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Role of Low Power VLSI in Electronic and Digital Image Processing Practical Techniques Applications

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ABSTRACT

In digital images when we used computer algorithms to perform image processing this term is generally called digital image processing. In the past, VLSI designers were mainly focused in area, performance, reliability and cost. But in today's world of electronics industries low power has emerged as a principal theme. For VLSI design technology power dissipation has become an important consideration as compare to other parameters. In this paper we described the basic introduction of some practical techniques which are used in digital image processing includes the role of low power VLSI design.

Keywords:- Image segmentation, Image enhancement, Image restoration, Image compression, Object recognition, Salt-and-Pepper noise, Neural networks, Low power VLSI, Voltage scaling, Adiabatic logic, HDL languages.

I. INTRODUCTION

Digital images plays vital role in daily life applications and in areas of technology and research. Basically a digital image is a numerical representation of an object. The term digital image processing refers to the collection of techniques for the manipulation of digital image by computers. A digital image is a collection of finite number of elements called pixels. Each of which has a particular location and value.

Broadly we can classify an image into 2 terms. (i)-Analog image, (ii)-Digital image. An analog image processing is based on the processing of 2-dimensional analog signals. In an analog image processing an image is manipulated by electrical means with the help of varying an electrical signal. The example of this is television image. In case of digital image it is the combination of pixels. Pixels are the smallest picture elements or sample. If we want to convert an analog image to digital image two important processes plays important role for this process first is sampling process and another one is quantization process. The main advantages are digital image processing is in this process we modify and purify an image very quickly and easily with the help of many processing techniques.

A digital image is a type of 2-dimensional discrete signal. In other words we can say that it is a type of N×N array of elements. The representation of 3×3 image is shown in figure 1 in the form of matrix. When we capture an image by using camera basically the source of energy is sunlight. And for the acquisition of the image a sensor array is used. The role of sensor array is that when the sunlight falls upon the object then some amount of light reflected by the object, sensor array sense this amount of reflected light. And at last generates a continuous voltage signal with the help of sensed data. The sampling and quantization process involves in this process.

1	0	1
0	1	0
1	0	1

Figure 1- Digital Image Representations in 3×3 Matrix Format

In the past time the major priorities of any VLSI designer is to reduce the area of the designed chip, improve the performance, and cost with reliability. Power consideration was mainly secondary thing. But in present scenario of electronics industries power consumption become an important factor of any chip or module designing. Behind this many important factors are plays important role. Such as portability, battery life, device/battery weight, cost, reliability and environment viewpoint. Power consumption gives lot of advantage and user friendly features of any electronic device. So low power consideration become an important factor of present electronics industries.

This paper presents the role of low power consideration in digital image processing practical techniques. We describe the need of low power in terms of digital image processing practical applications and the advantages of low power consumption. For this purpose we discuss the basic taxonomy of practical techniques of digital image processing.

The paper is organized as follows: - in Section II, practical technology for digital image processing is discussed. Subsequently, in section III, the role of low power VLSI in present electronics era is presented. In section IV, the role of low power VLSI in digital image processing practical techniques are given and discussed. Finally a conclusion will be made in the last section.

II. PRACTICAL TECHNOLOGY FOR DIGITAL IMAGE PROCESSING

In digital image processing many techniques are used for the analysis of image. The main purposes of these techniques are to improve the visual standard and user satisfaction. These techniques are also plays important role in many signal and image processing research applications, robotic vision, in medical research applications, and many more vision research applications [1-12].

Figure 2 represents the basic taxonomy diagram of practical technologies for digital image processing.

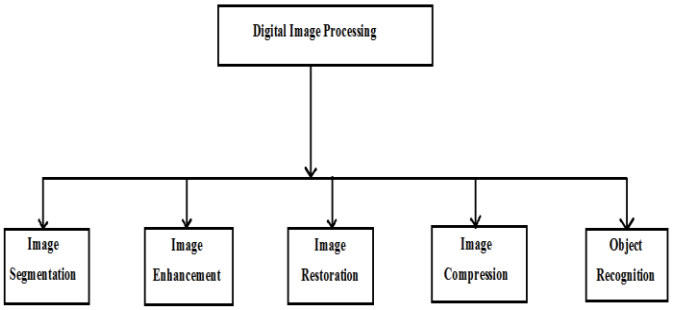

Figure 2-Taxonomy of practical technologies for D.I.P.

