جمهورية العراق

وزارة التعليم العالي والبحث العلمي

جامعة ديالى

كلية العلوم

قسم علوم الحاسوب

تصنيف مرض فايروس كورونا باستخدام نموذج التعليم العميق التجميعي المتنقل

رسالة مقدمة الى قسم علوم الحاسوب – كلية العلوم – جامعة ديالى كجزء من متطلبات نيل درجة الماجستير في إختصاص علوم الحاسوب

من قبل

ميسم علوان حسون

وبإشرف

أ.د. طه محمد حسن

1445هـ 2023م

CHAPTER ONE

GENERAL INTRODUCTION

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1.1 Introduction

The appearance of COVID-19, a novel coronavirus, stunned the whole globe. The virus has infected more than 500 million people globally, according to the World Meters report [1]. Due to the contagiousness of the virus and inadequate available treatments, the quick detection of an infected individual is crucial to halting the spread of the coronavirus [2]. The main way to spot an infected person is by their symptoms which point to a health issue in the sufferer. An infected person may exhibit symptoms like as fever, coughing, breathing difficulties, diarrhea, and a sore throat. On the other hand, not everyone with COVID-19 will have symptoms [3]. Therefore, it is quite difficult to identify someone who is affected. The health systems of several developed nations have been devastated by the huge increase in people afflicted by the corona. Ventilators and corona testing kits are in short supply in these countries. Therefore, in an effort to stop the spread of the coronavirus and protect their people, several countries have proclaimed a state of emergency. Patient screening is important for isolation and treatment in addition to enforcing lockdown. Polymerase chain reaction (PCR), a widely used technique, is used to detect coronavirus-infection in patients [4].

Results from the PCR, which uses clinical samples from patients, may be acquired in a few hours to two days. Due to PCR's limited sensitivity and lack of kits, studies indicate that it is less prone than other testing methods to produce false negatives [5]. Chest scans can be helpful for COVID-19 identification, according to studies reported in [6]. As a result, chest methods may be used to detect and identify coronavirus-infection in COVID patients. Two common radiologic procedures are the chest X-ray and the chest CT scan. Due to the uncomplicated accessibility of X-ray devices at hospitals and the patients' low exposure to ionizing radiation, the chest X-ray may be favored over the chest CT scan [7].

Chest X-rays must be examined by a radiological professional in order to recognize COVID-19 imaging patterns. When using deep learning (DL) models to identify positive occurrences in CT scan and X-ray images, CT scan performed better. This CT scan technique offers greater contrast compared to chest X-rays and comprehensive quality pictures, enabling models to accurately determine the CT for patients from the data [8]. DL methods offer a strong and reliable model for identifying various ailments in medical imaging. DL methods do not need user input since they extract attributes from a given picture [9].

Researchers employed transfer learning models to obtain optimum performance quicker than expected since traditional machine learning methods have to be trained from the bottom up, which is computationally expensive and requires a vast amount of data to achieve excellent performance [10]. It is for this reason that models that incorporate data (features, weights, etc.) from systems that have already undergone training already possess a functional comprehension of the features. It expedites neural network training compared to starting from scratch [11]. In the realm of handling diverse training and test data, innovative strategies such as TL-Transfer learning and ensemble learning have emerged as effective solutions. These approaches aim to fully leverage the valuable information present in both the initial and target domains to train an intelligent learner. To achieve this, ensemble techniques play a crucial role in transforming and combining the initial and desired data, ensuring that the pertinent knowledge from both domains is effectively utilized. By embracing these cutting-edge methodologies, the goal of training a highly capable and adaptable learner becomes achievable [12].

1.2 Related Work

Recently, and since the outbreak of the pandemic, many researchers have been working to diagnose the Coronavirus through a CT scan of the infected lung. The section below illustrates some of the previous studies that used different techniques to develop Coronavirus classification systems.

