ENHANCEMENT IN VISUAL QUALITY OF A DIGITAL IMAGE USING MULTI CORE PROCESSING

Beyyala Ajay Kumar*

P.Venkatesan**

Abstract

Generally digital image processing is carried out using mono processing unit with single core on it. In order to enhance the speed and to reduce the power consumption, multicore processing is introduced in which clock rates of individual cores are decreased but the overall speed increases as many cores function together. This also has an additional feature of reducing power consumption as clock rates are decreased. But visual quality is also an important requirement in any digital image processing to reproduce high clarity output. Presently there are many traditional techniques to improve visual quality of a digital image using single core processing unit. The enhancement of visual quality can be obtained, similarly as single core, by multicore processing much more effectively imparting benefits of multicore environment in quality improvement. This usage of multicore in visual quality improvement has many advantages like less time consumption with low power functioning, which is a desired characteristic of any innovative methods.

***Keywords* – Multi core processor, spatial resolution, fuzzy logic, intensity resolution, pixel**

* B.E. Final Year /E.C.E dept, S.C.S.V.M.V. University

** Senior Asst. Professor /E.C.E dept, S.C.S.V.M.V. University

I. MULTI-CORE SYSTEMS

A multi-core system is used obtain more performance by making use of the same dye area on the silicon to split multiple processors of lower clock rates , as opposed to a single processors of high clock rate on the same dye area. Any increment in clock rate would impact in significant power consumption. Thus Attempts are being made to switch to a multi-core environment. In this environment, much architecture gets developed with different feature sets. Integration of such heterogeneous systems is the current developer's and system engineer's challenge. A multi-core framework is a requirement in this upcoming industry which is a split between optimal solutions obtained using symmetric multiprocessing (SMP) versus heterogeneous system on chip (SoC). SMP implementations conventionally involve an HLOS implementation that performs a variety of operations: inter-processor communication, binary code split amongst processors, split or load optimization, memory management and bookkeeping, developer abstraction layers – these are features that are put in to make the framework parallelize any user code. Architectures can be classified in multiple ways to describe could be explained in terms of what is called the Flynn's taxonomy. There is no exhaustive characterization of the different types of parallel systems. The most popular taxonomy was defined by Flynn in 1966. The classification is based on the notion of a stream of information. Two types of information flow into a processor: instructions and data. Conceptually these can be separated into two independent streams, whether or not the information actually arrives on a different set of wires[2]. Flynn's taxonomy classifies machines according to whether they have one stream or more than one stream of each type.

The four combinations are SISD (single instruction stream, single data stream), SIMD (single instruction stream, multiple data streams), MISD (multiple instruction streams, single data stream), and MIMD (multiple instruction streams, multiple data streams)[3].

Similar features are required in a generic multi-core system where the differences occur in architecture, number of available processors, internal memory of each processor, memory hierarchy organization(distributed memory model, shared memory model,..) processing MHz(speed), IPC mechanisms (interconnect based, Shared memory communication etc.) and some external factors like compiler specifics, multi-linker coordination. These are multitudes of settings that need to be hand tailored by the system engineer to extract the maximum out of a given heterogeneous multi-core array. This process becomes tedious when it should happen afresh for every new system.

II. TRADITIONAL VISUL QUALITY ENHANCMENT TECHNIQUES

A. Segmentation:

In computer vision, segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyse. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images[1]. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics.

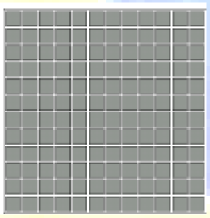

Fig1.Segmentation of image on spatial domain into pixels

The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a region are similar with respect to some characteristic or computed property, such as colour, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s). When applied to a stack of images, typical in medical imaging, the resulting contours after image segmentation can be used to create 3D reconstructions with the help of interpolation algorithms like marching cubes[6]. As this segmentation method divides entire image into number of segments as rows and columns, this number of pixels (pels or segments) is directly variant with the visual quality of the image up to a certain extent.

B. Sampling and Quantization

As the image is captured, it is transduced into electrical output for further processing of image. This electrical output is continuous voltage form whose amplitude and spatial behaviour are related to physical phenomenon being sensed. This analog output must be converted into digital form. This conversion involves two methods: sampling and quantization.

