Journal Paper Presentation

Title: Detection and Classification of Thyroid disease using Ultrasound images through Deep Learning

Team 2

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Thyroid diseases are the condition of thyroid gland. Thyroid diseases can affect anyone: men, women and children, but they are more common in women, and become more common with age. The thyroid gland is a small butterfly-shaped organ that is found in the neck just in front of voice box. It makes the thyroid hormones, T3 and T4, which acts as chemical messengers, travelling through blood stream to all the cells and tissues in the body. These thyroid hormones control the speed at which your body works, which is also called your body's 'Metabolism'. They therefore affect your heartbeat, energy levels, digestion, body temperature, and even how to think and feel. They are generally 4 types of thyroid diseases which are Hypothyroidism, Hyperthyroidism, Thyroid Nodules, and Thyroiditis. The diagnosis involves the investigation of blood test and thyroid scan or biopsy.

1)Texture Analysis of Ultrasound Medical Images for Diagnosis of Thyroid Nodule Using Support Vector Machine

Authors: Shrikant D. Kale, Krushil M. Punwatkar

Summary: In this paper thyroid texture analysis is done using matlab. In this paper, gray level co-occurrence matrix (GLCM) is used as the texture characterization technique. The 10 GLCM features are selected for feature extraction & GLCM matrix is calculated for four different orientations & different pixel distance from 1 to 15. The extracted features are classified using SVM classifier with linear kernel for diagnosis of thyroid nodule malignancy risk.

Dataset used: The total 85 thyroid ultrasound images were used which contains total 48 cancerous and 37 non-cancerous nodules was selected in the database. These thyroid images are available in the image gallery of Wilmington Endocrinology PA on the website. The image size of 546 × 410, with 24 bit depth size, true color image, format of images are JPEG.

Future work: It is suggested to propose other preprocessing techniques and feature extraction for nodule texture analysis.

2)Deep learning based classification of ultrasound images for thyroid nodules: a large scale of pilot study

Author: Qing Guan, Yunjun Wang, Jiajun Du, Yu Qin, Hongtao Lu, Jun Xiang, Fen Wang

Summary: To explore the ability of the deep learning network Inception-v3 to differentiate between papillary thyroid carcinomas (PTCs) and benign nodules in ultrasound images. There were 1,162 benign nodules in the training group and 190 benign nodules in the test group. A margin size of 50 pixels and an input size of 384×384 showed the best outcome after training, and these parameters were selected for the test group. In the test group, the sensitivity and specificity for Inception-v3 were 93.3% (195/209) and 87.4% (166/190), respectively. Inception-v3 was trained and tested to crop the margin of the images of nodules and provide a differential diagnosis. The sizes and sonographic features of nodules were further analyzed to identify the factors that may influence diagnostic efficiency. Inception-v3 displayed the highest accuracy for 0.5–1.0 cm nodules. The accuracy differed according to the margin description (P=0.024). Taller nodules were more accurately diagnosed than were wider nodules (P=0.015).

Dataset Used: A total of 2,836 thyroid ultrasound images from 2,235 patients were divided into a training dataset and a test dataset.

3)Classification of Thyroid Ultrasound Standard Plane Images using ResNet-18 Networks

Authors: Minghui Guo, Yongzhao Du

Summary: The thyroid ultrasound standard plane (TUSP) classification is quite essential for the ultrasound diagnosis of thyroid disease. In this paper, They applied the ResNet-18 model to TUSP images classification successfully and compares it with other classical convolutional neural network models.. The test set experimental results show that the 18-layer CNN model ResNet has a good performance for automatic classification of TUSP images, and the accuracy of TUSP images classification reaches 83.88%. CNN consists of an input layer, convolution layers, pooling layers, fully connected layers, and an output layer. The CNN consists of multiple convolution layers and pooled layers to implement a deeper network generally, and the fully connected layer can also use a multi-layered structure. The typical CNN models include ResNet, MobileNet, InceptionV3, Xception, AlexNet, LeNet, ZF_Net and so on.

Dataset Used: 4,509 TUSP images collected from the hospital's real data are randomly divided into 3,386 sheets as the training set and 1,123 sheets as the test set.

Future Study: The automatic classification method of TUSP images based on deep learning has great application prospects in clinical, which deserves further study.

4)Automated thyroid nodule detection from ultrasound imaging using deep convolutional neural networks

Authors: Fatemeh Abdolali, Jeevesh Kapur, Jacob L. Jaremko, Michelle Noga, Abhilash R. Hareendranathan, Kumaradevan Punithakumar.

