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Thyroid Ultrasound-Image Dataset

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Abstract. Thyroid Computer-Aided Diagnosis (CAD) systems have been developed to assist radiologists in improving efficiency, reliability, and diagnosis performance. Often the performance of these CAD systems is evaluated with different datasets that make it incomparable. A valuable thyroid ultrasound (US) dataset is presented in this work. This dataset consists of 2450 thyroid US images from 2018 to 2020 in Prospective Epidemiological Research Studies in Mashhad, Iran (PERSIAN), a large national cohort study. These US images have the ROI of thyroid nodules and the associated American College of Radiology (ACR) Thyroid Imaging Reporting and Data System (TIRADS) features by expert physicians provided in XML format. Dataset's images are categorized into five groups based on the ACR-TIRADS (Tirads1-Tirads5). The presented dataset is expected to be a valuable resource to develop and assess thyroid CAD systems to help radiologists better diagnose.

Keywords. Thyroid, Sonography, TIRADS, Computer-Aided Diagnosis

1. Introduction

The prevalence of thyroid nodules is increasing worldwide, especially in women (67% of adults). But, the malignancy rate of these nodules is low (5-15%), and no invasive treatment such as fine-needle aspiration (FNA) or surgery will be required for all detected nodules [1-3]. Ultrasonography (US) is the best cost-effective and no invasive tool for thyroid nodules diagnostic and management. However, interpretation of thyroid US images has low reproducibility due to the noise and speckle of the ultrasound images and the different experience levels of physicians [4]. To overcome these challenges, Thyroid Imaging Reporting and Data System (TIRADS) proposes standard terminology for reporting thyroid nodules risk characteristics for effective management and avoiding unnecessary FNA (biopsy) [5]. Five TIRADS are internationally approved, which are ATA [6], ACE [7], EUTIRADS [8], KTIRADS [9], ACR-TIRADS [10]. Among these

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approved TIRADS, the American College of Radiology (ACR) has introduced ACR-TIRADS has the highest performance [11, 12]. However, the reproducibility of these systems was still about 45% -75% due to different experience levels of physicians and time-consuming evaluation of TIRADS factors. Still, interpreting US thyroid images and accurate scoring of thyroid nodules is challenging [4,13].

Artificial intelligence-based computer-aided diagnosis (CAD) systems can eliminate this operator dependency on interpreting thyroid US images and improve the diagnosis reliability and accuracy [14-18]. An actual limitation for developing such systems is the lack of thyroid US-image databases. Building this accessible publicly database plays an essential role in developing algorithms and supporting the comparison results and performances of different CAD systems.

This work presents a database of thyroid US images containing 2450 thyroid images with a complete annotation and associated diagnostic description based on the ACR-TIRADS lexicon performed by three experts. Accurate regions of interest (ROIs) square of nodules and their ACR-TIRADS properties provide in XML format.

2. Materials and Methods

2.1. Image acquisition

This dataset consists of 2450 ultrasound images from 1037 patients referred for thyroid ultrasonography from 2018 to 2020 in Prospective Epidemiological Research Studies in Mashhad, Iran (PERSIAN), a large national cohort study. This image was taken using a single system (Philips affinity 50G Ultrasound Machine-12.5 MHz linear transducer 5 cm) in sagittal and transverse plans and saved in a JPEG format. Images with at least one thyroid nodule were included in this dataset, and images with color Doppler flow and very low-quality images were excluded from the dataset.

Each thyroid nodule in the dataset was independently analyzed for ultrasonographic characteristics by three experienced physicians. Two independent physicians with 10 and 9 years of experience in thyroid US imaging reviewed images and reported associated ACR TIRADS features and levels of nodules (TR1–TR5) individually. To reach a consensus conclusion, they consulted with a third experienced physician with 18 years of experience in thyroid US imaging for any discrepancy in their result.

We developed a windows application for physicians to report and score the images based on ACR-TIRADS and draw square regions of interest (ROIs). This application was implemented using the C# language in the visual studio 2019 and SQL Server database. A snapshot of our application is shown in Figure 1. The menu on the left side of the screen includes an image list, and the selected image shows in the center of the screen. This application consists of five tabs, including:

1. Crop tab: in this tab, the physician can choose the appropriate image and draw a rectangle around the nodule present in each image (ROI).
2. Properties tab: in this tab, the physician can select the appropriate property of each ACR-TIRADS category from ComboBox, and by clicking on the "Calculate TIRADS" button, the TIRADS score and level of the nodule are calculated automatically, and all information is stored in the database, and the relevant XML file is created and saved.
3. Search tab: searches are based on each ACR-TIRADS attribute, and images can be stored in a specific folder.

4. Database tab: this tab displays all saved data in the database.
5. XML tab: in this tab, the user can create and save an XML file for each ACR-TIRADS category of images.

Figure 1. Tirads Calculator application.

