

Tumor Detection by Using Image Processing

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Abstract: Medical Imaging Techniques (MITs) are non-invasive methods for looking inside the body without opening up the body surgically. It used to assist diagnosis or treatment of different medical conditions. There are many medical imaging techniques; every technique has different risks and benefits. This paper presents a review of these techniques; concepts, advantages, disadvantages, and applications. The concerning techniques are; X-ray radiography, X-ray Computed Tomography (CT), Magnetic Resonance Imaging (MRI), ultrasonography. And (real time information and cost) will present.

1. Introduction

The increase use of digital images in recent years due to the availability of technology equipment has made the process of dealing with the images of things possible. Conventional cameras are based on physics based which control lighting when the user enters the lens to control the amount and direction of light [1].

Not only the Digital camera requires a simple knowledge by the user, but also the principle of its work depends on converting light into Electrical discharges and converts the image into a series of binary digits (zeros and ones) to represent the points of the image [2].

The enormous development of computer technology and the great advances in digital recording of images helped the emergence of devices that allow access to images without chemical processing. It has raised some of the advantages offered by digital photography, such as the stability of the image quality (regardless of the length of the storage); the time for copies number; and the possibility of computer processing. Also, it has attended many of the workers in the Medical fields to the field of digital photography[3].

1.1. Medical images

Medical images are one of potential of significant progress in science and medicine which provide three-dimensional (3D). These images are put in the most important scientific imaging areas due first to the rapid progress and continuing in a calculated imaging medical images; and second to the progress in the analysis and diagnosis computer-aided methods as it is the case in the early detection of certain cancers. The challenge is in processing and image analysis in order to extract, measure and interpret the information. The goal of understanding of information is to put it in the practical implementation positions[7].

1.2. Medical Imaging Methods

Medical imaging of the term indicates the techniques and processes used to obtain images of the human body (or parts) for diagnostic purposes, therapeutic and research. It is considered a branch of the bio-diversity of photography and collaborates with a large radiology. There are some ways of measuring and recording physiological sort of medical imaging [8]. Below is a brief explanation for four of these ways.

1.2.1. Computed Tomography

It is called a computed tomography (CT) rays. It makes use of fixtures manufacturer of X-rays taken from different angles to produce CT images of a classless allowing the user to see inside the object without cutting. It is expected that the body thickness in the film affects the information where no ray can determine the location floor for the disease inside the human body in any case. The rays can be set bone fractures but cannot diagnose all diseases accurately by side image (side view) because the atherosclerosis may be behind the rib or any other member of hidden organ. In such a situation, the sectional image is required by the patient which became possible when Godfrey N. Hounsfield introduced the first CT scanner in 1972 [9]. The figure (1.1) shows a CT device.



Figure(1.1): CT device

1.2.2. Magnetic Resonance Imaging

The image is based on magnetic resonance imaging (MRI) on the nature of the hydrogen atoms in all parts of the body. These charged atoms more around their own axis and also rotate between a small magnetic field around each atom. Proton spins in random directions causing a very small magnetic field that cancels each other. But by placing them in an external magnetic field (B_0), they will be very strong, such as canned MR [10]. Varying amounts of images of different tissues emit a signal known as Proton Density. (PD). Other methods are the results of what happens after the RF pulse frequency of the radio waves protons tilt and return to their original status. During this time, relax emitted from each discovery of a proton signal. Relaxant happens in a couple of times known as the longitudinal relaxation (T_1) and transverse relaxation time (T_2) respectively. Differences in these three variables (PD, T_1 and T_2) are the basis for the production of magnetic resonance images with very good capabilities to distinguish between soft tissues[10,11]. Moreover, the imaging device uses magnetic resonance imaging to detect atherosclerosis for thorough examination of a patient so that to deviate the place of injury [11].

1.2.3. Ultrasound

Body imaging technology ultrasonic sound depends on the dropping sound package and pick up the reflection of the apostate from the member forming an image that is ranging from black to white (gray image). Due to different acoustic resistance between tissues of the body, the tissue shows high resistance (white tissue) useless black resistance occurred. As we know, the sound waves spread in the physical media such as: (air, water, solids) are longitudinal vibrations that occur away from the source of the sound waves composed, such as the waves of the sea. It is clear that these waves have a high frequency of 20,000 Hz which is higher than audible sound waves (20 Hz - 20,000 Hz). This technique is developed as a result of its importance when it becomes possible to produce threedimensional images of body organs, such as the fetus in the mother's womb[12,11]. Ultrasound imaging is important for the detection of many diseases, but in this treatise is very important "in the

filming of the heart and arteries nourishing it". The use of ultrasound is to penetrate the tissue and capture images of the heart on the screen[12].



