International Journal of Engineering & Technology, 7 (3.4) (2018) 28-33

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Study on Segmentation and Liver Tumor Detection Methods

Anil B C[1], Dr. Dayananda P[2]

[1] *Assistant Professor, Department of ISE,JSSATE, Bengaluru 560060,India*
[2] *Assistant Professor, Department of ISE,JSSATE, Bengaluru 560060,India*
**Corresponding author E-mail: dayanandap@gmail.com*

Abstract

Cancer plays a major risk for public health worldwide. According to the survey made by the cancer society predicts approximate about 42,220 new cases will be diagnosed and around 32,220 people will die of this cancer that is around 71% of people will die in 2018 and Liver cancer rate is increased by 3% for every year since 2000 and achieved second leading place for the cause of death. There is a continuous in the development with regard to prevent and different options for treating the cancer. Detection of cancer at its initial stages is very difficult with the help of pathological information's, so as any added support CAD systems using CT scan images are being designed from few decades in order to find out cancer in its early stage. In this paper discussed various segmentation techniques and liver tumor detection techniques to initial segment out the liver region from the abdominal and then to extract the efficient characteristics. Based on the characteristics presences of tumour is identified and separated out from the liver and finally analyse the stage of the cancer. Therefore the process is divided into three parts; 1.Region segmentation, 2.Liver Tumour segmentation and 3.Detection of Cancer stage. In this paper, study is done on different methods of liver region and tumour segmentation of abdominal CT scan to analyze liver tumor and detection of early stage of the tumor

Keywords: CT scan image, Segmentation, Early Stage Detection.

1. Introduction

The liver, in human body found to be a largest glandular organ placed on the right side of the stomach cavity just below the diaphragm as shown in the Figure 1 overview of the organ liver in the human body. Glycogen storage, protein synthesis, hormone production, regulates biochemical reactions and detoxifications are the major functions carried out by the liver. The liver one way or the other supports the other organs of the body through the hepatic artery and vein liver may gets blood around 25% of cardiac output. With the advancement of new technology in the medical field yet, no method, technology or a system replaces for the functions of the liver. The options still today is transplantation of liver from the living donors are also seems to be common due to the shortage of cadaver donor.

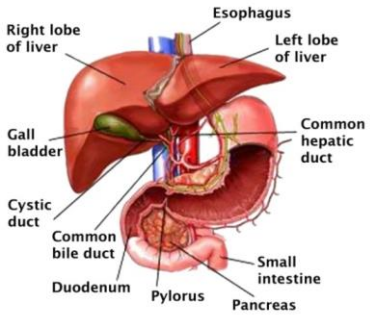

Fig 1: Liver of the human body.

Liver disease is one of the basic factors among the demise in around the world. Usually more than hundred types of cancer are emerged. The names of the cancer are formed by the name of the organ or type of tissue where the cancer originates. For instances lung cancer are formed by the cells in the lung and brain cancer in the cells of the brain. There is a substantial control and maintenance of the growth of cells in the human body. If the division of the cells becomes unbalance, the human body fails to produce the cells and forms a mass known as tumor. Along with the growth of the early stages, then it is named as tumor, as it moves to the secondary stage or uncontrollable stage and then named it as cancer. Based on the stages of the tumor as shown in the Table 1 chart of different stages of tumor, tumor can be easily treated, evacuated or quit spreading with organs of the body is named as benign type of tumor and an unsafe tumor which develops forcefully and cannot be quit spreading into different parts of the body is known as harmful malignant tumor.. Most of the types of cancers have four different stages, namely stages from 1 to 4. Figure 1 shows complexity of liver in human body.

There exist different types of cancer and its treatment available namely, therapy of radiation, surgery, chemotherapy, immunotherapy, stem cell transplants etc. it actually depends on the cancer type and its advanced development stages. The following chart in Figure 3 describes the scenario of cancer in India. Table 1 shows the different stages of cancer cells from elementary stage to advanced stage. The following chart in Figure 2 describes the scenario of cancer in India. Tumor, affects the working of the organ and the cells of tumor can turn to cancer and spread to other tissues or organs of the body. When the cancer cells are examined at when the cancer cells are examined at its early stages, then it is named as tumor, as it moves to the secondary stage or uncontrollable stage and then named it as cancer.

