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Survey on Segmentation Techniques for Spinal Cord Images

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Abstract - Medical imaging is a technique which is used to expose the interior part of the body, to diagnose the diseases and to treat them as well. Different modalities are used to process the medical images. It helps the human specialists to make diagnosis ailments. In this paper, we surveyed segmentation on the spinal cord images using different techniques such as Data mining, Support vector machine, Neural Networks and Genetic Algorithm which are applied to find the disorders and syndromes affected in the spinal cord system. As a result, we have gained knowledge in an identified disarrays and ailments affected in lumbar vertebra, thoracolumbar vertebra and spinal canal. Finally how the Disc Similarity Index values are generated in each method is also analysed.

Key words: Segmentation, Genetic algorithm, Data mining techniques, Medical Image Analysis

I. INTRODUCTION

The mathematical model and computing algorithms are applied to resolve the medical domain issues to detect and treat the diseases. The mathematical approach of similarity measure aids to find the variations using cluster and classification of data mining technique. And also Artificial Intelligence, Neural Networks, Association Rules, Decision Trees, Genetic Algorithm, Nearest Neighbor method etc., are used to provide valuable domain based solution in Science, Engineering, and Medical and Social issues.

Sk. Abid Hussain and Ch.Venkateswarlu defined the Data Mining (DM) is the mathematical core of the Knowledge Discovery in Databases (KDD) process, involving the inferring algorithms that explore the data, develop mathematical models and discover significant patterns (implicit or explicit) which are the essence of useful knowledge [1]. Imaging techniques encompass the fields of radiology, nuclear medicine and optical imaging and image-guided intervention are used to detect the abnormalities present in medical images.

The images are processed by using basic steps to smother the unwanted data such as noise and advance the quality of images for human visualization. The spinal cord is an essential structure of the central nervous system that relay messages to and fro between the brain and the body. The spine consists of 26 bones called vertebrae. The vertebrae protect the spinal cord and allowed to place and stay in an upright position. Damage to the spinal cord can result in defeat of feeling and loss of the capability to voluntarily control muscles, sometimes leading to paralysis. These diseases have an effect on the world population in a large scale.

II. MEDICAL IMAGE ANALYSIS USING DATA MINING TECHNIQUES

Medical image consign to a number of techniques that can be used as non-invasive methods of look inside the body. This means that the body does not to open up surgically for medical practitioners to see at various organs and areas. It can be used to aid diagnosis or treatment of different medical conditions. Methods of data mining must deal with the heterogeneity of data sources, data Structures, and the pervasiveness of Missing values for both technical and social reasons. For suitably formulate scientific question, thousands of data-elements can be brought to abide on finding a solution. Antonie et.al, [2] used two classification methods based on association rule mining for digital mammograms. Diagnosing early stages of breast cancer is somewhat difficult for the practitioners so they have given a Classification system to assist specialists in medical institutions. It can be done by these two algorithms that is Association Rule-based Classification with All Categories (ARC-AC) and Association Rule-based Classification by Categories (ARC-BC) was applied on the training data and the association rules were extracted. Classification Accuracy of the system reaches 80.33%. Janssen et.al, [3] stated that the hybrid method (cluster analysis and cognitive mapping) for journals covered by the Web of Science database. The above stated method proves superior with other components when applied separately. And also used the hybrid clustering (text-mining and cross citation) which is also provides a good result. The integrity of the resulting classification was even improved than that of the intellectual reference scheme.

Subasini et.al, [4] discussed a different data mining approaches that are utilized for breast cancer diagnosis and prognosis. They analysed the performance of conventional supervise learning algorithms viz. C5.0, ID3, APRIORI, C4.5 and Naïve Bayes. Experimental results show that C5.0 serves to be the best one with maximum accuracy. They discover the applicability of association rule mining technique to suspect the presence of breast cancer at earlier stage. Shi, lin et.al, [5] discussed that the graphic processing units (GPU) has emerged as a competitive parallel computing platform for computationally expensive and demanding tasks in a wide range of medical image applications. The continuous advancement of GPU computing is reviewed in three areas of medical image processing, namely segmentation, registration and visualization are surveyed. Smistad Erik et.al [6] also discussed about medical image segmentation on GPU. He concluded like, the most segmentation methods may benefit from GPU processing due to the methods' data parallel

structure and high thread count. However, factors such as synchronization, branch divergence and memory usage can limit the speedup.

Rajendran, P et.al, [7] proposed an image mining approaches with a hybrid manner. The major steps involved in their system are: pre-processing, feature extraction, association rule mining and hybrid classifier. The frequent patterns from the CT scan images are generated by frequent pattern tree (FP-Tree) algorithm that forms the association rules. The association rules based classifications have been made with the help of decision tree classification. The proposed hybrid approach of association rule mining and decision tree algorithm has been performing well compared to the existing classifiers. The accuracy of 95% and sensitivity of 97% were found in classification of brain tumors.