(a) Image Segmentation

In many practical digital image processing applications segmentation considered as a first step. The main objective of this step is verifying different features of an image which are merged due to some reasons. The word segmentation is refers for partitioning on an image. In practically we can use to partitioning of an image for computing many things such as median value of an image [13]. When we use segmentation process this is based on some specific approaches. Such as region approach, boundary approach, and edge approach. These all approaches are very useful for problem visualization and implementation a solution.

Broadly we can classify image segmentation process in two types. One is local segmentation process and another one is global segmentation process. In local segmentation process we can segment or partitioning an image in small windows. But in case of global segmentation process we can segment or partitioning an image much large amount of windows as compare to local segmentation.

The role of segmentation is provide a meaningful object or features in an image. There are many practical application of image segmentation process includes object detection, medical imaging, machine vision, traffic control systems, recognition tasks, video surveillance and many more. So with the help of image segmentation process we can also design many modules which are used in image processing applications.

(b) Image Enhancement

The main objective of image enhancement designing techniques is to improve the vision standard of an image. When image is transmitted in one place to other or we can say that during the transmission of image some external noise is introduced. This noise directly affects the visual standard of image. With the help of enhancement designing techniques we can remove noise very easily.

Broadly we can classified image enhancement process in two types one is spatial domain method and another one is transform domain method. In spatial domain method the operation is directly works on pixels. This method also classified in three parts one is point operation second one is mask operation and third one is global operation. In case of transform domain at first we take fourier transformation of an image and then transform it back to the spatial domain.

There are many filtering techniques are comes under enhancement process. Such as linear filtering, average filtering, and median filtering. Median filter are one of the most used for de- noising the images. With the help of median filter one can easily compute the median value of an image matrix and apply median value in original image matrix. Median filter is one of the most popular tool for removing salt-and-pepper noise in an images [14]. These median values are different from original replaced values or we can say that median values are similar as compare to other matrix values. Here salt refers to the maximum gray value (white) and pepper refers to the minimum gray value (black).

(c) Image restoration

The main objective of image restoration process is to balance or reduce the defects which de-grads the images. In other word we can say that when degraded observation is present in an image with the help of restoration process we reconstruct the original scene. When we have the cause or information about degradation then the deterministic process of image restoration is more effective. In practically there are many reasons behind the degradation includes not proper focus of lens, relative motion between object and camera, atmospheric turbulence and many more. These all reasons creates image blur. Generally the term of blur is known as the bandwidth reduction of an image. Broadly the term of image blurs is classified in three types. First is gauss blur second one is out-of-focus blur and third one is motion blur. The relative motion between an object and camera is the main cause of motion blur.

We can write a general restoration model in equation form as-

$$g(m,n) = h(m,n) * f(m,n) \quad \ldots\ldots(1)$$

In equation 1 f (m,n) represents the input image, h(m,n) represents the degradation, and g(m,n) represents the restoration function which is created through convolution process. * sign shows the convolution of h (m,n) and f(m,n).

Broadly we can classify the image restoration techniques in two types. (i)- Deterministic method, (ii)- Stochastic methods. The deterministic methods are also subdivided into 2 methods one is liner methods and another one is non-linear methods. In linear image restoration techniques we use many type filters includes inverse filter, pseudo-inverse filter, wiener filter and many more. The main advantage of liner methods is these are simple to use and fast. But they have some limited capabilities. For example in case of inverse filtering that is not always possible to obtain an inverse. The must condition of inverse is that matrix should be not in singular form. In case of non linear techniques these techniques are introduced spatial adaptively, non negativity and many more special functions. But the main drawback of non-linear methods is complex computational demand.

The stochastic image restoration techniques are mainly based on probability theory. It is used the philosophy of Bayesian inference.

One important tool to restore images is blind de-convolution. It is very powerful tool because it works on without or with little any prior knowledge. Image restoration process is also used with the help of process [15].

(d) Image Compression

The technological standard growth of digital image processing applications including multimedia, video teleconferencing, vision research operations, medical and satellite research operations and many more has increased the demand of effective image compression techniques. In image compression process the principle approach is to reduce the amount of data (bits) with preserving the image details. In the duration of image data transmission image compression plays vital role. Because it is also helps and defines the image data storage and transmission capacity. With the help of suitable compression technique we easily store and transmit our image data in a good way with preserve the quality of image data.