1.2.4. Gamma camera

The gamma or scintillation camera is an imaging device that is most commonly used in nuclear medicine. It is also called the Anger camera in honor of Hal O. Anger, who invented it in the late 1950s. Gamma cameras detect radiation from the entire field of view simultaneously and therefore are capable of recording dynamic as well as static images of the area of interest in the patient. The gamma camera has been used for thyroid, brain and kidney scanning and its immediate and potential uses after further modification are indicated.

2. Theoretical concepts

2.1. Digital image

Digital image consists of elements called (pixels). These pixels are located at the intersection of each row and column in the digital images array. They are the most common means in the information transfer, and that about 75% of the information received by the human is in the form of image scale[2,37]. Therefore, the digital image varies in its data, and may contain pixels that have a value of either zero or one. This image is called binary image, or may rate this image between zero or one (limited to the value of the image between zero or one), then is called the gray image. If this image contains basic colors which are red, green, and blue, then it is called color image (RGB) [38].

2.2. Representation of a digital image

Digital image is the e-file which forms the image elements (pixels) when it is displayed on a computer screen. The displayed image is two-dimensional matrix of numbers of pixels, each has its own address, and color representation. There are four types of images scale [39,40]. Figure(2.1) represents transform the image of the artery gray image to binary image.

A. Binary image

Binary image is a digital image which takes only two values color for each pixel. So that it has only one bit for each pixel usually uses black color when pixel equal to zero and white color when pixel equal to one in the representation of these images[37].

B. Gray – level image

In photography and computing, gray digital image is an image of the value of each pixel as one sample meaning that it holds only image density information of this kind. It has 8-bit per pixel so

that the values may take from (0) up to (255) consists exclusively of shades of gray, ranging from black at the weakest to the intensity White in the most powerful [37].

C. Color image

Image color possess a specific model that consists of three bands. Each one possesses one color which means there are three single-color image colored a red, green, and blue. It has 8-bit per pixel so that the values for Each color takes so that the image colored owns 24-bit (24 bit per pixel)[37].

2.3. Digital image processing

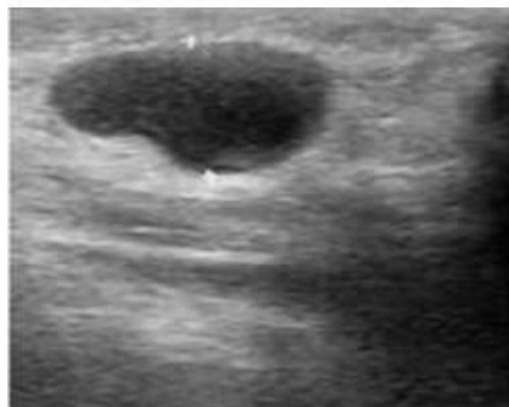
Image processing is one of the important branches in the computer world. It is interested in conducting operations on the images in order to improve them, according to specific or debriefing standards. Some may imagine that the digital processing of the image only means operations that the images and the introduction of decoration on them to show up later in another appearance that differs from the original appearance. However, the digital image processing radically is different from that.[41] Where the focus is on the appropriate digital encryption of the image to find ways to process digital data in order to make this image or information carried by the image usable by a computer or a robot or other machines. Therefore, the digital image processing is gaining great importance in realizing images; ie, the field when we make a computer or robot understands the digital image. It is also very important to recognize patterns or shapes of the field. Moreover the pattern recognition is of great importance in the automated processing of images that are taken by the Earth's surface, as an example. It is very important "in navigation based on maps of the earth's surface[14]. Therefore, the digital image processing system consists of six consecutive stages, respectively:

2.3.1. Image acquisition

Performance image acquisition, in the image processing, is always the first step in the workflow sequence because the image scale would be impossible to handle it. The image obtained is not fully equipped; a result of any device that was used to generate it, It is made by a light sensor such as camera [42].

