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Paper Authors
SD.MUJAHID ,S.SAI TEJA ,V.HRUTHIK ,T.TARUN ,T.JAYAVARDHAN
Mrs. P. PADMAVATHI ,Mr. Rajesh Pasupuleti

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VLSI REALIZATION OF IMAGE DENOISING USING DECISIONBASED ADAPTIVE MEDIAN FILTER

First Author:

SD.MUJAHID B.Tech (ECE), from SreeVenkateswara College Of Engineering, Nellore.

S.SAI TEJA B.Tech (ECE), from SreeVenkateswara College Of Engineering, Nellore.

V.HRUTHIK B.Tech (ECE), from SreeVenkateswara College Of Engineering, Nellore.

T.TARUN B.Tech (ECE), from SreeVenkateswara College Of Engineering, Nellore.

T.JAYAVARDHAN B.Tech (ECE), from SreeVenkateswara College Of Engineering, Nellore.

Second Author:

Mrs. P. PADMAVATHI . M. Tech, Associate ProfessorDepartment Of Electronics And Communication Engineering, SreeVenkateswara College Of Engineering, Nellore.

Third Author:

Mr. Rajesh Pasupuleti (Ph.D), HOD & Associate Professor, Department Of ECE, Sree Venkateswara College Of Engineering, Nellore

ABSTRACT

The noise in digital images is additive in nature in various cases. Such kind ofnoise is called to as Additive White Gaussian Noise (AWGN). This noise gets into imagewhile transmission, reception, storage and retrieval It is difficult to suppress AWGNbecause it corrupts more or less all the pixels in a image. Some filters such mean filterhad been proposed to suppress AWGN but in most cases it incorporates a blurring effectin the image. Image denoising is usually done before display or further processing likefeature extraction, segmentation, object identification, texture analysis, etc.

The intention of denoising is to suppress the noise efficiently and retaining theedges and other necessary features as far as possible. Many efficient digital image filtersare found that perform well under low noise conditions. But in the cases of moderate andhigh noise conditions their performance is limited. Thus, it is felt that there is sufficientscope to investigate and develop quite efficient. And proposed a spatial filter named ascircular spatial filter which performs well under high noise conditions. Suppose CSF hasto be used for real time applications such as before displaying the video on HDTV a realtime application.

It is hard to implement this algorithm on a general purpose computer where highamount of concurrency is needed. So in this work FPGA has been chosen as a targetwhich is suitable for video and image processing. Here we chose Stratix – II board toimplement the algorithm. The performance of the designed filters is compared with theexisting filters and the MATLAB simulation in terms of peak-signal-to noise ratio, rootmean-squared error.

1. INTRODUCTION

Image processing has got wide varieties of applications in computer vision,multimedia communication, television broadcasting, etc. That demand very good qualityof images. The quality of an image degrades due to

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introduction of additive whiteGaussian noise (AWGN) during acquisition, transmission/ reception and storage/retrieval processes. It is very much essential to suppress the noise in an image and topreserve the edges and fine details as far as possible.

In recent times, Field Programmable Gate Array (FPGA) technology has turn outto be a feasible target for the implementation of algorithms apt for video image processingapplications. The distinctive architecture of the FPGA has permitted the technology to beused in numerous such applications encircling all areas of video image processing.Since image sizes and bit depths raise better, software has turn out to be feweruseful in the video processing dominion. Real-time applications that are the target of thisproject are requisite for the high speeds desired in processing video applications. In totingup, a frequent quandary is dealing with the hefty amounts of data captured by means ofsatellites and ground-based recognition systems. DIVP systems are being engaged toselectively diminish the quantity of data to process, ensuring that only pertinent data isconceded on to a engineer analyst. sooner or later, it is predictable that most videoprocessing will be replaced with DIVP systems, with little human intervention. This isperceptibly beneficial since human data analysts are luxurious and perhaps notexclusively precise.

In the present research work, efforts are made to develop efficient spatial-domainimage filters that suppress noise quite effectively of FPGA Quartus Stratix-II device.