Table 1: Stages of cancer

Stages	Features
Stage 0	This stage is used to describe the cancer cells "in place" which means cancer cells are still they are in place they started and

	have not spread to other parts, this stage can be treated easily by removing an entire tumor with surgery.
Stage 1	This stage is small cancer stage not grown deeply in to other tissues it is called as early stage cancer .
Stage 2 & 3	These stage indicate tumors that are bigger and developed deeply into tissues, but not to other parts of body.
Stage 4	It is also called as metastatic or advanced stage here other organs or parts of body are affected by cancer cells.

In the course of the last few years, image processing innovations refinements have significantly widened the field of medical. Image processing analysis now gives much clearer and more precise pictures of tissues and organs. Imaging innovation as of now had lifesaving rescue impacts on capacity to recognize malignancy early and all the more precisely analyze the affected cells.
Computer axial tomography is a technique to produce images of body in different angles and in later stages CT scan uses processing techniques to extract image in different views especially in cross section of organs and different body tissues,
The following chart in Figure 2 describes the scenario of cancer in India.

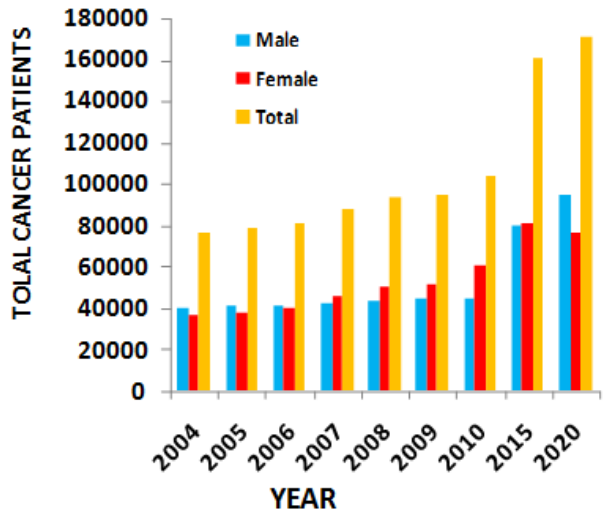

Fig 2: Chart of Year wise total cancer prevalence in India

These CT images consist of some different kind of soft tissues and many other structures that cannot be obtained through X-rays. By using these images doctors can easily diagnose the type of cell whether it is a malicious or normal cell. It is regularly elusive cancer cell of liver in beginning times as signs and indications frequently don't show up until the point that it is in its development stages.

Tumors of extensive size can be effectively identified by a few imaging procedures. Little liver tumors are difficult to identify by physical examination on the grounds that the vast majority of the liver is covered by rib cage's right side. By the time we identify the tumor, it might already be quite grown larger in size. But late detection does not save lives. In order to improve survival rate, liver cancer has to be detected in an early stage. When the tumor appears to be smaller in dimension and lesser marked features makes the task of identification of tumor is very tough task, but in order to provide best treatment accurate identification of location, size and borders type of tumors are important. So in this paper discussed about major segmentation techniques, Classification techniques and tumor detection techniques The remaining contents of this paper are prepared as follows: Following Section gives the major techniques that have been studied as part of the literature survey. Finally, we conclude our study in Section III followed by the references.

Segmentation and Liver Tumor Detection

In this section, we are presenting survey on Liver segmentation and tumor detection from CT scan images to analyze segmentation methods for liver region segmentation. The key objective is to highlight advantages and limitations of these methods. There are different techniques of segmentation and detection.

2. Segmentation

Segmentation is characterized as the methodology of dividing a image into a different regions which are not overlap, segmentation is a advanced milestone in the medical field and it is a principal concept for identification and analysis in the technique of image processing. The efficient and accurate segmentation and its results provides important data for clinical surgical. Different techniques have been proposed which mainly includes watershed segmentation, fuzzy cluster method ,region-growing method, thresholding method, etc..

