International Journal of Advanced Computer Technology (IJACT)

ISSN:2319-7900

Image processing techniques with minimal power consumption

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Abstract

In this paper we discuss the different image processing techniques, the recursive methods for enhancing the images and image processing with minimal energy application to visual communication with the help of Handheld Communication Devices (HCD) as example. A general introduction about image processing is specified followed by many sections. Section 1 contains the basic details about image processing and the methods of image processing. Section 2 holds details about the techniques and different tasks performed in image processing. Section 3 possesses information about the color representation and section 4 contains the details of energy consuming sources. Section 5 gives the optimization of the strategies of power consumption at algorithmic level and architectural level. Section 6 provides the overall philosophy concepts, that helps in the best understanding of the visual communication systems (VCS) with HCDs as a source of device and section 7 summarizes and specifies the future directions.

Introduction

Image processing is a technique which enhances the received raw images from a sensor or camera, process it and return images as the output. The images may be sensed from a satellite, space probes, aircraft, and pictures taken in cameras or any sort of day –to-day life from various applications. Image processing techniques have been developed in the last four to five decades. This image processing techniques has found its development due to the easy availability of powerful personnel computer, large sixe memory devices, graphics software, etc. The ultimate aim in a large number of image processing applications is to extract important features from image data, from which a description, interpretation, or understanding of the scene can be provided by the machine. Image processing can be defined as the processing or altering an existing image in a desired manner. Its general form pertains to the alteration and analysis of pictorial information. The most effective and a well known image processing system is probably the human brain along with eye. The system receives, enhances and stores images at enormous rates of speed. Image processing is utilized in various fields such as remote sensing, medical imaging, non – destructive evaluation, forensic studies, textiles, material science, military, film industry, document processing, graphics arts, printing industry, biology, astronomy, security, biometrics, satellite imagery, personal photos, etc.

The increase in communication of visual information over the past several decades has also resulted in many new image processing and visual communication systems being evolved into services. In today's world, energy management is becoming more increasingly a design factor for every device. The most common device in today's world is the Hand Held Communication devices (HCD). With the advent of these devices, energy conscious algorithms and architectures gained wide attention. Many new mechanisms and strategies for energy efficient hardware and software components were developed. A mobile handheld communication device (HCD) is an electronic computing device, which allows communication capability, more advanced processing capacity and more connectivity than the contemporary communicating cell phones. These HCDs are considered to be a handheld computer with the display screen integrated with a mobile telephone, which has many advanced computing skills and supports additional functionalities and services such as web browsing, music, television, gaming application, GPS localization, video conferences etc.

Section 1:-

Image processing:-

Image processing is the method or technique of accepting image as input and returns the same image as output in an enhanced and processed form. This is done at enormous rates of speed.

Methods of image processing:-

- Analog image processing
- Digital image processing

Analog image processing:-

Analog image processing is the technique in which the alteration of image is done through electrical means. For example, in television, the television signal is a voltage level with varying amplitude to denote brightness through the image. By electrically varying the signals, the images are altered. The brightness and contrast controls on TV set serve to adjust the amplitude and reference of the videos signal, resulting in the brightening, darkening and alteration of the brightness range of the image displayed.

Digital image processing:-

ISSN:2319-7900

Digital image processing is the process of converting the images to digital form using a scanner or digitizer and then processing it. It is the method of subjecting the numerical representation of the objects to a series of operations in order to obtain the desired output in a modified version. Digital image processing is the technique of processing a two – dimensional picture by a digital computer, which is an array of real numbers represented by a finite number of bits. The underlying principle of digital image processing is that the repeatability, versatility and the preservation of the original data precision.

Section 2:-

Techniques and different tasks performed in image processing:-

The various image processing techniques are:

- Image representation
- Image pre - processing
- Image enhancement
- Image restoration
- Image analysis
- Image reconstruction
- Image data compression

Section 3:-

Color representation:-

Among the visible wavelength 350 nm – 780 nm, only about 128 fully saturated colors can be distinguished. Three components distinguish the color. They are hue, saturation and luminance.

Hue:-

Hue is the degree to which a stimulus can be described as similar to or different from the stimuli that are described as red, green, blue and yellow.

Saturation:-

Saturation is defined as the purity of color, the amount of white is contained in the color.

Luminance:-

Luminance is the intensity of light which is given by

$$I(\lambda) = \rho(\lambda)\, L(\lambda)$$

$\rho(\lambda)$ = reflectivity of object

I = objective physics of the lightening of the object

Tristimulus theory:-

There are three types of cells in human retina of different response functions which overlap with each other and peak in the yellow – green, green and blue regions respectively. The responses of these cells to a signal of intensity $C(\lambda)$ are therefore $(C) = \int s(\lambda)\, C(\lambda)\, d\lambda$

If two colors produce the same responses then r (C1) = r (C2) then they are perceived as the same color.