- **N. Gianchandani, et al. 2020 [13],** presented ensemble models for the identification of COVID-19 from chest X-ray images using deep convolutional neural networks. Considered are DenseNet201, ResNet152V2, Inception-ResNetV2, and VGG16. The suggested approach may identify COVID-19 infection in both infected and non-infected individuals, including those with viral and bacterial pneumonia. Two well-known dataset are used to test the suggested models. The Kaggle datasets repository is where the initial dataset was found. Researchers from Qatar University and the University of Dhaka, together with colleagues and medical professionals, produced the second dataset. For the three-class classification and binary classification, they got an accuracy of 99.21% and 96.15 %, respectively.
- **P. Gifani et al. (2020) [14],** EfficientNets (B0, B1, B2, B3, B4, B5), NasNetLarge , NasNetMobile , InceptionV3, ResNet-50, SeResnet-50, Xception, DenseNet121, ResNext50, and Inception_resnet_v2 are among the 15 pre-trained CNNs- convolutional neural networks designs utilized in the approaches. They used a dataset of CT scans that was made available to the public, which included 349 images that were identified as COVID-19 positive as well as 397 scans that were COVID-19 negative but either healthy or had a range of lung conditions. The results of the experiments show that the five deep transfer learning architectures (EfficientNetB0, EfficientNetB3, EfficientNetB5, Inception_resnet_v2, and Xception) can be combined into a

majority voting system that outperforms the results of any of the models used alone. When applied to the diagnosis of COVID-19 using CT scans, the majority voting method improves upon previous methods in terms of precision (0.857), recall (0.854), and accuracy (0.85).

- **A. Mishra et al. (2020) [15]**, investigated many Deep CNN-based methods for identifying COVID-19 in chest CT scans. 360 COVID-19 positive patients and 397 negative-chest computed tomographic scans make up the COVID-CT dataset. The image came from the bioRxiv and medRxiv databases. The use of a decision fusion-based strategy, which integrates predictions from many separate models to create a single final forecast, is also suggested. VGG16, InceptionV3, ResNet50, DenseNet121, and DenseNet201 are some examples of these baseline models. The suggested decision fusion model surpasses the individual models, according to experimental data, with the greatest average accuracy, AUC, and F1-Score values of 0.8834, 0.8832, and 0.867, respectively. DenseNet121 performs the best among the separate models, which may be extremely useful for performing quick testing for COVID-19.
- **Z. Huang et al. (2020) [16],** This research proposed FaNet, a dual-task network based on deep learning (DL) that can swiftly detect and assess the severity of COVID-19 based on a variety of 3D -CT imaging and clinical symptoms. Greater spatial features are often available from 3D-CT imaging sequences than from individual CT images. Additionally, to improve assessment accuracy, the clinical symptoms, which radiologists often have quick and simple access to can be used as background information. As a consequence, experiments were conducted on 416 patient records, including 207 normal chest CT cases and 209 COVID-19 validated ones, using a network designed to include both CT image data and pre-existing clinical

symptom information. For test datasets, the proposed FaNet has a diagnostic evaluation accuracy of 98.28% and a severity assessment accuracy of 94.83%.

- **X. Wang. And et al. (2020) [17],** A weakly-supervised deep learning for COVID-19 categorization, a framework was created utilizing 3D CT volume and lesion localization. For each patient, the lung region was segmented using a pre-trained UNet; and then the segmented 3D lung region was fed into a 3D deep neural network to predict the probability of COVID-19 infectious; the COVID-19 lesions are localized by combining the activation regions in the classification network and the unsupervised connected components. 499 CT volumes were used for training, and 131 CT volumes were used for testing. The algorithm obtained a 0.959 ROC AUC, and a 0.976 PR AUC. When using a probability threshold of 0.5 to classify COVID-positive and COVID-negative, the algorithm obtained an accuracy of 0.901, a positive predictive value of 0.840, and a very high negative predictive value of 0.982.
- **J. Cruz (2021) [18],** introduces a framework that utilizes ensemble methods and two-phase TL for recognizing COVID-19 cases based on CT- scan images. A total of six pre-trained CNNs in ImageNet, including VGG16, ResNet50, Wide ResNet50-2, DenseNet161, DenseNet169, and Inception v3, were used to achieve a competitive performance. The dataset's authors collected 746 CT scan image from 760 preprints on medRxiv and bioRxiv that included 349 COVID-19 positives and 397 COVID-19 negatives. With an accuracy of around 86.70%, an F1 score of about 85.86%, and an AUC of about 90.82%, the recommended model proved its value in assisting radiologists in the diagnosis of COVID-19.
- **M. Kamil (2021) [10]**, adjusted a DL model to extract characteristics from chest X-ray and CT images for Covid-19 identification. After applying and comparing many transfer-learning models, a VGG-19 model was customized

to provide the greatest results for use in illness detection. The dataset of 1000 images was used to evaluate the diagnostic performance of all models. The model with the best accuracy (99%), sensitivity (97.4%), and specificity (99.4%) was the VGG-19. Superior performance in early Covid-19 identification was shown via (DL) deep learning and image processing.