The basic idea behind sampling is, if the continuous image is f that we want to convert into digital image an image may be continuous with respect to x and y coordinates and also in amplitude then we have to sample function in both coordinates and amplitude. Thus digitizing the coordinate axis is called sampling [1]. In signal processing, sampling is the reduction of a continuous signal to a discrete signal. A common example is the conversion of a sound wave (a continuous signal) to a sequence of samples (a discrete-time signal).A sample refers to a value or set of values at a point in time and/or space. A sampler is a subsystem or operation that extracts samples from a continuous signal. A theoretical ideal sampler produces samples equivalent to the instantaneous value of the continuous signal at the desired points.

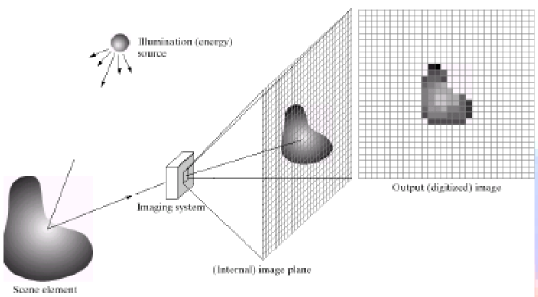

Fig.2 image sampling and quantisation of real image on spatial domain

Sampling can be done for functions varying in space, time, or any other dimension, and similar results are obtained in two or more dimensions. For functions that vary with time, let s(t) be a continuous function (or "signal") to be sampled, and let sampling be performed by measuring the value of the continuous function every T seconds, which is called the sampling interval[8]. Thus, the sampled function is given by the sequence:

s(nT),   for integer values of n.

The sampling frequency or sampling rate fs is defined as the number of samples obtained in one second (samples per second), thus fs = 1/T.

Reconstructing a continuous function from samples is done by interpolation algorithms. The Whittaker–Shannon interpolation formula is mathematically equivalent to an ideal low pass filter whose input is a sequence of Dirac delta functions that are modulated (multiplied) by the sample values. When the time interval between adjacent samples is a constant (T), the sequence of delta functions is called a Dirac comb. Mathematically, the modulated Dirac comb is equivalent to the product of the comb function with s(t)[5]. That purely mathematical function is often loosely referred to as the sampled signal.

Most sampled signals are not simply stored and reconstructed. But the fidelity of a theoretical reconstruction is a customary measure of the effectiveness of sampling. That fidelity is reduced when s (t) contains frequency components higher than fs/2 Hz, which is known as the Nyquist frequency of the sampler. Therefore s(t) is usually the output of a low pass filter, functionally known as an "anti-aliasing" filter. Without an anti-aliasing filter, frequencies higher than the Nyquist frequency will influence the samples in a way that is misinterpreted by the interpolation process.

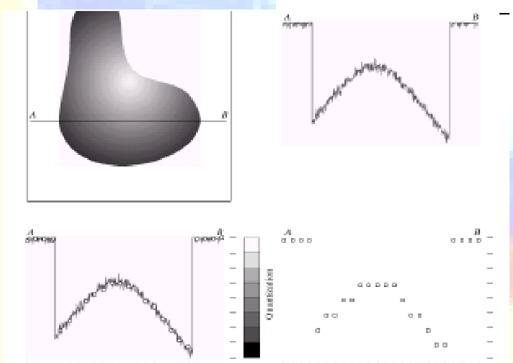

Fig.3 method of digitizing the output of sampled output of image

Digitizing the amplitude values is called quantization .the sampled values will be of very slight differences that the variation couldn't be easily traced as the adjacent samples vary only with small decimal values.so this must be quantised to represent in digital form to carry out processing. The intensity values must be converted into quantized digital values. Here the number of bits used to get quantised output matters as the number of bits increases the more number of intensity variations can be obtained.

C. Image Resolution:

Image resolution is most used term that describes the detail an image holds. The term is used for raster digital images, film images, and other types of images. Higher resolution means more image detail. Image resolution directly varies with the visual quality of the digital image

Image resolution can be measured in various ways. Basically, resolution quantifies how close lines can be to each other and still be visibly resolved. Resolution units can be tied to physical sizes (e.g. lines per mm, lines per inch), to the overall size of a picture (lines per picture height, also known simply as lines, TV lines, or TVL), or to angular subtenant[4]. Line pairs are often used instead of lines; a line pair comprises a dark line and an adjacent light line. A line is either a dark line or a light line[10]. A resolution 10 lines per millimetre means 5 dark lines alternating with 5 light lines, or 5 line pairs per millimetre (5 LP/mm). Photographic lens and film resolution are most often quoted in line pairs per millimetre.