Color models:-

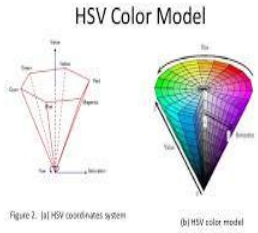
There exist three different color models. They are

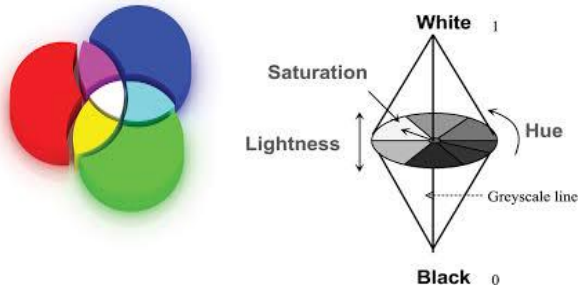
RGB model
HSV model
XYZ model

RGB model uses red green and blue as the three primaries to represent a color.

HSV model uses hue saturation and intensity to represent a color.

XYZ model is International Commission on Illumination, CIE.





Section 4:-

Energy consuming sources:-

In a visual communication system (VCS), the sources of power dissipation is categorized into five broad stages: processor unit, memories, visualization, interconnects and communication.

Processor:-

The first source of energy dissipation is the processors. The demand for high computing power in embedded processors has increased with the adequate growth in the handheld devices and network switches. The energy consumption by processor is categorized into the clock frequency and the CPU cache. CPU cache is used to reduce average time to access memory. With handheld devices, the CPU cache tends to continuously grow in the embedded processor demanding more energy thereby increasing the ratio of energy dissipation. Reducing the energy consumption in the processor cache has been one of the main processor design-

ISSN:2319-7900

issues. A way of prediction scheme for achieving high performance and low energy consumption of set-associative caches are being used. Drowsy cache scheme is investigated in-order to reduce the static energy consumption with multi-level supply voltages. A hybrid scheme for reducing dynamic and static cache energy simultaneously was also discussed. The second source of energy consumption of processor considered is the section related to clock frequency. In the modern processors, the clock frequencies are obtained by generated internal clock signals having higher frequencies than those of external buses. This growth in frequencies leads to an excessive increase in energy consumption in electronic circuits. In today's handheld device processor, three major power states are considered, run, idle, and sleep. It is noted that the sleep state contains multiple levels, each with a different set of components turned off. The major power state available on the processor Strong ARM SA – 1100 is used on Itsy. The major idle state has 10 minor states, one per supported frequency. While the run state has 20 minor states, two core frequencies for each of the 10 supported frequencies used by the rest of the processor.

Storage units:-

The power consumption in the storage units is very significant and must be taken into account in the design of any VCS. Storage unit support consumes much energy when its size augments and hence depending on the application this unit can represent a significant part of the total energy consumed by the system. In particular mobile visual communication and multimedia applications, the memory requires almost half the total energy consumed by the system. This is because memory activity depends on the number of accesses to other components, its size and its position in target architecture. A possible technology for storage units is flash memories, which are nonvolatile and can hold data without consuming energy. Moreover, when reading or writing, such memories consume less than 0.47 W, far less than a hard disk. Hard disks are the mostly used peripherals for storing data. Most hard disks have five power modes; in order of decreasing power consumption, these are active, idle, standby, sleep, and off.

Interconnections:-

Another source of energy dissipation of VCS is related to the components interconnections which is a contribution of both units of interconnections and memory accesses, significantly reducing the power consumption at processing level.

Display devices:-

The last source of power dissipation of a mobile visual communication considered is the display devices. The power consumption in Liquid Crystal Displays (LCD) and Organic Light Emitting Diode (OLED) screens used in handheld devices has a good resolution and sufficient color intensity. Their design requires high power backlight lamps and high capacity memory buffers. While they are supposed to have low consumption, these displays devices are in fact energy greedy. OLED (Organic Light-Emitting Diode) screens constitute a new generation of screens used in many PDAs, mobile phones, numerical cameras, etc. These screens, which emit a visible light at any angle, yield extremely sharp clear images, boast energy consumption lower than that of LCD screens and low manufacturing cost. Due to their advantages, OLEDs have been suggested as a good replacement for LCDs in many applications. Unlike LCDs requiring a backlight, which consumes enough energy, OLEDs produce their own light without the use of a backlight and, hence, dissipates very low energy. Other advantages of OLEDs over LCDs are reported in the literature; including its faster refresh rate, better contrast, exciting displays, and greater brightness.

Section 5:-

Optimization of the strategies of power consumption at algorithmic level and architectural level:-

Due to the need to achieve best compromise between high performances, small size and energy consumption minimization, the design of embedded systems for mobile devices is a complex task. New customer requirements and new applications running on mobile devices require the design of original innovative technologies at both levels application (software) and architectural (hardware). Applications optimization is the process of modifying a software system to make some aspect of its part work efficiently using fewer resources. Software optimization can occur at a number of levels including: design level, source code level, compile level and assembly level. Target architectures partly consist of interconnected integrated circuits (IC). Power consumption optimization mechanisms are used throughout the design flow, from low to high abstraction levels. Low-level techniques aim to reduce the physical capacity or supply voltage, whereas high-level ones are based on the principle of reducing the switching frequency. The basic principles of all energy reduction are based on the reduction of static energy, the use of sleep modes when no processing is required, the design of efficient architecture, best control of the clock frequency, and the reduction of supply.

