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| **An Automated Approach to detect Covid-19 from CT-Scan Images.** |
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| Submitted By: ABC  Registration # xxxx  Project Proposal  30th December 2022 |

[CHAPTER 01 3](#_Toc124788799)

[Abstract: 4](#_Toc124788800)

[Introduction: 4](#_Toc124788801)

1. [Aim & Objectives: 5](#_Toc124788802)
2. [Technical Background: 5](#_Toc124788803)
3. [What is idea behind Machine Learning? 6](#_Toc124788804)
4. [Applications: 7](#_Toc124788805)

[Image and Speech Recognition: 7](#_Toc124788806)

[Natural Language Processing: 7](#_Toc124788807)

[Predictive Analytics: 7](#_Toc124788808)

[Revolutionizing Technology: 7](#_Toc124788809)

1. [Convolutional Neural Networks (CNNs) 8](#_Toc124788810)

[**Evaluation** 9](#_Toc124788811)

[Image Processing As an applicati of CNN: 9](#_Toc124788812)

1. [Foundation of machine learning 11](#_Toc124788813)
2. [Neural Networks: 11](#_Toc124788814)
3. [Data Science : 12](#_Toc124788815)

[Artificial Intelligence: 12](#_Toc124788816)

1. [Deep Learning: 12](#_Toc124788817)
2. [Machine Learning 13](#_Toc124788818)

[Overview: 13](#_Toc124788819)

[Data Mining: 13](#_Toc124788820)

[Theory: 13](#_Toc124788821)

[Limitations: 14](#_Toc124788822)

[Model Assessment: 14](#_Toc124788823)

[Objectives: 17](#_Toc124788824)

[Ethical considerations: 18](#_Toc124788825)

[Pre-processing Overview 19](#_Toc124788826)

1. [Research Contributions 20](#_Toc124788827)
2. [Dataset Used 20](#_Toc124788828)

[Brief Literature Review: 23](#_Toc124788829)

[Deep learning-based diagnosis of COVID-19 (I) 24](#_Toc124788830)

1. [Related Works 25](#_Toc124788831)

[DL for the diagnosis of COVID-19 (II) 27](#_Toc124788832)

1. [Transfer learning 29](#_Toc124788833)
2. [Self-supervised learning 30](#_Toc124788834)

[Workflow: 32](#_Toc124788835)

[Research Methodology: 34](#_Toc124788836)

[Methodology: 34](#_Toc124788837)

[Project Schedule: 38](#_Toc124788838)

[Conclusion and Future Work 41](#_Toc124788839)

[Results: 41](#_Toc124788840)

[Bibliography & References: 43](#_Toc124788841)

# CHAPTER 01

# Abstract:

The COVID-19 pandemic has hit humanity hard in 233 different countries and so far, 6,583,217 people have died and this death toll is still going on (World meter, 2022). The escalating prevalence of COVID-19 and the associated serious casualties are placing severe pressure on the system's woefully inadequate health resources. The inefficiency and lack of testing is a major obstacle to controlling the spread of this disease. Most current tests are based on reverse transcription polymerase chain reaction (RT-PCR). Results take 4-6 hours, which is a long time compared to the rapid spread of COVID-19. In addition to inefficiency, RT-PCR test kits are in short supply. As a result, many infected people are not identified in time and continue to unknowingly infect others.

# Introduction:

The most effective method available for use in the field of medicine is deep learning [10]. It ia quick and effective way for determining the prognosis of many disorders using a high level of accuracy. To categorise the inputs into the many groups that the programmers want, there are models that have been specially trained. They have a variety of uses in medicine, including the diagnosis of cancer, the use of image processing to find malignancies, and the detection of heart issues [11]. Additionally, it is useful to distinguish between COVID-19-infected patients' CT scan results that are positive or negative.

Effective advances are needed to improve clinical productivity in healthcare and to simplify the diagnosis, care, and monitoring of COVID-19. Since it can scale more successfully, process information faster, and actually bypasses humans in some health-related jobs, later research has shown that artificial intelligence may be a promising breakthrough. Using machine learning and deep learning approaches, researchers have been encouraged to identify and classify new strains of COVID-19. This thesis will present a comprehensive study and analysis of the methodology of detection of coronavirus (COVID-19) from CT-Scan images using various deep learning and machine learning techniques.