2.3.2. Pre-processing

The purpose of pre-processing is to enhance the appearance of the image and to make it more convenient for other processes. It improves the manipulation of databases if the initial processing has not used the correct and timely manner will result in the loss of information from the image. It is also "the pre-processing removal noise, perform calculations and improved gray contrast of the image"[1,42].



2.3.3. Segmentation

Segmentation image So is the separation of important information (for example, an object in the image scale) from background. The goal of this division is to simplify or change the representation of the image to what is clearer and easier to analyze. Usually, segmentation of the image is used to determine the boundaries of objects and sites (lines, curves, etc.) in the pictures. More precisely, the

image is a segmentation process of appointing a label to each pixel in the image with the same name of some characteristics of pixels[42].

2.3.4. Features extraction

Beginning with extracting characteristic of the initial set of measured data and building derived values (features) is intended to be a useful and non redundant, The purpose is to facilitate the learning and dissemination of the subsequent steps leading to a better explanations. When the introduction of very large data to the algorithm, when it cannot be addressed, is suspected to be redundant. This leads to a decline in features that do not lead to the required vigor, therefore the feature extraction in the field of image processing that is useful in classification and recognition of images[3,42].

2.3.5. Classification

Digital image classification is the process of extracting information from the image. There are two methods for digital image classification supervised and unsupervised. supervised classification is used in multi-spectral images and unsupervised classification gives accurate results and fast way when applied in the computer selects the classification categories topically according to the relation between the numeric values in the range of the image used. [42].

2.3.6. Image understanding

It is the process of interpreting areas or objects in the image to find out what is happening and may include knowing what are the stuff and spatial relationship to each other and include making some decisions for further action [42].

2.4. Recognition System Structure

The structure of the atherosclerosis diagnosis system consists of the following stages:

1. Input image.
2. Preprocessing.
3. Segmentation artery.
4. Feature extraction.

Thyroid nodules

Thyroid nodules are lumps of solid or liquid-filled tumors that form inside the thyroid gland, which can be malignant or benign.

Evaluating thyroid nodules is clinically challenging. Thyroid nodules are frequently detected incidentally during the diagnostic imaging of the neck [1]. They may be found in 42–76% of people, becoming more prevalent with increasing age [2]. Most thyroid nodules are benign, but 10% may be malignant [3]. Thyroidectomy, radioactive iodine therapy, immunotherapy, or chemoradiotherapy to prevent recurrence and death may be indicated for thyroid cancer treatment depending on the histological subtype, patient preference, and comorbidities

Thyroid gland produces hormones that are helpful for the body to control metabolism. In general, thyroid disease can be divided into two broad groups of disorders: First group is the one which primarily affect the function of the thyroid and the second one is the one which involve neoplasms, or tumors of the thyroid. Both types of disorders are common in the general population. Abnormalities of thyroid function are usually related to production of thyroid hormone.

Types of thyroid cancer

There are 5 main types of thyroid cancer:

- **Papillary thyroid cancer.** Papillary thyroid cancer develops from follicular cells and usually grow slowly. It is the most common type of thyroid cancer. It is usually found in 1 lobe. Only 10% to 20% of papillary thyroid cancer appears in both lobes. It is a differentiated thyroid cancer, meaning that the tumor looks similar to normal thyroid tissue under a microscope. Papillary thyroid cancer can often spread to lymph nodes.

- **Follicular thyroid cancer.** Follicular thyroid cancer also develops from follicular cells and usually grows slowly. Follicular thyroid cancer is also a differentiated thyroid cancer, but it is far less common than papillary thyroid cancer. Follicular thyroid cancer rarely spreads to lymph nodes. Follicular thyroid cancer and papillary thyroid cancer are the most common differentiated thyroid cancers. They are very often curable, especially when found early and in people younger than 50. Together, follicular and papillary thyroid cancers make up about 95% of all thyroid cancer.

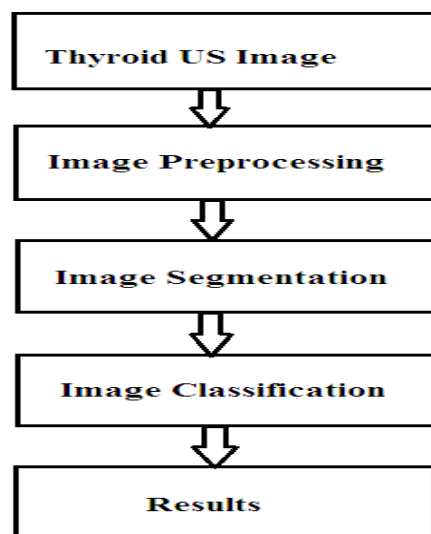
3. Introduction

For diagnosing thyroid diseases, different Imaging technologies are used

1. Radiology
2. Magnetic resonance imaging (MRI)
3. Nuclear medicine
4. Photo acoustic imaging
5. Tomography and Ultrasound imaging(US).

