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QUANTIFICATION OF PLEURAL EFFUSION ON CT IMAGES BY AUTOMATIC AND MANUAL SEGMENTATION

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Abstract:
The objective of this research is to make reliable estimation of pleural effusion volume in CT imaging using digital image processing algorithms. In order to make reliable estimation we need to do the manual and automatic segmentation of CT images and to perform the comparison of automatic and manual segmentation for the quantification of pleural effusion on CT images which provides help in the diagnosis of the pleural disease. Pleural effusion is the collection of excess fluid in the pleural cavity. Excessive amount of fluid can impair breathing by limiting the expansion of lungs. Heart failure, cancer, cirrhosis, pneumonia, tuberculosis and many other are the causes of pleural effusion. A number of noninvasive imaging techniques such as radiography, ultrasound and computed tomography (CT) can detect the pleural effusion. The problem faced is the quantification of pleural effusion volume for the purpose of diagnosis of the pleural disease. The objective of this research is to make reliable estimation of pleural effusion volume in CT imaging using digital image processing algorithm. In order to make reliable estimation we need to do the manual and automatic segmentation of CT images and to perform the comparison of automatic and manual segmentation for the quantification of pleural effusion on CT images which provides help in diagnosis of the pleural disease. The results obtained by both the aforementioned techniques indicate that the manual segmentation is better because automated technique has less number of pixels.

Keywords: Quantification; Pleural; Segmentation; Automatic.

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1. Introduction

In humans and in many other animals, the main organs of the respiratory system are lungs. Each lung is surrounded by the two pulmonary pleurae (known as visceral and parietal) in which there is thin fluid filled space called pleural cavity [1]. The collection of excess fluid in the pleural cavity is called Pleural effusion**.** Excessive amount of fluid can impair breathing by limiting the expansion of lungs [2]. Heart failure, cancer, cirrhosis, pneumonia, tuberculosis and many other are the causes of pleural effusion [3]. A number of noninvasive imaging techniques such as radiography, ultrasound and computed tomography (CT) can detect the pleural effusion [4]. CT scan or computerized axial tomography (CAT) has performed a vital role in diagnostic and therapeutic

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purposes because it produces cross-sectional images by using computer processing of particular areas from different angles of the body [5]. The problem faced is the quantification of pleural effusion volume for the purpose of diagnosis of the pleural disease. The research carried out in this thesis is based on the manual and automatic segmentation of pleural effusion on CT images and then performs the comparison by receiver operating characteristic curve (ROC). Mathew et al [8] proposed the simplest method for estimating the size of the pleural effusions on CT scans with the three point scale rule. The rule demonstrates the (small, medium and large) anterior posterior quartile and maximum anterior posterior quartile of the pleural effusions. There are several limitations first, the sample size was very small. Secondly, the pleural effusion cases were not taken randomly. Third, the separations for sizes were chosen as small, medium and large. Fourth, the patients of pleural effusions with bilateral side were included. Lastly, the measurements of CT scan were not confirmed with the basic radiographs grading systems. Yao et al [9] proposed computer aided automatic program designed for the estimation of the pleural effusions size. It is highly correlated with the radiologist grading. There are several limitations in the proposed program, the program is applied on 2D slice for segmentation, therefore the continuation of the pleural space between slices was difficult to maintain. Another limitation was the images used for the experiment were all having the drained plural fluid several months before, therefore the accuracy of the program did not verified. Jianhua Yao et al [10] proposed the program is designed for the quantification of the pleural effusion by completely automatic segmentation. The program runs in the background when patient go through the CT scanning processing and the volume of pleural effusion is calculated for the diagnosis of the disease. However, the proposed automatic segmentation program gives the best results when pleural effusions have specific shape and large pleural effusions. For measurement of loculated effusions the method cannot be used.

2. Materials and Methods

As the research problem is the quantification of pleural effusion on CT images. In order to meet with our objective the methodology was discussed in the following steps; first, the manual segmentation of the CT images was done with the GNU Image Manipulation Program (GIMP) software after that the manually segmented images are processed in MATLAB to plot the histogram and probability density function (PDF) of data in order to compute the mean and standard values. In second step, automatic segmentation of same CT images was performed by implementing region growing image processing algorithm. In addition, the morphological filter is applied on automatic segmentation images for the better results. In the last step, the comparison between the results obtained by manual segmentation and automatic segmentation is performed. Furthermore, the result obtained by applying morphological filter on automatic segmentation is also compared with manually segmented images. In both the cases, the comparison was made by using the receiver operating characteristic curve (ROC) in MATLAB.

