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Detection of Pulmonary Nodules in Thoracic CT Images Using Morphological Operations

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Abstract: Lung Cancer is one of the most serious health problems having highest mortality rate among all other types of cancer. Survival from lung cancer is directly related to its growth at its detection time. The earlier the detection is, the higher the chances of successful treatment are. Although surgery, radiation therapy, and chemotherapy have been used in the treatment of lung cancer, the five year survival rate for all stages combined is only 14%. Lung cancer is the leading cause of cancer-related deaths. 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 in 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.

1. Introduction

Multiple thresholding approach aims to find connected components of similar image gray-values. Though intensity-based thresholding methods are computationally cheaper than other pattern-recognition techniques for the detection of INCs, they also suffer considerable drawbacks. For example, it is difficult to adaptively determine multiple thresholds, because pulmonary nodules with a wide intensity range are embedded in an inhomogeneous parenchyma background. A novel CADe system was proposed for fast and adaptive detection of pulmonary nodules in chest CT scans. Morphological Operations are used for extraction of the lungs with higher accuracy, as well as comparable processing time and automation level. 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 features contributed for classification Lung Nodules. to the up-to-date statistics from the American Cancer Society, lung cancer is the leading cause of cancer-related deaths with over 159 000 deaths estimated for the United States alone in 2013, and the overall five-year survival rate for lung cancer is merely 16%.

The survival rate increases to 52% if it is localized, and decreases to 4% if it has metastasized. Therefore, to detect lung cancer at earlier stages is of great importance and computer-aided detection (CADe) in supplement to radiologists' diagnosis has become a promising tool to serve such purposes. 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 in 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 pre-processing, 2) initial nodule candidates (INCs) identification, and 3) false positive (FP) reduction of the NCs with reservation of the true positives (TPs). After defining the search space (i.e., the lung volume), INCs detection is the next step to build a CADe system. Various

INCs detection techniques have been extensively studied in recent years, such as multiple thresholding [11] [12], nodule enhancement filtering [13] [14] mathematical morphology [15] [16], and genetic algorithm template matching [17] [18] among many others. The most commonly used multiple thresholding approach aims to fin connected components of similar image gray-values. Though intensity-based thresholding methods are computationally cheaper than other pattern-recognition techniques for the detection of INCs, they also suffer considerable drawbacks. For example, it is difficult to adaptively determine multiple thresholds, because pulmonary nodules with a wide intensity range are embedded in an inhomogeneous parenchyma background. On the other hand, pattern-recognition techniques are complicated and usually computational intensive. This paper proposes an efficient means which shares the adaptive natures of pattern-recognition techniques and the simplicity of intensity based thresholding methods.

2. Coding and testing

Once the design aspect of the system is finalizes the system enters into the coding and testing phase. The coding phase brings the actual system into action by converting the design of the system into the code in a given programming language. Therefore, a good coding style has to be taken whenever changes are required it easily screwed into the system.

Coding standards are guidelines to programming that focuses on the physical structure and appearance of the program. They make the code easier to read, understand and maintain. This phase of the system actually implements the blueprint developed during the design phase. The coding specification should be in such a way that any programmer must be able to understand the code and can bring about changes whenever felt necessary Naming conventions of classes, data member, member functions, procedures etc., should be **self-descriptive**. One should even get the meaning and scope of the variable by its name. The conventions are adopted for **easy understanding** of the intended message by the user. So it is customary to follow the conventions. Script writing is an art in which indentation is utmost important. Conditional and looping statements are to be properly aligned to facilitate easy understanding. Comments are included to minimize the number of surprises that could occur when going through the code Testing is performed to identify errors. It is used for quality assurance. Testing is an integral part of the entire development and maintenance process. The goal of the testing during phase is to verify that the specification has been accurately and completely incorporated into the design, as well as to ensure the correctness of the design itself. For example the design must not have any logic faults in the design is detected before coding commences, otherwise the cost of fixing the faults will be considerably higher as reflected. Detection of design faults can be achieved by means of inspection as well as walkthrough. Testing is one of the important steps in the software development phase. Unit testing is conducted to verify the functional performance of each modular component of the software. Unit testing focuses on the smallest unit of the software design (i.e.), the module. The white-box testing techniques were heavily employed for unit testing. Functional test cases involved exercising the code with nominal input values for which the expected results are known, as well as boundary values and special values, such as logically related inputs, files of identical elements, and empty files.

Structure Tests are concerned with exercising the internal logic of a program and traversing particular execution paths. The way in which White-Box test strategy was employed to ensure that the test cases could Guarantee that all independent paths within a module have been have been exercised at least once.