The most commonly used method is ultrasound imaging because US imaging is less expensive, non-invasive and very easy to use. Image processing algorithms consists of different steps such as image pre-processing, segmentation, feature extraction, feature selection and classification

First, thyroid US image is taken. Image processing step includes removal of noise using filters and to enhance the image. Image segmentation is the process of partitioning an image into multiple segment or set of pixels used to locate object and boundaries. Each of the pixels in a region is similar with respect to some characteristics such as color, intensity or texture. Image classification of thyroid nodule is done in order to eliminate operator dependency and to improve the diagnostic accuracy.



Flowchart for the methodology

There had been various attempts towards the subjective techniques for diagnosis of thyroid gland nodule. We choose the most important research for thyroid nodule diagnosis to explain the steps to detect thyroid tumour.

Materials and Methods

Based on the previous literature and the opinions of doctors and experts, an accurate thyroid nodule detection and classification model is proposed based on deep neural networks and image enhancement.

3.1. Dataset

A digital database of thyroid ultrasound images is established. The dataset images were divided into two categories: **benign and malignant**. The classification of thyroid nodules is the result of diagnosis according to the shape, nodule composition, shape, margin, calcifications. A total of 508 patient ultrasound examinations were present in the dataset. Among these ultrasound images, there were 415 with nodules classified as benign and 93 with nodules classified as malignant. The specific original ultrasonic images data are shown in Figure

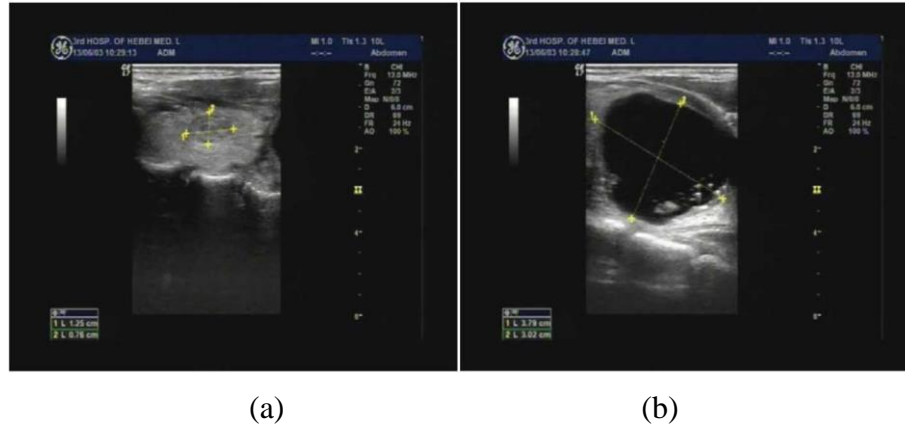


Figure 1

Examples of the original ultrasound image with thyroid nodules.

(a) The thyroid nodules of the upper four images are benign.

(b) The thyroid nodules of the lower four images are malignant

3.2. Image Analysis and Pre-processing

Ultrasound images are collected from different doctors and equipment; image pre-processing is very necessary. These pieces of equipment include Philips IU22, Philips HD15, and Siemens Acuson SEQUOIA 512; the size of the images also ranges from 600×450 pixels to 768×576 pixels. All images had to be resized and changed to the same distance scale. In order to make better use of the images for the diagnosis of thyroid nodules, we pre-processed the ultrasound images in three steps.

The first step of our image pre-processing is image segmentation, which is a process of segregating an image into numerous segments. Segmentation is required to change the representation of an image for easy analysis without altering meaningful information. Image segmentation is also an important step to extract redundant information from ultrasonic images. Figure 2 exhibits the segmentation of an image.