Broadly we can classify the compression techniques in two types (i)- lossless compression or reversible compression, (ii)- lossy compression or irreversible compression. In case of lossless compression after compression and decompression the image remains identical to the original image it means every bit of information is preserved. In other words we can say that

the reconstructed image is an exact replica of the original image. Mainly the lossless compression techniques are used in medical image compression applications. In case of lossy compression techniques the reconstructed image degrades with respect to original one. In this scheme a reconstructed image is achieved by elimination of some amount of redundancies. But in lossy compression we can achieve higher compression ratio with respect to lossless compression. Lossy compression techniques are mainly used in multimedia applications.

The lossless compression strategy is based on statistics of data and result of this compression provides the results in redundancy reduction. The lossy compression is based on meaning of information and provides the results in irrelevancy reduction. The main methods of lossless compression are predictive encoding plus and statistical encoding. The transform encoding plus quantization method is mainly used in lossy compression techniques. the typically compression factor of lossless compression is 2 to 3 and in case of lossy compression it is 6 to 12. By using fuzzy logic algorithm we can analysis the performance of image compression [16]. Different applications use different type's image compression techniques [17].

The basic image compression scheme is shown in figure 3.

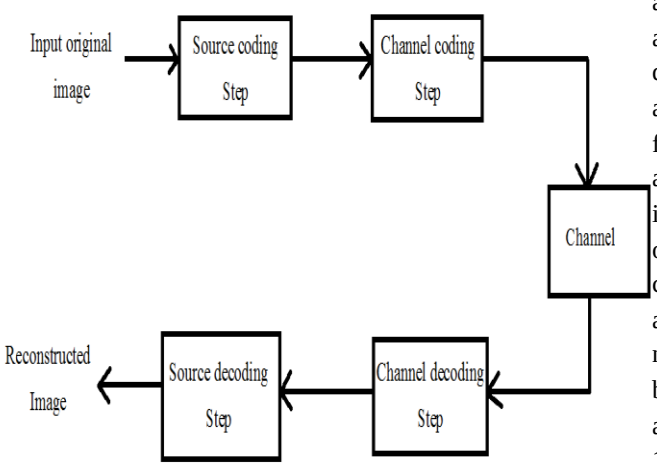

Figure 3- Image compression basic block diagram

(e) Object Recognition

The concept of object recognition is mostly used in machine vision industrial applications. The process of object recognition is used the analysis of data. This process tells us how machine or human nature is detects the data in simple way. When the object target expends in larger area some problem happens to detect the target due to some vision limitations. For this purpose this is the main need of suitable object recognition schemes. A good recognition systemhave standard qualities includes quick and accurate object recognition from noisy image data and many more. In other words we can say that object recognition is a process in which we recognition the pattern in the image. The term pattern is classified in three sub categories (i)- Vector form, (ii)- String form, (iii)- Tree representation.

The vector form of object recognition is based on quantitative description of pattern. It describes the image pattern with the help of input image features and many other criteria. In other words generally it differentiates the simple features of image and makes a simple computation. In case of string form it generates a pattern based on simple entities which are simply connected of primitives. Generally it is used when gray level gradual variation is presents in the images. The third tree representation is based on hierarchical ordering of the images. For example if we take the group of animals then according to the hierarchical representation the groups are divided in many parts such as domestic animals, wild animals, domestic herbivores animals, domestic carnivores animals, wild herbivores animals, wild carnivores animals and many other types.

Broadly we can classify the object recognition approaches in two terms one is decision theoretic approach and another one is structural approach. The decision theoretic approach is also called statistical approach and classified in two main sub-categories. In first category classical approach is comes. In classical approach parametric and non-parametric methods are included. In second category of decision theory is based on neural network approach. Neural networks are also classified in two types (i)- Single-layer neural networks, and (ii)- Multi-layer neural networks. Basically a neural network is characterized by its connection pattern between the neurons which is clearly shown in its architecture. In case of single-layer neural network it has 1 layer of connection weights. Mostly feed-forward networks are comes under single-layer neural networks. Some common examples of single neural networks are ADALINE, Perceptron. In case of multi-layer neural network it has more than 1 layer presents in input and output units. Generally they are called hidden units. It is used to solve more complicated problem as compare to single-layer neural networks. In structural approach of object recognition the structural features are assumed to be known. The structural features are also named as

primitives. The common difference between statistical approach and structural approach is that in statistical approach extracts the quantitative features and the structural approach extracts the morphological features and inter-relation between morphological features with in object.

So these are five main practical technologies which are mainly used in digital image practical applications.

