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A Study on Fast Adaptive Detection of Pulmonary Nodules in Thoracic CT Images Using a Hierarchical Vector Quantization Scheme

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Abstract* — This Computer-aided detection (CADe) of pulmonary nodules is critical to assisting radiologists in early identification of lung cancer from computed tomography (CT) scans. This paper proposes a novel CADe system based on a hierarchical vector quantization (VQ) scheme. Compared with the commonly-used simple thresholding approach, the high-level VQ yields a more accurate segmentation of the lungs from the chest volume. In identifying initial nodule candidates (INCs) within the lungs, the low-level VQ proves to be effective for INCs detection and segmentation, as well as computationally efficient compared to existing approaches. False-positive (FP) reduction is conducted via rule-based filtering operations in combination with a feature-based support vector machine classifier.

***Keywords*— Computer-aided detection (CADe), computed tomography (CT) imaging, false positive (FP) reduction, lung nodules, vector quantization (VQ).**

I. INTRODUCTION

Detection of pulmonary nodules has a crucial effect on the diagnosis of lung cancer, but the detection is a nontrivial task, not only because the appearance of pulmonary nodules varies a wide range, but also because nodule densities have low contrast against adjacent vessel segments and other lung tissues. Computed tomography (CT) has been shown as the most popular imaging modality for nodule detection, because it has the ability to provide reliable image textures for the detection of small nodules. The development of lung nodule CADe systems using CT imaging modality has made good progress over the past decade. Generally, such CADe systems consist of three stages: 1) image preprocessing, 2) initial nodule candidates (INCs) identification, and 3) false positive (FP) reduction of the INCs with preservation of the true positives (TPs). In the preprocessing stage, the system aims to largely reduce the search space to the lungs, where a segmentation of the lungs from the entire chest volume is usually required. Because of the high image contrast between lung fields and the surrounding body tissue, image intensity-based simple thresholding is effective, and is currently the most commonly used technique for lung segmentation. However, the determination of an accurate threshold is greatly affected by image acquisition protocols, scanner types, as well as the inhomogeneity of intensities in the lung region, especially toward the segmentation of pathological lungs with severe pathologies.

This paper proposes an adaptive solution to mitigate the difficulty of thresholding-based method in lung segmentation. Sufficient detection power for nodule candidates is inevitably accompanied by many (obvious) FPs. A rule-based filtering operation is often employed to cheaply and drastically reduce the number of obvious FPs, so that their influence on the computationally more expensive learning process can be eliminated. In general, FP reduction using machine learning has been extensively studied in the literature. Compared with unsupervised learning that aims to find hidden structures in unlabeled data, supervised learning, which aims to infer a function from labeled training data, is more frequently used to design a CADe system. The rules learned from the training dataset can be applied to the differentiation between nodules and non nodules in the test dataset. A number of supervised FP reduction techniques have been reported for the characterization of INCs, such as linear discriminant analysis (LDA), artificial neural network (ANN), and support vector machine (MULTI-SVM). This paper takes the advantages of both the rule-based filtering operation and the SVM learning for FP reduction.

Expert rules are learned from prior knowledge of true nodules annotated by the radiologists, while the classification rule for SVM is learned from two-dimensional (2-D) and three-dimensional (3-D) features extracted from the labelled subset. Inspired by our previous work, we have proposed a hierarchical vector quantization (VQ) approach to address the preprocessing and INCs detection issues in an adaptive manner, aiming to overcome the drawbacks of global thresholding methods. Compared with the existing approaches, the hierarchical VQ can be an alternative with either comparable detection performance and less computational cost, or comparable cost and better detection performance.

II. EXISTING SYSTEM

Pulmonary nodules (lung nodules) are a mass of soft tissue located in the lungs which can be diagnosed using any radiography techniques. Lung nodules does not cause any symptoms until till becomes malignant. Malignant nodules are most often caused by lung cancer, but can also be caused by cancer somewhere else in the body, for instance, breast cancer and colon cancer often spread to the lungs. Any person with the symptom are taken chest X-ray, if there are any abnormalities, they further investigate using MRI imaging. Lung nodules can be efficiently detected in MRI imaging techniques. Since MRI are really expensive and a low economic background denial people may not afford. clavicles in the chest radiographs (X-ray images) are suppressed with MTANN.