Wu et.al [01] has developed an automatic approach using CT scan image for delineation of liver using supervoxel based on graph cuts approach. Using thresholding and maximum intensity projection the volume of liver region is identified and extracted using a morphological operations and histogram adaptive thresholding method. The liver supervoxels is produced by simple linear iterative clustering (SLIC) method, where for seed selections largest liver slice is used for both foreground/background seeds and then for VOI supervoxels graph cuts algorithm is used. In the end abdominal CT experiment pictures are used to analyse the efficiency and accuracy of the advanced set of rules performed experimental outcomes shows that the presented novel technique can correctly come across the different regions of liver with processing time. Bing et.al [02] has set up a model called unified level set model by integrating the information obtained by the CT liver image like image gradient, region competition for segmenting the liver region. Liver tumor and its probabilistic distribution is found through unsupervised fuzzy clustering, clustering or statistical analysis, learning the probabilistic distribution the function for object indication is increased by defining the directional balloon force and regulate region competition.

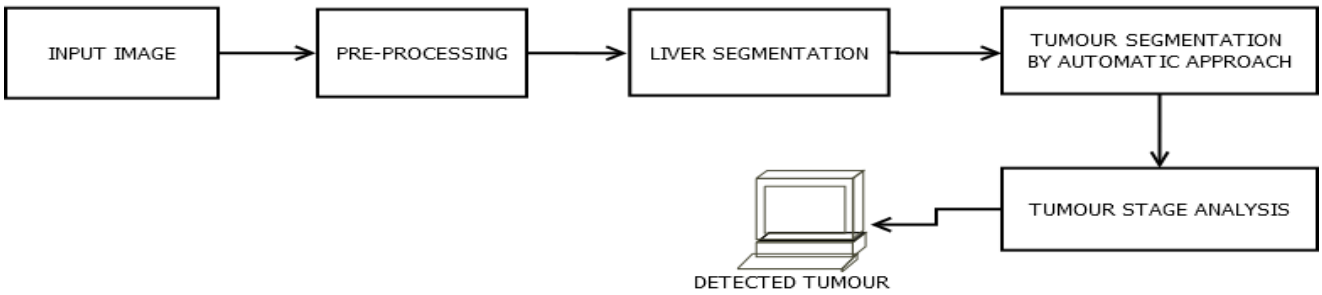

Fig 3: Architecture of Liver region segmentation tumor and tumor stage detection

Duda et.al [03] has considered three slices of liver images at the same location taken at mainly three different sequence of acquisition namely arterial, without contrast and stage of propagation. According to their approach initially, from each slice the texture features are extracted and concatenated into single multiphase vector which forms a triplet of textures. The work is focused on identifying most relevant features by recursive process, unstable and dependent features are removed at iteration and with the remaining features a small sub-set is selected with best suitable for accurate classification. The entire process is carried out with nine different extraction methods, 61 features are selected at each three slices of acquisition which forms 1511 texture triplets are formed. Finally a semi-automatic CAD system is designed to help in diagnosing the disease called depatic from dynamic contrast-enhanced CT scan images. Kumar et.al [04] has developed a design and implementation for CAD systems, mainly includes liver Segment and tumor, feature extraction and an ANN classifier to classify the liver haemangioma tumor and hematoma. Using morphological processing, adaptive threshold detection the liver is segmented from the CT scan and tumor region is suspected and extracted with the help of FCM clustering. The texture features is extracted using Fast Discrete Curve let Transform. The experimental results gives that classification accuracy obtained using wavelet based feature extraction is not higher than the FDCT method.

Alyaa et.al [05] has developed a method for 2D liver segmentation using a hybrid method, by combining the modified kMean, statistical structure and its derived first order features which are applied to the liver image to extract liver boundary and then further for classifying the liver diseases. The accuracy obtained through segmentation approach is carried out by extracting the statistical properties like Variance, Standard deviation and Mean; Skewness, Kurtosis, Entropy and Energy are calculated for liver tumor, which helps in the diagnosis of the type of tumor that was harmful or harmless. The proposed framework can be connected with a specific end goal to decide the development of tumor before it is noticeable to the human eye. Sheetal et.al [06] has presented a method for segmenting a liver cancer region by analyzing CT images. The system includes three stages: 1. Pre-processing to enhance the quality of image and done by applying median filters. 2. Applying region growing method for segmenting where uses the postulate namely: neighboring pixels within one region share similar values, i.e., we can compare each pixel with the other neighbor pixel and by comparing with certain criteria; the pixel which satisfies forms the same group or region of class. The hybrid techniques called by combining the boundary and the region criteria has been implemented. Finally the segmented out region is used for analyzing the detection of cancer. The proposed method finds the cancerous region accurately through the experiments carried out.

