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Research article

Predictive quantitative sonographic features on classification of hot and cold thyroid nodules

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ABSTRACT

Purpose: This study investigated the potentiality of ultrasound imaging to classify hot and cold thyroid nodules on the basis of textural and morphological analysis.

Methods: In this research, 42 hypo (hot) and 42 hyper-function (cold) thyroid nodules were evaluated through the proposed method of computer aided diagnosis (CAD) system. To discover the difference between hot and cold nodules, 49 sonographic features (9 morphological, 40 textural) were extracted. A support vector machine classifier was utilized for the classification of LNs based on their extracted features.

Results: In the training set data, a combination of morphological and textural features represented the best performance with area under the receiver operating characteristic curve (AUC) of 0.992. Upon testing the data set, the proposed model could classify the hot and cold thyroid nodules with an AUC of 0.948.

Conclusions: CAD method based on textural and morphological features is capable of distinguishing between hot from cold nodules via 2-Dimensional sonography. Therefore, it can be used as a supplementary technique in daily clinical practices to improve the radiologists' understanding of conventional ultrasound imaging for nodules characterization.

1. Introduction

A thyroid nodule can be formed as a result of the growth of an abnormal cell within the thyroid gland which may appear as a non-palpable or palpable mass. According to the national cancer institute, 56.870 new cases and 2.010 thyroid cancer related deaths occurred in 2017. There has been an increase in death rates at an average rate of 0.7% each year over 2005–2014 [1]. Serum thyrotropin (TSH) should be obtained as an initial evaluation process from all patients diagnosed with a thyroid nodule. For patients with a subnormal TSH level, before any further diagnostic procedures like fine needle aspiration (FNA), a radionuclide thyroid scan should be performed. The scan result can be hyperfunctioning (hot), isofunctioning (warm) or nonfunctioning (cold) (i.e., tracer uptake is less, equal or greater than the surrounding normal thyroid tissue respectively). Although hot nodules rarely represent malignancy, 3–15% of cold nodules have been reported as malignant [2–4]. Therefore, radionuclide scan plays a critical role in the evaluation of thyroid nodule in patients with low TSH level. For other cases with high TSH level, FNA should be performed due to the high risk of malignancy [3].

According to the American Thyroid Association (ATA), ultrasound is the main and preferred imaging modalities for thyroid nodule evaluation, while if a thyroid nodule is detected incidentally on any other imaging modalities, for more assessment ultrasonography should be performed [3]. An ultrasound image reflects diverse gray-level intensities and different tissues have different textures. Although there is no precise or mathematical definition of texture, it is simply conceived by the human eye. Image texture can be described by spatial variations in pixel intensity, patterns (homogen or heterogen, smooth, or coarse) of objects within an image. In other words, different patterns of echo

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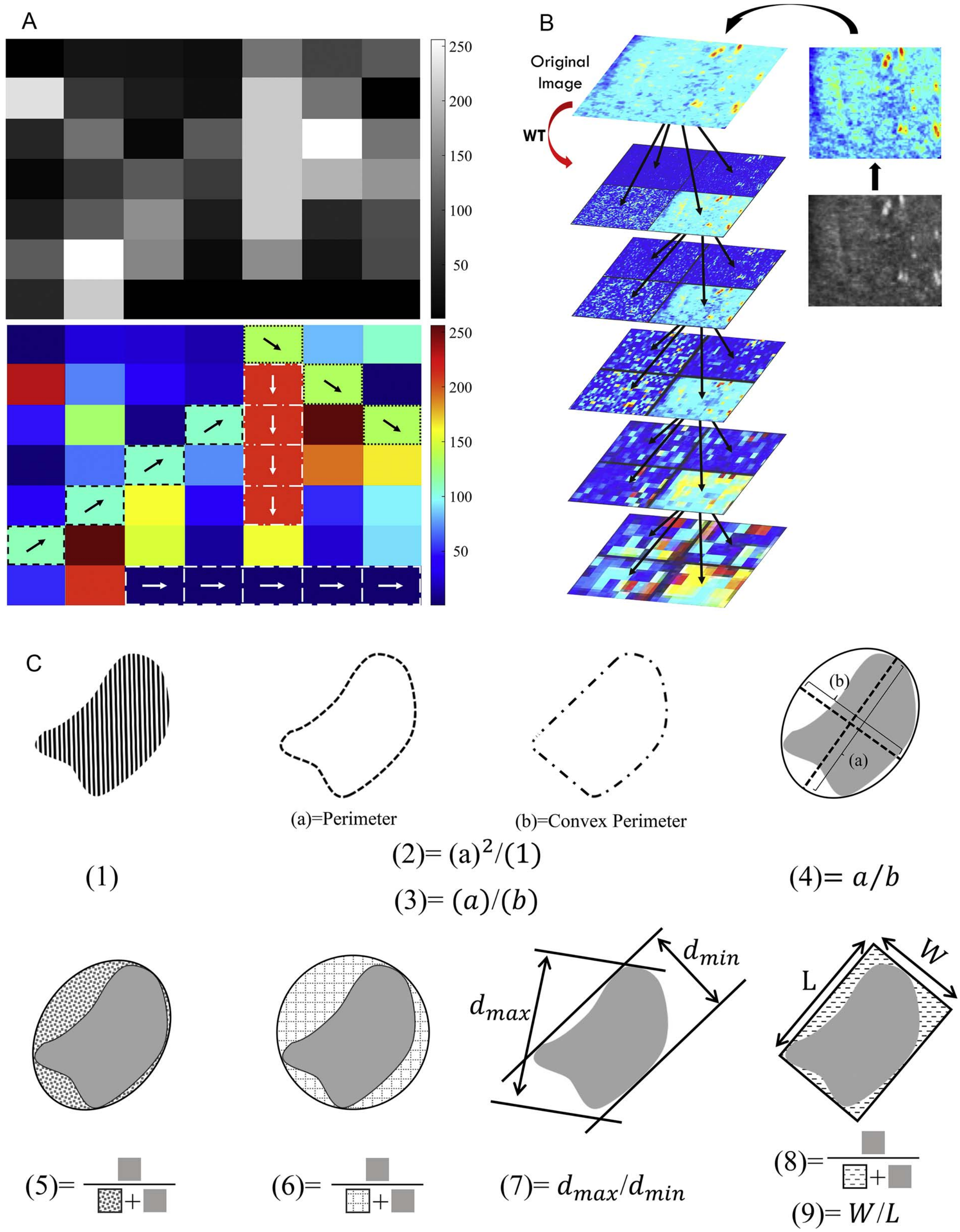

Fig. 1. Three quantitative groups were used in this study: (A), Run-length matrix: the arrows indicate the direction of runs of pixels having the same value; (B), Wavelet: features computed at five decomposition levels; and (C), Morphological based features.

from a nodule can form different textures within an ultrasound image. The structural abnormalities of a thyroid nodule are capable of representing different textures that can be extracted by visual inspection, but complex patterns are difficult to interpret [5,6].

Although radionuclide scan is the standard method for evaluation of a thyroid nodules function, its invasive, incurs health care costs and imposes anxiety and radiation doses on the patient [7]. Today, computer-aided diagnosis (CAD) systems have become an important part of clinical duty routines to help and improve the accuracy of an initial radiologist's diagnosis. CAD systems have an advantage over humans due to overcoming the limitations of human memory, fatigue, reproducibility and ability to detect pathological changes that cannot be