The proposed method will help the radiologist in deciding on the detection and diagnosis of cases infected with COVID-19 with high accuracy and efficiency in a shorter period of time. We expect that the use of machine learning to predict COVID-19 will reduce the time delay in the diagnosis of medical tests and empower health professionals to provide appropriate medical care to patients. The proposed work will be used to evaluate the most optimal detection and classification technique for COVID-19 in terms of accuracy and real-time detection. The performance of our model will be evaluated based on the confusion matrix and accuracy, sensitivity, and specificity metrics. This project will highlight the limitations of the COVID-19 dataset along with the challenges this work faces and attempt to come up with future research directions.

Key Terms: CNN (Convolutional Neural Networks), CT Scan Image Classification, Covid-19, Chest X-ray, Unsupervised Learning, Transfer Learning

## Aim & Objectives:

This dissertation aims to develop a computer-aided machine learning model that can be used for early diagnosis of COVID-19 from CT scans and X-ray samples, which may be useful for the treatment of COVID-19.

We will be able to use deep learning and machine learning techniques like CNN to effectively classify images in the project, which will be particularly useful in pushing the use of machine learning to solve many of the world's most pressing problems, which is quite significant. This work will serve as a reference for future research work as well as facilitate the design of a structure for a very deep learning model that will facilitate the development of future research.

## Technical Background:

In the current situation, COVID-19 has become a major issue affecting the population of the earth, shutting down various economic classes and numerous problems and challenges affecting everyone. For those who complain of its symptoms, accurate detection and diagnosis of the disease Covid-19 is essential. The researcher for this work found that there is a significant error rate in the diagnosis of the disease. In order to reduce the above percentage of errors, this circumstance must be optimized for the application of machine learning algorithms, especially deep learning.

Much effort has been devoted to finding alternative testing methods to mitigate the inefficiencies and shortages of existing tests for COVID-19.

Several studies have shown that computed tomography (CT) scans reveal clear radiological findings in patients with COVID-19 and hold promise as a more efficient and affordable testing method due to the widespread availability of CT equipment that can rapidly generate results. In addition, it reduces the burden on healthcare professionals when reading CT images, while several studies have developed deep learning methods to automatically interpret CT images and predict whether they are positive for COVID-19. Although these works have produced promising results, they are limited in two ways. First, for privacy reasons, the CT scan datasets used in these works are not publicly available. As a result, their findings cannot be replicated, and the trained models cannot be used in other hospitals.

In addition, the lack of an open source annotated COVID-19 CT dataset severely limits the research and development of more advanced artificial intelligence methods for more accurate CT-based testing of COVID-19. Second, to achieve clinical-level performance, these works require a large CT collection during model training. In practice, such a requirement is strict and many hospitals may not meet it, especially considering that health professionals are overloaded with COVID-19 patients and are unlikely to have time to collect and annotate large numbers of COVID-19 CT scans.

## What is idea behind Machine Learning?

Machine learning is a branch of artificial intelligence that uses algorithms and statistical models to enable computers to learn from data. It is a powerful tool for analysing and predicting behaviour, and has been used in a variety of applications, from medical diagnosis to fraud detection. Machine learning algorithms can be divided into supervised, unsupervised, and reinforcement learning. Supervised learning algorithms are used to predict outcomes based on labelled data, while unsupervised learning algorithms are used to identify patterns and clusters in data. Reinforcement learning algorithms are used to train machines to take specific actions in order to maximize their performance. By leveraging large datasets and powerful algorithms, machine learning has the potential to revolutionize the way we process and understand data.

USELESS DATA --------------------->USEFUL DATA

## Applications:

### Image and Speech Recognition:

Machine learning can be used to recognize and interpret images and speech. This technology can be used to create applications such as facial recognition, voice recognition, and automated transcription. With machine learning, computers can accurately process large amounts of data to identify images and speech patterns with high accuracy.

### Natural Language Processing:

Natural language processing (NLP) is the ability of machines to understand and interpret human language. Machine learning can be used to create applications such as automated customer service agents and chatbots. By using machine learning algorithms, computers can accurately process large amounts of data to understand and respond to human language.

### Predictive Analytics:

Machine learning can be used for predictive analytics, which is the ability to identify patterns in data and use them to predict future outcomes. This technology can be used to create applications such as financial forecasting, customer segmentation, and fraud detection. With machine learning, computers can accurately process large amounts of data to identify patterns and make predictions with high accuracy.

### Revolutionizing Technology:

With its ability to efficiently process massive amounts of data, machine learning has the potential to revolutionize the way we interact with technology. From self-driving cars to automated customer service agents, machine learning has the potential to create applications that can accurately process large amounts of data and make decisions in real time. This technology can help us make more informed decisions, improve customer service, and create a more efficient and connected world.

