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IDENTIFY AND LOCATE COVID-19 POINT-OF-CARE LUNG ULTRASOUND MARKERS BY USING DEEP LEARNING TECHNIQUE HOPFIELD NEURAL NETWORK

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***Abstract*— Deep Learning (DL) has shown promise in medical imaging, and in the aftermath of the recent COVID-19 pandemic, some research has begun to look into DL-based solutions for assisting in the identification of lung disorders. While previous research has focused on CT scans, this paper investigates the use of DL approaches to analyze lung ultrasonography (LUS) data. In particular, we present a new fully-annotated collection of LUS images derived from severity at the frame, video, and pixel levels (segmentation masks). We introduce three deep models based on these data that solve key tasks for the automatic processing of LUS images. In Transformer Networks, which predicts the disease severity score associated with an input frame while also providing pathological artifact localization in a weakly-supervised approach. We also present a new method for effective frame score aggregation at the video level based on uniforms. Finally, we analyze state-of-the-art deep models for calculating COVID-19 imaging biomarker pixel-level segmentations. Experiments on the provided dataset lead to a condition for all of the tasks considered, clearing the path for future research on DL for COVID-19 assisted diagnosis using LUS data.**

***Keywords*— COVID-19, deep learning, Hopfield neural network**

1. INTRODUCTION

The rapid global SCAR-CoV-2 outbreak caused a medical equipment shortage. Testing capacity has been severely limited due to a worldwide lack of mouth masks and mechanical ventilators. As an outcome, suspected patients and healthcare workers were given first priority for testing. However, in order to effectively contain the pandemic, thorough testing and diagnostics are critical. Indeed, countries that were able to combine large-scale testing of potentially affected people with extensive citizen surveillance were able to effectively limit the SARSCoV-2 virus. As a result of low testing capacity in most countries, the necessity for and search for alternate approaches to diagnose COVID-19 has grown. Furthermore, the current lab test, reverse transcription polymerase chain reaction (RT-PCR) arrays, is extremely reliant on swab method and placement.

This study addresses a number of issues connected to the development of automatic techniques to assist medical workers in the identification of COVID-19-associated illnesses. In specifically, we describe a novel deep architecture that automatically predicts the pathological scores associated with all frames of a LUS image sequence, based on the COVID-19 LUS scoring system. We additionally show that without pixel-level annotation, the proposed model contains malicious regions in an image that are linked with pathological artefacts.

2. LITERATURE SURVEY

This collection outlines the work of other researchers who are relevant to this research.

1. Xinggang Wang - For COVID-19 classification and lesion localisation, a weakly-supervised deep learning framework was created utilising 3D CT volumes. A pre-trained UNet was used to segment the lung region for each patient,

and the segmented 3D lung region was input into a 3D deep neural network to predict the infectiousness of COVID-19. Combining the activation regions in the classification network with the unsupervised connected components, the COVID-19 lesions are identified.

2. Deng-Ping Fen, Tao-Zhao - Automated detection of lung infections from computed tomography (CT) scans, as shown in this work, has a lot of promise for supplementing the traditional healthcare strategy for combating COVID-19. However, there are significant hurdles to segmenting infected regions from CT slices, including considerable variance in infection features and low intensity contrast between infections and normal tissues. Furthermore, collecting a huge amount of data in a short period of time is impracticable, preventing the training of a deep model. A unique COVID-19 Lung Infection Segmentation Deep Network (Inf-Net) is suggested to automatically identify infected regions from chest CT slices to overcome these problems.

3. Yifan Peng - The COVID-19 epidemic is the most recent hazard to global health. Despite the existence of vast datasets of chest X-rays (CXR) and computed tomography (CT) scans, there are currently few COVID-19 image collections available due to patient privacy concerns. Simultaneously, the number of COVID-19-related studies in the biomedical literature is rapidly increasing, including those that report findings on radiography COVID-19-CT-CXR consists of a peer receives of COVID-19 pictures CXR and CT deposited directly as from PubMed Central Open Access articles (PMC-OA) subgroup COVID-19-CT-CXR. Figures, captions, and pertinent figure descriptions were retrieved from the paper, and compound figures were divided into subfigures. We created a deep-learning model to differentiate CXR and CT figures from other figure types and classify them accordingly because they make up a substantial component of COVID-19 articles.

4. Rayan Yixiang Wang - In this research, Based on people's genes, a quantitative model is being developed to predict their vulnerability to COVID-19. Identifying those who are susceptible to COVID-19 infections is critical to halting the virus's spread. Researchers have previously discovered that people with comorbid disorders had a higher risk of becoming infected with COVID-19 and acquiring more severe COVID-19 symptoms. However, these patterns can only be discovered by correlational analysis of patient characteristics and COVID-19 infection severity.

5. S. Tabik - Deep learning neural networks have a lot of promise for developing COVID-19 triage systems and recognising COVID-19 patients, especially those with mild symptoms. Unfortunately, because present datasets are highly varied and biassed towards severe instances, such systems cannot be built. There are three parts to this article: (i) The high sensitivities achieved by the most recent COVID-19 classification models are decoded, (ii) We created COVIDGR-1.0, a homogeneous and balanced database that contains all levels of severity, from normal with Positive RT-PCR through Mild, Moderate, and Severe, in close collaboration with Hospital Universitario Clnico San Cecilio, Granada, Spain. COVIDGR-1.0 comprises 426 PA (PosteroAnterior) CXR views, 426 positive and 426 negative and (iii) For increasing the generalisation capacity of COVID-classification models, we propose the COVID Smart Data based Network (COVID-SDNet) methodology.