3. Results and Discussion

In this study the results of comparison of the manual and automatic segmentation are discussed, which is computed with the help of MATLAB codes by using ROC. As there are three cases of pleural effusion. The case 1 consist of 40 scanned CT images, the comparison of manual and automatic segmented images with the ROC. The true positive values are greater than the false positives and false negative values. It means the reliable estimation of pleural effusion space is

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segmented automatically by region growing algorithm. The accuracy of the compared images is 0.99, it seems better but it is not good because from the definition of accuracy it is the ratio of true positives and true negative values so, in the table you can see that the true negative values are greater than the true positive values, the precision of images is varying because it depends upon the true positive and false positive values, F1 score and MCC results have greater than 0.5 values, and it also shows the reliable comparison results. Table.1

Table 1: Comparison Result of Manual and Automatic Segmentation of Case 1

S.NO.	True Positive	False Positive	True Negative	False Negative	Accuracy	Precision	F1 Score	MCC
1.	2426	204	257608	1906	0.9919	0.9224	0.6969	0.7153
2.	1326	513	258522	1783	0.9912	0.7210	0.5359	0.5506
3.	2338	404	257947	1455	0.9929	0.8526	0.7155	0.7216
4.	2438	354	257363	1989	0.9910	0.8732	0.6754	0.6895
5.	2665	273	257451	1755	0.9922	0.9070	0.7243	0.7361
6.	2482	863	257633	1166	0.9922	0.7420	0.7098	0.7066
7.	2591	969	257367	1217	0.9916	0.7278	0.7033	0.6994
8.	2524	240	256577	2803	0.9883	0.9131	0.6239	0.6532
9.	2442	709	257195	1798	0.9904	0.7749	0.6608	0.6635
10.	2515	554	257153	1922	0.9905	0.8194	0.6701	0.6771
11.	2211	1175	257402	1356	0.9903	0.6529	0.6359	0.6313
12.	2472	244	256733	2695	0.9887	0.9101	0.6271	0.6554
13.	1413	560	258237	1934	0.9904	0.7161	0.5312	0.5455
14.	2968	363	257185	1628	0.9924	0.8910	0.7488	0.7550
15.	3076	573	256944	1551	0.9918	0.8429	0.7433	0.7446
16.	3062	717	256734	1631	0.9910	0.8102	0.7228	0.7227
17.	2933	905	257029	1277	0.9916	0.7642	0.7288	0.7254
18.	2776	1209	256941	1218	0.9907	0.6966	0.6958	0.6911
19.	2688	1072	257040	1344	0.9907	0.7148	0.6899	0.6856
20.	2809	1008	257046	1281	0.9912	0.7359	0.7105	0.7065
21.	2455	505	257101	2083	0.9901	0.8293	0.6548	0.665
22.	2435	980	257118	1611	0.9901	0.7130	0.6527	0.6501
23.	2324	1228	257014	1578	0.9892	0.6542	0.6235	0.6188
24.	1915	592	257577	2060	0.9898	0.7638	0.5908	0.6020
25.	2737	683	256906	1818	0.9904	0.800	0.6863	0.6888
26.	2863	517	256159	2605	0.9880	0.8470	0.6471	0.6607
27.	2604	969	256305	2266	0.9876	0.7287	0.6168	0.6182
28.	2833	834	256330	2147	0.9886	0.7725	0.6552	0.6574
29.	2957	462	255938	2787	0.9876	0.8648	0.6454	0.6619
30.	2245	740	256125	3034	0.9856	0.7520	0.5433	0.5592
31.	2810	686	256080	2568	0.9875	0.8037	0.6333	0.6423
32.	3205	944	254920	3075	0.9846	0.7724	0.6146	0.6207
33.	3161	638	255854	2491	0.9880	0.8320	0.6689	0.6766
34.	3244	387	255676	2837	0.9877	0.8934	0.6680	0.6851
35.	1895	316	258120	1813	0.9918	0.8570	0.6403	0.6583
36.	2313	124	257564	2143	0.9913	0.9491	0.6711	0.69851
37.	2239	203	257811	1891	0.9920	0.9168	0.6813	0.7017
38.	2454	224	257158	2308	0.9903	0.9163	0.6596	0.6832
39.	2098	339	257987	1720	0.9921	0.8608	0.6708	0.6843
40.	2351	236	257289	2268	0.9904	0.9087	0.6525	0.6762