The main objective is to develop a technique so that lung nodules can be detected using X-ray imaging at an early stage. A multiresolution massive training artificial neural network (MTANN) is an image processing technique used for suppressing the contrast parameter of ribs and clavicles. The purpose is to develop the CADe with improved sensitivity and specificity by use of Virutal Dual Energy (VDE) chest radiographs. Ribs and clavicles in the chest radiographs (X-ray images) are suppressed with MTANN.

A. Disadvantages of Existing System

Most existing system have following disadvantages:

- The existing methods are not faster and adaptive.
- The ribs may cause unwanted error in the detection of pulmonary nodules.
- The processing time of x-ray image is more and so it delay's the result of identification of pulmonary nodule.
- Accuracy as well as efficiency is low

III.PROPOSED SYSTEM

In VQ was originally used for data compression in signal processing, and became popular in a variety of research fields such as speech recognition, face detection, image compression and allows for the modeling of probability density functions by the distribution of prototype vectors. The general VQ framework evolves two processes: 1) the training process which determines the set of codebook vector according to the probability of the input data; and 2) the encoding process which assigns input vectors to the codebook vectors. The well-known Linde–Buzo–Gray (LBG) algorithm has been widely used for the design of vector quantizer. The algorithm aims to minimize the mean squared error and guarantees to converge to the local optimality. A very important but difficult task in the CADe of lung nodules is the detection of INCs, which aims to search for suspicious 3-D objects as nodule candidates using specific strategies. This step is required to be characterized by a sensitivity that is as close to 100% as possible, in order to avoid setting a priori upper bound on the CADe system performance. Meanwhile, the INCs should minimize the number of FPs to ease the following FP reduction step. This section presents our hierarchical VQ scheme for automatic detection and segmentation of INCs.

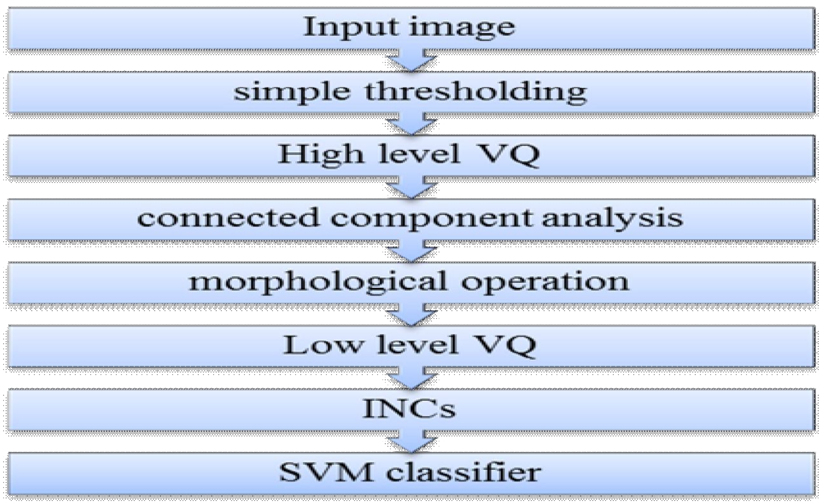

Fig. 1 Proposed System

A. Self-adaptive VQ Algorithm

VQ was originally used for data compression in signal processing, and became popular in a variety of research fields such as speech recognition, face detection, image compression and classification, and image segmentation. It allows for the modeling of probability density functions by the distribution of prototype vectors. The general VQ framework evolves two processes: 1) the training process which determines the set of codebook vector according to the probability of the input data; and 2) the encoding process which assigns input vectors to the codebook vectors. The well-known Linde– Buzo–Gray (LBG) algorithm has been widely used for the design of vector quantizer. The algorithm aims to minimize the mean squared error and guarantees to converge to the local optimality.