6. Henderi - The goal of this research is to develop a model decision support system for diagnosing patients who have been exposed to Covid-19, such as those in charge, patients under supervision, and those who have tested positive for the virus. The creation of a model decision support system intends to provide information regarding the progression of COVID-19 and to assist the community in self-diagnosing COVID-19 infection. The authors of this study apply the forward

chaining method to derive conclusions from the Covid-19 symptoms.

3. HOPFIELD NEURAL NETWORK:

A Hopfield neural network is a type of artificial neural network that is unique. It represents a form of memory known as associative or content addressable memory. This means that the memory content is not accessed via a memory address, but rather that the network responds to an input pattern with the most similar stored pattern. The Hopfield network can be mathematically examined.

The Hopfield network's units are binary threshold units, which means they can only have two states: on or off. The value is decided by whether or not the unit's input exceeds its threshold. The relationships between binary (firing or not-firing) neurons are described by discrete Hopfield nets. The state of a neural network is characterised by a vector that records which neurons are firing in a binary word of N bits at a given time.

The input and output patterns of a Hopfield network that operates in a discrete line form, or in other words, the input and output patterns are discrete vectors, which can be binary 0,10,1 or bipolar +1,1+1,1. The network's weights are symmetrical, and there are no self-connections, hence wij = wji and wii = 0.

4. ALGORITHM

Case 1 − Binary input patterns

For a set of binary patterns **s** p, **p = 1 to P**
Here, **s** p = **s₁** p, **s₂** p,..., **sᵢ** p,..., **sₙ** p

Weight Matrix is given by

$$w_{ij} = \sum_{p=1}^{P}[2s_i(p) - 1][2s_j(p) - 1] \quad for\, i \neq j$$

Case 2 − Bipolar input patterns

For a set of binary patterns **s** p, **p = 1 to P**
Here, **s** p = **s₁** p, **s₂** p,..., **sᵢ** p,..., **sₙ** p

Weight Matrix is given by

$$w_{ij} = \sum_{p=1}^{P}[s_i(p)][s_j(p)] \quad for\, i \neq j$$

4.1. ENERGY FUNCTION EVALUATION

An energy function is a bonded and non-increasing function of the system's state.

The stability of a discrete Hopfield network is determined by the energy function Ef, also known as the Lyapunov function, which is defined as follows:

$$E_f = -\frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} y_i y_j w_{ij} - \sum_{i=1}^{n} x_i y_i + \sum_{i=1}^{n} \theta_i y_i$$

Condition - When the state of a node changes in a stable network, the aforementioned energy function decreases.

Suppose when node **i** has changed state from $y_i^{(k)}$ to $y_i^{(k+1)}$ then the Energy change ΔE_f is given by the following relation.

$$\Delta E_f = E_f(y_i^{(k+1)}) - E_f(y_i^{(k)})$$

$$= -\left(\sum_{j=1}^{n} w_{ij} y_i^{(k)} + x_i - \theta_i\right)(y_i^{(k+1)} - y_i^{(k)})$$

$$= -(net_i)\Delta y_i$$

Here $\Delta y_i = y_i^{(k+1)} - y_i^{(k)}$

The energy change is due to the fact that only one unit at a time may update its activation.

5. MATERIALS AND METHODOLOGY:

DL has proven to be effective in a variety of computer vision applications, including object recognition and detection as well as semantic segmentation. As a result of these achievements, DL has recently become more widely employed in medical applications, such as biomedical picture segmentation and pneumonia identification from chest X-rays. These key papers show that, with the availability of data, DL can help with and automate preliminary diagnosis, which are extremely important in the medical sector.

1. DATA SETS:

- Covid positive samples from https://github.com/ieee8023/covid-chestxray-dataset

- Normal chest x-ray samples sampling from kaggle chest x-ray dataset https://www.kaggle.com/paultimothymooney/chest-xray-pneumonia

Reasoning :
why is it positive?
Where is the infected region located?
What is the confidence that is positive?

2. METHODOLOGIES:

A Hopfield neural network learning approach is provided for efficiently handling combinatorial optimization issues. The learning approach modifies the energy function's constraint term and cost term to keep the Hopfield network updated in a gradient descent energy direction.

Hopfield Neural Network (HNN) is a type of neural network that combines cyclic and recursive features with storage and binary systems. John Hopfield invented it in 1982. The key to determining the weight of a Hopfield neural network is to do so under stable conditions. There are two forms of Hopfield neural networks: discrete and continuous. The activation function is the main distinction.

The Hopfield Neural Network (HNN) is a model for human memory simulation. Machine learning, associative memory, pattern recognition, efficient calculation, VLSI, and parallel implementation of optical devices are just a few of the artificial intelligence applications.

6. RESULT AND DISCUSSION

We've split the dataset into two halves, one for training and the other for testing. Where the training set accounts for 80% of the data and the testing set accounts for 20%. The dataset's original COVID positive values are 266 (more than 34.77 percent), while its COVID negative values are 499 (more than 65.23 percent). Training COVID positive Values in the dataset are 222, which is over 36.27 percent, and Training COVID negative Values in the dataset are 390, which is over 63.73 percent, according to the dataset. There are 44 Test positive Values in the dataset, which is over 28.76 percent, and 109 Test negative Values, which is over 71.24 percent. For this, we used a hopfield neural network model with a best alpha of Alpha = 0.001 and an accuracy of over 83.66 percent.

7. CONCLUSION

In this work, we argue that early diagnosis is critical for both the patient's treatment and the prevention of transmission. Chest x-ray images from Covid-19 and non-Covid-19 individuals were used for this study. Hopfield neural networks, a deep learning technique, is used to categorize these photos. It can aid in clinical practise because the classification accuracy is calculated with a high accuracy rate of 83.66 percent. Furthermore, despite the size of the data collection, it is divided into two groups: positive and negative data sets. The accuracy rate of Hopfield neural network approaches is the topic of the performance examination.

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