Deep Learning in Classification of Covid-19 Coronavirus, Pneumonia and Healthy Lungs on CXR and CT Images

Subtitle Biomedical Engineering

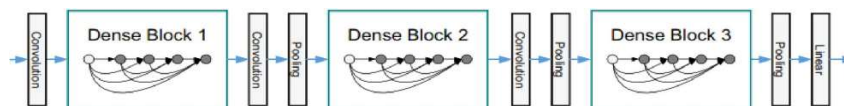Prof. Habil. Dr. Eng Mihaela Ruxandra LASCU
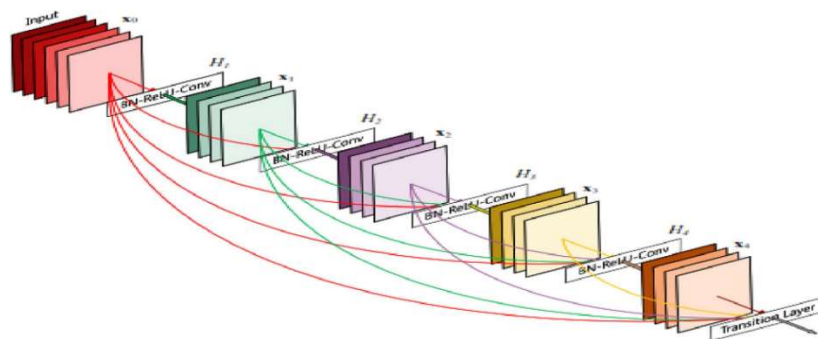
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Fig.1   DenseNet architecture with three blocks

Fig. 2   DenseNet classic architecture

COVID-19

Abstract

COVID-19 identification is a difficult assignment that constantly demands a careful analysis of a patient's clinical images, as COVID-19 is found to be very alike to pneumonic viral lung infection. In the paper, a transfer learning model to accelerate prediction processes and to assist medical professionals is proposed. Finally, the main purpose is to do an accurate classification between Covid-19, pneumonia and healthy lungs using CXR and CT images. This research is interdisciplinary where technology merges with medicine, having a practical impact on everyday life.

KEY TERMS

Transfer Learning: Utilizes existing models to save time and resources.

Image Preprocessing: Enhances image quality for better analysis.

Haralick Features: Extracts important texture information from images.

**Neural Network**: Uses ResNet-101 for high accuracy in classification.

Practical Application: Assists in the rapid diagnosis of COVID-19, aiding in better pandemic management.

Introduction

The aim of this study is better identification of COVID-19, in this sense the transfer learning method has been implemented to chest X-ray (CXR) and computed tomography (CT) bio-images of diverse kinds of lungs maladies, including CORONAVIRUS 2019 (COVID-19). CORONAVIRUS 2019 disease (COVID-19) is caused by severe acute respiratory syndrome coronavirus 2 (SAR- SCoV-2). Due to the very infectious character, deficiency of proper treatment, fast detection of COVID-19 is growing essential to hinder the significant spread and to smooth the trajectory for the appropriated designation of finite clinical assets.

Consequently, the deep learning (DL) strategies of chest CXR and CT for COVID-19 classification have been conscientiously explored. In an open-source convolutional neural network platform named COVID-Net is proposed and adapted for COVID-19 cases recognition in CXR and CT images. COVID-Net can obtain good sensitivity for COVID-19 cases with a sensitivity of 80%.

In this paper, deep convolutional neural networks (DCNN) are evaluated for diagnosing COVID-19
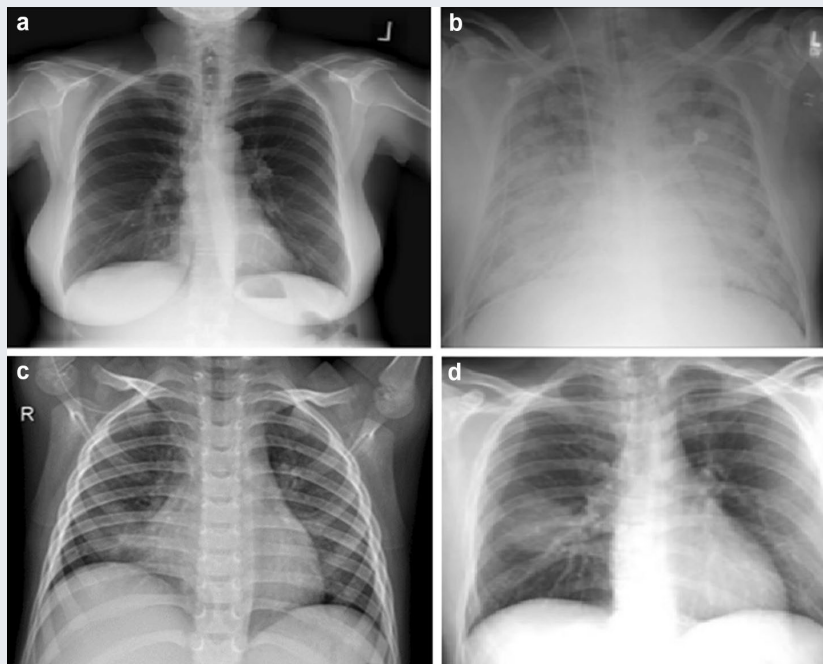
4 F i g . **a** Normal, **b** lung opacity, **c** viral pneumonia, **d** COVID-19

