ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, *Vol 9(7), DOI: 10.17485/ijst/2016/v9i7/87731, February 2016* *ISSN (Online) : 0974-5645*

Automated Detection of Lymphadenopathy in Neck Resulting from Oral SCC on 3D CT Imaging

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Abstract

Background/Objectives: Detection of lymphadenopathy is challenging issue in medical field. Squamous Cell Carcinoma (SCC) can lead to a certain typeoflymphadenopathy which is different from all other pathological factors. Nowadays detection of these cases is done by expert radiologists, Computing Tomography (CT), and sonography and etc., challenges in detection of this type of lymphadenopathy in neck is mainly due to neck anatomy which similar objects are close to each other. **Methods/Statistical Analysis:** In this paper, was presented a method to detect this type of the lymphadenopathy in neck by 3dimensional (3D) image processing techniques and Computer-Aided Diagnosis (CAD) systems. This method consists of four steps. The first is preprocessing, the second is thresholding and morphological operation, the third is feature extraction and the last is classification. By using this method, detection of lymphadenopathy will be done more accurate and less time consuming. **Findings:** This method is done in 18 neck CT data sets, consisting of lymphadenopathy by SCC cells. The sensitivity of using this method is 94%. **Applications/Improvements:** The goal is to introduce a sensitive, accurate and generalizable method with the least false positive.

Keywords: CT Images, Lymphadenopathy, Neck, Squamous Cell Carcinoma (SCC)

1. Introduction

The role of lymphatic system is detectionanddestructionof external pathogenic factors. Carcinoma cells of ectodermal origin tend to spread through the lymphatic system, which leads to the immune system reaction calledlymphadenopathy. Although, most external pathogenic factors causes this reaction but the lymphadenopathy of Squamous Cell Carcinoma (SCC) origin is different from the others.

The challenges in radiologic detection of lymphadenopathies are due to the complex anatomy of the head and neck region, todayComputer-Aided Diagnosis(CAD) systems are commonly used for detection of pathologic lymph nodes in different organs[2–7]. Even in some cases it can be used instead of manual detection[8–12].

There are reports of detection of pathologic lymph nodes by CAD systems in regions like Abdomen[13–15], Thorax[16,17], Axillary[18],Lung[19–23], Chest andMediastinal[24–27]. In those papers, different image processing techniques and methodswereused.The template matching was used in the Fourier space to extract neck lymph nodesautomatically[28,29].Wherein the lymph node intensity was adjusted manually for each dataset. This method is not fully automated[2]. As a further progress, the detection of the neck pathologic lymph nodes was done by using 3DStableMass-SpringModel (SMSM)[3,12]. This method is completely automatic and it was done on 3D images[3].

This paper presents a method to detect lymphadenopathyresulting from SCC by 3D image processing techniques and Computer-Aided Diagnosis (CAD) systems. We believe this method is easier, more accurate and less time consuming[30].

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2. Proposed Method

The whole picture is shown asFigure1. The following is the description for each process

2.1 Preprocessing

The purpose of preprocessing is the removing of noisesin order to enhance the image quality.

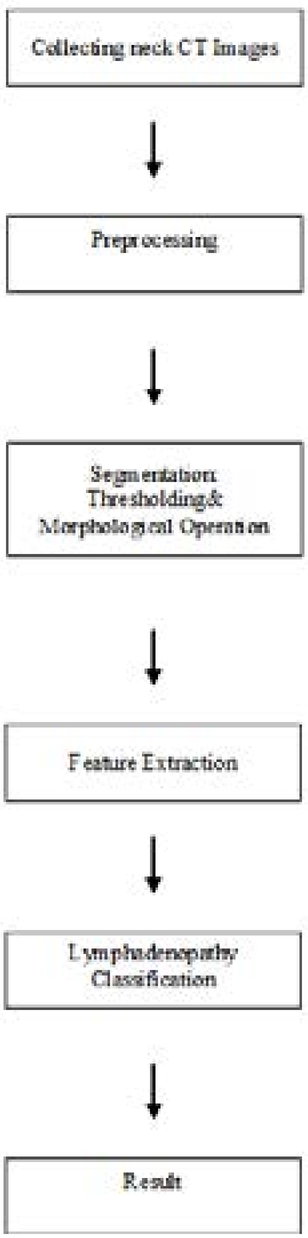
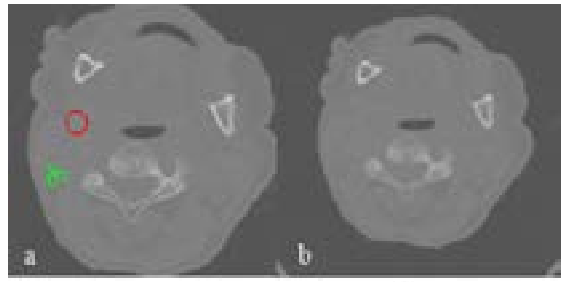


Figure 1. of all processes to detect lymphadenopathy.



(a) (b)

Figure 2. Figure2.One CT image slice.(a) Before preprocessing. (b) After preprocessing.

For this process, we used the median filter method which is a nonlinear digital filtering technique, often used in digital image processing with certain conditions[2,29]. It should be noted, another filtering method (which method?) was applied on CT images too, but better resultswere achieved by using median filter technique. The result of applying preprocessing technique is showninFigure 2.

2.2 Segmentation

Global thresholding and morphological operations are used for segmenting neck CT images to detect lymphadenopathy.

2.2.1 Thresholding

Intensity of pathologic lymph nodes is close toother organs of the neck. For this reason the fully automatic thresholding cannot be used. Thus a semi-automatic iterative thresholding algorithm was used. In this method the CT-scan was separated into two regions based ondensity, the high-density and low-density regions.