M. Obayya et.al [07] has explained the method by developing two-stage algorithm, first by using a set of different pre-processing steps such as boundary extraction algorithms filtering and threshold , followed by applying FCM clustering method to separate out the liver from the affected region of the liver for further process. The output of segmentation method forms a cluster with detected pixels into 3 different group of clusters called background, liver and suspicious regions pixels. Later by applying any intelligent method can identify the severity of the detected suspicious region, and also to identify the type of the infection. Jianhua Liu et.al [08] has combined different methods in order to achieve effective segmentation like, region merging approach, edge detection and the watershed algorithm. A well defined method has been followed: a. Image by applying: gray-scale image conversion, Sobel operator to find the incline image, and then applying OTSU method to find out the threshold value. By using Thresholding small areas can be eliminated. b. Vincent's algorithm is used to divide the image obtained from first step. c. By calculating the average gray-scale criteria of regions which are adjacent and average gray-scale and segmented regions are merged. This approach solves the problems of over-segmentation, as a result finally obtains closer, continuous and more accurate lesion region contour.

Moghbel et.al [09] has described a new automatic hybrid segmentation approach by combining cuckoo optimization and fuzzy c-means algorithm with random walker's algorithm. The approach has been proved a higher accuracy with other algorithms. Segmentation method is applied on publicly valid medical datasets with varying contrast and enhancements and as an advantage the method has lower error in determining the tumor compared with manual segmentation. Therefore their method can be replaced with other segmentation methods. Singh et.al [10] has applied k-means and Ant Colony Optimization methods for liver segmentation. Ant Colony Optimization is an search algorithm inspired by characteristics of real ants and it is a famous tool for minimization of cost functions and it is used to overcome the drawback of k-clustering technique. The different Quantitative analysis is performed based on the accuracy and specificity. Table 1 shows the survey made on different segmentation algorithm. Xuechen et.al [11] has presents a completely semi automated division strategy for liver CT examines utilizing level set and fuzzy c-mean grouping. In the beginning step, the difference of unique picture is upgraded to make limits clearer; further in second step, a fuzzy c-mean spatial grouping joining with anatomical earlier information is utilized to separate liver area consequently finally, a separation regularized level set is utilized for process of removing impurities; at last, morphological operations are utilized as post-handling. T trial result demonstrates that strategy can accomplish specificity and high precision.

3. Liver Tumor Detection

Tumor detection is crucial for increasing the early detection of tumors and to increase chances of survival in cancer patients.

Current developments in medical image processing have enabled the acquisition of high-definition Computer axial tomography images and thus it helps doctors to recognize both tiny and large tumors by inspection through eyes. Megha et.al [13] has proposed an automated liver segmentation method and tumor by extraction suitable features and finally classifies the tumor as benign tumor or malignant tumor. Initially with the help of Gaussian filter the noise is removed, then by using region growing method segmenting of liver is done and future performs morphological operations as post-processing. Features called shape and texture feature namely GLCM and Contour Signature method are used to classify

the tumor. Table 2 gives comparative analysis for various Segmentation Techniques and table 3 shows different Classification of tumor techniques.

Table 2: Survey on Segmentation Techniques

Title	Year	Method Used	Result	Limitation
Automatic segmentation of liver tumours from multiphase contrast-enhanced CT images based on FCNs [29]	2017	MC-FCN (Multi channel fully convolutional network)	Accuracy (92%) is better than FCN	Complexity is more, Dataset size only 58
Automatic 3D Liver Location and Segmentation via Convolutional Neural Network and Graph Cut [30]	2017	3D CNN	Accuracy 91% Automatic without any user interaction	Limited datasets(40)
Comparative Study of Different Techniques Used for medical image Segmentation of Liver from Abdominal CT Scan[28]	2016	Connected component algorithm	More accurate	It gives good segmentation results. further improvement is done by FCM
Automated Segmentation of Suspicious Regions in Liver CT using FCM [7]	2015	FCM , Region based methods Morphological operations, and	Accuracy FCM-93.3% Region based-91.28%	Lack of intelligent method to specify the severity of the detected suspicious region, and also in specify the type of the infection
Optimized Liver Segmentation using Ant Colony Optimization [10]	2015	Ant Colony Optimization, k-means	Accuracy- 94.05% Specificity- 95.86	Best clustering algorithm is k means , the quality is based on the starting condition and it may converge to local minima
Liver Segmentation from CT Image Using Fuzzy Clustering and Level Set	2013	level set ,fuzzy c-mean clustering	Achieved high accuracy (0.9986)	If background is simple it is efficient.
A Computer-Aided Diagnosis of Liver Tumors Based on Multi-Image Texture Analysis of Contrast-Enhanced CT. Selection of the Most Appropriate Texture Features [3]	2012	Run Length Matrices Gray Level Difference Matrices, Laws Texture Energy, First Order statistics, Gradient based and adaptive boosting algorithm, Co-Occurrence Matrices,	Accuracy - 88.94%.	Depends on the image resolution
Diagnosis of Liver Tumor from CT Images Using Fast Discrete Curvelet Transform [4]	2011	FCM clustering FDCT and feed-forward network	Accuracy-93.3%, specificity-96%, sensitivity-90%.	Number of images was too small and interpret the weights/biases of the neural network is very difficult for normal technicians