2. LITERATURE SURVEY

IMAGE DENOISING FILTERS

Image denoising is a frequent course of action in digital image processing for thesuppression of additive white Gaussian noise (AWGN) that might have corrupted animage during its acquisition or transmission. This method is conventionally performed inthe spatial-domain or transform-domain by filtering. In spatial-domain filtering, thisaction is performed on image pixels directly. The main idea behind the spatial-domainfiltering is to convolve a mask with the whole image. The mask is a small sub-image ofany arbitrary size (e.g., 3×3, 5×5, 7×7, etc.). Other common names for mask are: window,template and kernel.

FUNDAMENTAL STEPS IN DIGITAL IMAGE PROCESSING:

The basic components in digital image processing are shown in fig 2.2.1. The firststep in processing is image acquisition i.e., to get the digital image required forprocessing. It involves the conversion of a scene into a digital representation by sensorslike microdensitometer, image dissectors, vidicon cameras and photosensitive solid-statearrays.

After digital image is obtained, the next step deals with pre-processing the image.The absolute function of pre-processing is to progress the image in areas that increasesthe chances for the success of the other process by which the techniques for enhancingcontrast, removing noise and isolating regions. Segmentation, dividing an input imageinto its ingredient objects. The raw pixel data, the output of segmentation is transformedinto a form suitable for computer processing and processing is done by representationblock. Description, also called feature solution deals with extracting features that are isbasic for differentiating one class of objects from another. Recognition is a process thatassigns a label to an object based on the information provided by its recognized objects.

Finally, the knowledge base controls the interaction roping and assigning pattern vectorsinto different pattern classes. The methods for this type of recognition are minimumdistance classifiers, correlates etc.

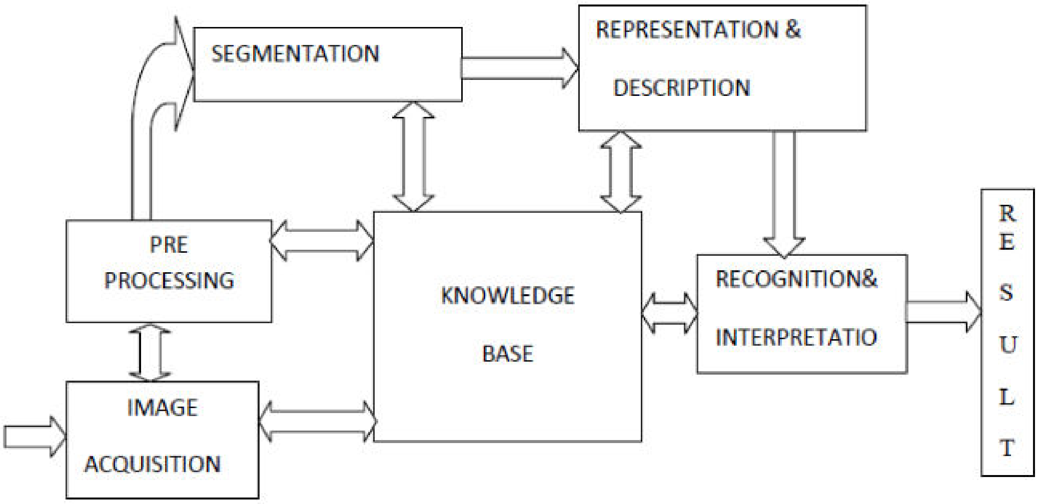

Fig: Fundamental steps in Image processing

DENOISING FILTERS

Usually, sliding window technique is employed to perform pixel-by-pixeloperation in a filtering algorithm. The local statistics obtained from the neighborhood ofthe center pixel give a lot of information about its expected value. If the neighborhooddata are ordered (sorted), then ordered statistical information is obtained. If this orderstatistics vector is applied to a finite impulse response (FIR) filter, then the overall schemebecomes an order statistics (OS) filter.