- **X. Wu et al. (2021) [19],** introduced an innovative system called COVID-AL, which utilizes CT images and patient-level labeling for the diagnosis of COVID-19. The COVID-AL system incorporates two main components: lung region segmentation performed by a 2D U-Net and COVID-19 diagnosis carried out using a unique hybrid active learning approach. This approach takes into account both sample variability and predicted loss simultaneously. To ensure accurate COVID-19 diagnosis, a specially designed 3D residual network is employed within the COVID-AL system. Extensive evaluation of the system is conducted using a large CT scan dataset sourced from CC-CCII. Remarkably, even with only 30% of the data labeled, the COVID-AL system achieves over 95% accuracy when utilizing deep learning techniques on the entire dataset, showcasing its effectiveness.
- **V. Shah, et al. (2021) [20],** proposed manuscript focuses on differentiating the CT scan images of COVID-19 and non-COVID 19 CT using different deep learning techniques, and CT scan dataset about covid-19. From a total of 738 CT scan images, 349 images from 216 patients were confirmed to have COVID-19 whereas 463 images were of the non-COVID-19 patients. A self-developed model named CTnet-10 was designed for the COVID-19 diagnosis, having an accuracy of 82.1%. Also, other models that were tested are DenseNet-169, VGG-16, ResNet-50, InceptionV3, and VGG-19. The VGG-19 proved to be superior with an accuracy of 94.52% as compared to all other deep learning models.

- **N. Shaik and T. Cherukuri (2022) [21],** suggested a unique ensemble method for making decisions that combines the power of many deep neural network topologies. Two benchmark CT scan datasets, COVID-CT, which contains 746 images, and SARS-CoV-2, which has 2482 chest CT scan images, are used to test the efficiency of the proposed ensemble classifier. They refine multiple pre-trained models utilizing Lung CT Scan image, including VGG16, VGG19, InceptionV3, ResNet50, ResNet50V2, Inception, ResNetV2, Xception, and MobileNet. A powerful ensemble classifier is built using all of these trained models, and it provides the final prediction. The studies show that the suggested ensemble strategy for identifying COVID-19 infection from lung CT scan pictures is superior, to current ensemble approaches and achieves 93.33 accuracy.

Table (1.1) provides a comprehensive summary of previous studies, highlighting various parameters that facilitate a clear understanding of the techniques, methodologies, and results employed. This table serves as a valuable resource for easily comprehending the key aspects of the prior research endeavors.

Table (1.1) Summary of the Previous Work

References	year	Datasets	Algorithms	Samples	Accuracy
N. Gianchandani, et al.[13]	2020	chest X-rays two datasets	Ensemble transfer models	----	96.51 for binary class 99.21 for three class
P. Gifani et al.[14]	2020	CT scans	5 Deep Transfer Learning Architecture	746 CT scan	85%

A. Mishra et al. [15]	2020	CT scans medRxiv and bioRxiv	5 CNN, DenseNet121 the best accuracy	737 CT scan	88.34%
Z. Huang et al.[16]	2020	3D- CT image And “clinical symptoms”	Fa-Net	349 CT scan image	98.28%
X. Wang. and et al.[17]	2020	3D CT scan	3D DNN	630 CT scan	90.1%
J. Cruz [18]	2021	CT scan	ensemble methods and two-phase Transfer Learning	760	86.7%
M. Kamil [10]	2021	X-ray and CT images	VGG-19	977 X-ray 23 CT scan Total =1000 images	99%
X.Wu et al. [19]	2021	CC-CCII CT scan	3D Residual network	---	Over 95%
V. Shah, et al. [20]	2021	CT Scan Image	CTnet-10 The best accuracy VGG19		94.52%
N. Shaik and T. Cherukuri [21]	2022	SARS-CoV-2 and COVID-CT are two standard CT scan datasets.	Ensemble Approach	2482 746	93.33 %

1.3 Problem Statement

The COVID-19 disease rapidly spread worldwide in early 2019, and reports from hospitals indicated the limited sensitivity of RT-PCR tests in detecting infections during the early stages. The emergence of the Coronavirus had a profound impact on various aspects of life, including the economy, education, and transportation. This led to a global lockdown, resulting in a significant number of fatalities within a short timeframe across the globe.

Given these circumstances, there is a critical need for efficient diagnostic mechanisms that can swiftly identify this disease, allowing for timely containment and treatment of patients before the virus progresses within their bodies. In this regard, leveraging CT images and employing ensemble deep transfer learning algorithms, along with preprocessing techniques designed specifically for CT scan images, become crucial.