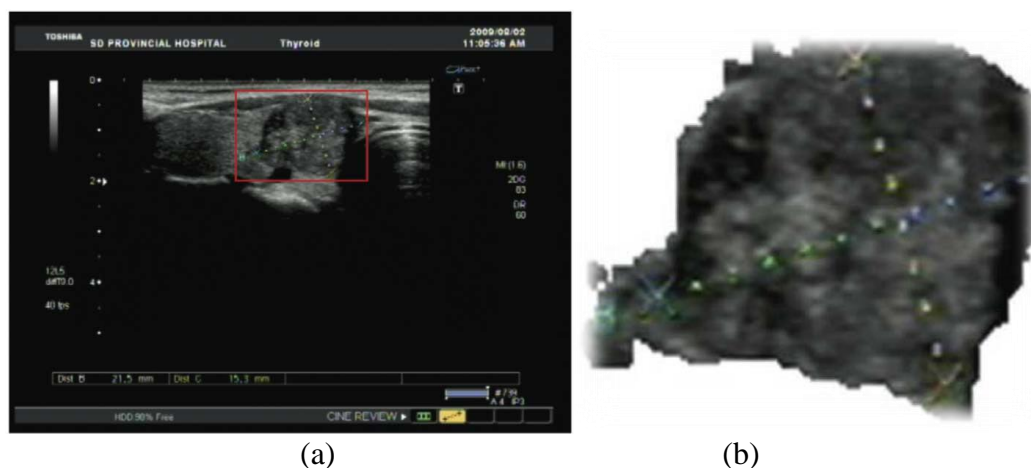


Figure 2: Image segmentation.

(a) Original image. (b) Segmented and extracted image

The second step is to resize the images. It is resized to have the same distance scale which is the physical space represented by each pixel in the image. This step is used to improve the quality of the image by removing the undesired distortion from the image. The resizing of the image is also an important guarantee for the unity of the image data. In this study, the size of the image is uniformly adjusted to 200×200 pixels.

Image standardization is **the third step**, also the final step of pre-processing. Image standardization is the process of centralizing the data by removing the mean value. According to the convex optimization theory and the data probability distribution, data centralization conforms to the law of data distribution, which makes it easier to obtain the generalization effect after training. Data standardization is one of the common methods of data pre-processing. Figure 3 shows the changes of the image before and after image standardization.

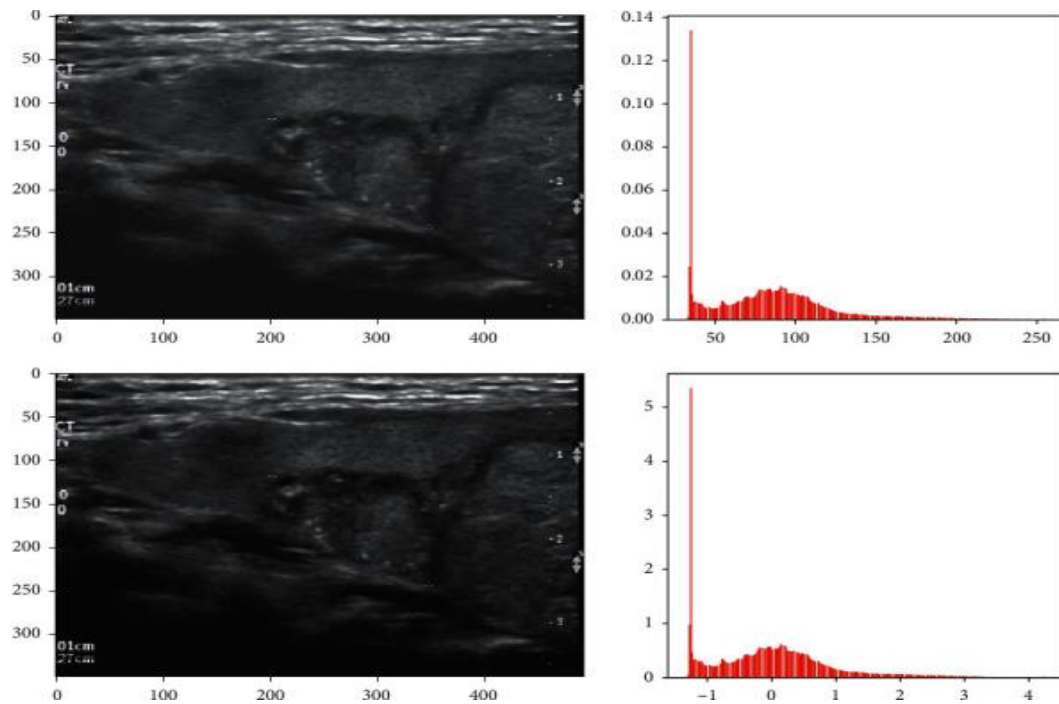


Figure 3 : Image standardization.