MEAN FILTER

The moving average or mean filter (MF) is a linear filter . All the input data aresummed together and then the sum is divided with the number of data. It is very simpleto implement in hardware and software. The computational intricacy is very squat. Itworks fine for low power AWGN. As the noise power increases, its filtering performancedegrades. If the noise power is high, then a larger window should be employed for spatialsampling to have better local statistical information. As the window size increases, MFproduces a reasonably high blurring effect and thus thin edges and fine details in an imageare lost.

RANK ORDER FILTER

The rank order filter is median (MED) filter, on the other hand, is a nonlinearfilter. The median is a very simple operation. The taxonomy (ordering) process iscompleted on the input vector, the job is done as the mid-value is taken as the output. Ofcourse, if the length of the input vector is even, then the average of two mid-orderedstatistical data is taken as output. Usually, such a computation is not required in most ofimage processing applications as the window length is normally an odd number. Thus,the MED operation can be completed in a very short time. That is, a MED filter may beused for online and real-time applications to suppress noise. If an image is corrupted witha extremely squat variance AWGN, then this filter can perform a good filtering operation.

CIRCULAR SPATIAL FILTER

Mean and Wiener filters suppress additive white Gaussian noise (AWGN) froman image very effectively under low and moderate noise conditions. But, these filtersdistort and blur the edges unnecessarily. Lee filter and non-local means (NL Means) filterwork well under very low noise condition. The method noise [88] for these filters is lowas compared to other spatial-domain filters. The computational complexity of simplemean filter is low whereas that of NL-Means filter is very high. Mean, Wiener, Lee andNL-means filters are incapable of suppressing the Gaussian noise quite efficiently underhigh noise conditions.

3. PROPOSED WORK METHODOLOGY

The median filter is a non-linear digital filtering technique, often used toremove noise from an image or signal. Such noise reduction is a typical pre-processingstep to improve the results of later processing (for example, edge detection on an image).Median filtering is very widely used in digital image processing because, under certainconditions, it preserves edges while removing noise (but see the discussion below), alsohaving applications in signal processing.

Typically, by far the majority of the computational effort and time is spent oncalculating the median of each window. Because the filter must process every entry in thesignal, for large signals such as images, the efficiency of this median calculation is acritical factor in determining how fast the algorithm can run. The naïve implementationdescribed above sorts every entry in the window to find the median; however, since onlythe middle value in a list of numbers is required, selection algorithms can be much moreefficient. Furthermore, some types of signals (very often the case for images) use wholenumber representations: in these cases, histogram medians can be far more efficientbecause it is simple to update the histogram from window to window, and finding themedian of a histogram is not particularly onerous.

Median filter is a classification of order statistics filter. OS filters are interestingbecause:

a) they offer a compromise in performance between linear filters and MED filters;

b) it is possible to design an optimal (among OS filters) MSE filter for estimating

signal immersed in noise, whose performance is superior to linear filtering.

There exists a vast body of literature on use of order statistics for parameter estimation. This provides a strong justification for using moving function of OS to recoversmooth varying signals immersed in noise.

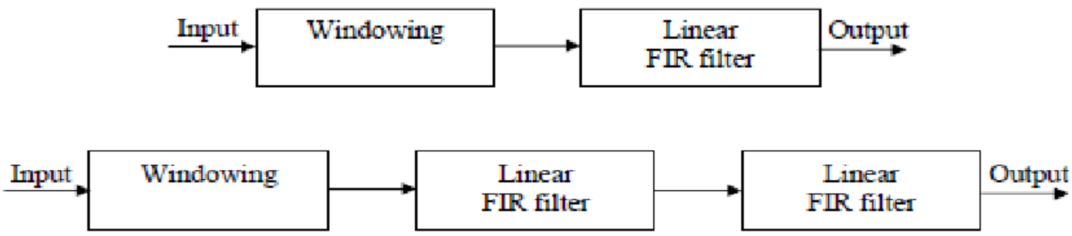

Figure: Generalized block diagram of the order statistics filter

The similarity and differences between the linear FIR filtering and OS filteringcan be understood from the block diagrams of the processes shown in Figure. When bothof them are compared, it is easily realized that the OS filtering process is similar to FIRfiltering except the inclusion of an extra intermediate stage, the algebraic ordering. Thus,the OS and the linear filters are equivalent operations over sufficiently smooth regions ofsignal. On the other hand, these two processes must result in different outputs for thesignals that are not sufficiently smooth