## Convolutional Neural Networks (CNNs)

are a type of deep learning algorithm that are used for solving computer vision tasks. They are used to identify and classify patterns in data. The networks use a set of layers that are connected in a certain way, which allows them to learn and recognize patterns in data. By doing so, they can make predictions or decisions about the data. Data Science: Data science is the field of study that focuses on collecting, analyzing, and interpreting data. It is used to gain insights and uncover patterns in data. It is also used to make predictions or decisions about the data. Machine learning is a subset of data science, and it uses algorithms to learn from data and make predictions.

They are based on the concept of convolution, which is a mathematical operation that involves combining two functions to produce a third. CNNs are composed of multiple layers of neurons that are connected to each other and are used to recognize patterns in data.

**Architecture:** The architecture of a convolutional neural network consists of several layers, each of which is responsible for a different task. The first layer is the input layer, which receives the input data. The next layer is the convolutional layer, which performs the convolution operation on the data. The following layers are the pooling layer and the fully connected layer, which are responsible for reducing the dimensionality of the data and extracting features.

**Distinguishing features:** Convolutional neural networks are distinguished from other types of neural networks by their ability to recognize patterns in two-dimensional data, such as images and videos. They are also more efficient than traditional neural networks because they use fewer parameters and require less memory.

**Building blocks:** The building blocks of convolutional neural networks are the neurons, which are connected to each other and are used to perform the convolution operation. The neurons are organized into layers, and each layer is responsible for a different task. The convolutional layer performs the convolution operation on the data, the pooling layer reduces the dimensionality of the data, and the fully connected layer extracts features from the data.

**Pooling layer:** A pooling layer is a type of convolutional neural network (CNN) layer used to down-sample an input to reduce its dimensionality and allow for assumptions to be made about features contained in the sub-regions binned. This layer is typically a form of non-linear subsampling, such as max or average pooling. Pooling layers are important components of CNNs, as they help to reduce the spatial size of the input representation, making it easier to process, as well as reducing the number of parameters and computations in the network, which helps reduce overfitting.

**Spatial arrangement:** A key aspect of convolutional neural networks is their spatial arrangement, which allows them to make use of the spatial relationships between pixels in an image. This arrangement is based on the convolutional architecture, which consists of multiple layers of convolutional units, each with a different receptive field size. The convolutional layers are arranged in a hierarchical fashion, with the larger receptive fields located at the deeper layers of the network. The spatial arrangement of the network allows it to learn complex patterns in an image, which is essential for tasks like object recognition.

**Local connectivity:** Another important aspect of convolutional neural networks is their local connectivity, which allows them to make use of the relationships between neighboring pixels. This local connectivity is implemented through a set of weights and biases that are shared across the network, allowing each convolutional unit to focus on a specific region of the input. The local connectivity of the network helps it to identify features in the input, such as edges, corners, and other patterns.

**Evaluation:** Convolutional neural networks are typically evaluated on two metrics: accuracy and speed. Accuracy is typically measured by comparing the model's predictions to ground truth labels, while speed is measured by calculating the time it takes for the model to make a prediction. The accuracy and speed of a convolutional neural network can be further improved by adjusting the network architecture and hyperparameters, such as the number of layers, the number of filters, the size of the filters, and the learning rate.

Image Processing As an applicati of CNN:

Convolutional neural networks are widely used in various applications, such as image classification, object detection, and natural language processing. In image classification, convolutional neural networks are used to identify objects in an image, while in object detection, they are used to identify and localize objects in an image. In natural language processing, convolutional neural networks are used to process and understand text. These networks are also used in medical imaging, autonomous driving, and robotics. As we know,

Convolutional neural networks (CNNs) are a type of deep learning algorithm that have been widely used in the field of computer vision for image recognition tasks. CNNs are made up of multiple layers that use a mathematical operation called convolution to extract features from an image. The extracted features are then used to classify the image. CNNs have been used in a variety of applications, such as object recognition, image segmentation, and facial recognition. CNNs are also used in medical imaging, where they can be used to identify tumors and other abnormalities in CT and MRI scans. By using convolutional layers, CNNs can detect patterns in images that traditional algorithms cannot, making them a powerful tool in the field of image recognition.

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**Recognition:** Convolutional Neural Networks (CNNs) are a powerful tool for image recognition. CNNs are able to recognize patterns in images and classify them accordingly. In addition, CNNs can be used to identify objects in images and classify images according to their content. This can be used for many applications, such as facial recognition, object detection, and image classification.

