Detecting Subacute Thyroiditis after COVID-19 infection using Deep Learning Techniques – A Case Study

A Sheik Abdullah, R Suganya, A M Abirami, K R A Bhubesh
Department of Information Technology, Thiagarajar College of Engineering, Madurai, Tamil Nadu, India

asait@tce.edu, rsuganya@tce.edu, abiramiam@tce.edu, bhubesh59588@student.tce.edu

Abstract. The act of Subacute Thyroiditis (ST) is considered to be a challenge in medical informatics which severely affects half of everybody. It plans the thyroid knobs of high-goal thyroid ultrasound. The mechanism formulates the C cells in the Thyroid gland, which makes a hormone that helps control the levels of calcium in the body which gets affected after COVID-19. Hundreds of research teams have been working in recent days to collect data and apply computational techniques to analyze and interpret the experimental results in COVID-19. Still, only a few researched the impact of Thyroid due to COVID-19. In the proposed architecture, we introduced CNN with GapNET-PL and Convolutional Block Attention Module (CBAM) to improve the overall mechanism and also utilize the significant features from the Pooling layer. We collected real-time ultrasound thyroid image dataset consists of 19 images from COVID-19 infected patients for preparing and approval of the proposed model. The significance of this work is to gauge the relationship between's contamination with COVID 19 and the improvement of ST utilizing AI procedures. The trial results show that the assessment of thyroid datasets with the proposed approach has given 89% of accuracy with improvement in P-value <0.001. The training parameters provided valid results with improvisation in statistical performance. Thereby this research can support doctors in the domain of imaging analytics with the aid of AI-systems in reasoning COVID-19 diseases related to Subacute Thyroiditis. Hence this can be strongly recommended for the validation of medical data and its risk factors that contribute towards the disease.

1. Introduction

Covid sickness 2019 (COVID-19), an irresistible illness brought about by extreme intense respiratory condition Covid 2 (SARS-CoV-2), was first recognized in December 2019 in Wuhan, the capital of China's Hubei region. While the World Health Organization (WHO) announced 'mystery pneumonia' on
December 31, 2019, and it has spread universally, bringing about the progressing 2019–20 Covid pandemic. The ordinary clinical manifestations of COVID-19 incorporate high fever, hack, sore, throat, migraine, weariness, muscle torment, and windedness.

The severity of this disorder could be well established by the fact that while the initial seven cases were accounted for on January 20, 2020, in the United States of America, by April 2020, it crossed over 300,000 cases.

New exploration shows Covid can influence thyroid. As of late, The Journal of Clinical Endocrinology and Metabolism[1] distributed an article theoretical that investigated the association between SARS-CoV-2 and thyroid wellbeing, expressing that a patient (who didn't beforehand live with thyroid illness) was found to have created subacute thyroiditis, a thyroid sickness of viral or post-viral root, in the wake of having been determined to have COVID-19. Subacute thyroiditis also called granulomatous thyroiditis, or giant cell thyroiditis [14].

Subacute thyroiditis is an aggravation of the thyroid organ that follows an upper respiratory viral disease. Infections that contaminate the upper respiratory parcel incorporate flu, adenovirus, mumps, enteroviruses, and others. The viral contamination sets off the irritation, causing expanding and torment in the thyroid zone. Dryness and trouble gulping may likewise happen because of pressure in the throat. Imaging innovation is vital for the analysis of Subacute thyroiditis sicknesses, so there have been a ton of exploration concentrates on Computer Aided Diagnosis (CAD) for imaging innovation [21]. Normal clinical pictures used to analyze thyroid infections incorporate ultrasound, CT, SPECT, and so on. Ultrasound imaging has the benefits of good constant, helpful activity, and ease, so it is broadly utilized in the clinical finding of thyroid infections[7].

Papillary thyroid disease (just like the case with follicular thyroid malignant growth) ordinarily happens in the moderately aged, with a pinnacle frequency in the third and fourth many years. It is more normal in ladies with a M:F proportion of 1:2.5 (territory 1:1.6-3:1) . It represents the dominant part (~70%) of every thyroid neoplasm and 85% of every single thyroid malignancy. There are a few cases in London recently created of a fiery thyroid sickness called subacute thyroiditis [8].

The U.S. Communities for Disease Control (CDC) exhorts that individuals who are invulnerable traded off are at higher-danger of serious sickness from COVID-19. Immuno traded off individuals have a more fragile invulnerable framework and make some harder memories battling diseases. In any case, the resistant framework is mind boggling, and having immune system thyroid illness doesn't imply that an individual is invulnerable bargained or will be not able to fend off a viral disease [9]. Hitherto, there means that patients with immune system thyroid illness are at more serious danger of getting COVID-19 or of being all the more seriously influenced should they obtain the COVID-19 contamination. [2]

Generally In ~20% of patients, lymph hub metastases are the principal introduction. In half of kids and 20% of grown-ups a cervical lymph hub is obvious at the hour of conclusion. But it is the time to check and categories thyroid nodules after COVID-19 from small children to older ones.