Summary: proposed a novel deep neural network architecture with carefully designed loss function regularization, and network hyperparameters to perform nodule detection without complex postprocessing refinement steps. CNN-based approaches such as fast R-CNN, Faster R-CNN and Mask R-CNN have achieved increasing success in object detection tasks. Mask R-CNN is the most recent CNN architecture for object detection. In this study, They have presented a novel framework for fully-automated thyroid nodule detection which can facilitate analysis of thyroid ultrasound scans. Accurate and automatic thyroid nodule diagnosis is a crucial step in detecting cancer and in reducing diagnosis time, and bias from clinicians. They included modifying the conventional Mask R-CNN loss function, tailoring transfer learning and data augmentation strategies to adapt the model to thyroid nodule detection task. The mean average precision for the proposed method, Mask R-CNN, Faster R-CNN and conventional Mask R-CNN are 0.82, 0.74 and 0.78, respectively. The proposed Mask R-CNN achieved highly accurate detection results despite the large variations in the ultrasound data and outperformed Faster R-CNN and conventional Mask R-CNN.

Dataset used: The local training and testing datasets consist of 2461 and 820 ultrasound frames acquired from 60 and 20 patients with a high degree of variability, respectively.

5)Classification of Thyroid nodules in ultrasound images using deep model based transfer learning and hybrid features

Authors: Tianjiao Liu, Shuaining Xie, Jing Yu, Lijuan Niu, Weidong Sun

Summary: convolution neural networks (CNNs) is used as feature extraction method for ultrasound images. CNN model trained with a massive natural dataset is transferred to the ultrasound image domain, to generate semantic deep features and handle the small sample problem. Then, combined those deep features with conventional features such as Histogram of Oriented Gradient (HOG) and Local Binary Patterns (LBP) together, to form a hybrid feature space. use a ImageNet pre-trained ConvNets to extract features and combine them with hand crafted features. SVM is used for nodule classification. In this paper, a feature extraction method for ultrasound images is presented to classify the thyroid nodules into benign and malignant. The comparison results shown that, our proposed hybrid method outperformed both the pre-trained CNN model and the traditional single-type feature method with the accuracy of 93.1%.

Dataset Used: Real world 1037 images taken from the Cancer Hospital of Chinese Academy of Medical Sciences, which are clinically verified. 1037 thyroid nodule ultrasound images, including 651 benign images and 386 malignant images.

Future Work: planning to complete further tuning of the CNN, and improve classification accuracy especially for the malignant nodules.

6)Thyroid Nodule Detection in Ultrasound Images with Convolutional Neural Networks

Authors: Shuaining Xie, Jing Yu, Tianjiao Liu, Qing Chang, Lijuan Niu, Weidong Sun

Summary: This paper focuses on the problem of thyroid nodule detection, aiming to achieve a fully automated method for delineating the nodule bounding box from the thyroid ultrasound image. In this paper, (Single shot detector) SSD based object detection method is proposed, to solve the problem of nodule detection in the thyroid ultrasound images. Facing the large variety of size and small number of thyroid nodules in the dataset. To overcome it, SSD neural network was implemented. This method is evaluated on clinical data and compared to the ground truth labeled by doctors. The experimental results show that this proposed method achieves 90.08% accuracy.

Dataset Used: Data was provided by Cancer Hospital Chinese Academy of Medical Sciences, containing 1110 thyroid ultrasound images from 609 patients. divide the data into training and test sets by a ratio of 8:2.

7)Feature Selection and Thyroid nodule classification using transfer learning

Authors: Tianjiao Liu, Shuaining Xie, Yukang Zhang, Jing Yu, Lijuan Niu, Weidong Sun

Summary: In this paper, a feature extraction method for the thyroid nodules classification is proposed. Both traditional low-level features and high-level deep features extracted from CNN model are used. Deep features can provide us more generic semantic meanings to the limited medical dataset. A CNN model trained with ImageNet data is transferred to the ultrasound image domain, to generate semantic deep features under small sample condition. Then, combined those deep features with conventional features such as Histogram of Oriented Gradient (HOG) and Scale Invariant Feature Transform (SIFT) together to form a hybrid feature space. In this paper, we transfer the CNNs model learned from ImageNet as a pre-trained feature extractor to our ultrasound image dataset, to explore its versatility as a high level feature description. To get better classification results, we propose a hybrid approach combining hand-crafted features with deep features, and a feature subset selection process is employed for the thyroid nodule classification and got the accuracy of 92.3%

Datasets used: dataset taken for Cancer Hospital of Chinese Academy of Medical Sciences. 1037 thyroid ultrasound images, including 651 benign and 386 malignant images. extracted nodule regions and resized them to 224×224.