III: ROLE OF LOW POWER VLSI TECHNOLOGY IN PRESENT ELECTRONICS ERA

In present time, low power consideration has become an important theme of electronics industries. In the past, VLSI designer mainly concentrate on area, performance, reliability and cost. But in present era low power become an important principle. The motivation for low power consideration or reducing power consumption differs application to application. Behind this many reasons or factors are plays vital role. Here we discussed about these important factors.

(a) Portability

The meaning of portability refers to the term which is easily carried or moved. In present time the portable devices such as mobile phone, laptops etc. plays important role in our daily life. These devices give a standard as well as good facility to our daily routine works. In case of these portable devices we need good battery back up to perform/use our work. A smart battery back-up provides strong work functionality. So power plays vital role for creating the strong battery back-up in our portable devices. Because we want strong or more battery back-up if we increase the power rating of battery then the size and weight of the battery will also be increased so this is a disadvantage. We also want to control the size and weight of our device. So what will we do? The solution of this is the use of low power consuming components which consumes less power and our battery back-up will be strong and the problem of size and weight will also easily reduced. So in simple words we can say that the portable devices (current and future) will suffer two main problems in the absence of low power technology one is very short battery life and another one is heavy battery pack.

(b) Cost

If any device takes more power consumption then definitely the cooling process or operation will also be very costly. Because high power consuming devices requires high and big level cooling fans or equipments for controlling the device temperature. Which are much costly as compare to small cooling equipments/fans. So this is also a drawback of high power consuming devices. Because cost is also very important factor so this is the main condition to use lower consuming devices. Hence we can say that low power devices also very important with respect to cost factor.

(c) Reliability

If we use high power then it directly affects our system temperature it means our system temperature will increased due to high power. And as a result the probability of several silicon failure mechanisms will increase. Because every 10 °C increase in operating temperature roughly doubles component's failure rate [18]. So if we want the internal component safety of our device low power is one of the best option. Hence we can say that the concept of low power is also plays important role with respect to reliability factor.

(d) Size

When we use high power consuming components for developing purpose of our devices then definitely each component disturbs or create problem for his neighbor component. Because when one component will be hot much then definitely it will be directly affects the functionality of his neighbor component. For this purpose to much spacing required between two components. And at last the size of device will be increased. So this is also a drawback of use of high power. For this problem low power is also one of the best solution. Hence we can say that use of low power consuming components plays vital role with respect to device size factor.

(e) Environmental Viewpoint

High power consuming devices are definitely produce large amount of heat in environment for example suppose in one industry 1000 peoples is working in their high power consuming devices. Definitely they produce large amount of heat which creates very serious problem for environmental point of view. If they will use low power consuming devices for their work normally low heat produce as compare to high power devices. Hence we can say that the concept of low power is also play very important role with respect to environmental viewpoint.

These are some important factors which describes the need and role of low power VLSI in present era. And many other important factors are comes in low power VLSI which is directly and indirectly describes the need of low power VLSI. The motivation for low power

consideration or reducing power consumption differs application to application in different fields.

IV. ROLE OF LOW POWER VLSI TECHNOLOGY IN DIGITAL IMAGE PRACTICAL TECHNOLOGY

In present time digital image practical technology based applications plays vital role in research and development area. Because the demand of high definition multimedia applications, medical technology applications, and many more vision based applications are increasing day by day. Generally the designing and development phase of any new device in electronics industry is comes under VLSI technology. And in VLSI technology low power factor plays vital role. In other words we can say that the power consideration become the basic need of any designer. So we can say that concept of low power is the principle theme for designing purpose.

In case of digital image practical technology based application low power designing also plays important role. For example suppose we design a median filter. Median filter is one of the mostly used tool in digital image practical technology. There are many practical methods for designing a median filter. But if they takes more power and shows maximum delay then these are not satisfactory because these types approaches increased the cost of designed process, there computational speed may be not satisfactory, their size and weight also may be not satisfactory and many type other drawbacks will present in those methods.

Low power concept provides lot of advantages such as cost, less power consumption, size and weight, portability, good computational speed, low complex hardware implementation, good delay and many more. So if designer follow some specific rules and points in his mind definitely he/she will design a good practical module.

Here we discuss some ideas which will help for designing of practical module.

(a) Use of Better design techniques

When we design any module then this is the main condition to use better technique or algorithm. Designer will must focus on shortest path based algorithms. If designer focus the shortest path algorithm definitely it will take minimum number of amount memory elements or internal elements. And definitely minimum number of elements will take less power. So our objective related to power consumption will be solve in very easy manner. Hence we can say that use of better approach/algorithm provides us a user friendly device or module. In case of designing of median filter if we use minimum number of memory elements then definitely our power consumption is reduced and it also provide us a good delay. So use of better design techniques is plays important role for designing digital image practical technologies as well as any electronics device.