D. Pixel Resolution

The term resolution is often used for a pixel count in digital imaging, even though American, Japanese, and international standards specify that it should not be so used, at least in the digital camera field An image of N pixels high by M pixels wide can have any resolution less than N lines per picture height, or N TV lines[1]. But when the pixel counts are referred to as resolution, the convention is to describe the pixel resolution with the set of two positive integer numbers, where the first number is the number of pixel columns (width) and the second is the number of pixel rows (height), for example as 7680 by 4320. Another popular convention is to cite resolution as the total number of pixels in the image, typically given as number of megapixels, which can be calculated by multiplying pixel columns by pixel rows and dividing by one million. Other conventions include describing pixels per length unit or pixels per area unit, such as pixels per inch or per square inch. None of these pixel resolutions are true resolutions, but they are widely referred to as such; they serve as upper bounds on image resolution.

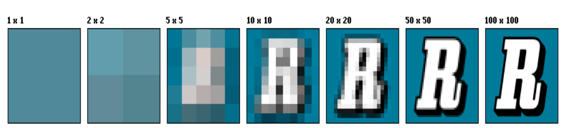

Fig.4 Image quality enhancement wit pixels increase

According to the same standards, the number of effective pixels that an image sensor or digital camera has is the count of elementary pixel sensors that contribute to the final image, as opposed to the number of total pixels, which includes unused or light-shielded pixels around the edges.

Below is an illustration of how the same image might appear at different pixel resolutions, if the pixels were poorly rendered as sharp squares (normally, a smooth image reconstruction from pixels would be preferred, but for illustration of pixels, the sharp squares make the point better?

An image that is 2048 pixels in width and 1536 pixels in height has a total of 2048×1536 = 3,145,728 pixels or 3.1 megapixels. One could refer to it as 2048 by 1536 or a 3.1-megapixel image.

Unfortunately, the count of pixels isn't a real measure of the resolution of digital camera images, because colour image sensors are typically set up to alternate colour filter types over the light sensitive individual pixel sensors. Digital images ultimately require a red, green, and blue value for each pixel to be displayed or printed, but one individual pixel in the image sensor will only supply one of those three pieces of information. The image has to be interpolated or demos iced to produce all three colours for each output pixel.

E. Spatial Resolution

Quantitatively spatial resolution can be explained in many ways with line pairs per unit distance, and dots per unit distance being among the most common measures. The measure of how closely lines can be resolved in an image is called spatial resolution, and it depends on properties of the system creating the image, not just the pixel resolution in pixels per inch (ppi)[1]. For practical purposes the clarity of the image is decided by its spatial resolution, not the number of pixels in an image. In effect, spatial resolution refers to the number of independent pixel values per unit length.

The spatial resolution of computer monitors is generally 72 to 100 lines per inch, corresponding to pixel resolutions of 72 to 100 ppi. With scanners, optical resolution is sometimes used to distinguish spatial resolution from the number of pixels per inch [12].

In remote sensing, spatial resolution is typically limited by diffraction, as well as by aberrations, imperfect focus, and atmospheric distortion. The ground sample distance (GSD) of an image[13], the pixel spacing on the Earth's surface, is typically considerably smaller than the resolvable spot size.

In astronomy one often measures spatial resolution in data points per arc second subtended at the point of observation, since the physical distance between objects in the image depends on their distance away and this varies widely with the object of interest. On the other hand, in electron microscopy, line or fringe resolution refers to the minimum separation detectable between adjacent parallel lines (e.g. between planes of atoms)[11], while point resolution instead refers to the minimum separation between adjacent points that can be both detected and interpreted e.g. as adjacent columns of atoms, for instance. The former often helps one detect periodicity in specimens, while the latter (although more difficult to achieve) is key to visualizing how individual atoms interact.

In Stereoscopic 3D images, spatial resolution could be defined as the spatial information recorded or captured by two viewpoints of a stereo camera (left and right camera). The effects of spatial resolution on overall perceived resolution of an image on a person's mind are yet not fully documented. It could be argued that such "spatial resolution" could add an image that then would not depend solely on pixel count or Dots per inch alone[10], when classifying and interpreting overall resolution of a given photographic image or video frame.

Fig.5 example of Image quality variations with spatial resolution increase

Increase in the detail in the image though doesn’t increase the image quality actually. Due to the apparent contrast increase in the image makes that image perceived as improved quality to the human eye

F. Intensity Resolution

Intensity resolution refers to the small discernible change in the intensity level. We have considerable discretion regarding the number of samples used to generate a digital image, but this is not true regarding the number of intensity levels .based on hardware considerations, the number of intensity levels usually is an integer power of two. The most common number is 8 bits, with 16 bits being used in some applications in which enhancement of specific intensity ranges is necessary[14]. Generally number of bits used to quantise intensity is deduced as intensity resolution.