PROPOSED MODEL

DECISION-DIRECTED FILTERS

In a practical situation, since the probability of having an impulse noise is lessthan 1, all the pixels of a digital image are not corrupted with the impulse noise. Therefore,it is expected that a noisy pixel is surrounded by at least some non-noisy pixels. However,this assumption is not always true when the noise density is very high. In any case, thetotal number of corrupted pixels is less than the total number of pixels in the image.Hence, it is not required to perform filtering operation on every pixel for eliminating theimpulse noise. Rather, it is computationally economical to filter only the corrupted pixelsleaving the non-noisy pixels unchanged. This approach reduces the blurring effect in therestored image, as the magnitude of a non-noisy pixel is not affected by filtering.

Basically, the noise removal method proposed here constitutes two tasks:

identification of corrupted pixels and filtering operation only on those corrupted pixels.Thus, the effectiveness of this scheme lies on the accuracy and robustness of detection ofnoisy pixels and efficiency of the filtering methodology employed. Many researchers have suggested various methods for locating the distorted pixels as well as filteringtechniques. Each of these methods has different shortcomings and hence fails toreproduce images very close to original ones. It is over-filtering distortion, blurring effector high computational involvement. In addition, as the density of the impulse noise isgradually increased, the quality of the image recovered by the existing methodscorrespondingly degrades.

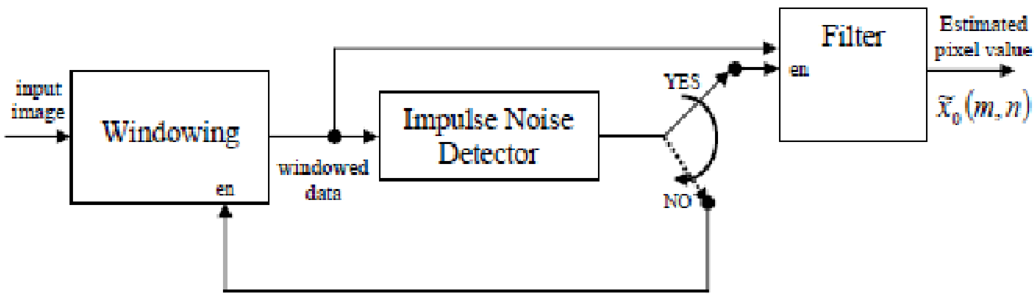

Fig: Block Schematic of a Decision-Directed Filte

The input image is a 2-D matrix. It is spatially sampled and a windowed data,usually 3×3 or 5×5, comes to the processing system at an instant. To take a decision ona pixel its neighborhood pixels are considered. That is why, the spatial windowing isemployed to sample the image data. The impulse noise detector must precede the filter(may be MED or some variant of MED or any special filter) as

shown in Figure. If theimpulse detector has detected an impulse (output state of detector = 'YES') at aparticular instant, then only control signal is passed to the filter unit to perform filteringoperation on the windowed data set. On the other hand, if the impulse detector doesn'tfind any noise, then no control signal is given to the filter unit; rather, the windowsampler is enabled to take the next data sample.

HARDWARE IMPLEMENTATION

The test bench setup for the FPGA implementation of the image denoising using theproposed algorithm is shown in Figure 2. The external interface, such as, reading theimage and displaying the image on the display are done with the help of MATLAB. Theimage denoising algorithm was implemented on the FPGA. The image is read with thehelp of MATLAB and salt and pepper noise of fixed noise density is added to the image.The corrupted pixel values of the image are copied into the memory initialization file ofthe input memory. The denoising algorithm is implemented on the FPGA by reading thevalues from the input memory and the denoised output image is stored in the outputmemory. The denoised outputs are taken back to the MATLAB for displaying.