B. INCS Detection VIA A Hierarchical VQ Scheme

A very important but difficult task in the CADe of lung nodules is the detection of INCs, which aims to search for suspicious 3-D objects as nodule candidates using specific strategies. This step is required to be characterized by a sensitivity that is as close to 100% as possible, in order to avoid setting a priori upper bound on the CADe system performance. Meanwhile, the INCs should minimize the number of FPs to ease the following FP reduction step. This section presents our hierarchical VQ scheme for automatic detection and segmentation of INCs.

C. False Positive Reduction From INCS

1) *Rule-Based Filtering Operation*: It is challenging to thoroughly separate nodules from attached structures due to their similar intensities, especially for the juxta-vascular nodules (the nodules attached to blood vessels). Since the thickness of blood vessels varies considerably (e.g., from small veins to large arteries), a 2-D morphological opening disk with radius of 1 up to 5 pixel was adopted to detach vessels at different degree. We can see that almost all of the nodules are within 3–30 mm in volume equivalent diameter, and the majority are small nodules with a size of less than 10 mm.
2) *SVM Classification*: A supervised learning strategy is carried out using the SVM classifier to further reduce FPs. Our feature-based SVM classifier relies on a series of features extracted from each of the remaining INC after rule-based filtering operation.

IV. RESULTS

The proposed CADe system was validated on a subset of the largest publicly available database—LIDC–IDRI.The system was implemented with MATLAB 8.6 2015b.

