Chapter 35
Noise Removal in Lung LDCT Images by Novel Discrete Wavelet-Based Denoising With Adaptive Thresholding Technique

Shabana R. Ziyad
Prince Sattam bin Abdulaziz University, Saudi Arabia

Radha V.
Avinashilingam Institute for Home Science and Higher Education for Women, India

Thavavel Vaiyapuri
https://orcid.org/0000-0001-5494-5278
Prince Sattam bin Abdulaziz University, Saudi Arabia

ABSTRACT

Cancer is presently one of the prominent causes of death in the world. Early cancer detection, which can improve the prognosis and survival of cancer patients, is challenging for radiologists. Low-dose computed tomography, a commonly used imaging test for screening lung cancer, has a risk of exposure of patients to ionizing radiations. Increased radiation exposure can cause lung cancer development. However, reduced radiation dose results in noisy LDCT images. Efficient preprocessing techniques with computer-aided diagnosis tools can remove noise from LDCT images. Such tools can increase the survival of lung cancer patients by an accurate delineation of the lung nodules. This study aims to develop a framework for preprocessing LDCT images. The authors propose a noise removal technique of discrete wavelet transforms with adaptive thresholding by computing the threshold with a genetic algorithm. The performance of the proposed technique is evaluated by comparing with mean, median, and Gaussian noise filters.

DOI: 10.4018/978-1-6684-7544-7.ch035

INTRODUCTION

Lung cancer is the second most common cancer in the USA [American Cancer Society. (n.d.)]. Some of the causes of lung cancer include smoking and inhalation of harmful chemical compounds generated by vehicles and industries. The detection of cancer at an early stage is a challenging task for radiologists. Some of the tests performed for diagnosing lung cancer include chest X-ray imaging, CT imaging, biopsy, and sputum cytology [Cancer Council Victoria. (n.d.)]. Chest X-ray is the primitive form of diagnosis of lung related diseases and the next generation witnessed the development of more effective diagnosing test, the X-ray CT. The X-ray CT technique, however, had drawbacks of exposure to high doses of radiation. This health hazard was one of the serious predicaments that demanded urgent attention from researchers. The scientific advancement in the field of imaging tests led to the introduction of Low Dose Computed Tomography (LDCT) as a preferred imaging modality for patients with lung diseases. This development proved to be a breakthrough in the diagnosis of lung cancer.

Among the existing CT imaging techniques, LDCT imaging provides good-quality images while exposing the patient to a low dose of radiation. In the National Lung Screening Trial (NLST), the radiation dose given to patients in LDCT screening test is 2 mSv, compared to the radiation dose for full-chest CT scan which is approximately 8 mSv in the diagnostic study intended to follow up the detection of nodules in patients with lung cancer (McCunney & Li, 2014). The NLST study revealed that annual screening of heavy smokers with LDCT reduced the death rate from lung cancer by 20% compared to screening by conventional chest X-ray (Schabath et al., 2016). LDCT technique has a shortcoming of generating noisy image. The noise is induced in the image due to various factors such as reduced radiation dose, machine calibration, and reconstruction algorithms.

Multimedia techniques in Health care allows the patient related data such as images, texts, audio and video to be stored and processed efficiently (Rathee et al., 2020). LDCT images are stored in Digital Imaging and Communications in Medicine (DICOM) format. This is an international standard developed for storage and transmission of the medical images. LDCT images are a challenge to radiologists in detecting nodules that are minute and camouflage with the vessels and the background region. An automated Computer-Aided Diagnosis (CADx) proves to be one of the efficient tools to aid radiologists in detecting lung nodules accurately. CADx includes five phases: preprocessing, segmentation of the region of interest, feature analysis, classification, and performance analysis.

The preprocessing step involves improving the quality of the images under study, which in turn improves the subsequent phases of the CADx. In this study, preprocessing is carried out to eliminate noise in LDCT images and enhance the contrast of these images to boost the performance of the CADx. The section "Noises in LDCT Images" describes the noise prevalent in LDCT images. The "Related Work" section throws light on literature related to this topic. The section "Theoretical Background" discusses the types of existing denoising filters, the mathematical concept of wavelets, Discrete Wavelet Transform (DWT), and denoising method using DWT. The subsequent section discusses the proposed algorithm for denoising LDCT images. The section on experimental results tabulates the results of preprocessing.

NOISES IN LDCT IMAGES

The artifacts in the LDCT images can be classified as patient-related artifacts [Hacking & Cuete (n.d.)], machine-related artifacts, and transmission-related artifacts (Boas & Fleischmann, 2012). Patient-related