8)Detection and classification of the breast abnormalities in digital mammograms via regional convolutional neural network

Authors: M. A. Al-masni, M. A. Al-antari, J. M. Park, G. Gi, T. Y. Kim, P. Rivera, E. Valarezo, S.-M. Han, and T.-S. Kim

Summary: This paper implements a YOLO-based CAD system to detection and diagnosis of breast cancer masses. The input images are pre-processed then resized to a unified size. YOLO structure is trained by the entire breast image with its ROI bounding boxes and class labels. YOLO-based CAD system contains four main stages: mammograms preprocessing, feature extraction utilizing multi convolutional deep layers, mass detection with confidence model, and finally mass classification using fully connected neural network (FC-NN). The system distinguishes between benign and malignant lesions with an overall accuracy of 85.52%.

Dataset Used: A database of mammograms from Digital Database for Screening Mammography (DDSM) is used to train and test our YOLO-based CAD system. The DDSM database is created by the University of South Florida and it has been widely utilized in breast research purposes. It contains 2,620 cases.

Future Work: need large sets of training data to improve the performance. Increasing the training cases for the further investigation of YOLO based CAD system performance.

9)Texture Analysis for Classification of Thyroid Ultrasound Images

Authors: Hanung Adi Nugroho, Made Rahmawaty, Yuli Triyani, Igi Ardiyanto

Summary: In this paper, classification of thyroid ultrasound images is done by using some texture features into two classes i.e. cystic and solid cases. Through nodule structure and characteristics. The process involves preprocessing, segmentation, feature extraction and classification. Image pre-processing is conducted to enhance the detection capability followed by some methods of morphological operation, that is active contours without Edges (ACWE) and histogram equalization. The feature extraction is developed based on texture analysis by using Gray Level Cooccurrence Matrix (GLCM), Histogram and Gray Level Run Length Matrix (GLRLM). Finally, Multilayer Perceptron (MLP) is used to classify cystic nodule from solid nodule. It gives the accuracy of 89.74%.

Dataset Used: The dataset consists of 39 ultrasound images which grouped into 25 cystic cases and 14 solid cases provided by Department of Radiology, RSUP Sardjito Yogyakarta.

Future Work: suggested to propose other preprocessing technique and feature extraction for nodule texture analysis.

10)A comparison between a deep convolutional neural network and radiologists for classifying regions of interest in mammography

Authors: Thijs Kooi, Albert Gubern-Merida, Jan-Jurre Mordang, Ritse Mann, Ruud Pijnappel, Klaas Schuur, Ard den Heeten, and Nico Karssemeijer

Summary: In this paper, authors employed a deep Convolutional Neural Network (CNN) for the classification of regions of interest of malignant soft tissue lesions in mammography and show that it performs comparable to experienced radiologists. The CNN was applied to 398 regions of 5 × 5 cm, half of which contained a malignant lesion and the other half depicted suspicious

regions in normal mammograms. m. Four radiologists were participated in the study. The accuracy of CNN was 87%, which was higher than the overall accuracy of the radiologists which was 84%.

Future Work: Advanced CAD can be made using deep CNNs or statistical learning methods which will be able to read mammograms independently.

11)Feasibility Study of Texture Analysis Using Ultrasound Shear Wave Elastography to Predict Malignancy in Thyroid Nodules

Authors: Kunwar Suryaveer singh bhatia, Absalom chung lung lam, Sze wing angel pang, Defeng wang, and Anil tejbhan ahujha

Summary: Ultrasound (US) elastography is a non-invasive imaging technique that measures and displays tissue contrast derived from the elastic modulus or related elasticity properties. Textural analysis of ultrasound shear wave elastography (SWE) was evaluated to discriminate benign and malignant thyroid nodules. Sixteen papillary thyroid cancers and 89 benign hyperplastic nodules in 105 patients underwent SWE using four static pre-compression levels. Got the accuracy of 70.9% which shows that this feasibility study suggests SWE textural analysis can accurately distinguish benign and malignant thyroid nodules.

Dataset Used: SWE was performed under 105 patients (29 males, 76 females)

Demerits: Dataset is not sufficient. They used only the USG images of thyroid suffering patients.