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Histogram of accuracy of case 1, which is computed from the comparison. In which you can see that 0.991 is accuracy of 9 compared images, 0.992 is accuracy of 8 compared images and 0.993 is accuracy of 5 compared images and so, on. Figure 1.

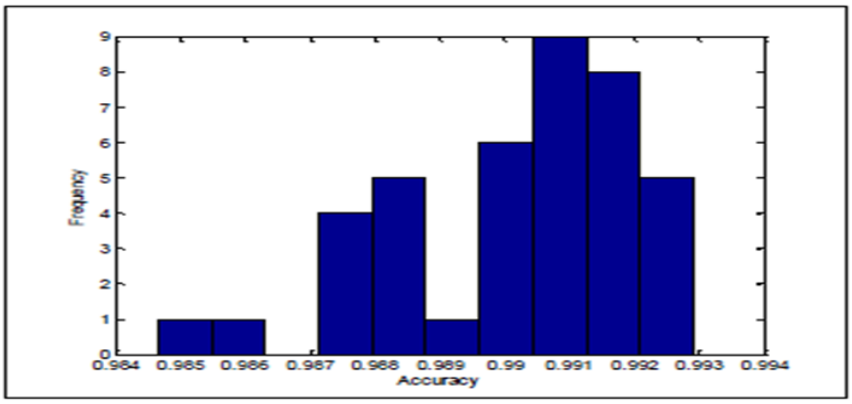

Figure 1: Histogram of Accuracy of Case 1

The case 2 consist of 28 scanned CT images, the comparison of manual and automatic segmented images is shown in Table 5.2. As you can see in the table that some images have true positive values are less than the false positive values like in S.no 2, 7, 21 this is because of our automated segmentation image is not much have pleural effusion data as compared to the manual one. The accuracy ratio of the data is 0.99, same problem as discussed earlier in table 5.1 but the precision, F1 score and MCC are varying and some have below 0.5 values because of less difference in the true positive and false positive values. Table.2

Table 2: Comparison Result of Manual and Automatic Segmentation of Case 2

S.NO.	True Positive	False Positive	True Negative	False Negative	Accuracy	Precision	F1 Score	MCC
1.	291	253	260546	1054	0.9950	0.5349	0.3080	0.3381
2.	541	646	260064	893	0.9941	0.4557	0.4128	0.4117
3.	547	166	259817	1614	0.9932	0.7671	0.3806	0.4383
4.	635	421	259782	1306	0.9934	0.6013	0.4237	0.4405
5.	1064	1044	259332	704	0.9933	0.5047	0.5490	0.5478
6.	1143	644	259640	717	0.9948	0.6396	0.6268	0.6243
7.	909	1096	259611	528	0.9938	0.4533	0.5281	0.5325
8.	975	551	259756	862	0.9946	0.6389	0.5798	0.5796
9.	1044	368	259692	1040	0.9946	0.7393	0.5972	0.6061
10	1025	334	259716	1069	0.9946	0.7542	0.5936	0.6051
11	1222	429	259551	942	0.9947	0.7401	0.6406	0.6439
12	1271	399	259648	826	0.9953	0.7610	0.6748	0.6769
13	1262	164	258920	1798	0.9925	0.8849	0.5626	0.6013
14	1087	107	258867	2083	0.9916	0.9103	0.4981	0.5559
15	1594	1293	257922	1335	0.9899	0.5521	0.5481	0.5430
16	1893	837	257798	1616	0.9906	0.6934	0.6068	0.6070
17	1347	865	258687	1245	0.9919	0.6089	0.5607	0.5585
18	997	597	258707	1843	0.9906	0.6254	0.4497	0.4644
19	1606	806	258614	1118	0.9926	0.6658	0.6253	0.6228
20	166	26	261362	590	0.9976	0.8645	0.3502	0.4350
21	92	118	261418	516	0.9975	0.4380	0.2249	0.2565
22	137	114	261418	475	0.9977	0.5458	0.3174	0.3486
23	300	204	261178	462	0.9974	0.5952	0.4739	0.4828
24	341	158	261192	453	0.9976	0.6833	0.5274	0.5406
25	397	168	261188	391	0.9978	0.7026	0.5868	0.5939
26	228	182	261070	664	0.9967	0.5560	0.3502	0.3756
27	474	180	260832	658	0.9968	0.7247	0.5307	0.5494
28	408	321	260884	531	0.9967	0.5596	0.4892	0.4915