Table 3: Survey on Classification of tumor

Title	Year	Method Used	Features Used	Accuracy
Automatic segmentation and automatic seed point selection of nasopharyngeal carcinoma from images using region growing based approach [31]	2017	BPN	Shape borders, Morphological features	Database size, Filtering out non object to extract the right object(object area, circularity and the mean of gray scale object)
Computer-Aided Classification of Liver Lesions from CT Images Based on Multiple ROI [18]	2016	FCM clustering, Region growing	Shape, texture and intensity	Benign-0.983 Malignan-0.983
Liver Cancer Identification using Adaptive Neuro-Fuzzy Inference System [26]	2016	Canny edge detection, FCM.	Texture Feature and wavelet based	Accuracy-96%
Segmentation and Classification of Tumor in Computed Tomography Liver Images for Detection, Analysis and Preoperative Planning [25]	2014	Region growing, water-shed algorithm	Intensity features, GLCM	Accuracy-96%
A Robust system for Segmentation of primary Liver Tumor in CT images [23]	2013	Adaptive thresholding, FCM, Region Growing	GLCM	Accuracy-92.3%.

In order to diagnosis liver tumors Mala et.al [14] studied different techniques to in the neural network and potential role wavelet. The different types of tumors considered are haemangioma, hepatoadenoma ,hepatocellular carcinoma and cholangio carcinoma. Haemamgioma is a harmless lymph non cancerous cell and it is abnormal growth of blood vessels, hepatoadenoma is an harmful benign liver, hepatocellular carcinoma is an popular liver cancer cell found in mainly adults, cholangio carcinoma is a type of cancer that is formed by mutated epithelial cells and Each of the tumor regions is extracted and the textural features are used to train the Probabilistic Neural in order to differentiate different types of tumors. Jianhua Liu [8] the anatomic morphological processing, adaptive threshold decision, liver knowledge, based on intensity information and are the main methods used for implementation. Fuzzy C Means Clustering (FCM) is used for tumor region is extraction and then for extracted tumor region to get Vertical, Diagonal and Horizontal image details. Biorthogonal wavelet transform is applied. For these Vertical, Horizontal and Diagonal details of images SGLDM is developed and finally order co occurrence or statistical features is extracted.S. S. Kumar et.al [15] has determined a (CAD) computer-aided diagnostic system for diagnosing harmless and harmful liver tumors. By using morphological processing and adaptive threshold liver tumor is segmented, from the affected parts of the tumor region features are automatically extracted using the textural features and FCM.By increasing number of samples performance can be increased this system can be used further to identify the other liver disease. Vincey et.al [16] has explained the CAD for early phase from the chest CT images. A novel approach for CT images segmentation has been discussed. This paper explains by considering 2-D CT images. This work was done out in 4 stages. In the beginning stage, liver image features skill sets were developed and in the next stage is noise reduction is done. In the next stage it is related to the liver is segmented to extract ROI features by using algorithm like region growing approach. In final stage it extraction of the corresponding liver nodule is done. In this research paper 2-D images result analysis is done. So detection of Liver Cancer cells at early stage can be possible and then risk is reduced.