The major error that was faced during the project is linking error. When all the modules are combined the link is not set properly with all support files. Then we checked out for interconnection and the links. Errors are localized to the new module and its intercommunications. The product development can be staged, and modules integrated in as they complete unit testing. Testing is completed when the last module is integrated and tested.

Integration testing is a systematic technique for construction the program structure while at the same time conducting tests to uncover errors associated with interfacing. i.e., integration testing is the complete testing of the set of modules which makes up the product. The objective is to take untested modules and build a program structure tester should identify critical modules. Critical modules should be tested as early as possible. One approach is to wait until all the units have passed testing, and then combine them and then tested. Christo Ananth et al. [5] proposed a system, this system has concentrated on finding a fast and interactive segmentation method for liver and tumor segmentation. In the pre-processing stage, Mean shift filter is applied to CT image process and statistical thresholding method is applied for reducing processing area with improving detections rate. In the Second stage, the liver region has been segmented using the algorithm of the proposed method. Next, the tumor region has been segmented using Geodesic Graph cut method. Results show that the proposed method is less prone to shortcutting than typical graph cut methods while being less sensitive to seed placement and better at edge localization than geodesic methods. This leads to increased segmentation accuracy and reduced effort on the part of the user. Finally Segmented Liver and Tumor Regions were shown from the abdominal Computed Tomographic image.This is the last chance to detect and correct errors before the system is installed for user acceptance testing.

The software testing process commences once the program is created and the documentation and related data structures are designed. Software testing is essential for correcting errors. Otherwise the program or the project is not said to be complete. Software testing is the critical element of software quality assurance and represents the ultimate the review of specification design and coding. Testing is the process of executing the program with the intent of finding the error. A good test case design is one that as a probability of finding an yet undiscovered error.

3. White box testing

This testing is also called as Glass box testing. In this testing, by knowing the specific functions that a product has been design to perform test can be conducted that demonstrate each function is fully operational at the same time searching for errors in each function. It is a test case design method that uses the control structure of the procedural design to derive test cases. Basis path testing is a white box testing.

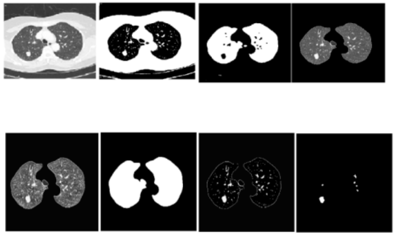

Fig 1. Results of White box testing

4. Black box testing

In this testing by knowing the internal operation of a product, test can be conducted to ensure that "all gears mesh", that is the internal operation performs according to specification and all internal components have been adequately exercised. It fundamentally focuses on the functional requirements of the software.

5. Software testing strategies

A software testing strategy provides a road map for the software developer. Testing is a set activity that can be planned in advance and conducted systematically. The logical and syntax errors have been pointed out by program testing. A syntax error is an error in a program statement that in violates one or more rules of the language in which it is written. An improperly defined field dimension or omitted keywords are common syntax error. These errors are shown through error messages generated by the computer. A logic error on the other hand deals with the incorrect data fields, out-off-range items and invalid combinations. Since the compiler s will not deduct logical error, the programmer must examine the output. Condition testing exercises the logical conditions contained in a module. The possible types of elements in a condition include a Boolean operator, Boolean variable, a pair of Boolean parentheses A relational operator or on arithmetic expression. Condition testing method focuses on testing each condition in the program the purpose of condition test is to deduct not only errors in the condition of a program but also other a errors in the program.

Integration testing is a systematic technique for constructing the program structure while at the same time conducting tests to uncover errors associated with. Individual modules, which are highly prone to interface errors, should not be assumed to work instantly when we put them together. The problem of course, is "putting them together"- interfacing. There may be the chances of data lost across on another's sub functions, when combined may not produce the desired major function; individually acceptable impression may be magnified to unacceptable levels; global data structures can present problems. Integration testing is a systematic technique for constructing the program structure while at the same time conducting tests to uncover errors associated with. Individual modules, which are highly prone to interface errors, should not be assumed to work instantly when we put them together. The problem of course, is "putting them together"- interfacing. There may be the chances of data lost across on another's sub functions, when combined may not produce the desired major function; individually acceptable impression may be magnified to unacceptable levels; global data structures can present problems.

At the culmination of integration testing, software is completely assembled as a package. Interfacing errors have been uncovered and corrected and a final series of software test-validation testing begins. Validation testing can be defined in many ways, but a simple definition is that validation succeeds when the software functions in manner that is reasonably expected by the customer. Software validation is achieved through a series of black box tests that demonstrate conformity with requirement. After validation test has been conducted, one of two conditions exists.