12)Application of support-vector-machine-based method for feature selection and classification of thyroid nodules in ultrasound images

Authors: Chuan-Yu Chang, Shao-Jer Chen, Ming-Fong Tsai

Summary: In this paper, six support vector machines (SVMs) were adopted to select significant textural features and to classify the nodular lesions of a thyroid. It involves the pre-processing, feature extraction, and feature evaluation. Methods for extracting spatial and frequency features from an image were presented. Since there was a large number of extracted features, feature evaluation was used to reduce the number of features which are used to train SVMs and to retain significant features for the subsequent classification of thyroid nodules. The results showed that the proposed classification method can successfully identify six types of thyroid nodule (enlarged follicles, follicular cells with follicles, papillary cells with follicles, follicular cells with fibrosis, papillary cells with fibrosis, and fibrosis) with high accuracy.

Dataset Used: 76 thyroid nodular lesions were studied from 61 patients (48 females and 13 males). Dataset collected from General Electric Healthcare, Chalfant St. Giles, UK.

13)An improved deep learning approach for detection of thyroid papillary cancer in ultrasound images

Authors: Hailiang Li, Jian Weng, Yujian Shi, Wanrong Gu, Yijun Mao, Yonghua Wang, Weiwei Liu, Jiajie Zhang

Summary: Faster R-CNN is used for the thyroid papillary carcinoma detection in ultrasound images and added a spatial constrained layer to CNN so that the detector can extract the features of surrounding region in which the cancer regions are residing. by concatenating the shallow and deep layers of the CNN, the detector can detect blurrier or smaller cancer regions. Got the overall accuracy of 93.1%.

Dataset Used: collected 1027 ultrasound images of 300 cases from the Department of head and neck of Sun Yat-sen University Cancer Center.

Future Work: can investigate new strategies to detect more kind of cancer region considering the context and will further study how to generate a exhaustive and practical diagnostic report.

14)Ultrasound image analysis using deep learning algorithm for the diagnosis of thyroid nodules

Authors: Junho Song , Young Jun Chai, Hiroo Masuoka, Sun-Won Park, Su-jin Kim, June Young Choi, Hyoun-Joong Kong, Kyu Eun Lee, Joongseek Lee, Nojun Kwak, Ka Hee Yi, Akira Miyauchi

Summary: Fine needle aspiration (FNA) (type of biopsy procedure) is the procedure of choice for evaluating thyroid nodules. It is indicated for nodules >2 cm, even in cases of very low suspicion of malignancy. FNA has associated risks and expenses. In this paper, image analysis model using a deep learning algorithm was developed and evaluated if the algorithm could predict thyroid nodules with benign FNA results. Transfer learning method using the Inception-v3 model is used to classify benign and malignant nodules. Inception-v3 model architecture consists of the following layers which are pretrained, and contain information that can discriminate between images: a stem layer, 3 Inception-A layers, 5 Inception-B layers, 2 Inception-B layer, a pooling layer, a dropout layer, a fully connected layer, and a softmax layer. e. The diagnostic performance of the algorithm was promising with the accuracy of 94%.

Dataset Used: 1358 (670 benign, 688 malignant) thyroid nodule images were collected from SMG-SNU Boramae Medical Center, Seoul, Korea in TIFF format. Then the nodules on the images were cropped into squares (299 * 299 pixel).

15)Thyroid nodules classification and diagnosis in ultrasound images using fine-tuning deep convolutional neural network

Authors: Olfa Moussa, Hajer Khachnaoui, Ramzi Guetari, Nawres Khlifa

Summary: In this paper, fine-tuning approach based on deep learning using a Convolutional Neural Network model named resNet50 is used to classify and detection of thyroid in US images. ResNet-50 (50 layers) holds 16 blocks, each of them includes a convolutional layer. Residual block consists of three layers in this order: 1 × 1 convolution − 3 × 3 convolution − 1 × 1 convolution. ResNet uses 7 × 7 convolution with stride 2 to down sample the input by the order of 2 as well as the pooling layer. The fine-tuning is the process of adapting the pretrained weights of a CNN to different data sets through the use of the backpropagation. It got the accuracy of 97.33% while VGG-19 model had 81.83% which suggest the proposed approach improves the accuracy of the classification of thyroid nodules and outperformed the VGG-19 model.

Data Used: Two public database were used DDTI (Digital Database Thyroid Image) and Ultrasoundcases.info. DDTI is a thyroid ultrasound image database performed by two experts in 299 patients with thyroid disorders, containing 451 thyroid images with the size 560 × 360, including 376 malignant images and 75 benign images. The images were extracted from thyroid ultrasound video sequences captured with TOSHIBA Nemio 30 and TOSHIBA Nemio MX Ultrasound devices.

Demerits: the present study was not able to classify the thyroid nodules into all classes of the different TI-RADS scores and it was restricted in only two classes (benign and probably malignant).

Future Work: will continue further tuning on the proposed DCNN in order to improve accuracy specifically for the benign nodules.