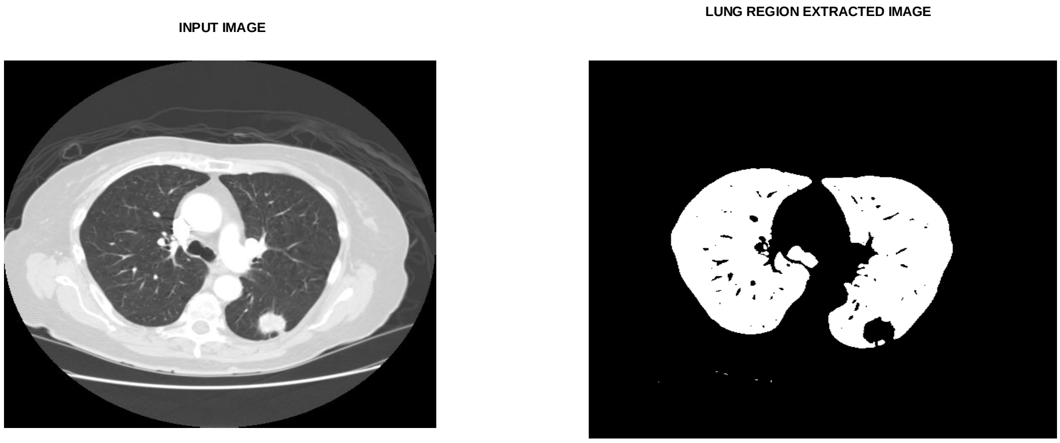

Fig 2. Input Image & Extracted Lung Image

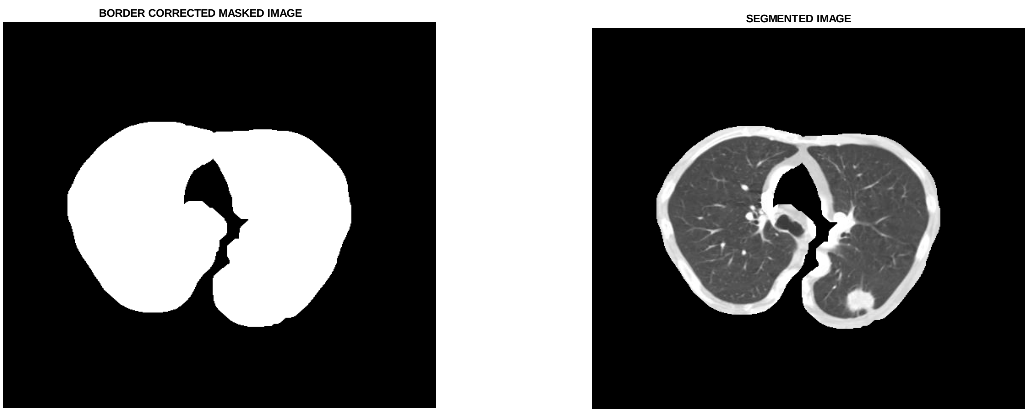

Fig 3. Border Connected Image & Segmented Image

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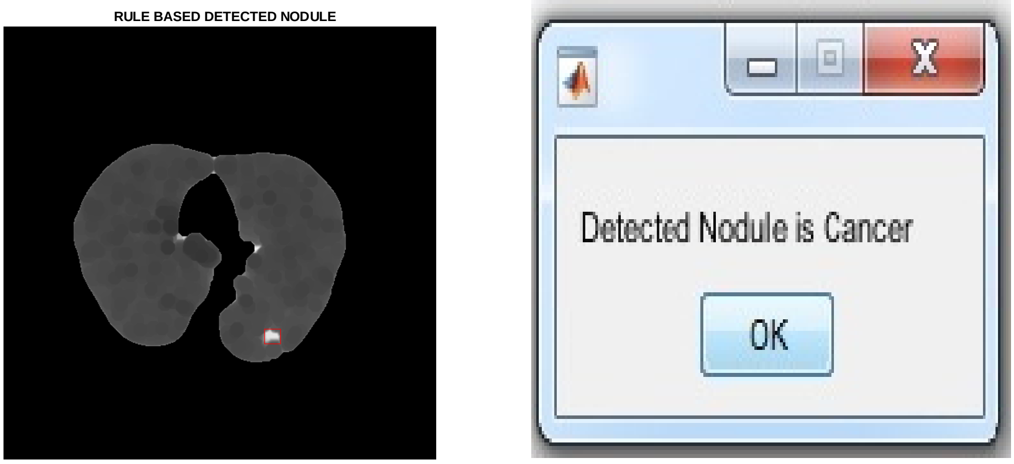

Fig 4. Nodule Detected Image & Output Of Classifier

V. CONCLUSIONS

In this paper, a novel CADe system was proposed for fast and adaptive detection of pulmonary nodules in chest CT scans. Based on our previous work of self-adaptive online VQ for image segmentation, we developed a hierarchical VQ scheme for INCs detection. The high-level VQ proves to be feasible to replace the commonly-used simple thresholding scheme for extraction of the lungs with higher accuracy, as well as comparable processing time and automation level. The following low-level VQ illustrates adequate detection power for non-GGO nodules, and is computationally more efficient than the state of-the-art approaches. In this study, simple expert rules were firstly employed to exclude obvious FPs from being considered by the sophisticated feature-based SVM classifier. The SVM classification results indicated that gradient features contributed the most against any of the other three groups of features (geometric, geometric, intensity, and Hessian features). The forward feature selection strategy showed that the SVM classifier performed the best in the "gradient + intensity" feature space rather than for any other feature combinations. Compared with existing CADe systems evaluated on the same lung image LIDC database, our approach showed a comparable detection capability but a lower computational cost. In particular, we reported the performance of our system for the detection of juxta-pleural nodules. The proposed hierarchical INCs detection approach is fast, adaptive, and fully automatic. The presented CADe system yields comparable detection accuracy and more computational efficiency than existing systems, which demonstrates the feasibility of our CADe system for clinical utility.

REFERENCES

[1] R. Siegel, D. Naishadham, and A. Jemal, "Cancer statistics," CA Cancer J. Clin., vol. 63, pp. 11–30, 2013.

[2] C. I. Henschke, D. I. McCauley, D. F. Yankelevitz, D. P. Naidich, G. McGuinness, O. S. Miettinen, D. M. Libby, M. W. Pasmantier, J. Koizumi, N. K. Altorki, and J. P. Smith, "Early lung cancer action project Overall design and findings from baseline screening," Lancet, vol. 354, no. 9173, pp. 99–105, 1999.