In the beginning stage of cancer cells proper radiotherapy treatment is given for Liver Cancer patients. Divya et.al [17] has instructed for the classification of different liver images in order to detect the stages with the help of unsupervised classifier and abnormal detection through spatial Fuzzy clustering algorithm. Here probabilistic neural network with radial basis function will be used

for Stage classification. Spatial Fuzzy C-Mean clustering algorithm is applied for segmentation and neural network is used for classifying the different phases of liver tumor into, malignant, benign or normal cell. This research paper gives the more accurate result by using Fuzzy based segmentation technique, clustering

methods in all different cases and reliable than thresholding. Data processing techniques with image and Probabilistic Neural Network were used to implement a semi automated Tumor classifications.
Decision making was done in two different phases, by using the four level wavelet decomposition, features extraction is done and in next stage using probabilistic neural network (PNN) features are extracted. The PNN provides accurate and fast classification thanother different neural networks techniques.

Hussein Alahmer et.al [19] explained a semi automatic system consists of three different phases; in the initial stage, lesion's detection and liver segmentation is done automatically. In next phase features which are efficient and useful are extracted and in the last stage with the help of the novel contrasting feature difference approach classification is done for liver lesions to identify whether the cell is malignant and benign. Different types of features like texture features, intensity are extracted from both the surrounding normal liver tissue and lesion area,both areas differentiated features is then used as the new lesion descriptors. Liver lesions are classified into malignant or benign by taking training from machine learning classifiers with the help of new lesion descriptors.This proposed approach can overcome the problems of varying ranges of textures between patients, demographics and intensity.
Ali et.al [05] has explained with the help of Multi-Support Vector Machine (Multi-SVM) and semi automated identification and classification of various stages of liver lesions. This research paper method can be utilised to differentiate focal diseases of liver such as Hepatocellular carcinoma, Hemangioma ,Cyst and along with normal liver. differentiation between hepatocellular carcinoma hepatocellular carcinoma ,cysts, hepatocellular carcinoma, , and normal tissue as a supervised learning problem and with the help of Multi-SVM to classify the diseases using histogram based features and Haralick local texture descriptors calculated from Regions Of Interest, as input. ROI selection significantly impact on the classification performances, thus in this paper a semi automatic Regions of interest selection using Fuzzy c-means initialized by level set technique. One-Against-All (OAA) method is used for multi-class classification. Amitha Raj et.al [20] has proposed an automated computer aided identification of liver tumors from CT images. Initially liver is segmented using MRF embedded level set method. It provides robustness to noise and fast segmentation. The shape ambiguities of the segmented liver are found out by shape analysis methods which use training sets are used for correction. From the corrected liver segmentation, with the help of graph cut method hepatic tumors are detected and by using SVM feature extraction is done. Saranya et.al [22] has deal with the detection of liver tumor from CT images. It mainly includes segmentation, detection and calculating the tumor affected area with the help of FCM technique. This technique is used to segment the tumor clearly and gives the shape and size of the tumor. To identify the shape and size of the tumor will help the doctors for give better treatment. Finally PSNR and Entropy values are evaluated with the help of segmented tumor. Implementation of FCM technique and some default tools help to detect the shape of tumor. Finally the tumor part is extracted from CT images and its exact position and shape is determined to calculate the abnormality area. Table 4 shows comparative analysis of accuracy with respect to features in classification for deduction of tumor.

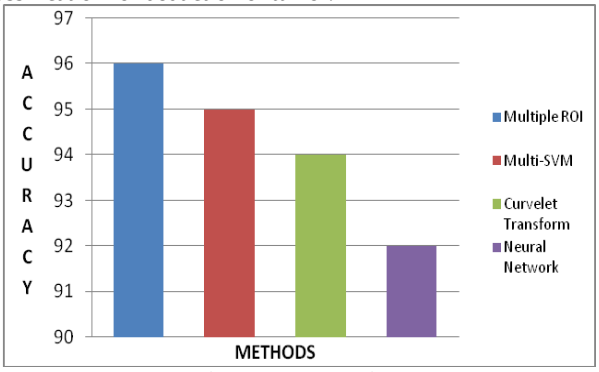

Fig 4: Accuracy of various Methods for Tumor detection.