Power consumption optimization at algorithmic level:-

It is well known that optimization of power consumption at the algorithmic level have the most impact on the final consumption of the circuit. A huge number of strategies and techniques have been developed in the area of algorithmic optimization. The use of data preprocessing, redundancy reduction, approximation, and sequencing can be considered to optimize an algorithm.

ISSN:2319-7900

Power optimization at the architectural level:-

Many tasks in mobile communication systems can be implemented either in dedicated hardware or in software on programmable devices. The challenge is to partition tasks between hardware and software to take best advantage of energy-efficient solutions. To this end, a number of specific strategies and techniques have been developed, for instance allocation and scheduling. Allocation, concerns occupation of resources during the entire time when a task is executed or just during the time a resource is used. The choice of the allocation strategy for VCS applications depends on several factors including the underlying constraints of the target application and energy savings. Scheduling gives the order in which the resources will be used and coordinates their accesses. Scheduling allows energy reduction using file system scheduling; implements the advantages of turning the hard disk off, and improves the battery capacity by adjusting to its recharge characteristics.

Section 6:-

Accentuation:-

Energy consumption is a critical concern for mobile devices. Significant work has been devoted to reduce the energy consumption through better software and hardware. However, few of them have made their work into commercial products. Software running on PC desktops has been adapted and migrated to handheld devices. To be adapted efficiently, software designers have to take into account the energy factor, and the different features and circumstances of this migration and adaptation. It is of interest to design and build new software specifically dedicated to handheld devices. This kind of software, which is different than PC desktops software, has to take into account the energy factor as a primary paradigm during the software design process.

VCS can be seen as successive transformations of images and videos. Researchers and engineers have long been focused on the development of these transformations, which are applied to pixels or other structures derived from pixels, without an in-depth understanding of images. The semantic nature of the metadata and the hierarchy in the physical phenomena imply that there are several layers of data within an image. These layers allow a better understanding of the image/video and consequently allow the conception of suitable minimal energy architectures. Unfortunately, most existing today's cameras does not support this philosophy, and the image is deduced after long processing to improve its subjective quality.

Even if they have an impact on system energy efficiency, human factors and user interfaces have unfortunately often been ignored in almost all the work dedicated to the energy optimization in mobile devices. Therefore, even with a perfect user interface, HCD still spend time and energy waiting for user answers. This is due to an increasingly large speed gap between users and devices in their interactions. In fact, human capacities impose limits on VCS energy efficiency. Thus, theoretical studies of the minimal energy requirements for user interfaces based on human sensory limits must be deeply explored. It will be very useful to develop algorithms dedicated to reduce the energy consumption, focuses on optimizing the interaction itself, i.e., reducing the interaction energy and improve user productivity.

Section 7:-

Conclusion:-

In this paper, we have first discussed image processing and the various image processing methods. Further on, the discussion was made on the techniques and the various tasks performed under image processing and the methods of representing color were then noticed. We have first clarified various sources of energy consumption immobile VCS. We have found that the sources of power dissipation in a mobile

VCS are generally categorized into five broad stages: processor unit, memories, visualization, interconnects and communication. A huge number of strategies and techniques have been developed in the area of algorithmic optimization. The use of data preprocessing, redundancy reduction, approximation, and sequencing can be considered to optimize an algorithm. In this paper, we clarified the various consumption energy sources in mobile devices, and made a synthesis of the adequate energy estimation and optimization solutions at the software and hardware levels. We saw that the growth in multimedia and communication areas has influenced the design of the mobile visual communication devices. Indeed, the world became strictly depended on communication and information technologies simultaneously in its industrial, commercial and domestic activities. With the fulgurating evolution of the mobile and real time VCSs, managing of design processes and particularly compactness of these systems, the increase in their performance and the significant reduction of their consumption, are the major technical challenges. Indeed, today's cell phones, for example, have many modes of operations beyond making and receiving calls. These devices also play video games or music and display video, or just stay in standby. Many of these"modes" can be characterized and optimized in software, increasing the importance of software optimizations for energy-efficient systems. Tradeoffs need to be made between performances; flexibility and energy efficiency in these devices. The challenge is to minimize energy consumption while not significantly impacting the effective performance and flexibility. Minimizing energy consumption can't be a second thought. Designers must seek out all opportunities to reduce energy to achieve their low energy design goals. This starts with a comprehensive plan including optimizing energy consumption early in the design process where there is greater potential savings and more flexibility in implementa-

tion. New energy-saving systems, components and architectures have thus been and continue to be developed in the mobile visual communication area. The energy reduction at the high abstraction level of conception is based on adequate accuracy between the hardware and software which aims to improve on one hand techniques of rapid prototyping and on other hand joint software-material design.

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