III. MEDICAL IMAGE ANALYSIS IN DIFFERENT TECHNIQUES

Image segmentation plays a significant role in image processing as it helps in the extraction of suspicious regions from the medical images. Particularly, analysing various kinds of disease and illnesses through medical images are utilizing the image segmentation concepts. Some of the applications of image processing are medical field, remote sensing, pattern recognition, video processing and microscopic image and so on. Pham et.al [8], discussed the image segmentation in different imaging modalities and with the difficulties encountered in each modality. The segmentation of medical images will strive towards improving the accuracy, precision, and computational speed of segmentation methods, as well as reducing the amount of manual interaction.

In MRI modalities, Carballido–Gamio [9] discuss the segmentation of vertebral bodies from sagittal T1-weighted MR images using normalized cuts [10] with the Nystrom approximation method [11]. T1-weighted MR images are first pre-processed by Anisotropic Diffusion algorithm [12] that smooth's the image without distorting the edges. They test their work on only six subjects (coil correction, interpolation between slices, anisotropic diffusion, 3-D local histograms of brightness and display) for lumbar area.

Zheng et al. [13] proposed a method for segmenting the lumbar vertebrae from digital video fluoroscopic images provides an image sequences with many frames, but which often suffer due to noise, exacerbated by the very low radiation dosage. They have showed how the Hough transform (HT) algorithm can be used to solve those problems. That method applied to images of a calibration model (comprised of two human lumbar vertebrae (L3 and L4) linked at the position of the centrum of the disc by means of a universal joint) .The results showed promise and potential for object extraction from poor quality images and that models of spinal movement can indeed be derived for clinical application.

Li et.al [14]. Specified an approach was widely employed to segment objects in medical images, such as airway, cartilage, and prostate. To segment the single surface the polynomial – time algorithm is developed. The graph search framework is an efficient approach to obtain a globally optimal segmentation surface that represents the object boundary. The algorithm time complexity is low-order polynomial, is thus very efficient.

Soma Banerjee et al.[15] to be enhance and segment the SONAR image which is used to identify the obstacles present in the underwater. Used Lee filtering to suppress speckle noise and Fuzzy C-Means (FCM) clustering is used to extract the Region of interest (ROI) to calculate the position, size and centre of gravity (CoG) of the obstacle. The proposed algorithm is measured using Peak Signal-to-Noise Ratio (PSNR) comparatively gives better result.

Papavassiliou et.al, [16] Developed approaches to extract text lines and words from hand written document. Piece-wise projection is used to segment gap and text from vertically divided image document. Viterbi algorithm is used to find the optimal succession of gap and text using the parameter. Word segmentation is based on the gap metric activities such as soft margin linear SVM. Their method shows a better performance.

Pankaj Valand et.al,[17] they have used the hybrid algorithm which integrate both genetic algorithm(GA)and ant colony algorithm(ACO). This algorithm shows feasible in dealing with dynamic input, where input image is constantly changing. The time taken is higher than the other edge deduction methods like Canny, Sobel, Roberts or Per Witt. A multi-processor environment can solve the time issues observed in experimentation.

IV.SEGMENTATION ON SPINAL CORD IMAGES

The segmentation process is applied to analysis the spinal cord medical image to detect the similar measure and variations. Image segmentation techniques have become increasingly important for medical images related to spinal disorders. Segmentation Methods applied on Spinal cord image analysis is discussed below. And dice similarity index (is a statistic used for comparing the similarity of two samples) for segmentation is also evaluated in some of the papers.

Wang, Zhijie et.al [18] stated Regression Segmentation that is for M3 (M ^{3} spinal images including multiple anatomic structures, in multiple anatomic planes, from multiple imaging modalities) spinal images in one single unified framework. Multi-dimensional support vector regression (MSVR) re-weighted least square (IRWLS) algorithm, Multi-kernel MSVR learning algorithms are used for M3in single unified framework .The proposed regression segmentation approach was thoroughly tested on images from 113 clinical questions including both disc and vertebral structures, in both sagittal and axial planes, and from both MRI and CT modalities. The overall result reaches a high dice similarity index (DSI) 0.912 and a low boundary distance (BD) 0.928 mm.

Korez, Robert, et al [19] described an optimization technique based on interpolation theory. It is applied to detect the location of individual vertebrae within the spinal column. The segmentation of individual vertebrae is performed by an improved shape-constrained deformable model approach. The framework was evaluated on two publicly available CT spine image databases of 50 lumbar and 170 thoracolumbar vertebrae. Result of Dice coefficient is 83.6% for vertebra

detection, and an overall mean of symmetric surface distance of 0.3mm and Dice coefficient of 94.6% for vertebra segmentation.