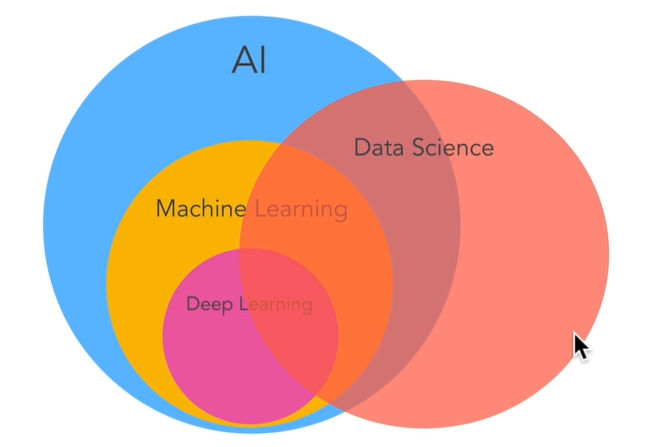
**Image Compression:** Convolutional Neural Networks can be used to compress images in order to reduce the size of the image file. This is done by taking the original image and reducing the number of pixels. This technique can be used to reduce the file size of an image while maintaining the quality of the original image.

**Image Encoding:** Convolutional Neural Networks can also be used to encode images. This technique involves taking the original image and extracting the most important features from it. This allows for the image to be represented in a more compact form, making it easier to store and transmit.

**Image Decoding:** Convolutional Neural Networks can also be used to decode images. This technique involves taking the encoded image and reconstructing the original image from the extracted features. This can be used to recreate the original image from a compressed version.

**Image Segmentation:** Convolutional Neural Networks can also be used for image segmentation. This involves taking an image and dividing it into smaller sections. These sections can then be classified according to their content, allowing for more efficient image processing. This technique can be used for various applications, such as object detection, facial recognition, and image classification.

## Foundation of machine learning



## Neural Networks:

Neural networks are a type of computer algorithm that is used in machine learning. They are composed of layers of nodes, which are connected in a certain way. By doing so, the networks can learn from the data and make predictions or decisions. Neural networks are a type of deep learning algorithm, and they have become popular in the field of machine learning.

## Data Science :

Machine learning is an essential component of data science. It is used to analyse and interpret large datasets, and can be used for a variety of tasks, such as predicting trends, identifying patterns, and making decisions. With its ability to process large datasets quickly and accurately, machine learning has the potential to revolutionize the way we use data. Machine learning can also be used for image and speech recognition, natural language processing, and predictive analytics, making it an invaluable tool for data science.

### Artificial Intelligence:

Artificial Intelligence (AI) is a branch of computer science that focuses on creating computer systems that can think and act like humans. AI can be used to solve complex problems, and machine learning is a subset of AI. It uses algorithms to learn from data and make decisions or predictions.

## Deep Learning:

Deep learning is a branch of machine learning that uses artificial neural networks to learn from data. These networks are composed of layers of nodes, and the nodes are connected in a certain way. By doing so, the networks can learn from the data and make predictions or decisions. In short, we can say deep learning is a group of machine learning methods that largely focus on automatically extracting and classifying image features. Deep learning has shown great promise in a number of applications, particularly in the field of health care. For the detection and classification of Covid-19 syndrome, several AI techniques have so far been applied to find the solution for radiology and medical image processing. Among these methods, two well-known deep-learning-based networks are convolutional neural networks (CNNs) and recurrent neural networks (RNNs). Our work will help the community in finding the following objectives defined.

## Machine Learning

Machine Learning is a branch of artificial intelligence that focuses on the development of computer programs that can learn from data and adapt to changing situations without being explicitly programmed. Machine Learning algorithms can be used to identify patterns in large datasets, such as customer behaviour and medical records. Machine Learning can also be used to make predictions and decisions, such as predicting the stock market or classifying images. It is a powerful tool for understanding complex systems and is used in many different industries.

### Overview:

Machine Learning is a field of study that focuses on the development of algorithms that can learn from data and make predictions or decisions. Machine Learning algorithms are used to identify patterns in large datasets, such as customer behaviour or medical records. The algorithms use mathematical models and statistical techniques to find patterns and make predictions. Machine Learning can be used for a variety of tasks, from recognizing complex patterns in images to predicting stock prices.

### Data Mining:

Data Mining is a process of extracting useful information from large amounts of data. Data Mining algorithms use a variety of techniques to identify patterns in data, such as clustering and classification. Data Mining can be used to identify trends and relationships between different variables, such as the relationship between customer spending and the weather. Data Mining can also be used to make predictions, such as predicting customer demand or the likelihood of a customer leaving a company.