4. Conclusion

Study of several segmentation approaches and tumour classification has been done. In this study, the various segmentation and detection techniques are explained briefly with key objectives and limitations. This paper provides an analysis and description of the different kind of techniques and methods proposed, developed for processing CT scan image of liver. This paper presents various Segmentation techniques applicable to liver region and detection of tumor techniques. Discussed different techniques automate the process of segmentation and helps in the identification of tumors, all these techniques are semi automated so they are faster and easier than the procedures followed by doctor to recognise. By the study it is seen that tremendous work has been done in the field of diagnosing of liver cancer cells, yet at the same time there exists space for more additional work.

Table 4: Survey on Tumor detection Techniques

Title	Year	Features	Accuracy
Computer-Aided Classification of Liver Lesions from CT Image Based on Multiple ROI [19]	2016	Intensity features, Texture features and Shape features	96
Automated Focal Liver Lesion Staging Classification based on Haralick Texture Features and Multi-SVM. [27]	2014	GLCM based texture features with Multi-SVM-88 6 histogram features	95.11% 95.08% 91.83%
Diagnosis of Liver Tumor from CT Images using Curvelet Transform [4]	2010	Curvelet Wavelet	Curvelet - 94.3% Wavelet- 88.6%
Neural Network based Texture Analysis of Liver Tumor from Computed Tomography Images. [26]	2008	wavelet based texture and PNN classifier	92%

5. References

[1]. Weiwei Wu, Zhuhuang Zhou, Shuicai Wu and Yanhua Zhang, "Automatic Liver Segmentation on Volumetric CT Images Using Supervoxel-Based Graph Cuts", Hindawi Publishing Corporation Computational and Mathematical Methods in Medicine, 2016.

[2]. Bing Nan Li, Chee Kong Chui , Stephen Chang and Sim Heng Ong, "A new unified level set method for semi-automatic liver tumor segmentation on contrast-enhanced CT images", Elsevier ,Expert Systems with Applications, Vol. 39 , pp. 9661 – 9668, 2012.