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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] 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] Christo Ananth, D.L.Roshni Bai , K.Renuka, C.Savithra, A.Vidhya, "Interactive Automatic Hepatic Tumor CT Image Segmentation", International Journal of Emerging Research in Management &Technology (IJERMT), Volume-3, Issue-1, January 2014,pp 16-20

[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] HAN et al.: FAST AND ADAPTIVE DETECTION OF PULMONARY NODULES IN THORACIC CT IMAGES 659 [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.

[16] K. Awai, K. Murao, A. Ozawa, M. Komi, H. Hayakawa, S. Hori, and Y. Nishimura, "Pulmonary nodules at chest CT: Effect of computer-aided diagnosis on radiologists' detection performance," Radiology, vol. 230, no. 2, pp. 347-d352, 2004.

[17] Y. Lee, T. Hara,H. Fujita, S. Itoh, and T. Ishigaki, "Automated detection of pulmonary nodules in helical CT images based on an improved templatematching technique," IEEE Trans.Med. Imag., vol. 20, no. 7, pp. 595–604, Jul. 2001.

[18] J. Dehmeshki, X. Ye, X. Lin, M. Valdivieso, and H. Amin, "Automated detection of lung nodules in CT images using shape-based genetic algorithm," Comput. Med. Imag. Graph., vol. 31, pp. 408–417, 2007.

[19] X. Ye, X. Lin, J. Dehmeshki, G. Slabaugh, and G. Beddoe, "Shape-based computer-aided detection of lung nodules in thoracic CT images," IEEE Trans. Biomed. Eng.., vol. 56, no. 7, pp. 1810–1820, Jul.2009

[20] A. Riccardi, T. S. Petkov, G. Ferri, M. Masotti, and R. Campanini, "Computer-aided detection of lung nodules via 3-D fast radial transform, scale space representation, and Zernike MIP classification," Med. Phys., vol. 38, no. 4, pp. 1962–1971, 2011.

[21] A. Retico, P. Delogu, M. E. Fantacci, I. Gori, and A. Preite Martinez, "Lung nodule detection in low-dose and thin-slice computed tomography,"Comput. Biol. Med., vol. 38, no. 4, pp.525–534,2008
.

[22] B. Golosio, G. L. Masala, A. Piccioli, P. Oliva, M. Carpinelli, R. Cataldo, P. Cerello, F. DeCarlo, F. Falaschi, M. E. Fantacci, G. Gargano, P. Kasae, and M. Torsello, "A novel multithreshold method for nodule detection in lung CT," Med. Phys., vol. 36, no. 8, pp. 3607–3618,
2009.

[23] M. Tan, R. Deklerck, B. Jansen, M. Bister, and J. Cornelis, "A novel computer-aided lung nodule detection system for CT images," Med. Phys., vol. 38, no. 10, pp. 5630–5645, 2011.

[24] D. Chen, Z. Liang, M. R.Wax, L. Li, B. Li, and A. E. Kaufman, "A novel approach to extract colon lumen from CT images for virtual colonoscopy," IEEE Trans. Med. Imag., vol. 19, no. 12, pp. 1220–1226, Dec. 2000.

[25] H. Han, L. Li, F. Han, H. Zhang, W. Moore, and Z. Liang, "Vector quantization-based automatic detection of pulmonary nodules in thoracic CT images," in Proc. IEEE Conf. Rec. Nucl. Sci. Symp./Med. Imag. Conf., 2013, pp. M22–41.

[26] A. Gersho and R.M. Gray, Vector Quantization And Signal Compression, Boston, MA, USA: Kluwer Academic, 1992.
[27] C. C. Chang and W. C. Wu, "Fast planar-oriented ripple search algorithm for hyperspace VQ codebook," IEEE Trans. Image Process., vol. 16, no. 6, pp. 1538–1547, Jun. 2007.

[28] C. Garcia and G. Tziritas, "Face detection using quantized skin color regions merging and wavelet packet analysis," IEEE Trans. Multimedia, vol. 1, no. 3, pp. 264–277, Sep. 1999.

[29] K. L. Oehler and R. M. Gray, "Combing image compression and classification using vector quantization," IEEE Trans. Pattern Anal.Mach. Intell., vol. 17, no. 5, pp. 461–473, May 1995.

[30] L. Li, D. Chen, H. Lu, and Z. Liang, "Segmentation of brain MR images: A self-adaptive online vector quantization approach," Proc. SPIE, 2001, vol. 4322, pp. 1431–1438.