IMAGE SEGMENTATION USING GPU

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Abstract

Image segmentation is the process of dividing image in to multiple pixels. We do image segmentation for analyzing the image in more meaningful way. In medical field minute details of image are also matter a lot that's why it is very difficult to process. They need to be divided in such a manner so that their minute details can be easily examined. To divide the image into parts is called segmentation. In this work image segmentation is used to find the region of interest (ROI). The algorithm is presented in four different implementations: sequential CPU, parallel CPU, GPU, and hybrid CPU-GPU. We compare the execution times of the four versions with each other and with other closely related image segmentation algorithms we will be implementing this by using MATLAB. Keyword: Image Enhancement, ROI, Fuzzy C-Mean. GPU programming, parallel programming;

1. Inrtoduction

1.1 Image Segmentation

Image segmentation is an image processing technique that divides an image into contiguous regions, or segments. All pixels in one of these segments are similar according to some criterion, such as color or intensity. By forming these clusters of similar elements, the process eliminates noise and facilitates posterior analysis. Segmentation is a crucial step for many applications where it is important to discern objects or boundaries within the image. Some examples are: pattern recognition applied to medical imaging. Image segmentation is one of the most crucial tasks in image processing and computer vision.

In spite of nearly four decades of research, image segmentation remains a challenging problem. Recently developed fuzzy connectedness framework and it extensions have been extensively utilized in many medical applications. These include multiple sclerosis lesion detection and quantification via MR imaging, upper airway segmentation in children via MRI for studying obstructive sleep apnea, electron tomography segmentation, abdominal segmentation, automatic brain segmentation in MR images with the assistance of an atlas, clutter-free volume rendering and artery-vein separation in MR angiography, in brain tumor delineation via MR imaging, and automatic breast density estimation via digitized mammograms for breast cancer risk assessment. However, one problem with the fuzzy connected image segmentation algorithms has been their high. computational requirements for large image data. Parallel computing using a Graphics Processing Unit (GPU) can address this problem. The GPU's substantial arithmetic and memory bandwidth capabilities, coupled with its recent addition of user programmability, has allowed for general-purpose computation on graphics hardware (GPGPU). Many non-graphics-oriented computationally expensive algorithms have been implemented on the GPU. Developers prefer GPUs over other alternative parallel processors such as cluster of workstations owing to several advantages including their low cost and wide availability. Owens et al. presented a comprehensive survey of latest research in GPU

computing. Since medical imaging applications intrinsically have data-level parallelism with high compute requirements, they are very suitable to be implemented on the GPU.

1.2 Approches in Image Segmentation

There are three general approaches to segmentation, termed thresholding, edge-based methods and regionbased methods.

1.2.1 Thresholding-based:

In thresholding pixels are allocated to categories according to the range of values in which first shows boundaries which were obtained by thresholding the muscle image. Pixels with values less than 128 have been placed in one category, and the rest have been placed in the other category. The boundaries between adjacent pixels in deferent categories have been superimposed in white on the original image. It can be seen that the threshold has successfully segmented the image into the two predominant.

1.2.2 Edge-based:

Segmentation, an edge alter is applied to the image, pixels are classified as edge or non-edge depending on the alter output, and pixels which are not separated by an edge are allocated to the same category. Second shows the boundaries of connected regions after applying Prewitt's alter and eliminating all non-border segments containing fewer than 500 pixels. (More details will be given in finally.

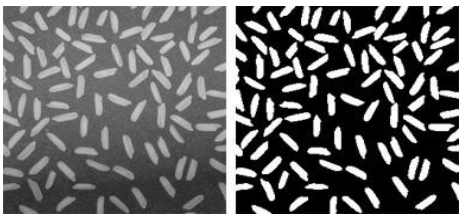
1.2.3 Region based:

Segmentation algorithms operate iteratively by grouping together pixels which are neighbors and have similar values and splitting groups of pixels which are dissimilar in value. The boundaries produced by one such algorithm, based on the concept of watersheds.