1.4 The Aim of this Thesis

The primary aim of this thesis is to develop a robust and fast model for the accurate diagnosis of Covid-19 using CT scan images. This will be achieved by leveraging the power of ensemble and transfer learning techniques, which involve utilizing pre-trained models.

- Using several filters to enhance the performance of these models through various methods.
- Using the pre-trained models (Transfer Learning) to achieve the highest level of accuracy in Covid-19 classification.
- Combine the decisions from these models to obtain the most reliable and accurate classification.
- Using a local dataset (Iraq-CoV) to boost and improve the system performance.

1.5 Outlines of this Thesis

Following are how the remaining chapters of this thesis are arranged

Chapter 2: Theoretical Background

The theoretical underpinnings of the methodologies employed to diagnose Covid-19 utilizing the CT scan images presented in this thesis are made clear in this chapter.

Chapter 3: The Proposed System

The suggested diagnostic system, including its design and implementation, is covered in this chapter.

Chapter 4: Research Results and Evaluation

This chapter presents and assesses the implementation outcomes of the suggested system stages.

Chapter 5: Conclusions and Future Work

The findings of this effort are presented in this chapter. It also offers recommendations for further research.

الخلاصة

صنفت منظمة الصحة العالمية(WHO) المرض الذي تم اكتشافه مؤخرًا COVID-19 بأنه تع7للاا جائحة. يعد اكتشاف COVID-19 في مرحلة مبكرة أمرًا حيويًا للسيطرة الفعالة على الوباء الناتج. يعد نموذج التعلم العميق للمجموعة أمراً حاسمًا في تصنيف حالات COVID-19 من خلال الجمع بين شبكات عصبية متعددة وتحسين الدقة. نهجها المتكامل يقلل من سوء التصنيف ، ويوفر فهمًا شاملاً للمرض مما يساعد المتخصصين في الرعاية الصحية في اتخاذ قرارات مستنيرة.

تقدم هذه الأطروحة كفاءة وفعالية النظام المعتمد على التعلم العميق التجميعي المتنقل لتشخيص كوفيد -19 (EDTLSD-COVID19) باستخدام صور التصوير المقطعي المحوسب على الصدر (CT Scan). يركز النظام على التصنيف المبكر والدقيق للفئات الثنائية. يتكون EDTLSD-COVID19 من عدة مراحل ، بما في ذلك تحميل مجموعة البيانات والمعالجة المسبقة للصور Gaussian Filter و Median Filter و Average Blur و Brightness Multiplication و Affine Transformation) ، وزيادة الصورة ، والتعلم التلوي من المستوى الأول باستخدام خوارزميات تعلم النقل (VGG16، VGG19، ResNet-50) ، واقترح إصدار NCNN. كما يتضمن أيضًا التعلم التلوي من المستوى الثاني للتحكم في الوزن من خلال Dirichlet Ensemble والتعلم التلوي من المستوى الثالث من أجل التصنيف الأمثل باستخدام نموذج الانحدار اللوجستي.

يستخدم EDTLSD-COVID19 المقترح مجموعة البيانات المتاحة للجمهور SARS-CoV-2 للتجريب واختبار النظام. مع حقبة تدريب 200 ، يحقق النظام معدل دقة مذهل يقارب 100٪.فننننننننننن علاوة على ذلك ، يُظهر النظام أداءً استثنائيًا عبر مقاييس مختلفة مثل precession وspecificity وrecall وScore F1 ، مما يدل على قدرته على تحقيق القيم المثلى.

أظهر EDTLSD-COVID19 المقترح الدقة المثلى عند اختباره على مجموعة بيانات محلية تم الحصول عليها من مستشفى اليرموك ومستشفى بعقوبة العامة (Iraqi-CoV) والتي تتضمن (699) عينة. تؤكد هذه النتائج الممتازة على قابلية تطبيق النظام في بيئات الرعاية الصحية ، مما يجعلها أداة قيمة لمساعدة المتخصصين في الرعاية الصحية بدقة لا تشوبها شائبة في إدارة وتشخيص حالات COVID-19.

تفوق نظام EDTLSD-COVID19 المقترح في الأداء على الأعمال ذات الصلة من حيث الدقة ، حيث حقق 99,99٪ مع مجموعة بيانات SARS-CoV-2 ودقة 100٪ مع مجموعة بيانات أشعة مقطعية محلية (Iraq-CoV).