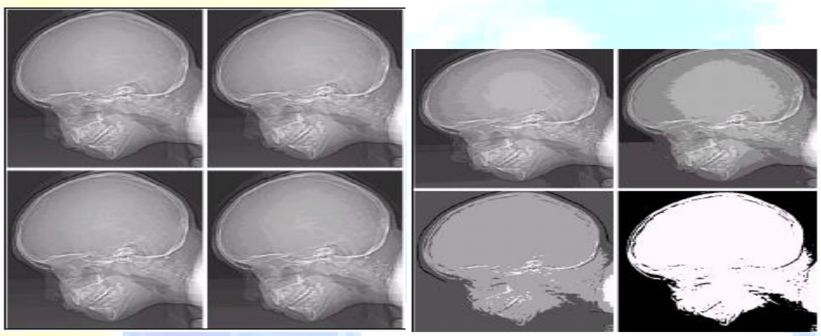

Fig.6 Images of 256,128,64,32,18,8,4,2 intensity levels

III. VISUAL QUALITY IMPROVEMENT USING FUZZY LOGIC

Fuzzy logic is a type of many-valued logic or probabilistic logic; it deals with reasoning that is approximate rather than fixed and exact. In contrast with traditional logic they can have varying values, where binary sets have two-valued logic, true or false, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false.[1] Furthermore, when linguistic variables are used, these degrees may be managed by specific functions

Fuzzy image processing is the collection of all approaches that understand, represent and process the images, their segments and features as fuzzy sets. The representation and processing depend on the selected fuzzy technique and on the problem to be solved.it includes membership functions the membership function of a fuzzy set is a generalization of the indicator function in classical sets. In fuzzy logic, it represents the degree of truth as an extension of valuation.

Degrees of truth are often confused with probabilities, although they are conceptually distinct, because fuzzy truth represents membership in vaguely defined sets, not likelihood of some event or condition.

Consider the general problem of contrast enhancement, one of the principal applications of intensity transformations [1]. We can state the process of enhancing the contrast of a grey scale image using the following rules:

IF a pixel is dark, THEN make it darker.

IF a pixel is grey, THEN make it grey

IF a pixel is bright, THEN make it brighter

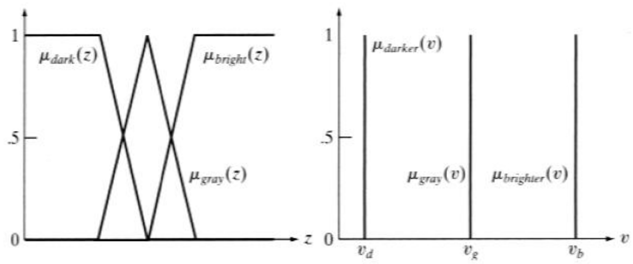

Fig.8 graphical representation of fuzzy logic

Keeping in mind that these are fuzzy terms, we can express the concepts of dark, grey, and bright by the membership functions.in terms of the output, we can consider darker as being degrees of a dark intensity value (100% black being the limiting shade of dark), brighter, as being degrees of bright shades and grey as being degrees of intensity in the middle of the grey scale. In this example, we are interested in **constant** intensities, whose strength is modified. Therefore, the output membership functions are **singletons** (constant)[1]. The various degrees of intensity in [0 1] occur when singletons are clipped by the corresponding rules. In this situation, for the input z0 the output:

$$v_0 = \frac{\mu_{dark}(z_0)\cdot v_d + \mu_{gray}(z_0)\cdot v_g + \mu_{bright}(z_0)\cdot v_b}{\mu_{dark}(z_0) + \mu_{gray}(z_0) + \mu_{bright}(z_0)}$$

Fuzzy image processing is computationally intensive, since the fuzzification, processing conditions for all rules, implication, aggregation, and defuzzification must be [14] applied to **every** pixel in the input image.

Original low-contrast image (intensities in a narrow range)

Result of histogram equalization – contrast is increased but there are areas with overexposed appearance

Result of a rule-based contrast modification approach

Fig.7 quality changes for different enhancement techniques

IV. QUALITY ENHANCEMENT WITH MULTI CORE SYSTEMS

As the visual quality improvement involves many tasks to be performed in an order to reconstruct the original acquired image with high visual quality, it will be good if tasks are simultaneously fulfilled, rather than one after the other, and combine to produce digital image output .This method reduces much processing time for image enhancement. Thus, if single cores are replaced with multicores, then speed of processing increases and at the same time electric power utilised for the processing is reduced as clock rates are being reduced.