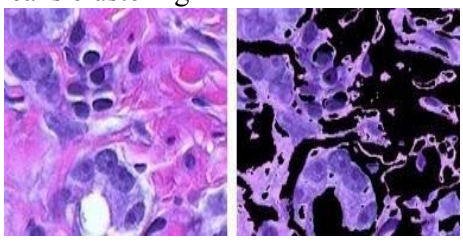
1.3 Segmentation Methods In Image Proce---ssing and Analysis

Image segmentation is the process of dividing an image into multiple parts. This is typically used to identify objects or other relevant information in digital images. There are many different ways to perform image segmentation, including:

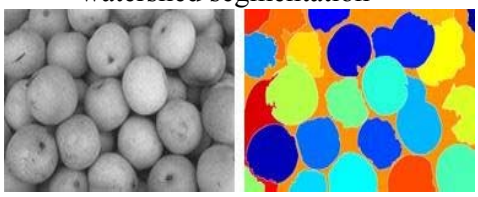
- Thresholding methods such as Otsu's method



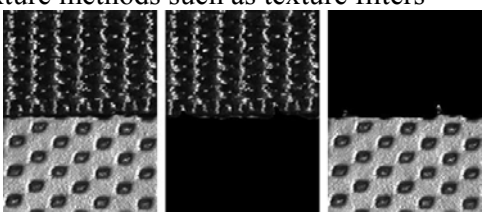
- Color-based Segmentation such as K-means clustering



- Transform methods such as watershed segmentation



Texture methods such as texture filters



2. Related Work

2.1 Duraisamy et al [1]

―Cellular Neural Network based on medical image segmentation using Artificial Bee Colony Algorithm‖ Author introduces an effective CNN based segmentation method with lung and brain MRI images. Author take two steps: 1) Pre-processing of the brain and lung images, 2) Segmentation using cellular neural network in the pre-processing step, image de-noising is done using the linear smoothing filters, such as Gaussian Filter. Then, the pre-processed image is segmented according to CNN-based image segmentation. Finally, the different MRI images (brain and lung) are given to the proposed approach to evaluate the performance of the proposed approach in segmentation process. The Comparative analysis is carried out Fuzzy C-means (FCM) and K-means classification. The efficiency is achieved with brain and lung MRI images. The Comparative analysis is carried out with Fuzzy C-means (FCM) and K-means classification. From the comparative analysis, the accuracy of proposed segmentation approach produces better results than that of existing Fuzzy C means (FCM) and K-means classification.

2.2 M.A et al [2]

―Medical image segmentation using Fuzzy C-Mean (FCM) and dominant grey levels of image‖ Picture division is a basic piece of clinical demonstrative devices. Therapeutic pictures for the most part contain clamor. Accordingly, exact division of therapeutic pictures is profoundly difficult; on the other hand, precise division of these pictures is essential in right analysis by clinical instruments. We proposed another technique for picture division taking into account predominant ash level of picture and Fuzzy C-Mean (FCM). In the hypothesized system, the color picture is changed over to ash level picture and stationary wavelet is connected to abatement clamor; the picture is bunched utilizing standard FCM, thereafter, bunches with blunder more than an edge are partitioned to two sub groups. This methodology proceeds until there stay no such, wrong, groups. The prevailing joined segment of each one group is acquired — if existed. In acquired prevailing joined segments, the n greatest associated parts are chosen. N is detailed based upon considered number of bunches. Midpoints of ash levels of n chose segments, in ash level picture, are considered as Dominant light black levels. Prevailing ash levels are utilized as group focuses. In the end, the picture is grouped utilizing determined group focuses. Exploratory results are showed to show viability of new system.