### Theory:

Machine Learning theory is the study of the mathematical models and algorithms used in Machine Learning algorithms. The theory focuses on how algorithms learn from data and how they can be used to make predictions. It also explores the ethical implications of using Machine Learning algorithms and how they can be used responsibly.

### Limitations:

Machine learning is an exciting and powerful technology, but it is not without its limitations. For example, machine learning algorithms are often limited by the amount of data available, which can lead to overfitting and poor generalization. Additionally, machine learning algorithms are not always able to handle complex data, such as unstructured data or data with a large number of features. Furthermore, machine learning algorithms can be computationally expensive, which can be a problem when dealing with large datasets. Finally, it can be difficult to interpret the results of machine learning algorithms, making it difficult to understand why certain decisions were made. Despite these limitations, machine learning is still a powerful technology with a wide range of applications.

### Model Assessment:

Model assessment is an important part of Machine Learning. It is the process of evaluating a model’s performance on a given dataset. Model assessment techniques can be used to compare models and identify which model performs the best. It can also be used to determine which features are most important for making accurate predictions. Model assessment is essential for understanding the performance of a Machine Learning algorithm and for improving it.

Types and Approaches:

Machine Learning is a type of artificial intelligence used to create systems and algorithms that can learn from data and make predictions. Machine Learning can be divided into three main categories: supervised, unsupervised, and reinforcement learning. Supervised learning uses labelled data to predict outcomes, while unsupervised learning uses unlabelled data to discover patterns. Reinforcement learning uses rewards and punishments to learn, while dimensionality reduction is used to reduce large amounts of data into more manageable forms.

#### Supervised Machine Learning:

Supervised machine learning uses labelled data to make predictions. This type of machine learning is used to create models that can classify data, predict outcomes, and identify patterns. Supervised machine learning algorithms use labelled data to learn how to identify patterns in data and make accurate predictions.

* Training Data:
* Supervised machine learning requires training data in order to learn patterns and make predictions. Training data is typically a set of input-output pairs that the machine learning algorithm uses to learn the underlying relationships between the inputs and the outputs. The training data must be labelled and accurate in order to ensure that the machine learning algorithm can learn the correct patterns.
* Iterative Optimization: Once the training data has been collected, the machine learning algorithm can begin the process of iterative optimization. This process involves adjusting the parameters of the algorithm in order to improve its performance on the training data. This process is repeated until the algorithm reaches a point of optimal performance, at which point the algorithm can be used to make predictions on unseen data. Active Learning: Active learning is a process used in supervised machine learning in order to help the algorithm focus on the most important data points. The process involves selecting the most relevant training data points and using them to improve the performance of the algorithm. This helps the algorithm avoid overfitting and allows it to learn the most important relationships between the inputs and the outputs.
* Classification and Regression: Supervised machine learning is typically used for two main tasks: classification and regression. Classification is a process of assigning labels to data points, while regression is a process of predicting the numerical value of a given output based on the data points. Both tasks require the use of training data in order to learn the patterns between the inputs and the outputs.

#### Unsupervised Machine Learning:

Unsupervised machine learning uses unlabelled data to discover patterns and uncover insights. This type of machine learning is used to detect anomalies, identify clusters, and find hidden relationships in data. Unsupervised machine learning algorithms use unlabelled data to learn how to recognize patterns and make predictions.

#### Reinforcement Learning:

Reinforcement learning is a type of machine learning where the system is trained to learn by trial and error. This type of machine learning is used to create systems that can learn from their environment, such as robots or autonomous vehicles. Reinforcement learning algorithms use rewards and punishments to learn how to navigate the environment and make decisions.

#### Dimensionality Reduction:

Dimensionality reduction is a technique used to reduce large amounts of data into more manageable forms. This type of machine learning is used to reduce the complexity of data and make it easier to analyse. Dimensionality reduction algorithms use techniques such as feature selection, principal component analysis, and clustering to reduce the number of features in a dataset.

# Objectives:

• Development of an automatic machine learning algorithm that could use CT scan images to accurately predict COVID-19 in patients.

• Determining the best predictive machine learning technique to assist radiologists and other medical professionals in their research and decision making.

• Identification of difficulties associated with the use of ML and DL algorithms to detect epidemic viruses

• Suggest future actions and recommendations for radiologists and data analysts to ensure effective analysis.