2.2. Image Preprocessing

To make a relevant and valuable data set, image preprocessing is necessary. Image preprocessing of this work contains three steps, ROI extraction, artifact removal, and image resizing. Tirads Calculator performs ROI extraction of thyroid nodules. Since the original ultrasound images have patient information and a physician's caliper, we removed this inappropriate information and caliper by histogram analysis with python programming. We then resized the image size to 640×480 pixels.

3. Results

This dataset contains 2450 ultrasound thyroid images in JPEG format with relevant XML files. The size of the images was 640×480 pixels. The images are categorized into five groups based on ACR TIRADS (Tirads1-Tirads5).

Each XML file contains discriminant information such as the age and sex of patients, the size of the thyroid image, all the ACR-TIRADS properties, and coordinates of each nodule in the image.

Table 1. The number of images in each ACR-TIRADS level

Level	TIRADS-1	TIRADS-2	TIRADS-3	TIRADS-4	TIRADS-5
No	646	506	696	933	174

The age distribution of 1037 patients was 52.07 ± 11.68 (mean ± standard deviation) years, and the age range was between 29 and 89 years. Gender ratio was 60.17% (n=624) female and 39.82% (n=413) male. The number of images in each ACR-TIRADS level is shown in Table 1. Examples of original images and images without caliper and inappropriate information and sample images with ROI rectangles drawn by Tirads Calculator are represented in Figure 2.

4. Discussion

Interpretation of thyroid ultrasound images is a time-consuming task and has inter-observer variability due to differences in' physicians' experience and the nature of ultrasound images. Artificial intelligence-based CAD systems can eliminate this operator dependency on the interpretation of thyroid US images and improve the diagnosis reliability and accuracy. Still, the lack of thyroid US-image databases is a fundamental limitation for developing such systems. Lina Pedraza et al. (1) provides a dataset that contains 347 B mode ultrasound images from 299 patients (29 men, 270 women) scored by two observers in TIRADS. Their XML files contain classification data on two classes, benign and malignant. Our proposed paper presents 2450 Ultrasound images from 1037 patients (413 men, 624 Women) in jpeg format. This work produces a valuable thyroid US dataset with all associated ACR-TIRADS features and ROI of thyroid nodules by three expert physicians in the XML file. This dataset is ANN-ready with no artificial artifacts and is usable for all image analysis tasks in detecting and classifying thyroid nodules. It supports the performance comparison of the different CAD systems to help the expert improve the accurate diagnosis and decrease interpretation variation and unnecessary thyroid biopsies.

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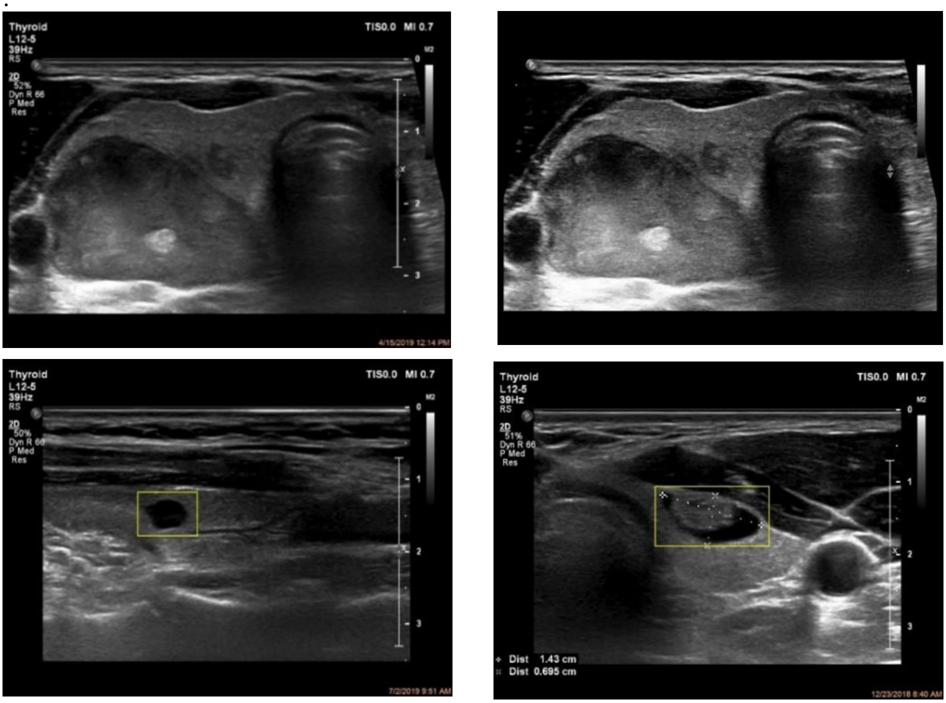

Figure 2. Example of original images and images after removing symptoms (above) and images with ROI rectangles drawn by Tirads Calculator (below)

5. Availability of Data and Materials

A sample of data described in this data note can be freely and openly accessed on the Harvard data server under (https://doi.org/10.7910/DVN/5E6IFH), and the whole database is accessible upon request.

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