In multicore frames are distributed among the core to carry out the tasks. A multiprocessor system executing a single set of instructions (SIMD), data parallelism is achieved when each processor performs the same task on different pieces of data. A single execution thread controls operations on all pieces of data. In others, different threads control the operation, but they execute the same code .In a multiprocessor system, task parallelism is achieved when each processor executes a different thread (or process) on the same or different data. The threads may execute the same or different code. In the general case, different execution threads communicate with one another as they work. Communication takes place usually to pass data from one thread to the next as part of a workflow. Data parallelism emphasizes the distributed (parallelized) nature of the data, while task parallelism emphasizes the distributed (parallelized) nature of the processes or functions. Most real programs fall somewhere on a continuum between task parallelism and data parallelism[7].

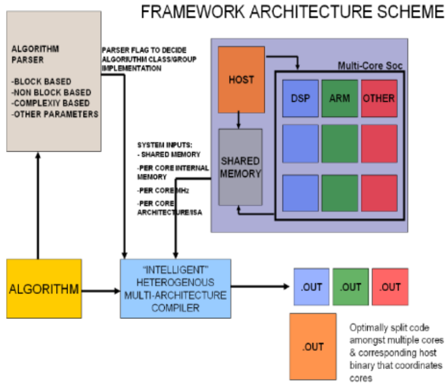

Fig.9 architecture of multicore processor functioning

There is a wide variety of multi-core architectures, instruction set types, memory models and interconnects. It is difficult for a developer who is well versed in one such configuration to start developing seamlessly in another. For example, a GPU developer can't develop code on a hypercube processor directly. Especially in the field of computer vision, the researchers have very little knowledge on exploiting parallel computing. Thus it is important to give the developer an interface where the architecture differences are abstracted out. Here the challenge is to generate optimized code using the interface.

Multi-Architecture intelligent compiler be able to build this code for a particular platform. The framework abstracts out the higher level information and compiler takes it on from that level. The role of algorithmic parser common to both use cases is to identify the local, global and globalocal parts of a generic image processing algorithm. This can also be achieved manually by user tagging of the code sections.

V. CONCLUSION

Though image quality improvement is major requirement in any digital image processing, it is also required to have low power consumption and high processing speed of processing. Traditional single core processors cannot satisfy these features so there is a need for multi core environment in digital image processing to enhance the visual image quality .Hence there is a demand for installing multicore systems in visual image quality improvement techniques to have to effective digital image processing.

REFERENCES

[1] Digital Image Processing, 3rd edition, Rafal C. Gonzalez and Richard E. Woods.

[2] "A Multi-Core Framework for Non-Block Based Image Processing" B Ravi Kiran, Y Senthil Kumar and Anoop K P.

[3] F.J. Seinstra, D; Koelma, J.M; Geusebroek (2000). "A Software Architecture for User Transparent Parallel Image Processing". ISIS technical report series, Vol. 14.

[4] Cristina Nicolescu; Pieter Jonker (2000). "Parallel low-level image processing on a distributed-memory system". J. Rolim et al. (Eds.): IPDPS 2000 Workshops, LNCS 1800, pp. 226-233, Springer-Verlag, Berlin Heidelberg, 2000.

[5] *Thomas* Bräunl (2001). "Tutorial in Data Parallel Image Processing". Australian Journal of Intelligent Information Processing Systems (AJIIPS), vol. 6, no. 3, 2001, pp. 164–174.

[6] Linda G. Shapiro; George C. Stockman (2001). "Computer Vision". pp. 279- 325, New Jersey, Prentice-Hall.

[7] R.M. Haralick, and L.G. Shapiro, Computer and Robot Vision, Vol-1, Addison Wesley, Reading, MA, 1992.

[8] R. Jain, R. Kasturi and B.G. Schunck, Machine Vision, McGraw-Hill International Edition, 1995.

[9] W. K. Pratt, Digital image processing, Prentice Hall, 1989.

[10] A.C. Bovik, Digital Image Processing Course Notes, Dept. of Electrical Engineering, U. of Texas at Austin, 1995.

[11] J.C. Russ, The Image Processing Handbook, CRC Press, Boca Raton, FL., 1992.

[12] R Hummel, "Histogram modification techniques", Computer Graphics and Image Processing, Vol. 4, pp. 209-224, 1975.

[13] S. E. Umbaugh, "Computer Vision & Image Processing," Prentice Hall PTR, 1998.