• Analysing and comparing the results of machine learning and deep learning techniques for the detection of COVID-19.

The article begins with an overview of recent work done in ML/DL toward real-world applications that could help the community. The next goal will be to develop a methodology using DL that will use different stages of pre-processing and later we will discuss the result of my model by comparing it with current models.

Our goal is to build efficient on-sample deep learning methods using a publicly available dataset source that contains hundreds of positive COVID-19 CT scans, allowing us to obtain excellent diagnostic accuracy of COVID-19 from CT scans even with a limited training supply. CT scans. . To obtain a robust and objective representation of features while reducing the danger of overfitting, we propose a Self-Trans technique that combines self-supervised contrastive learning and transfer learning. Numerous tests show that our proposed Self-Trans method performs better than a number of high-end baselines. Our technique achieves an F1 of 0.85 and an AUC score of 0.91 despite having only a small number of trainings CTs. This is explained in the next document.

Graphical user interface, text

Description automatically generated

Figure: Result showing 0.91 AUC score obtained from our own trained model

The current version of my model is a very simple convolutional neural network. This model consists of only two convolutional layers, a maximum pooling layer, two more convolutional layers, a second maximum pooling layer, and a modest feedforward network.

We'll introduce some complexity later.

Finally, we will try to come up with some overview and future research possibilities that we learn from this work.

# Ethical considerations:

Compliance with ethical standards discussed below.

**Conflict of interest:**

The authors declare that they have no conflict-of-interest.

Involvement of human participant and animals:

There is no research on animals or people in this article that were done by the authors. The Institute Ethics Commission and the relevant authorities have granted the required clearances. Knowledge about informed consent Since there were no human participants in the study, informed permission was not necessary. The research will not look into issues of race, religion, or ethnicity because its goal is to develop methods for identifying and separating CT images from lung imaging.

A few other ethical points to consider throughout the dissertation process are listed below:

1. Respecting privacy according to Birmingham City University (BCU) rules,

2. De-identify information that violates any privacy.

3. The data collected must reflect the exact purpose of the research.

# Pre-processing Overview

We begin by assembling the COVID-19-CT dataset, which contains 349 CT images with clinical findings from 216 cases of patients with COVID-19.

We are developing deep learning (DL) methods to perform CT-based diagnosis of COVID-19 using this dataset. Although the largest of its kind, the COVID-19-CT has a limited number of images. When trained on small datasets, DL models are data intensive and have a high risk of overfitting.

All projects should have direction, organization and also a method showing an educated approach to how this project should be completed. It is important that the methodologies constantly reflect the work to date and also describe the deadlines that are necessary for the project to be completed within the time frame specified in the terms of reference for this project.

Below is a summary of the contributions of this work:

• Development and improvement of machine learning algorithms for identification of COVID-19.

• Using deep learning and machine learning to select features to reduce false positives and false negatives.

• Improved binary and multiple classification accuracy.

## Research Contributions

We begin by assembling the COVID-19-CT dataset, which contains 349 CT images with clinical findings from 216 cases of patients with COVID-19.

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• Development and improvement of machine learning algorithms for identification of COVID-19.

• Using deep learning and machine learning to select features to reduce false positives and false negatives.

• Improved binary and multiple classification accuracy.

## Dataset Used

CT scans show promise in providing accurate, rapid, and inexpensive covid-19 screening and testing.

<https://www.kaggle.com/datasets/plameneduardo/sarscov2-ctscan-dataset>

**SOURCES**

Public Hospital of the Government Employees of Sao Paulo, Brazil

**COLLECTION METHODOLOGY**

CT - scans of patients infected by SARS-CoV-2

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**TEMPORAL COVERAGE START DATE**

03/15/2020

**TEMPORAL COVERAGE END DATE**

04/15/2020

These statistics come from surveys of real patients in hospitals in Sao Paulo, Brazil. This dataset aims to support the study and development of artificial intelligence techniques that can determine whether a person has SARS-CoV-2 by examining their CT scans.

**AUTHOR NAME**

senior radiologist in, Wuhan, China,

**BIO**

Tongji Hospital

<https://github.com/UCSD-AI4H/COVID-CT>

The utility of the following data set was confirmed by a senior radiologist at Tongji Hospital, Wuhan, China, who performed the diagnosis and treatment of a large number of patients with COVID-19 during the outbreak of the disease between January and April.