2.3 Harini et al [3]

―Image Segmentation Using Nearest Neighbor Classifiers Based On Kernel Formation For Medical Images‖, comprises of formation of kernel for the medical images by performing the deviation of mapped image data within the scope of each region from the piecewise constant model and based on the regularization term based on the function of indices value of the region. The functional objective minimization is carried out by two steps minimization in image segmentation using graph cut methods, and minimization with respect to region parameters using constant point computation. Nearest neighbor classifiers are introduced to the benchmarked image data segmented portions. Among the different methods in supervised statistical pattern recognition, the nearest neighbor rule results in achieving high performance without requirement of the prior assumptions about the distributions from which the training sets are taken.

2.4 Bhagat et al [4]

―Web Based Medical Image Retrieval System Using Fuzzy Connectedness Image Segmentation and Geometric Moments‖ fuzzy connectedness image segmentation for medical image retrieval in Oracle using digital imaging and communications in medicine (DICOM) format. Paper includes the comparison of image retrieval techniques with the proposed fuzzy connectedness image segmentation combined with geometric moment. Paper also gives the implementation details of proposed algorithm in Oracle. For the analysis purpose author implemented feature extraction methods for color, texture and shape based feature extraction Connectedness with Geometric Moments. From the carried proposed medical image retrieval algorithm FCISGM gives more precise result as compared to Average RGB, Color Moments, Gray Level Cooccurrence Matrix, Local Color Histogram, Global Color Histogram and simplicity.

2. 5 M.R et al [5]

―Image segmentation using fuzzy rule based system and graph cuts‖ In this work manages division of the light black scale, shade and surface pictures utilizing diagram cuts. From the data picture, a diagram is built utilizing force, color and composition profiles of the picture all the while. In light of nature of the picture, a fluffy guideline based framework is intended to discover the weight that ought to be given to a particular picture gimmick amid chart advancement. The diagram acquired from fluffy principle based weighted normal of diverse picture peculiarities is further utilized as a part of standardized chart cuts system. The diagram is iteratively bi-parceled through the standardized chart slices to get ideal parcels bringing about portioned picture. The Berkeley division database is utilized to test our calculation and division results are assessed through probabilistic rand list and worldwide consistency blunder routines alongside double classifiers based methodologies like affectability, positive prescient esteem and Dice likeness coefficient. It is demonstrated that the introduced division system gives powerful results to most kind of the pictures.

2.6 M et al [6]

―Inter-intra frame segmentation using colour and motion for region of interest coding of video‖ author exhibit a division system that is in view of consolidated color with worldly gimmicks like movement vectors. In the past division routines for area of investment (ROI) coding has just built division in light of one peculiarity, for example, movement, shade and luminance and so forth. The division framework that we proposed is in light of two gimmicks there by joining the qualities of each one different division method e.g. devotion and consistency of district consolidated with moving locales. Most importantly we section picture (pixels level) inside edge in light of shade and afterward in the second step we fragments the pictures (square level) in a set of casings in view of movement. This is beginning work of our undertaking where we need to layer feature by uprooting perceptual excess taking into account human visual perceptual capacities. Human see pictures in term of items which can never be caught in general picture or its worldwide peculiarities. Keeping in mind the end goal to distinguish the Region of Interest (ROI)

2.7 A. et al [7]

―Roi based error concealment of compressed object based image using QIM data hiding and wavelet transform‖ Transmission of computerized information through radio portable channel encounters blurring impact that prompts serious debasement in quality. Lapse covering is a post processing system to enhance this quality debasement. One such calculation is proposed here utilizing whole number wavelet, information concealing and area of-investment (ROI) coding usefulness. Edge based picture division and morphological operations are utilized together to discover ROI. Halftoning method is then used to acquire picture digest from this ROI. To restore the human intrigued share of a picture, the data of ROI is implanted as picture summary into the locale offoundation (ROB) utilizing information concealing in light of quantization record tweak (QIM). Recreation results demonstrate that the plan gives noteworthy execution change different lost pieces in ROI without influencing the similarity of the standard JPEG 2000 coding plan.