De Leener et.al [20], presented a new framework combining propagation segmentation [21] and a vertebral level identification method. Their segmentation method is based on the multi-resolution propagation of tubular deformable models. Coupled with an automatic inter vertebral disk identification method. The framework was validated on 17 healthy issues and on one patient with Spinal Cord injury against manual segmentation. Results have been compared with an existing active surface method and show high local and global accuracy for both spinal cord and spinal canal (Dice coefficients =0.91 0.02) segmentation.

Mirzaalian et.al [22], proposed a vertebra segmentation algorithm using statistical shape modelling and a machine learning-based boundary detector. They have used Standard graph cut (GC) based algorithm which reduces fall in the boundary. The image parts depicting individual vertebrae are spatially normalized with respect to their bounding box information in terms of translation, orientation, and scale leading to more accurate results. Finally segmentation elevated accuracy on 7 CT volumes each depicting 22 vertebrae. The results indicate a symmetric point-to-mesh surface error of 1:37 _ 0:37 mm, which matches the current advanced.

Ogwueleka et.al [23], proposed a method to attain a data collected were computed using k-means clustering algorithm implemented on Excel Visual Basic for Applications (VBA) Macro. Cluster values generated from the program was calculated. Result obtained about 38.47% is at risk of direct-drug prescription. The result implies that, there is tendency of low productivity and inefficiency among 38.47% of the working force.

Hashemi et.al, [24] Proposed a contrast enhancement method based on the genetic algorithm. The main contribution of this method is using a simple chromosome structure and genetic operators to increase the visible details and contrast of low illumination images especially with high dynamic range. For each chromosome fitness is calculated and then applied Cross over and mutation operators. Results showed that the proposed method produce more natural looking images.

Lim et.al [25], introduced a new method for accurate spinal vertebrae segmentation which is capable of dealing with noisy images with missing information. This can be achieved by bring together an edge mounted Wilmore flow, and a prior shape kernel density estimator to the level set segmentation framework. As the prior shape model provides much needed prior knowledge when information is missing from the image, and draws the level set function towards prior shapes. The edge-mounted Willmore flow helps to capture the local geometry and soothes the evolving level set surface. An overall accuracy of 89:32 _ 1:70% and 14:03_1:40 mm are achieved based on Dice similarity coefficient and Hausdorff distance.

Kawahara et.al [26], they proposed modifications to the minimal path search algorithm that drastically reduce the required memory and run-time to make their high dimensional minimal path optimization computationally feasible. They validate the results over five vertebrae levels of magnetic resonance volumes (MR-20 volumes total) and show improvements on volume agreement with expert segmentations and less user interaction when compared to current hi-tech methods.

Grady et.al, [27] they presented an algorithm for general image segmentation based on a small set of pre-labelled pixels. These pre-labelled pixels may be given either interactively or generated automatically for any medical images when it is needed. For this Interactive segmentation algorithm, random walker algorithm and graph cuts algorithms are used. The approach on real images shows that it provides a unique, quality, solution and extremely fast speed of the physical world. The vibrational problem is formulated on a graph. This can be concentrated on a specialty solver.

Wang et.al [28] proposed a method to adapt the interactive random-walk solvers to be a fully automatic cascaded pipeline. The segmentation pipeline is initialized with robust voxel wise classification using Haar-like features and probabilistic boosting tree. The topology of the spinal canal is extracted from the segmentation and further refined for the subsequent random-walk solver. Experiments validate the capability of the proposed method with promising segmentation performance, even though the resolution and the contrast of given dataset with 110 patient cases (90 for testing and 20 for training) are low and various bone pathologies occur frequently.

V. Conclusion

Diagnosis and treatment of diseases are a challenging problem in the medical images. Segmentation in image processing helps in the deduction of edgy region from the medical images. Analysing various kinds of diseases and disorders through medical images are consumed the image segmentation concepts. The Various algorithms and techniques used on medical image of spinal cord are such as, Fuzzy C-Means (FCM), Structural Similarity Index, Hybrid method (Text-Mining, cross-citation based). Data Mining techniques, Genetic Algorithm, support vector machine (SVM), vertebi object boundaries, learning algorithms optimization technique, Propagation segmentation (PropSeg), level set(Dice similarity coefficient and Hausdorff distance), minimal path search algorithm, subsequent random-walk methods to identify the similarity and variations on the Spinal cord image analysis. Each algorithms and new methods are efficiently applied on spinal cord images and produced good results when it is compared with other methods. Further research work focused to analysis the medical image using above stated few algorithms. And also we can find the possibility to assist the medical practitioners to diagnose and to treat the diseases in better way.

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