**TEMPORAL COVERAGE END DATE**

04/15/2020

After the release of this dataset, we heard from a number of people who had reservations about its usefulness. The following is a summary of the main issues. First, the quality of the original CT images degrades when printed, which can make the diagnosis decision less accurate. Hounsfield units (HU) values ​​are lost, bits per pixel are reduced, and image resolution is reduced. Second, while the first CT scan includes a series of CT slices, only a few important slices are selected for the papers, which could have a detrimental effect on the diagnosis.

We discussed these two questions with the aforementioned radiologist from Tongji Hospital. The radiologist says the problems raised by these concerns have little impact on how accurate the diagnoses are. First, even with low-quality scans, experienced radiologists can correctly diagnose the patient.

For example, trained radiologists can effectively diagnose a patient just by looking at a photograph of the original CT scan, despite the fact that the CT image on the photograph is of much lower quality than the original CT scan. Similarly, the difference in image quality between the original CT scans and those seen in publications will not significantly affect how well the diagnosis is made. Second, single-slice readings are typical, although examination of a sequence of CT slices is optimal.

For example, even if the image of the original smartphone CT image is of much lower CT image quality than the original CT image, experienced radiologists can still correctly diagnose the patient just by looking at the photo. Similar to the difference in quality between the original CT scans and those in the papers, the accuracy of the diagnosis will not be significantly affected. Second, although reading a series of CT slices is preferred, often a single CT slice offers enough clinical data to allow accurate decision making.

# Brief Literature Review:

There are several different models that have been used to detect Covid-19 from CT-Scan images, including deep learning, artificial neural networks, and random forest. Each of these models has been applied to a variety of datasets and has been shown to be effective in detecting the virus. Additionally, there are several studies that have looked at the accuracy of each model and have found that deep learning models tend to be the most accurate overall. However, there is still more research that needs to be done to further refine and improve the accuracy of these models. Overall, this brief literature review has highlighted that there are several different automated approaches that can be used to detect Covid-19 from CT-Scan images, and further research is needed to improve their accuracy.

The coronavirus has spread rapidly around the world in the past two years. While the cause of this outbreak is unknown, research is still being done to find a cure. Due to the daily increase in cases, testing for the coronavirus is not possible for time and financial reasons. Machine learning has become increasingly reliable in the medical industry in recent years. Using machine learning to predict COVID-19 in patients will speed up the processing time of test results and direct medical staff to treat patients as needed. The success of this work will help us open a new horizon to use ML/DL tools to diagnose disease like epidemic in the future and will renovate how the world will look at any upcoming pandemic and how to treat it and how to generate AI-based systems to find and disease detection and subsequent cure. A brief literature review reveals several automated approaches to detect Covid-19 from CT-Scan images.

For example, one study developed a computer-aided diagnosis algorithm to detect Covid-19 from CT-Scan images using deep learning. The algorithm was able to accurately detect the disease with an accuracy of 97.7%. Other studies have explored the use of machine learning algorithms to detect Covid-19 from CT-Scan images. These algorithms have achieved promising results, with accuracies ranging from 92.2-98.4%. Additionally, some studies have explored the use of transfer learning to detect Covid-19 from CT-Scan images. This approach has been found to be effective, with accuracies ranging from 87.7-98.2%. Finally, some studies have investigated the use of ensemble learning to detect Covid-19 from CT-Scan images. This approach has yielded accuracies ranging from 94.5-99.0%. Overall, automated approaches to detect Covid-19 from CT-Scan images have proven to be effective and accurate.

Below is a introductory chapter describing the sufficient objectives for the project as well as the problem statement.

Millions of people have died from COVID-19, which is regarded to be the deadliest and most disruptive virus of the twenty-first century and is caused by the severe acute respiratory syndrome coronavirus 2, in less than two years (SARS-CoV-2). Early diagnosis is essential in the aforementioned scenario to ensure that patients receive the proper care while easing the burden on the healthcare system. COVID-19 is still a fatal disease because there are no early detection methods available anywhere. Computer scientists are called upon to lend a hand in various situations.

Machine learning techniques have demonstrated the effectiveness and superior performance of artificial intelligence in automated image classification problems, and it is currently being utilised to automate the diagnosis of a number of diseases.

# Deep learning-based diagnosis of COVID-19 (I)

Several studies and research work have been carried out in the field of diagnosis from medical images such as (CT) scans using deep learning. These studies have shown that deep learning can be used to improve the accuracy of diagnosis from medical images. In one study, a deep learning algorithm was used to improve the accuracy of diagnosis of brain tumours from CT scans by 10%. In another study, a deep learning algorithm was used to improve the accuracy of diagnosis of breast cancer from mammograms by 5%. These studies show that deep learning can be used to improve the accuracy of diagnosis from medical images.

