

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

Erfaneh Rezaei Kejani¹, Yousef Ebrahimdoost^{2*} and Afsaneh Alikhasi³

¹Department of Computer, Islamic Azad University, Karaj Branch, Karaj, Iran;
erfanehrt@yahoo.com

²Department of Mathematical, Islamic Azad University, Islamshahr Branch, Islamshahr, Iran;
yousef.ebrahimdoost@iiu.ac.ir

³Breast Clinic, Cancer Institute, Tehran University of Medical Science, Tehran, Iran;
Afsaneh.Alikhasi@gmail.com

Abstract

Background/Objectives: Detection of lymphadenopathy is challenging issue in medical field. Squamous Cell Carcinoma (SCC) can lead to a certain type of lymphadenopathy 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 detection and destruction of external pathogenic factors. Carcinoma cells of ectodermal origin tend to spread through the lymphatic system, which leads to the immune system reaction called lymphadenopathy. 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, today Computer-Aided Diagnosis (CAD) systems are commonly used for detection of pathologic lymph nodes in different organs²⁻⁷. Even in some cases it can be used instead of manual detection⁸⁻¹².

There are reports of detection of pathologic lymph nodes by CAD systems in regions like Abdomen¹³⁻¹⁵, Thorax^{16,17}, Axillary¹⁸, Lung¹⁹⁻²³, Chest and Mediastinal²⁴⁻²⁷. In those papers, different image processing techniques and methods were used. The template matching was used in the Fourier space to extract neck lymph nodes automatically^{28,29}. Wherein the lymph node intensity was adjusted manually for each dataset. This method is not fully automated². As a further progress, the detection of the neck pathologic lymph nodes was done by using 3D Stable Mass-Spring Model (SMSM)^{3,12}. This method is completely automatic and it was done on 3D images³.

This paper presents a method to detect lymphadenopathy resulting from SCC by 3D image processing techniques and Computer-Aided Diagnosis (CAD) systems. We believe this method is easier, more accurate and less time consuming³⁰.

* Author for correspondence

2. Proposed Method

The whole picture is shown as Figure 1. The following is the description for each process

2.1 Preprocessing

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

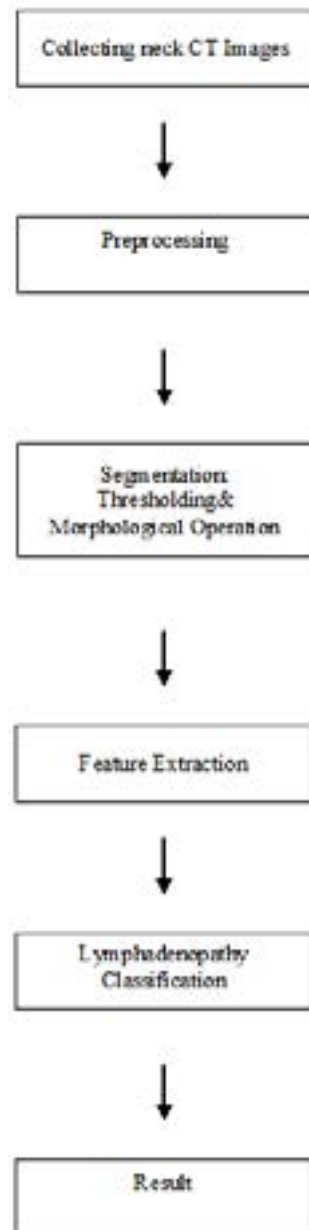


Figure 1. of all processes to detect lymphadenopathy.

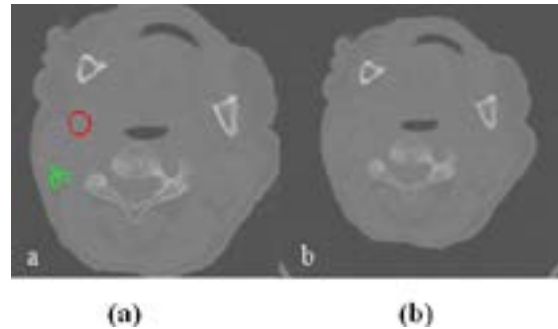


Figure 2. Figure 2. One CT image slice. (a) Before preprocessing. (b) After preprocessing.

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 results were achieved by using median filter technique. The result of applying preprocessing technique is shown in Figure 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 to other 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 on density, 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 $G2$. μ_1 μ_2
- Compute a new threshold value:
- Repeat steps 2 through 4 until the difference in T in successive iterations is smaller than a predefined parameter T_0 .

After applying this algorithm, the gray level CT

images converted to binary images and the images were prepared for further processes as shown in Figure 3.

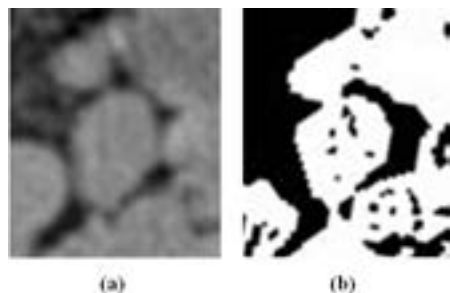


Figure 3. Lymphadenopathy segmentation. (a) Original pathologic lymph node. (b) After thresholding process.

2.2.2 Morphological Operation

This process is used to fill the holes and gaps of the images. Opening and erosion are two processes which are used 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 some clinical examination and consulting expert 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 Figure 5. That area size is between 145px and 370px. Area size 265px was considered appropriate for applying to other cases. After this process, some extra objects were removed.

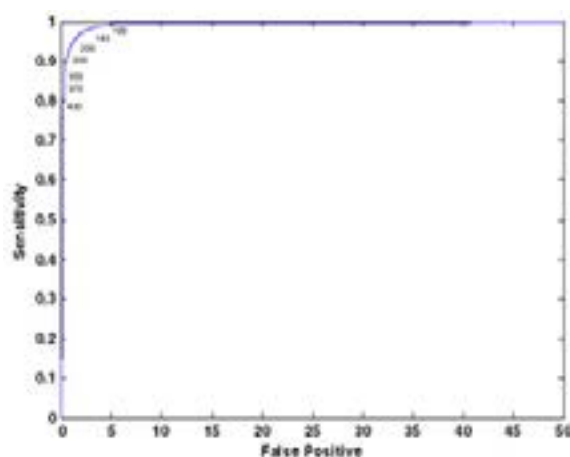


Figure 5. FROC chart after using size feature extraction.

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. By categorizing all pixels in a digital image into one of several classes.

3. Results

Two expert radiologists commented on whether a lymph node is pathologic or normal. The final result is shown 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 sensitivity for each case. Final sensitivity was 94%.

4. Conclusion

In this paper, we described the objective and benefits of automated lymphadenopathy detection in neck 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.

5. References

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