[3]. Dorota Duda, Marek Krętowski and Johanne B´ezy-Wendling, "A Computer-Aided Diagnosis of Liver Tumors Based on Multi-Image Texture Analysis of Contrast-Enhanced CT. Selection of the Most Appropriate Texture Features", Studies in Logic, Grammar and Rhetoric, 2013.
[4]. S.S. Kumar and Moni DRS, "Diagnosis of Liver Tumor from CT Images Using Fast Discrete Curvelet Transform", Computer Aided Soft Computing Techniques for Imaging and Biomedical Applications, pp. 1 – 6, 2010.
[5]. Dr. Alyaa H. Ali , Entethar M. Hadi , "Diagnosis of Liver Tumor from CT Images Using First Order Statistical Features", International Journal of Engineering Trends and Technology (IJETT), Vol. 20, No. 3, 2015.
[6]. Sheetal M. Deokar and S. M. Hambarde, "Detection of Liver Cancer in Ct Scan Images", International Journal of Innovative Technology & Adaptive Management (IJITAM), Vol.1, No. 6 , 2014.
[7]. M. Obayya and El.Rabaie, "Automated Segmentation of Suspicious Regions in Liver CT using FCM", International Journal of Computer Applications ,Vol. 118, No. 6, 2015.
[8]. Jianhua Liu, Zhongyi Wang and Rui Zhang, "Liver Cancer CT Image Segmentation Methods based on Watershed Algorithm", IEEE, 2009.
[9]. Mehrdad Moghbel, Syamsiah Mashohor, Rozi Mahmud , M. Iqbal Bin Saripan, "Automatic Liver Tumor Segment Action on Computed Tomography For Patient Treatment Planning And Monitoring" , EXCLI Journal 2016.
[10]. Ina Singh and Neelakshi Gupta, "Optimized Liver Segmentation using Ant Colony Optimization" , International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), Vol. 4, No. 9, 2015.
[11]. Xuechen Li , Suhuai Luo and Jiaming Li, "Liver Segmentation from CT Image Using Fuzzy Clustering and Level Set", Journal of Signal and Information Processing, Vol. 4,pp. 36 – 42,2013.
[12]. N. UmaDevi and R.Poongodi, "Integration of Spatial Fuzzy Clustering with Level Set for Efficient Image Segmentation", International Journal of Computer Science & Communication Networks, Vol. 3,No.4,pp.296 – 301,2014.
[13]. Megha Ganjre and J. P. Gawande, "Automated Segmentation of Liver and Tumor and Feature Extraction from Abdominal Ct Images Using Region Growing Method" , Proceedings of 10 th IRF International Conference, 2014
[14]. K.Mala, V.Sadasivam, and S.Alagappan, "Neural Network based Texture Analysis of Liver Tumor from Computed Tomography Images", World Academy of Science, Engineering and Technology International Journal of Medical, Health, Biomedical, Bioengineering and Pharmaceutical Engineering Vol. 2, No.1, 2008.
[15]. S. S. Kumar and Dr. R. S. Moni, "Diagnosis of Liver Tumor from CT Images using Curvelet Transform", (IJCSE) International Journal on Computer Science and Engineering, Vol. 02, No. 04, pp. 1173 – 1178, 2010.
[16]. Ms.Vincey Jeba and Malar.V, "Computer Aided Diagnosis for liver Cancer Feature Extraction" , The International Journal of Engineering and Science (IJES) ,Vol. 2, No. 11, pp. 27 – 30, 2013.
[17]. Vincey Jeba Malar and Saravana Kumar, "Computer Aided Diagnosis for Liver Cancer using Statistical Model", IJRET: International Journal of Research in Engineering and Technology, Vol. 2, No. 12, 2013.
[18]. Divya.v, "Analysis of CT Liver Images for Tumor Diagnosis Based on PNN Classifier and Clustering Model", International Journal of Modern Computer Science (IJMCS),Vol. 4, No. 2, 2016.
[19]. Hussein Alahmera and Amr Ahmeda, "Computer-Aided Classification of Liver Lesions from CT Images Based on Multiple ROI", International Conference on Medical Imaging Understanding and Analysis, 2016.
[20]. Amitha Raj a and Jayasree M b, "Automated Liver Tumor Detection Using Markov Random Field Segmentation" , International Conference on Emerging Trends in Engineering, Science and Technology (ICETEST - 2015), Vol. 24 , pp.1305 – 1310, 2016.
[21]. S. Saranya, "Liver Tumor Detection for Ct Images", International Journal on Recent and Innovation Trends in Computing and Communication, Vol. 4, No. 4, pp. 635 – 637, 2014.
[22]. Ahmed M.Mharib, "Survey on liver CT image segmentation methods", Artificial Intelligence Review, VOl.37, pp. 83 - 95, Springer 2011.
[23]. Sonali Patil,V.R.Udupi and Deepti Patole, "A Robust system for Segmentation of primary Liver Tumor in CT images", International Journal of Computer Applications, Vol. 75 , No. 13, 2013.
[24]. M V Sudhamani and G T Raju, "Segmentation and Classification of Tumor in Computed Tomography Liver Images for Detection, Analysis and Preoperative Planning", International Journal of Advanced Computer, Vol.4, No.14, 2014.
[25]. Marwa I.M. Obayya and Nihal F.F. Areed, " Liver Cancer Identification using Adaptive Neuro-Fuzzy Inference System", International Journal of Computer Applications, Vol. 140 ,No.8, 2016.
[26]. K.Mala, V.Sadasivam, and S.Alagappan, "Neural Network based Texture Analysis of Liver Tumor from Computed Tomography Images", International Journal of Biological and Medical Sciences 2:1 2007.
[27]. AA Sakr, ME Fares, M Ramadan, "Automated focal liver lesion staging classification based on Haralick texture features and multi-SVM", International Journal of computer applications.
[28]. M.Jayanthi "Automated focal liver lesion staging classification based on Haralick texture features and multi-SVM", IEEE WiSPNET 2016 conference.
[29]. Changjian "Automatic segmentation of liver tumours from multiphase contrast-enhanced CT images based on FCNs"2017", Artificial Intelligence in Medicine Volume 83, November 2017, Pages 58-66.
[30]. Fang Lu et.al**, "**Automatic 3D Liver Location and Segmentation via Convolutional Neural Network and Graph Cut,2017, International Journal of Computer Assisted Radiology and Surgery February 2017, Volume 12, Issue 2, pp 171–182.
[31]. Mazin Abed Mohammed, "Automatic segmentation and automatic seed point selection of nasopharyngeal carcinoma from images using region growing based approach" ,2017, Journal of Computational Science Volume 20, May 2017, Pages 61-69.