Any Subacute thyroiditis presents an indicative test as up to half of everybody will have thyroid knobs of some portrayal on high-goal thyroid ultrasound [10]. There has recently been incredible fluctuation in examining thyroid knobs for certain administrators regularly suctioning thyroid sores while others utilize
conventional discriminators, for example, size in choosing whether or not to continue to needle biopsy. The subacute thyroiditis illness is typically determined to have blood tests and imaging, (for example, a ultrasound) and thyroid capacity tests to comprehend your T3, T4, and TSH chemical levels. Also, patients ought to go through testing for incendiary markers called erythrocyte sedimentation rate and C-receptive protein. Both of these markers will be expanded in the event that you have beginning phases of subacute thyroiditis.

AI (ML) is a subset of Artificial Intelligence (AI) where the calculations settle on the most ideal choices by examination, interpretation, and learning from structured data. ML algorithms build an excellent mathematical model based on sample data called training data. Quite possibly the most famous profound neural organizations is the Convolutional Neural Network (CNN). It takes this name from numerical straight activity between networks called convolution. CNN has various layers; including convolutional layer, non-linearity layer, pooling layer and completely associated layer. The convolutional and completely associated layers have boundaries however pooling and non-linearity layers don't have boundaries. CNN has an incredible exhibition in AI issues, particularly in the applications that manage picture information, for example, biggest picture order informational index (Image Net), PC vision, and in common language preparing (NLP). Therefore, the deep learning method has been proposed as a solution to the process of automation with a good accuracy and speed for categorization of Subacute Thyroiditis due to COVID-19.

The main aim is to take the support of the doctors in the same field for developing an AI-based system that aids in reasoning COVID-19 diseases related to Subacute Thyroiditis. Early analysis for speedy recuperation is the fundamental focal point of this work.

2. Literature Review

The creators [3] utilized Support Vector Machine (SVM) procedures for include determination and characterization of thyroid knobs from ultrasonic pictures. The creators [2] considered the ultrasonography of thyroid organ and confirmed that the hypo echoic zones of the influenced tissue have absence of stream on shading in Doppler US; also identified the variations in size of gland in the ultrasonic images. The authors [18] studied acute, subacute and riedel’s thyroiditis for Japan and Israel patients and documented the clinical features of subacute thyroiditis. They also referred to the impact caused by the mast cells by analyzing thyroid gland images. The authors [12] studied nearly 120 patients from Nepal, given clinical treatment to them and hence recommended a medicine for Thyroiditis, which in turn cured 94% of patients from their pain.

The work by the authors [1] submitted a diagnostic report of Subacute Thyroiditis in a young man who was affected by thyrotoxic and identified different parameters and their levels. The authors [6] used a deep learning approach with a fine tuned GoogLeNet model and detected malignant thyroid nodules from the benign nodules using ultrasound images. Similarly the work by the authors [13] used Convolution Neural Network (CNN) with modified DenseNet architecture for studying SPECT images to identify the diseases like Graves’ disease, Hashimoto disease, and subacute thyroiditis. The creators [16] built up a PC supported framework dependent on AI calculations which offered a second assessment to radiologists for investigating the danger of thyroid tissues using ultrasound imaging. Some used machine learning techniques like SVM, Counterfeit Neural Network and Random Forest Classifier for surface arrangement of thyroid pictures.
The creators [15] utilized Ultrasonography for distinguishing the examples of thyroid knobs and connected the qualities of generous and threatening knobs with neurotic determination. The authors [4] [5] studied the different Ultrasonography of Thyroid gland and characterized its various features like benign and malignant, thyroglossal cyst, thyroid parenchyma and so on. Their examining techniques helped in prior treatment. The authors [11] Studied Bangalore-based patient records and identified the common causes of Thyroiditis. They used Tc scan images for diagnosis and concluded that females are more prone to Thyroiditis than the males. The work by the authors [20] Did a detailed study on the use of different techniques for classification of thyroid nodules. The authors [17] used SVM classifier to detect abnormal tumor in thyroid region using ultrasonic images. Some of the authors used Fluffy C Means grouping calculation and morphological separating procedures for dividing the irregular part from the multimodal pictures like mind, bosom and thyroid organ [19].

From the literature, it is understood that only very minimal work has been done for automating the detection of issues with thyroid gland [22]. This project proposes to develop an automated system for early diagnosis in thyroid gland problems using US or SPECT images and would give recommendations to radiologists or endocrinologists. Our key contributions are summarized as follows:

- To classified subacute thyroiditis after COVID-19 from normal thyroid (Two class problem)
- To segment the malignant subacute thyroiditis and explore the affected regions in ultrasound image modality
- Comprehensive experiments are conducted on the USTD dataset and proved the efficacy of the proposed architecture.