2.8 Xiao et al [8]

―Unsupervised video segmentation method based on feature distance‖ With the development of network and communication technology, large volumes of video data are generated every day. How to retrieve information efficiently from the video documents becomes a valuable issue. To address this problem, the contents of the digital videos should be annotated and indexed beforehand. Shot boundary detection is the first step for indexing and retrieving the contents from a video. Usually there exist both distinct and indistinct shot boundaries throughout a video, so the detection of these shots becomes a difficult task. According to this problem we propose an unsupervised clustering algorithm based on feature distance Io self-organize and dynamically analyze the video data, hereby segmenting the video hierarchically.

3. Techniques in Image Segmentation

3.1 FCM ALGORITHM

Fuzzy c-means (FCM) is a method of clustering which allows one piece of data to belong to two or more clusters. This method (developed by Dunn in 1973 and improved by Bezdek in 1981) is frequently used in pattern recognition. It is based on minimization of the following objective function:

$$J_m = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^{m}\left\|x_i - c_j\right\|^2$$

where m is any real number greater than 1, u_{ij} is the degree of membership of x_i in the cluster j, x_i is the I th of d-dimensional measured data, c_j is the d-dimension center of the cluster, and ||*|| is any norm expressing the similarity between any measured data and the center. Fuzzy partitioning is carried out through an iterative optimization of the objective function shown above, with the update of membership u_{ij} and the cluster centers c_j by:

$$J_m = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^{m}\left\|x_i - c_j\right\|^2$$

Where is a termination criterion between 0 and 1, whereas k is the iteration steps? This procedure converges to a local minimum or a saddle point of J_m. The algorithm is composed of the following steps:

1. Initialize U=[u_{ij}] matrix, $U^{(0)}$
2. At k-step: calculate the centers vectors C(k)=[cj] with U(k)

$$J_m = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^{m} \left\| x_i - c_j \right\|^2$$

3. Update $U^{(k)}$, $U^{(k+1)}$

$$J_m = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^{m} \left\| x_i - c_j \right\|^2$$

4. If $\| U^{(k+1)} - U^{(k)} \| <$
5. Then STOP; otherwise return to step 2

In medical field minute details of image are also matter a lot that's why it is very difficult to process. They need to be divided in such a manner so that their minute details can be easily examined. To divide the image into parts is called segmentation. In this work image segmentation is used to find the region of interest (ROI). The segmentation will be accomplished using fuzzy C mean technique.

3.2 K-FCM ALGORITHM

in this approach the kernel based fuzzy C mean approach is used for the segmentation of the image. In this kernel based segmentation approach used for segmentation process this approach can be implemented to manipulate the input data into higher dimensions of feature vectors by using the nonlinear map. This feature space division of the image is known to be the small regions of the image that have been separated for the implementation of FCM to each single region by providing kernel values. In this approach the image is firstly de-noised by using nonlinear spatial filter to enhance the quality of the image. In this approach one advantage is that it automatically defines the number of clusters that have to develop using KFCM. This approach firstly utilizes kernel values and then computes the fuzzy membership functions for the image regions using the computation equations. It finds the centered for each sub feature space of the image and this process goes till to the best cluster centers has been found for each region of the image. This approach is more robust to noise and original clustered forms and outliers of the image. This approach includes class of robust non-Euclidean at distance measures for original data spaces. This approach simple retains computation simplicity. In KFCM approach Euclidean distance between neighbor pixels has been computed on the basis of that distance various parts of the image. This approach provides better performance for the nonspherical and complex dataset that has not been provided by FCM.