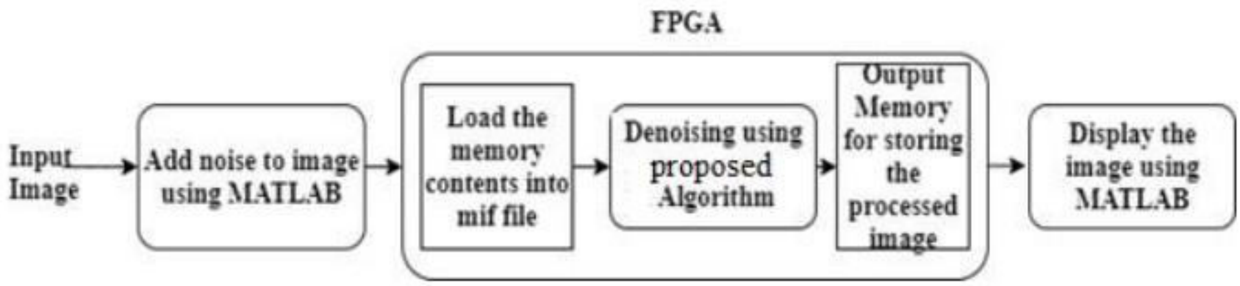

Figure: Block diagram of Image denoising algorithm

The block diagram for a real time hardware implementation of the image denoisingusing proposed algorithm is shown in figure 3. Here, Stratix II FPGA is chosen forimplementation of the algorithm where the image is read with the help of camera. Theanalog inputs are converted to digital inputs with the help of an ADC. The input valuesare stored in SRAM1 which is the external memory provided on the board. The image isdisplayed on the monitor with the help of DAC after processing it. The hardwaresetup for the image denoising is shown in Figure.

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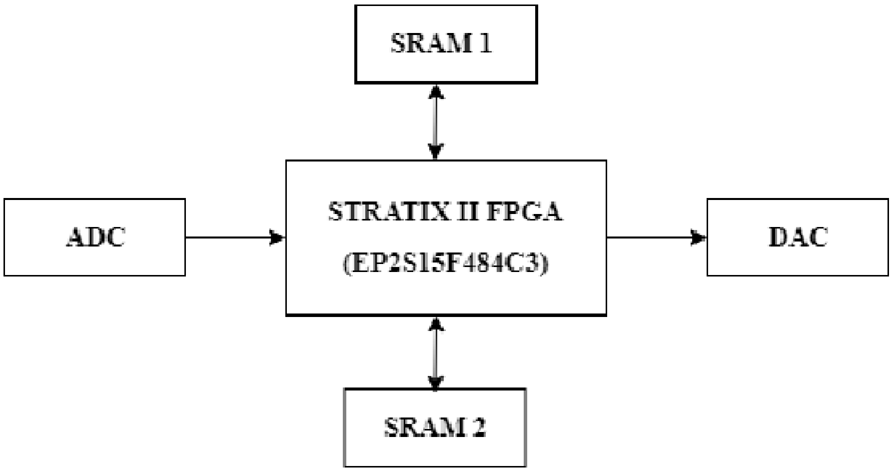

Figure: Expected Hardware setup for the proposed work

4. CONCLUSION

The present work focuses on implementation of Image denoising algorithm intothe stratix II FPGA. Salt & pepper noise was used in the present work wherein itcontains noise either in the form of white or black pixel. The resolution of the imagewas 64 X 64 gray scale image. MATLAB was used for reading the image anddisplaying the image on the console. The image denoising algorithm was implementedin the Quartus tool. The 3 X 3 median filter proves to be effective when the noisevariance in the image was low. And it fails to work when the noise variance increases.The results obtained using the quartus tool and the result from the matlab are samewhen the noise variance is low. As the noise variance increases, the 7 X 7 filter wasused for denoising. The results shows better performance compared to the matlab. ThePSNR was used as a performance metric in the present work.

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