3.3. Image Enhancement

Image enhancement algorithms are often used to adjust the brightness, contrast, saturation, and hue of the image, improve the definition of the image, and reduce the image noise. The purpose of image enhancement is to obtain the useful information of the image. Image contrast enhancement is the most important in image enhancement. There are two methods of image contrast enhancement: direct contrast enhancement method and indirect contrast enhancement method. Histogram equalization is a common indirect contrast enhancement method.

The histogram of an image represents the probability density function (PDF) value of the pixel values in the image over the entire grayscale range. If most of the pixels are concentrated in the low gray area, the image will appear dark, but if they are concentrated in the high gray area, it will appear bright. Histogram equalization is to adjust the grayscale distribution of the image to make the distribution on the grayscale of $0 \sim 255$ more balanced. Histogram equalization uses the cumulative function to adjust the gray value to elevate the contrast of the image, thus improving the visual effect of the image. Figure 4 shows the changes of the image and the histogram before and after histogram equalization.

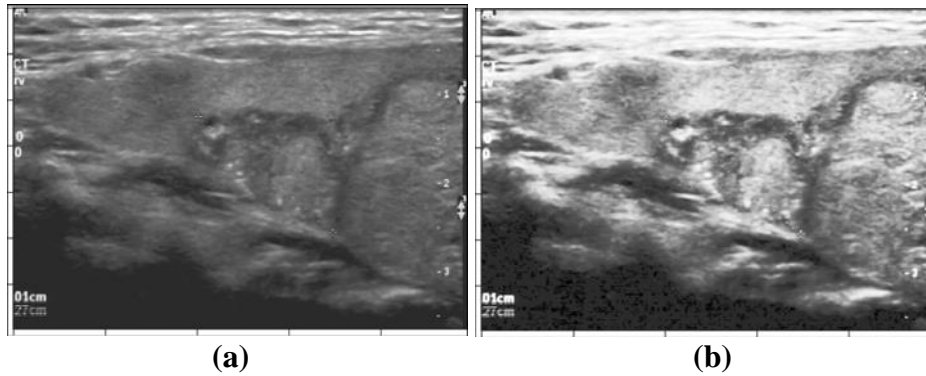


Figure 4 Histogram equalization.

(a) The original image. (b) The histogram equalized image

3.4. Deep Neural Networks (DNNs)

Neural network is an extension based on the perceptron, and a DNN is a feed-forward, artificial neural network that has more than one layer of hidden units between its inputs and outputs. According to the location of different layers, the neural network layers of DNN can be divided into three categories: input layer, hidden layer, and output layer. The first layer is the input layer, the last layer is the output layer, and the middle layer is the hidden layer. Layers are fully connected; that is, any neural unit in layer n must be connected with any neural unit in layer $n + 1$. Each hidden unit j typically uses the logistic function to map its total input from the layer below, x_i to the scalar state, y_i , that it sends to the layer above. The logistic function is given by

$$y_i = \frac{1}{1 + e^{-x_i}}$$

where $x_i = b_j + \sum y_i w_{ij}$, b_j is the bias of unit j , i is an index over units in the layer below, and w_{ij} is the weight on a connection to unit j from unit i in the layer in the following. Of course, there are other activation functions here. The logistic function is the most commonly used as the activation function.

DNN can be trained by back-propagating derivatives of the cost function that measures the discrepancy between the target outputs and the actual outputs produced for each training sample. For the large training sets, it is more efficient to use the strategy of “minibatch” for training deep neural networks model. That is to say, we compute the derivatives on a small, random “minibatch” rather than the whole training set, before updating the weights in proportion to the gradient.