This iterative algorithm is as follow:

- Select an initial estimate for T.
- Segment the image using T. This will produce two groups of pixels: G1 consisting of all pixels with gray level values less than T and G2 consisting of pixels with values more than T.
- Compute the average gray level values and for the pixels in the regions G1 and G2. µ1 µ2
- Compute a new threshold value:
- Repeat steps 2 through 4 until the difference in T in successive iterations is smaller than a predefined parameter T0.

After applying this algorithm, the gray level CT images converted to binary images and the images werepreparedforfurther processes as shown inFigure3.

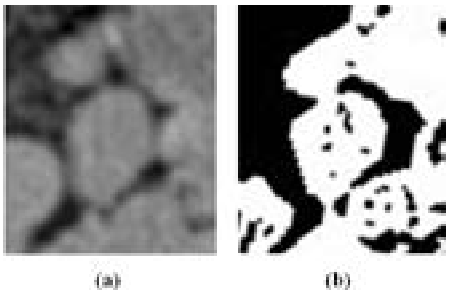


Figure 3. Lymphadenopathy segmentation.(a) Original pathologic lymph node.(b) After thresholding process.

2.2.2 Morphological Operation

Thisprocessisusedtofilltheholesandgapsoftheimages. Opening and erosion are twoprocesseswhichareused in this step with 4-connected neighbors. The morphological operation separates pathologic lymph node from other objects.

2.3 Feature Extraction

In this step, the features of pathologic lymph nodes are cleared enough to separate it from other objects in CT images.

2.3.1 Position

Lymph nodes in the neck have been divided into seven levels shown in Figure 4. In order to increase accuracy and decrease false positive, we limited the usage of our method to level II, III and IV lymph nodes which are close to carotid artery and jugular vein which are easily found in CT images.

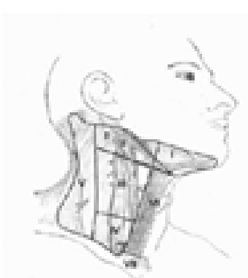


Figure 4. Lymph nodes of neck region.I. Submental and submandibular, II. The upper jugular chain, III. The middle jugular chain,IV. Lower jugular chain, V. posterior triangle of the neck, VI. Prelaryngeal and VII. Superior mediastinal.

First carotid artery and jugular vein are found in the original and processed CT images. Then some extra objects were removed (mask method).

2.3.2 Size

The size of a pathologic lymph node is a feature that helps to discern it from other lymph nodes. After someclinicalexaminationandconsultingexpert radiologist and specialist doctor, the approximate size of regional lymph nodes were guessed.

The area size of pathologic lymph nodes in our pilot on 10 cases are shown in in Figure5. That area size is between 145px and370px. Area size 265pxwas considered appropriate for applying to other cases. After this process, some extra objectswerere moved.

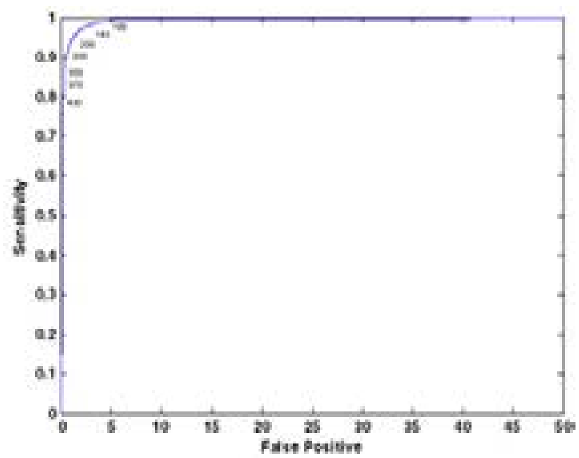


Figure 5. FROC chart after using size feature extraction.

After feature extraction, pathologic lymph node is distinguished from other objects.

2.4 Classification

The purpose of classification is to determine whether the detected lymph node is pathologic. Bycategorizing all pixels in a digital image into one of several classes.

3. Results

Twoexpertradiologistscommented on whether a lymph node is pathologic or normal. The final result areshown in Table 1.

Table 1. The result of lymphadenopathy detection

Case	TP	FP	FN	Sensitivity
Case1	2	0	0	100%
Case2	1	0	0	100%
Case3	5	2	0	100%
Case4	5	1	1	83%
Case5	3	1	0	100%
Case6	1	0	0	100%
Case7	4	3	1	80%
Case8	6	2	1	85%
Case9	3	0	0	100%
Case10	4	0	0	100%
Case11	6	3	2	75%
Case12	2	0	0	100%
Case13	3	1	0	100%
Case14	5	0	1	83%
Case15	4	0	0	100%
Case16	4	1	0	100%
Case17	3	0	0	100%
Case18	5	3	0	100%

After earning results for all cases, we could compute the sensitivityforeach case. Final sensitivity was 94%.

4. Conclusion

In this paper, we described the objective and benefits of automated lymphadenopathy detectioninneck region resulting from Oral SCC and CAD systems. The accuracy of this technique was reasonable. However authors state that there were some limitations for this study. First, the authors believe that if more cases were available, we could test our method more accurately and our results would have been more generalizable. Second, the segmentation process was quite challenging due to the complex anatomy of the neck and similarity of pathologic lymph nodes to other objects in this region.Third,in classification process, we used the comments of two expert radiologists. This way of classification is somehow subjective. We suggest more studies to be done, using definite objective theories and methods like fuzzy logic instead of expert comments for this step of process. The goal is to introduce a sensitive, accurate and generalizable method with the least false positive.

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