3.3 PENALIZED FCM ALGORITHM

PFCM approach is an extension of FCM approach. In FCM approach spatial information about image is not taken into consideration it only depends on the different gray level information about the image. FCM is very sensitive to noise so Penalization of FCM is purposed. General Principal of this approach is only to interoperate neighbor pixel information. In order to incorporate the spatial context into FCM objective function is penalized by regularized term. This is inspired by NEM algorithm. Objective function given by

$$I_{PFCM} = \sum_{i=1}^{k}\sum_{i=1}^{c}(U_{ik})q \quad d^2(x_k, v_i) \\ \gamma \sum_{i=0}^{n}\sum_{i=0}^{n}\sum_{i=0}^{n} U_{ik\,(1-U_{iq})^q w_{kj}} \quad (1) \; +$$

This approach used for the image segmentation utilized regularization term for the removal of noise sensitive in the FCM. A function ɣ (<=0) controls the effect of penalty term used in the PFCM. Value of the penalty term should be minimum for the better execution of
FCM algorithm in the process of image segmentation
[9].

3. 4 ROI (REGION OF INTEREST)

A region of interest (often abbreviated ROI), is a selected subset of samples within a dataset identified for a particular purpose.[1] The concept of a ROI is commonly used in many application areas. For example, in medical imaging, the boundaries of a tumor may be defined on an image or in a volume, for the purpose of measuring its size. The end cordial border may be defined on an image, perhaps during different phases of the cardiac cycle, for example end-systole and end-diastole, for the purpose of assessing cardiac function. In geographical information systems (GIS), a ROI can be taken literally as a polygonal selection from a 2D map. In computer vision and optical character recognition, the ROI defines the borders of an object under consideration. In many applications, symbolic (textual) labels are added to a ROI, to describe its content in a compact manner. Within a ROI may lay individual points of interest (POIs).

3.5 GPU BASED IMAGE SEGMENTATION

Modern GPUs used for general-purpose computations have a highly data parallel architecture. They are composed of a number of cores, each of which has a number of functional units, such as arithmetic logic units (ALUs). One or more of these functional units are used to process each thread of execution, and these groups of functional units are called thread processors throughout this review. All thread processors in a core of a GPU perform the same instructions, as they share a control unit. This means that GPUs can perform the same instruction on each pixel of an image in parallel. The terminology used in the GPU domain is diverse, and the architecture of a GPU is complex and differs from one model and manufacturer to another. For instance, the two GPU manufacturers NVIDIA and AMD refer to the thread processors as CUDA cores and stream processors, respectively. Furthermore, the thread processors are called CUDA cores in the CUDA programming language and processing elements in Open CL (Open Computing Language). GPU perform the same instructions, as they share a control unit. This means that GPUs can perform the same instruction on each pixel of an image in parallel. The terminology used in the GPU domain is diverse, and the architecture of a GPU is complex and differs from one model and manufacturer to another. For instance, the two GPU manufacturers.

3. Conclusion

Approach Used	Advantages	Disadvantages
FCM	This approach is beneficial for the simple and spherical datasets or images. This approach identifies similar cluster using the centurions from each cluster and find neighborhood pixel values[1]	This approach does not provide better performance for non-spherical and complex data values. This approach is very noise sensitive[2]
P-FCM	Penalized fuzzy c mean approach has advantage of a term penalty for the removal of noise variation in the FCM algorithm. This approach regularizes the penalty tem which increase the segmentation performance of the algorithm[9]	This approach is mainly based on the penalty value used for the regularization of the penalty term. Is the value of particular term is higher than the centeriods values of the clusters get disrupted and degrade the performance[10]
K-FCM	This can be efficient for the nonspherical and complex databases, robust to noise available in the image and number of clusters has been defined automatically in this approach [3]	The KFCM has main disadvantage of multiple use of kernel values for variant feature space computation used in the algorithm. These feature spaces sometimes get correlate with other feature space but the kernel value process each segment in different way[13]
GPU BASED IMAGE SEGMENTATION	GPUs used for general-purpose computations have a highly data parallel architecture. This process each thread of execution and these groups of functional units are called thread processors [1].	Architecture of a GPU is complex and differs from one model and manufacturer to another [10].

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