[3] S. A. El-Baz and J. Suri, Lung Imaging and Computer Aided Diagnosis. Boca Raton, FL, USA: CRC Press, 2011.

[4] H. MacMahon, J. H. M. Austin, G. Gamsu, C. J. Herold, J. R. Jett, D. P. Naidich, E. F. Patz, and S. J. Swensen, "Guidelines for management of small pulmonary nodules detected on CT scans: A statement from the Fleischner society," Radiology, vol. 237, no. 2, pp. 395–400, 2005

[5] B. van Ginneken, S. G. Armato 3rd, B. de Hoop, S. van Amelsvoort-van de Vorst, T. Duindam, M. Niemeijer, K. Murphy, A. Schilham, A. Retico, M. E. Fantacci, N. Camarlinghi, F. Bagagli, I. Gori, T. Hara, H. Fujita, G. Gargano, R. Bellotti, S. Tangaro, L.Bola˜nos, F. De Carlo, P. Cerello, S. Cristian Cheran, E. Lopez Torres, M. Prokop, "Comparing and combining algorithms for computer-aided detection of pulmonary nodules in computed tomography scans: The ANODE09 study," Med. Image Anal., vol. 14, no. 6, pp. 707–722, 2010..

[6] A. El-Baz, G. M. Beache, G. Gimel'farb, K. Suzuki, K. Okada, A. Elnakib, A. Soliman, and B. Abdollahi, "Computer-aided diagnosis systems for lung cancer: Challenges and methodologies," Int. J. Biomed. Imag., vol. 2013, pp. 1– 46, 2013

[7] J. Pu, J. K. Leader, B. Zheng, F. Knollmann, C. Fuhrman, F. C. Sciurba, and D. Gur, "A computational geometry approach to automated pulmonary fissure segmentation in CT examinations," IEEE Trans. Med. Imag., vol. 28, no. 5, pp. 710–719, May 2009.

[8] S. Ukil and J. M. Reinhardt, "Anatomy-guided lung lobe segmentation in X-ray CT images," IEEE Trans. Med. Imag., vol. 28, no. 2, pp. 202–214, Feb. 2009.

[9] "I. Sluimer,M. Prokop, and B. van Ginneken, "Toward automated segmentation of the pathological lung in CT," IEEE Trans. Med. Imag., vol. 24, no. 8, pp. 1025–1038, Aug. 2005.
[10] E. M. van Rikxoort, B. de Hoop, M. A. Viergever, M. Prokop, and B. van Ginneken, "Automatic lung segmentation from thoracic computed tomography scans using a hybrid approach with error detection," Med. Phys., vol. 36, no. 7, pp. 2934–2947, 2009.
[11] T. Messay, R. C. Hardie, and S. K. Rogers, "A new computationally efficient CAD system for pulmonary nodule detection in CT imagery," Med. Image Anal., vol. 14, no. 3, pp. 390–406, 2010.
[12] W. Choi and T. Choi, "Genetic programming-based feature transform and classification for the automatic detection of pulmonary nodules on computed tomography images," Inf. Sci., vol. 212, pp. 57–78, 2012.
[13] Q. Li, S. Sone, and K. Doi, "Selective enhancement filters for nodules, vessels, and airway walls in two- and three-dimensional CT scans," Med. Phys., vol. 30, no. 8, pp. 2040–2051, 2003.
[14] A. Teramoto and H. Fujita, "Fast lung nodule detection in chest CT images using cylindrical nodule-enhancement filter," Int. J. Comput. Assisted Radiol. Surg., vol. 8, no. 2, pp. 193–205, 2013.
[15] C. I. Fetita, F. Preteux, C. Beigelman-Aubry, and P. Grenier, "3-D automated lung nodule segmentation in HRCT," in Medical Image Computing and Computer-Assisted Intervention—MICCAI 2004, (Lecture Notes in Computer Science Series). Berlin, Germany: Springer-Verlag, 2003, vol. 2878, pp. 626–634.