3. Proposed Methodology

3.1 Dataset Description

We have collected real time Ultrasound Thyroid Dataset (USTD) for our work. USTD consists of normal thyroid images, COVID-19 impact subacute thyroiditis (ST) images. The dataset comprises of a bunch of B-mode Ultrasound pictures, including a total comment and indicative depiction of dubious thyroid pictures by radiologists [23]. The dataset incorporates a few kinds of pictures as thyroiditis, growth knobs, goiter and ordinary thyroid shown in figure 1.
USTD is split into different mutually-exclusive sets; train (60%), validation (20%), and test (20%). The test set is kept private for benchmarking purposes, while the train and validation sets are made public for both training and method evaluation.

3.2 Methodological workflow

This proposed method analyses the subacute thyroiditis for Coronavirus patients utilizing profound learning algorithms. The system architecture in Figure 1 consists of four phases namely

A. Data collection – Thyroid nodule Ultrasound scan images and COVID-19 Person anthropometric data (age, sex, location, fever, sick, throat pain, confirmed date, admitted date, thyroid TSH level and other Thyroid parameters),

B. Data Analysis - Pre-processing – Removes unwanted noise from images and eliminates outliers from the dataset.

C. Implementation by Deep learning algorithms

1. CNN architecture “GapNET –PL”
2. CBAM – Convolutional Block Attention Module
3. Concatenate results obtained from Deep learning and Neural networks to get the output.

D. Model evaluation – Proposed model as depicted in Figure 2 will be evaluated by Medical experts to check the reliability of our system.
The fundamental goal of the venture is to create an AI-based automated system that aids in reasoning COVID-19 diseases related to thyroid gland and early diagnosis for Subacute Thyroiditis and to segment the malignant subacute thyroiditis and explore the affected regions in ultrasound image modality [24].

### 3.3 Subacute Thyroiditis (ST) localization with CNN using Gap-Net-PL

GapNet-PL that has been intended to handle the attributes of ST information and utilizations worldwide midpoints of filters at various deliberation levels. We can present the biggest comparison of CNN architectures including GapNet-PL for Thyroiditis localization in ST images of COVID-19 patients. We propose Convolutional Block Attention Module (CBAM) for feed-forward convolutional neural organizations [25]. Given a middle of the road highlight map, our module consecutively construes consideration maps along two separate measurements, channel and spatial, at that point the consideration maps are increased to the information include map for versatile element choice cycle. Since CBAM is a lightweight and general module, it tends to be incorporated into any CNN designs GapNet-PL consistently with insignificant overheads and is start to finish teachable alongside base CNNs. We approve our CBAM through broad investigations on ImageNet-1K, MS COCO location, ResNet and ImageNet models and finally performance is evaluated by Sensitivity, specificity, F1- Score, ROC Curve and AUC [26]. Currently we are collecting datasets.

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**Figure 2. Proposed methodology**

**Figure 3. Report analysis on Subacute syndrome**
3.4 Validation

In the fourth phase of the work, the training model built has to be tested and validated for new sets of testing data [28]. A detailed technical report on the performance of the application is generated in consultation with radiologists or endocrinologists. And also, they would validate our results then and there and willing to support our team to develop Artificial Intelligence (AI) based Thyroid nodule image analysis [27]. The validation has been made and observed in Figure 3 and Figure 4. The observed metrics is tabulated in Table 1.

| Metric       | value    |
|--------------|----------|
| Accuracy     | 89%      |
| precision    | 88.97    |
| Recall       | 87.15    |
| Roc_curve    | 0.62     |
| F1_score     | 0.72     |
| Epochs       | 25 epochs|
| Layers       | 3convolution layers |
| No_of_train_images | 200     |
| No_of_test_images  | 100     |
4. Conclusion

Imaging analytics is one among the research area, which aids technology in healthcare practice. It disseminates the process of adhering technology-driven clinical informatics in practice. The proposed AI-based automated system uses content-based image retrieval for COVID-19 ST, and clinical practitioners can use it for the early detection and diagnosis for infected patients. Deep residual learning framework can be used for subacute thyroiditis image recognition from ultrasound images. The layers are reformulated as learning residual functions concerning the layer inputs. Residual networks are easier to optimize and gain accuracy from deep features. The proposed method provided an improved accuracy in evaluation and validation of thyroid images. Hence from this analysis, the phenomenon of early diagnosis or segmenting the malignant subacute thyroiditis and exploring the affected regions in the ultrasound image can be observed and diagnosed to get valuable health service.

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