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ARTIFICIAL INTELLIGENCE IN INTERNET OF MEDICAL IMAGING THINGS: THE POWER OF THYROID CANCER DETECTION

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Abstract: The paper proposed an approach for thyroid cancer detection based on artificial intelligence in Internet of Medical Imaging Things (IoMIT) ecosystem. Ultrasonic imaging collected in IoMIT ecosystem is the best way for thyroid cancer diagnosis. Image segmentation and detection of benign and malignant thyroid nodules is an important part of the proposed approach. It is implemented in Apache Spark using MLlib based on Convolutional Neural Networks (CNNs). Finally, the results of medical imaging analytics are discussed.
Key words: Internet of Things (IoT), Internet of Medical Imaging Things (IoMIT), Artificial Intelligence (AI), Big Data (BD), Thyroid Cancer Detection.

1. INTRODUCTION

The fourth-generation Internet is at the heart of a global change of the information environment, healthcare and industrial development worldwide. The Internet of Things (IoT) blurs the boundary between the real and the virtual environment. It is not only a basic tool for developing the new digital world but also a tool for developing a future society of shared knowledge. Companies are eager to lay the bricks and help pave the road to better, more personalized healthcare through integration of connected devices in the new Internet of Medical Things (IoMT).

That is, IoMT is constantly offering new tools and services as well as efficiencies that make up an integrated healthcare system with the view of ensuring patients are cared for better, health care costs are reduced significantly and treatment outcomes are improved. They are interconnected. In the last year in the scientific community, increasingly being discussed question of whether these two trends are not two sides of the same coin [1, 2].

These new devices not only help us to understand more about our health, but also collect big data from us. IoT and BD are two areas that are able to revolutionize the research in medicine. The core of these trends is Artificial Intelligence (AI) that adds value to medicine. The global artificial intelligence in medicine market was valued at USD 1.603 billion in 2017 and is projected to reach a value of USD 12.150 billion by 2023, at a CAGR of 40.15% over the forecast period, 2018-2023 [3].

The largest donor of big data in medicine that required analytics based on artificial intelligence is medical imaging. Especially prevalent is the use of medical imaging to early cancer detection. The cancer detection at the early stage is high importance to save the human life.

The next sections of the paper will discuss the Internet of Medical Imaging Things for thyroid cancer detection and finally the experimental results will be presented and concluded.

2. INTERNET OF MEDICAL IMAGING THINGS (IoMIT)

The idea of Internet of Medical Imaging Things (IoMIT) is not new. It is traced back at the beginning of the 21 century with the concept of connecting and monitoring medical imaging equipment via remote servers over the Internet.

In 2015, three big vendors *GE Healthcare, Siemens Healthcare and Philips Healthcare* pave the path to the 2-nd generation of IoMIT (IoMIT 2.0) using three different approaches based on GE Healthcare All-in-one Health Cloud, remote monitoring of equipment such as Lifenet and Siemens Remote Services in partnership with Microsoft Azure and Philips Healthcare’s HealthSuite Digital Platform becoming the way forward for the company’s medical imaging IoT strategy [4, 5].

Medical imaging is the technique and process used to create images of the human body for clinical purposes or for purposes of medical science, including the study of anatomy and physiology. These medical images show the body of patients in depth and the changes of internal organs that may be caused by various diseases [6].

In modern medicine, the most common methods of X-ray in medical imaging are X-ray radiography, computed tomography (CT), mammography, angiography and fluoroscopy. Another method used in medical imaging is molecular imaging, ultrasound imaging (sonography) and magnetic resonance imaging (MRI). Some of the most common types of medical images used for thyroid cancer detection are ultrasound, CT and scans using nuclear medicine.

3. ARTIFICIAL INTELLEGENCE FOR MEDICAL IMAGING ANALYTICS

In the next couple years there will be a further data explosion with the use of bidirectional patient portals, where patients can upload their own medical data and images. Artificial intelligence has captured the imagination and attention of doctors over the past couple years as several companies and large research hospitals work to perfect these systems for clinical use.

Looking at the medical imaging analytics, image segmentation is particularly important process associated with splitting the image into multiple segments or set of pixels used to locate the object and boundaries. Each pixel in a region is similar with respect to certain characteristics such as color, intensity or texture. Segmentation plays an important role in determining the qualitative and quantitative characteristics of the studied objects. Solving the stage of segmentation depends substantially on the number and type of the feature selection. The segmentation challenge of medical imaging in general is the fact that the images have very similar gradation levels (grayscale) and almost identical texture of examined objects, leading to the emergence of significant error segmentation. Another challenge is the lack of a set of training data, and low resolution and poor contrast of medical images.

The other important point in medical imaging analytics is the classification and analysis. There are a variety of advanced techniques for classification and analysis of medical images, such as Artificial Neural Networks (ANN), Support Vector Machine (SVM), fuzzy sets, Genetic Algorithms (GA), Fuzzy Support Vector Machines (FSVM), and Principle Component Analysis (PCA). There is a wide spectrum of algorithms for image classification based on genetic algorithms and neural networks [7].

Moreover, companies like IBM, Philips and Siemens have already started integrating AI into their medical imaging software systems. IBM Watson has been cited for the past few years as being in the forefront of medical AI, but has yet to commercialize the technology.