(b) The scaling of supply voltage

This is also one of the best method to minimization of power. We can reduce the power with the help of reducing supply voltage but in case of this delay increased linearly. So this is the biggest challenge for all designers to scale the supply voltage without compromising the performance of device. So designer used different types techniques for this purpose. These are static voltage scaling, multi-level voltage scaling, dynamic voltage and frequency scaling, and adaptive voltage scaling. In static voltage scaling technique different blocks or we can say that subsystems are given different fixed voltages. In case of multi-level voltage scaling this technique is normally based on switching operation between two or more fixed voltages. In other words we can say that this method is an extension of static voltage scaling method in which the supply voltage is switched between fixed voltages. The concept of multi-level voltage scaling is that in this less delay presents in high Vdd gates but higher dynamic and static power presents. Larger delay presents in low Vdd gates but les power dissipation. The key advantage of this method is that total power dissipation can be reduced with maintain the overall circuit performance. In case of dynamic voltage scaling we also scale frequency in other words when we scale down the voltage we also scale down the frequency. Here we applied large numbers of voltage levels to different workloads. In case of adaptive voltage scaling we use a control loop to adjust the frequency and voltage for the purpose of changing workload.

These all approaches are used to application to application. It means according to our application designer choose one best scaling approach which is not affects our performance. In case of digital image processing application these approaches are also used for designing the module. For example when designer design any pipelined and parallelism architectural based model then static voltage scaling concept plays important role. Parallel and pipelined based architecture

are mostly used for designing enhancement, segmentation, and restoration based module. Parallel processing also plays very important role to reduce the power consumption in CMOS based circuits. And key point of parallel approach is that performance loss can be compensates by using this. And when we want to scale device feature size then static voltage scaling concept also plays vital role. Where standard cell base modules are designed the designer can choose the multi-level scaling concept. So application to application designer select any approach of supply voltage scaling.

(c) Using Power reusing and management techniques

For designing purpose of digital image processing module designer can also chose some power management techniques such as static and dynamic management techniques. For the purpose of power reusing use of adiabatic circuits is one of the best option. Adiabatic circuit mainly follows some standard rules includes when there is a voltage potential between source and drain transistor mode will remain off, and when current is flowing through transistor the mode will be turn on the transistor and never pass current with the help of diode. With the help of these types techniques designer will save power and also reuse it. These techniques are plays important rule for designing of image enhancement, segmentation and compression modules.

(d) By Using CAD Methodologies and Techniques

Digital image processing practical technologies are based on various types algorithms. For example median filter designing algorithm, segmentation process based module algorithms, compression based algorithms and many more other. The simplest method or way to implement these algorithm is by using HDL based languages or other CAD methodologies. Many designers are used HDL languages such as VHDL or Verilog, and CAD methodologies. There are many types optimization techniques for power reduction comes under CAD methodology includes system design, behavioral synthesis, logic synthesis, physical design, circuit design [18]. The main advantages of these methodologies are these are easy for implementation and we can directly change the system design with the help of change in our prepared program. If a designer or programmer is well skilled then definitely with the help of these methodologies he/she minimize the memory elements as well as delay. This is depends upon designer skill.

(e) In Physical Design Process Low Power Management by designer

There are many steps involved in physical design process includes partitioning, floor-planning and placement, routing, compaction, and extraction and verification. The use of these steps provides a good path for designing purpose. If a designer use these steps with a carefully manner and use smart way for these techniques (for example in routing process minimum amount or shortest interconnection between two blocks) then it will be good for device performance. In case of digital signal processing applications many time these process plays vital role for module designing. This step is also depends on the skills of designer.

These are some special techniques for power reduction which are mostly used for designing purpose of digital image processing practical technologies. If designer keep these things in his/her mind then definitely he/she will design a good module.

V. CONCLUSION

In this paper we presented the role of low power VLSI in present electronics era and with respect to the digital image processing practical technologies. Low power consideration plays very important role in present time. Any designer which is works on electronics designing modules mainly focus on power consideration. Our main objective in this paper to narrate the basic ideas and importance of low power VLSI with respect to digital image processing because image processing applications are also plays vital role in researches and growing technological field. One can easily understand the practical applications of digital image processing and the importance of low power VLSI with the help of this paper. This paper will also provide a good help for designing of digital image processing application with respect to low power tools or modules.

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