3.5. Classification of Thyroid Nodules

Image classification task of thyroid nodules includes two parts: training and testing. After pre-processing the image data, we get the data that can be used directly. In order to make better use of image information, we carry out the image enhancement. Then, 80% of the data is used as training data and the other 20% as test data. DNN is chosen for classification. The classification accuracy, precision, recall, and F1-score are used as the standard to evaluate the classification model. At the same time, we also compare the classification results with the general machine learning classification algorithm, for example, K-nearest neighbors, decision tree, naive Bayesian model, support vector machine, logistic regression, and reinforcement learning. The process of thyroid nodule processing and classification based on deep neural networks is shown in Figure 5.

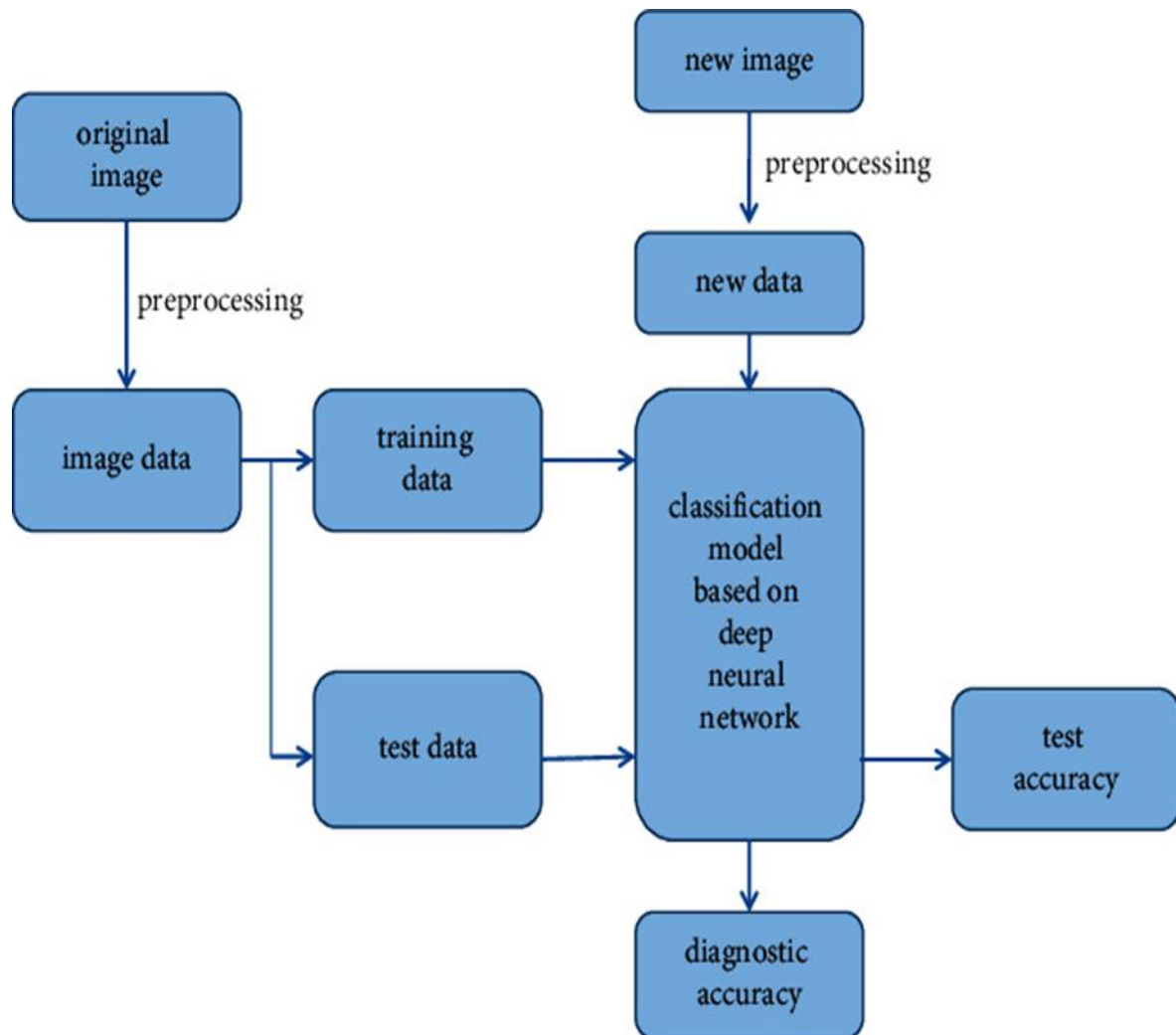


Figure 5 Framework of thyroid nodule classification based on deep neural networks.

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