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histogram of accuracy of case 2, which is computed from the comparison table 5.2. In which you can see that between 0.997-0.998 is accuracy of 6 compared images, and between 0.993 -0.994 is accuracy of 4 compared images and 0.99 is accuracy of 3 compared images and so, on. Figure 2.

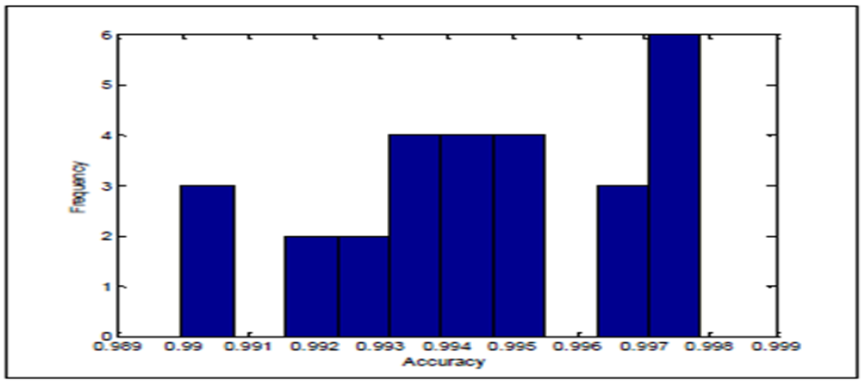

Figure 2: Histogram of Accuracy of Case 2

The case 3 consist of 23 scanned CT images, the comparison of manual and automatic segmented images is shown in Table 5.2. As you can see in the table that true positive values are greater than the false positive values but mostly are lesser than the false negative. This is because of automated segmentation, which is not done accurately due to the selection of seed points and thresholds. The accuracy is same but again same problem because of true negative values are higher than the true positive values and precision ratio of the data is alright but F1 score and MCC are varying and some have below 0.5 values due to the true positive values are lesser than the false negative vales. Table.3

Table 3: Comparison Result of Manual and Automatic Segmentation of Case 3

S.NO.	True Positive	False Positive	True Negative	False Negative	Accuracy	Precision	F1 Score	MCC
1.	519	486	259291	1848	0.9910	0.5164	0.3078	0.3327
2.	599	588	259312	1645	0.9914	0.5046	0.3491	0.3631
3.	644	353	259721	1426	0.9932	0.6459	0.4199	0.4454
4.	1241	941	258543	1419	0.9909	0.5687	0.5125	0.5106
5.	1322	492	258894	1436	0.9926	0.7287	0.5783	0.5876
6.	1382	810	258620	1332	0.9918	0.6304	0.5633	0.5625
7.	1176	426	259246	1296	0.9934	0.7340	0.57731	0.5879
8.	1079	68	258895	2102	0.9917	0.9407	0.4986	0.5622
9.	889	158	259540	1557	0.9934	0.8490	0.5090	0.5531
10.	981	106	259730	1327	0.9945	0.9024	0.5779	0.6173
11.	962	79	259637	1466	0.9941	0.9241	0.5546	0.6030
12.	1324	193	259382	1245	0.9945	0.8727	0.6480	0.6683
13.	781	122	258942	2299	0.9907	0.8648	0.3921	0.4654
14.	1059	368	258619	2098	0.9905	0.7421	0.4620	0.4951
15.	1441	493	258116	2094	0.9901	0.7450	0.5269	0.5468
16.	1098	178	258239	2629	0.9892	0.8605	0.4389	0.4999
17.	1609	568	258597	1370	0.9926	0.7390	0.6241	0.6282
18.	1169	618	259120	1237	0.9929	0.6541	0.5575	0.5603
19.	1627	438	258582	1497	0.9926	0.7878	0.6270	0.6371
20.	375	27	260277	1465	0.9943	0.9328	0.3345	0.4346
21.	435	109	260111	1489	0.9939	0.7996	0.3525	0.4232
22.	471	142	260193	1338	0.994	0.7683	0.3889	0.4453
23.	527	176	260061	1380	0.9940	0.7496	0.40383	0.4529

