Collaboration between interactive three-dimensional visualization and computer aided detection of pulmonary embolism on computed tomography pulmonary angiography views

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Abstract
This paper explores the benefits of interactive three-dimensional (3D) visualization of stimuli using a computer aided detection (CAD) system of pulmonary embolisms (PEs), on computed tomography pulmonary angiography (CTPA) views. We designed a new CAD method that prompts the PE sites on CTPA views; we then utilized two interactive approaches of 3D visualization to assess CAD performance. This collaboration allows different methodologies to be used to assess PE-CAD performance, by comparison with the common method in which radiologists are prompted with CAD stimuli directly on the CTPA views. Both 3D approaches are based on the voxel size of the CTPA examination, and consider the acquisition settings. A set of ten retrospective CTPA cases were collected, with different acquisition parameters, in terms of voxel size and spatial resolution. 3D visualization CAD performance was examined by an experienced radiologist. Both 3D visualization methods proved to have a constructive impact on improving CAD performance. The rate of true positive (TP) responses increased by 27%; while the rate of false positive (FP) responses dropped by 31%. We concluded that evaluation of PE-CAD performance utilizing interactive 3D visualization could increase or ascertain the correct rate of TP stimuli, as well as noticeably reduce FP responses.

Keywords 3D visualization • Computer aided detection • Computerized tomography pulmonary angiography CTPA

1 Introduction
Three-dimensional (3D) visualization has considerable applications in medicine. For example, in diagnostic imaging, 3D visualization is used to present data acquired using 3D medical imaging devices [1], and in radiotherapy and surgery it is used for the 3D delineation of lesions affecting some human organs and tissues [2]. However, computer aided detection (CAD) is a tool that it is aimed at helping radiologists detect abnormalities [3, 4]; some CAD software have attained clinical merit, whilst some are still under development.

Pulmonary embolism (PE) occurs due to the formation of a clot inside veins or arteries, hindering blood flow [8, 9]. It is expected—according to clinical projections on disease mortality—that PE disease may become the third leading cause of death by 2030 [24]. Computed tomography pulmonary angiography (CTPA) can detect the occurrence of PE [5–8]. The largest collaborative clinical trial of CTPA examination was conducted in the PIOPED (Prospective Investigation of Pulmonary Embolism Diagnosis) study; the results revealed a specificity of 96% and sensitivity of 83% [10]. A recent review reported that the sensitivity and specificity of CTPA scans may vary between the range of 83–100 and 89–96%, respectively [6]. This means that misdiagnoses, which are potentially life-threatening or a prospective health burden, may occur. The marketable PE-CAD systems reported favorable sensitivity...