Methods

-Preprocessing images to enhance their quality.

-Segmenting lung images to focus on the areas of interest.

-Extracting features from these segmented images using a method called Haralick texture features.

-Using these features to train a neural network to classify the images into one of four categories: normal, lung opacity, viral pneumonia, and COVID-19.

Learning transfer gives the possibility to find out about this new illness COVID-19, using the knowledge we have about the pneumonia virus. This demonstrates the apprehensiveness achieved from a new architecture trained to detect virus related pneumonia that must be transferred for COVID-19 detection. Transfer learning presents a considerable dissimilarity in results when compared to the result of traditional groupings. It is not necessary to create a separate model for the classification of COVID-19. This simplifies complicated issues by adopting the available model for COVID-19 determination. Automated diagnosis of COVID-19 using **Haralick texture** features is focused on segmented lung images and problematic lung patches. Lung patches are necessary for the augmentation of COVID-19 image data. In this way, Prof. Lascu did not need to create a new model from scratch, which saved time and resources.

Women in STEM - Facts about the author.

Mihaela Ruxandra LASCU is Professor Habil. Dr. Engineer at Politehnica University Timişoara, Romania, Electronics and Telecommunications Faculty. For more than 24 years, she has been teaching courses in the fields of Virtual instrumentation, LabVIEW, MATLAB, Data Acquisition, Graphical programming, Sensors and actuators, Biomedical signal processing, Biomedical instrumentation. She led or was a member of more than 30 research projects carried out at national and international level. She is also involved in teaching quality assurance, study programs accreditation. She has published 7 technical books and more than 100 papers on her fields of interest. She was visiting professor at Berufsakademie Lörrach, Germany and at the University Institute of Technology IUT Angers, France. Prof. Lascu is ISETC, AECE, ELSEVIER, WSEAS reviewer and WSEAS conferences member in scientific committees. She is a Member of the Association for Electromagnetic Compatibility from Romania; member of the National Society of Medical Engineering and Biological Technology from Romania; IEEE Member - The Institute of Electrical and Electronics Engineers, Inc., New York, USA; IEEE Engineering in Medicine and Biology Society. Prof. Lascu was rewarded with a Diploma of excellence in 2006 for outstanding results in scientific research and Diploma FLUKE Metrology Akademie.

Results

The model showed high accuracy in distinguishing between healthy lungs, pneumonia, and COVID-19. It used a neural network architecture called ResNet-101, which is effective for image classification tasks.

Research ensures accurate classification between Covid-19, pneumonia and healthy lungs using CXR and CT images by using transfer learning methods. On the other hand, it demonstrates the importance of research in saving patients' lives by establishing a quick diagnosis and appropriate treatment.

Discussion

What is Covid 19?

What represents the transfer learning method?

Why did the research use a large amount of CXR and CT data

What is the importance in day-by-day life of the research results.

Conclusion

The results suggest that the implemented model is improved considering other existing models because the accuracy obtained is over the recently obtained results. The results obtained have been presented and visualized in a comprehensive way taking into consideration the demanding problems that are discouraging in this domain. The Coronavirus 2019 recognition architecture has thrived using incorporated data from multiple sources. This virus infection has been detected by examining peculiar characteristics found in the bio images studied. If the viral infection is detected earlier, lives will be saved. The obtained outcomes are quite reliable for all distinctive processes as the proposed architecture can detect healthy lungs, viral pneumonia, and COVID-19. It is believed that the new architecture that is implemented in this study, delivers a petite step in building refined Coronavirus 2019 diagnosis architecture using CXR and CT bio-images.
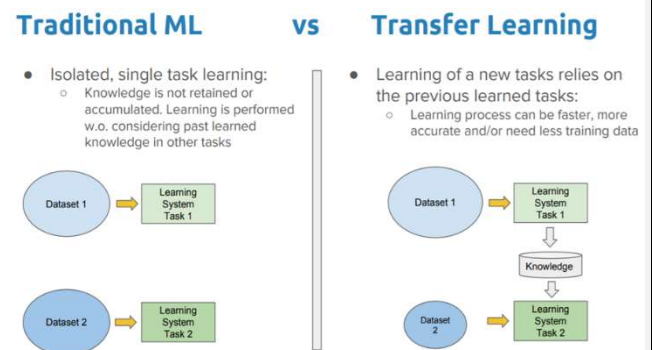
Resources:

Reference the original article:
https://doi.org/10.1007/s40846-021-00630-2
-Publish in Journal of Medical and Biological Engineering (2021) 41:514–522

Any other resources that will help understanding (articles, videos, podcasts etc):

- TV Reportaj: Cum arată plămânii bolnavilor de COVID-19. Pot fi afectați chiar și pacienții fără simptome https://www.digi24.ro/stiri/actualitate/sanatate/video-cum-arata-plamanii-bolnavilor-de-covid-19-pot-fi-afectati-chiar-si-pacientii-fara-simptome-1358414
- Video animation: Coronavirus Animation: High Impact Demonstrates How COVID-19 Impacts the Body https://www.youtube.com/watch?v=78jLBNSqc3g
- Video animation: What happens if you get Coronavirus https://www.youtube.com/watch?v=5DGwOJXSxqg
- Video animation: Global COVID 19 Prevention https://www.youtube.com/watch?v=rAj38E7vrS8
- Perumal, V., Narayanan, V., & Rajasekar, S. J. S. (2020). Detec- tion of COVID-19 using CXR and CT images using transfer learning and Haralick features. *Applied Intelligence*. https://doi.org/10.1007/s10489-020-01831-z
- El Asnaoui, K., & Chawki, Y. (2020). Using X-ray images and deep learning for automated detection of coronavirus disease. *Journal of Biomolecular Structure and Dynamics*. https://doi.org/10.1080/07391102.2020.1767212

Traditional ML vs **Transfer Learning**

- Isolated, single task learning:
  - Knowledge is not retained or accumulated. Learning is performed w.o. considering past learned knowledge in other tasks

- Learning of a new tasks relies on the previous learned tasks:
  - Learning process can be faster, more accurate and/or need less training data

Reflection Questions:

1.What is COVID 19?

a) CORONAVIRUS 2019 disease (COVID-19) is caused by severe acute respiratory syndrome coronavirus 2 (SAR- SCoV-2).

b) COVID 19 is a bacteria coming from cats.

c) COVID 19 is a virus coming from monkeys

Answer: a) COVID 19 is caused by a coronavirus 2(SAR- SCoV-2).

2.Where did Prof. Lascu get the large amounts of data used in the research?

a) extract lung contour from the CXR and CT lung images.

b) extract lung contour from the NMR (Nuclear Magnetic Resonance) images.

c) extract lung contour from photographs.

Answer: a) extract lung contour from the CXR and CT lung images

3. What represents the transfer learning method?

a) learning by doing

b) learning from experience

c) learning a new task relies on the previous learned tasks.

Answer: c) learning of a new task relies on the previous learned tasks.

4. What is the importance in day-by-day life of the research results?

a) can help medical professionals quickly and accurately diagnose COVID-19 from CXR and CT images.

b) ensure better management of the pandemic.

c) better life

Answer: a) can help medical professionals quickly and accurately diagnose COVID-19 and b) better management of the pandemic.
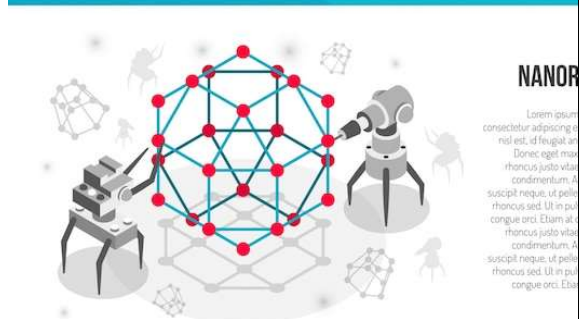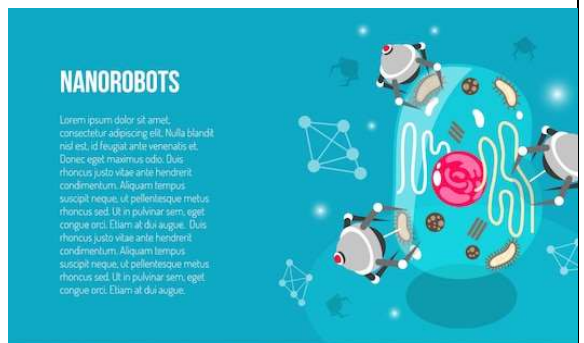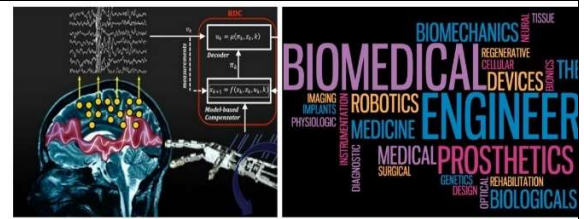
Lesson Plan Title:

Deep Learning in Classification of Covid-19 Coronavirus, Pneumonia and Healthy Lungs on CXR and CT Images

Objectives:

- Students will understand the basics of deep learning and how it is applied in medical image classification, specifically in distinguishing between COVID-19, pneumonia, and healthy lungs using chest X-ray (CXR) and computed tomography (CT) images.

- Students will understand the importance of research in saving patients' lives by establishing a rapid diagnosis and appropriate treatment.

- To increase students' interest in Biomedical Engineering.

Materials:

- Project handout - communication documents.

- Computer with internet access and projector

- Presentation slides (prepared in advance)

- Handouts summarizing key points from the paper

- Whiteboard and markers

- Video animations about COVID 19.

Background Information:

This virus was identified for the first time given in humans in December 2019 in Wuhan, China. The World Health Organization (WHO) declared the outbreak of a public health emergency of international concern on 30 January 2020 and a pandemic on 11 March 2020. By 4 March 2023, the pandemic had caused more than 680 million cases and 6.8 million confirmed deaths, being one of the deadliest in history. The severity of the symptoms of those who get sick with COVID-19 varies greatly from one person to another. Elderly people suffering from other diseases are more prone to severe forms or that endanger their lives, however COVID-19 can have negative effects on anyone's health regardless of age.

Apart from the impact on people's physical health, the COVID 19 pandemic had multiple consequences on mental health, human relationships, economic and social development in general. Another reason not to neglect this disease is that we are still learning the best ways to treat people who have COVID-19. In this context, the research carried out by Prof. Mihaela LASCU contributes to a faster and better diagnosis of the disease.

Introduction (10 minutes)

- Greeting and Attendance (2 minutes)

- Hook (5 minutes):

- Show a short video clip or image of a chest X-ray and ask students what they think it shows.

- Ask what were the effects that the students felt during the pandemic?

- Objective Overview (3 minutes):

- Explain the objective of the lesson: to learn how deep learning helps in diagnosing diseases from medical images

Background Information (10 minutes)

- What is Deep Learning? (5 minutes)

- Briefly explain deep learning and neural networks using simple terms.

- Show a diagram of a neural network.

- Medical Imaging (5 minutes)

- Explain what CXR and CT images are and why they are important in diagnosing lung diseases.

- Discuss the challenges in distinguishing between COVID-19 and pneumonia from these images

Main Content (25 minutes)

- Transfer Learning (10 minutes):

- Explain the concept of transfer learning and how it saves time and resources.

- Use an analogy, such as learning to ride a bike before learning to ride a motorcycle.

- The Study's Method (10 minutes):

  - Describe the steps taken by the researchers:

    - Preprocessing images

    - Segmenting lung areas

    - Extracting Haralick texture features

    - Training the neural network

    - Show visual aids for each step.

Results and Importance (5 minutes)

- Discuss the accuracy of the model and its practical applications.

- Emphasize how this technology can help doctors diagnose COVID-19 quickly and accurately.

Activity (10 minutes)

- Group Discussion (5 minutes):

  - Divide students into small groups and give them a handout with questions to discuss:

    - How does deep learning help in medical fields?

    - What are the benefits and potential challenges of using AI in healthcare?

- Share and Reflect (5 minutes):

  - Groups share their discussions with the class.

  - Reflect on the importance of interdisciplinary knowledge (biology and computer science).

Conclusion (5 minutes)

- Recap Key Points (3 minutes)

  - Summarize the main points of the lesson.

- Q&A (2 minutes)

  - Open the floor for any questions.

Homework Assignment

 - Research Task:

   - Ask students to find another application of deep learning in healthcare and write a short paragraph about it.

Assessment:

Participation in group discussions.

Responses during Q&A.

Completion of the homework assignment.

Notes:

o   Adjust the complexity of the explanations based on the students' prior knowledge.
o   Ensure that visual aids are clear and easy to understand.
o   Be prepared to provide additional examples or analogies to clarify complex concepts.