Histogram of accuracy of case 3, which is computed from the comparison table 5.3. In which you can see that between 0.9941 is accuracy of 6 compared images and between 0.993 -0.9939 is accuracy of 4 compared images and 0.991 is accuracy of 3 compared images and so, on. Figure 3.

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4. Conclusion

Quantification of pleural effusion has been in research over several decades. Both the manual and automatic segmentation of CT images have been used and advantages of one over the other are discussed by researchers. The work presented in this thesis provides analysis of automatic and manual segmentations. Observations based on three different cases of pleural effusion each have 40, 28 and 23 CT scans are provided. The manual segmentation is performed using GIMP software and histograms and PDF are plotted. Automatic segmentation is performed using region growing images processing algorithm. Morphological filter is also implemented to improve the results obtained by automatic segmentation. The results in table 5.9 shows that the volumetric quantification of pleural effusion in manual segmentation is better than the automatic segmentation because the image segmented by automated technique has less number of pixels therefore it provides less information compared to image segmented by manual segmentation. The same table also indicates that the results obtained by applying morphological filter on automated segmented images is statistically closest to the results obtained of manually segmented images. The performance of automatic segmentation can be improved by using different image processing algorithm such as thresholding.

References

[1] R. W. Light, Pleural diseases. Lippincott Williams & Wilkins, 2007.
[2] J. M. Porcel and R. W. Light, "Pleural effusions due to pulmonary embolism.," Curr. Opin. Pulm. Med., vol. 14, no. 4, pp. 337–42, Jul. 2008.
[3] T. Laisaar, "Life expectancy of patients with malignant pleural effusion treated with video-assisted thoracoscopic talc pleurodesis," Interact. Cardiovasc. Thorac. Surg., vol. 5, no. 3, pp. 307–310, Feb. 2006.
[4] J. C. Shank and R. F. Latshaw, "Pleural effusion.," Am. Fam. Physician, vol. 17, no. 3, pp. 143–149, 1978.
[5] "Body CT (CAT Scan)." [Online]. Available: https://www.radiologyinfo.org/en/info.cfm?pg=bodyct. [Accessed: 09-Jan-2019].
[6] M. Hazlinger, F. Ctvrtlik, K. Langova, and M. Herman, "Quantification of pleural effusion on CT by simple measurement," Biomed. Pap., vol. 158, no. 1, pp. 107–111, 2014.
[7] S. Exhibit, M. I. Kalokairinos, S. G. Vassiliadis, C. G. Vossou, A. I. Ciurea, and C. Ciortea, "Estimation of the volume of the pleural effusion by computed tomography," Eur. Congr. Radiol., pp. 1–12, 2010.
[8] M. P. Moy, J. M. Levsky, N. S. Berko, A. Godelman, V. R. Jain, and L. B. Haramati, "A new, simple method for estimating pleural effusion size on CT scans," Chest, vol. 143, no. 4, pp. 1054–1059, 2013.
[9] J. Yao, W. Han, and R. M. Summers, "Computer aided evaluation of pleural effusion using chest ct images," Proc. - 2009 IEEE Int. Symp. Biomed. Imaging From Nano to Macro, ISBI 2009, pp. 241–244, 2009.
[10] J. Yao, J. Bliton, and R. M. Summers, "Automatic segmentation and measurement of pleural effusions on CT," IEEE Trans. Biomed. Eng., vol. 60, no. 7, pp. 1834– 1840, 2013.

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