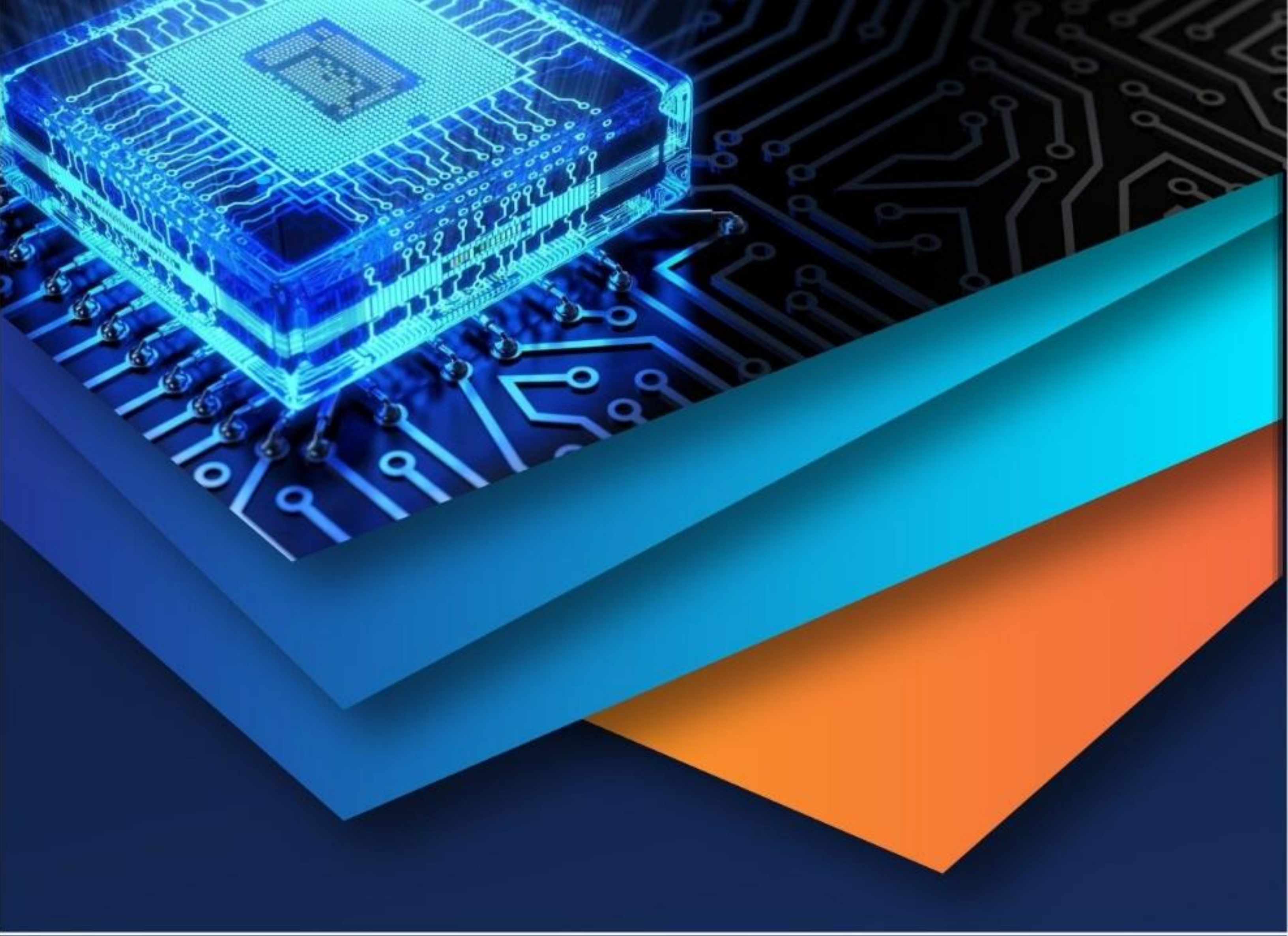

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