4. THYROID GLAND: ESSENCE, TOOLS AND DATASETS

The thyroid gland is an organ that is shaped like a butterfly and is positioned on the lower part of the neck, just below the larynx. The main function is to release hormones that control metabolism. The thyroid's hormones regulate vital body functions, including: breathing, heart rate, central and peripheral nervous systems, body weight, muscle strength, body temperature, cholesterol levels and by females – the menstrual cycle. The thyroid is part of the endocrine system, which is made up of glands that produce, store, and release hormones into the bloodstream so the hormones can reach the body's cells. The thyroid gland uses iodine from the foods you eat to make two main hormones: Triiodothyronine (T3) and Thyroxine (T4). The hypothalamus and the pituitary communicate in order to control T3 and T4. These hormones control the speed of the metabolism inside cells and digestion speed. This means if the T3 and T4 levels are too high your metabolism will speed up, which leads to higher heart and digestion rates. This is linked to other side effects such as: anxiety, nervousness, hyperactivity, sweating, trembling, hair loss and others. Low levels of T3 and T4 lead up to slowed down metabolism, meaning that the heart rate and metabolism get lower. The side effects being: Tiredness, difficulty concentrating, dry skin and hair, depression, muscle pain and trouble with sleeping [8].

The most common way to detect anomalies in the thyroid is during a physical exam, a doctor can check for lumps or swelling in the neck, a larger-than-normal thyroid and how the patient is feeling in general. Blood tests can check for levels of hormones released by other organs in the body. After a thyroid nodule is found, most commonly an ultrasound is performed to confirm the presence of a nodule and assess the status of the whole gland [9].

In the recent years there has been a lot of research in the field of thyroid cancer detection and prevention, a lot of tools and databases has been developed through the years with the help of computers that have accelerated, automated and eased the research.

The Cancer Genome Atlas is a project started in 2005, to catalogue genetic mutations responsible for cancer, using genome sequencing and bioinformatics. TCGA applies high-throughput genome analysis techniques to improve our ability to diagnose, treat, and prevent cancer through a better understanding of the genetic basis of this disease [10].

Thyroid Cancer Risk Assessment Tool or TCRAT is the R package "thyroid" provides software for calculating the absolute risk of second primary thyroid cancer following a childhood cancer based on a prediction model developed and validated by researchers at the National Cancer Institute [11].

The Thyroid dataset is a comprehensive dataset that contains nearly all the PLCO study data available for thyroid cancer incidence and mortality analyses. The dataset contains one record for each of the approximately 155,000 participants in the PLCO trial [12].

This paper has been proposed an approach for thyroid cancer detection based on AI in the Internet of Medical Imaging Things ecosystem.

5. PROPOSED APPROACH FOR THYROID CANCER DETECTION BASED ON ARTIFICAL INTELLEGENCE

The proposed approach for thyroid cancer detection is based on analysis and anomaly detection of ultrasound medical images.

Medical imaging analytics is consisted of three stages: 1) pre-processing of medical images, 2) anomaly detection, and 3) post-processing include presenting the results and visualization in friendly manner to the thyroid cancer experts.

The main task of pre-processing in medical imaging is to suppress unwanted noise and to make the attribute selection. It depends of implementation the pre-processing can used different approaches, in more cases the filtering approach is used for attribute selection, wherein the attribute selection is independent of the algorithm for anomalies detection.

The second stage of the proposed approach is anomaly detection. This stage compounds image segmentation and detecting regions of interest (ROI) that contain normal and abnormal objects. Image segmentation is an important part in image analysis. Segmentation is the process of dividing the image into regions with similar properties such as level grayscale, color, texture, brightness, contrast, etc. At this stage it will be implemented segmentation based on textural features (such as sharp edges, shape of the object, place of the object, etc.). In this paper, Convolutional Neural Networks (CNNs) will be used for classification and anomaly detection of thyroid cancer.

6. EXPERIMENTAL RESULTS AND ANALYSIS

The proposed approach for thyroid cancer detection is implemented in Apache Spark using MLlib based on CNNs classifiers in the Internet of Medical Imaging Things ecosystem. For the case of medical imaging analysis and anomaly detection, the dataset with 282 samples training set and 250 sample validation set is used. The dataset contains 96 malignant samples and 186 benign samples.

The CNNs uses multiple layers in order to achieve greater accuracy, in this case it uses 5 layers. Each convolution layer has 500 nodes and last convolution layer is flattened to use a fully connected layer.

Image classification using CNNs is done by applying the back propagation algorithm. The textural features in CNN help to resolve misclassification.

Table 1.

Experimental Results	***Convolutional Neural Networks***
Accuracy *(TP+TN)/N*	*72,9 %*
Sensitivity *TP/(TP+FN)*	*78,7 %*

The CNNs are applied to classify benign and malignant nodules and to detect anomalies for thyroid cancer detection. The results of the CNNs classification are presented in the table 1.

The experimental results are good performed. Furthermore, these results are with a limited amount of samples in datasets.

7. CONCLUSION AND FUTURE WORK

This paper has proposed an approach for thyroid cancer detection based on artificial intelligence in IoMIT ecosystem. The proposed approach for thyroid cancer detection has been implemented in Apache Spark using MLlib based on CNNs classifier. Finally, the results of medical imaging analytics have been discussed.

The future work will be to use more images and bigger dataset to classify different types of anomalies for early diagnosis of thyroid cancer. Moreover the future plan involves the meetings and discussion with thyroid cancer experts which will be essential to the validation process.

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