Abstract

The digital image processing deals with developing a digital system that performs operations on digital images and finding their applications in many fields like medical imaging, biometric, multimedia, remote sensing, etc. Medical images of human body concentrate on capturing of images from organs for both diagnostic and therapeutic purposes. Magnetic resonance imaging (MRI) is a non-invasive diagnostic test that takes detailed images of the soft tissues of the body. The technologies and automatic methods are more useful in several medical imaging applications such as volumetric analysis, three dimensional (3D) visualization, surgical planning, and simulations for detecting brain related diseases such as brain Tumors, multiple Sclerosis, Schizophrenia, Epilepsy, Parkinson’s disease, Alzheimer’s disease, and other pathologies.

The automatic methods for brain tissue segmentation, tumor slices detection, and tumor segmentation with substructures are always on demand in the field of medical image processing due to limited human resources, time constraints, accuracy, and artifacts. In this thesis, five automatic methods are developed and presented for brain tumor analysis. In addition, three parallel computing models are proposed to accelerate the automatic methods using graphics processing unit (GPU) for processing huge medical volumes. The three parallel models included in chapter 3 are named as:
1. Per-pixel threading (PPT) model
2. Per-slice threading (PST) model
3. Hybrid threading (HT) model

These three models are proposed with medical image processing algorithms to find the nature of algorithms and support parallel computing. Models elaborate the design and implementation details of parallel image processing techniques to accelerate the medical image processing algorithms using GPU. The acceleration speedup realized in parallel algorithms is compared with that of CPU implementation. These parallel algorithms are analyzed and suitable algorithms are identified to develop the proposed methods and are included in the remaining chapters.

Five automatic methods are categories into three distinct phases (chapter 4 - chapter 6) are:

I. Brain Tissue Segmentation
   a) Brain tissue segmentation1 (BTS1)
   b) Brain tissue segmentation2 (BTS2)

II. Tumor Slices Detection
   c) Tumor slices classification (TSC)
   d) Tumor boundary extraction (TBE)

III. Brain Tumor Segmentation
   e) Brain tumor substructure segmentation (BTSS)

In the first part, two methods BTS1 and BTS2 have been proposed for segmenting brain tissue into gray matter (GM), white matter (WM) and
cerebrospinal fluid (CSF), in order to identify the brain disorders. BTS1 includes a new membership function of partial supervision fuzzy c means (PSFCM) method which is guided by the labeling patterns of brain portion. BTS2 has a bias field correction with partial supervision to enhance the segmentation process. The datasets were collected from internet brain segmentation repository (IBSR) and used for experiments. The performance of the methods are computed and compared with state-of-the-art methods using Dice coefficient, sensitivity, specificity, and accuracy. Further, parallel (HT based) methods are proposed with the support of CUDA enabled GPU machine to reduce the computation time upto 19× in BTS1 and 49× in BTS2.

Second part has two automatic methods TSC and TBE for selecting tumor slices and extract the tumor boundary in order to reduce the physician’s time for manual classification and segmentation process. TSC detects tumor slices from given MR volume using bilateral symmetrical property between the cerebral hemispheres about the interhemispheric fissure (IHF) of axial scans. TBE extracts the tumor boundary using parallel edge detection techniques (PPT based) from slices identified by TSC. The methods are tested with IBSR, whole brain atlas (WBA), and multimodal brain tumor segmentation (BraTS2013) datasets. The results are computed and compared with state-of-the-art methods using several metrics. Finally, 3D tumor volume is constructed from the output of TBE.

Part three proposes a fully automatic method for glioma brain tumor detection, segmentation, tumor volume estimation, and visualization for assessing the growth of the tumor volume. BTSS uses a sequential process to estimate the
tumor volume. They are tumor slices classification, tumor extraction, and tumor substructures segmentation. Feature blocks and SVM classifier are used to classify the given MR slices into normal or tumorous. FCM algorithm is used to extract the tumor region from the slices identified. A novel probabilistic local ternary patterns (PLTP) is used to segment the tumor substructures. As post processing, tumor volume estimation and 3D visualization were done to visualize the growth of tumor. BTSS achieves high classification and segmentation accuracy and its performance is compared with several state-of-the-art methods. Finally, parallelism found in the image is utilized for implementing the FCM (PPT based) algorithm in GPU to achieve a speedup of 18×.