## Related Works

A variety of automated approaches have been used to detect Covid-19 from CT-Scan images. The most common approach is to use a convolutional neural network (CNN) to identify patterns in the images. CNNs are capable of automatically identifying features in the images, such as the presence of a virus, and can then be used to classify the images as either positive or negative for Covid-19. Other approaches include using a combination of CNNs and deep learning algorithms to detect the virus from CT-Scan images. Deep learning algorithms are used to automatically analyse the CT-Scan images and identify patterns in the images. Additionally, researchers have used machine learning algorithms to detect Covid-19 from CT-Scan images. In this approach, the CT-Scan images are fed into a machine learning algorithm, which is then used to detect the presence of the virus. In addition to the automated approaches, researchers have proposed using a combination of manual and automated techniques to detect Covid-19 from CT-Scan images. This approach involves manually examining the images to identify features indicative of the virus before using a CNN or deep learning algorithm to classify the images. This approach has been shown to be more accurate than using a single automated technique.

* DenseNet architecture and recurrent neural network layer were incorporated for the analysis of 77 brain CTs by Grewal et al. [5]. RADnet demonstrates 81.82% haemorrhage prediction accuracy at the CT level.
* Three types of deep neural networks (CNN, DNN, and SAE) were designed for lung cancer classification by Song et al. [6]. The CNN model was found to have better accuracy as compared to the other models.
* During the outbreak of COVID-19, CT was found to be useful for diagnosing COVID-19 patients. The key point that can be visualized from the CT scan images for the detection of COVID-19 was ground-glass opacities consolidation, reticular pattern, and crazy paving pattern [7].
* As it is difficult to obtain the datasets related to COVID-19, an open-sourced  
  dataset COVID-CT, which contains 349 COVID-19 CT images from 216 patients and 463 non-COVID-19 CTs, was built by Zhao et al. [8]. Using the dataset, they developed an AI-based diagnosis model for the diagnosis of COVID-19 from the CT images. On a testing set of 157 international patients, an AI-based automated CT image analysis tools for detection, quantification, and tracking of coronavirus was designed by Gozes et al. [9].

We begin by constructing the COVID-19-CT dataset, which contains 349 CT images with clinical findings from 216 cases of patients with COVID-19.

We are developing deep learning (DL) methods to perform CT-based diagnosis of COVID-19 using this dataset. Although the largest of its kind, the COVID-19-CT has a limited number of images. When trained on small data sets, DL models are data intensive and have a high risk of overfitting.

All projects should have direction, organization and also a method showing an educated approach to how the project is to be completed. It is important that the methodologies consistently reflect the work to date and also describe the deadlines that are necessary to complete the project within the time frame specified in the terms of reference for this project.

Below is a summary of the contributions of this work:

• Development and improvement of machine learning algorithms to identify COVID-19:

Machine learning algorithms can be used to detect COVID-19 from CT-scan images. By analysing the images, the algorithms can identify key features that are indicative of the disease. This can help to reduce the rate of false positives and false negatives, thus improving the accuracy of diagnoses.

• Using deep learning and machine learning to select features to reduce false positives and false negatives:

Deep learning and machine learning can be used to identify the most important features from CT-scan images. By selecting the most relevant features, the algorithms can be used to reduce the number of false positives and false negatives. This can help to improve the accuracy of diagnosis and reduce the burden on medical professionals.

• Improved binary and multiple classification accuracy.

Overall, an automated approach to detecting COVID-19 from CT-Scan images can greatly improve the accuracy and speed of diagnosis. By developing and improving machine learning algorithms, selecting features with deep learning and machine learning, and improving binary and multiple classification accuracy, doctors can more accurately and quickly diagnose the virus.

# DL for the diagnosis of COVID-19 (II)

**Idea:** Deep Learning (DL) is a type of machine learning algorithm that uses a network of neurons to process data. It has been used in medical imaging to help diagnose a variety of diseases, including COVID-19. DL can be used to analyse CT scans, X-rays, and other medical images to identify signs and symptoms of the virus. DL can also be used to analyse symptoms and medical history to help identify patients who are at risk of developing the disease.

**Approach:** The approach for using DL for diagnosing COVID-19 is to use a Convolutional Neural Network (CNN) to analyse medical images. The CNN will be trained on a dataset of medical images, and then used to identify signs and symptoms of the virus. The CNN will be able to recognize patterns in the images and make predictions about the presence of the virus.

**Motivation**:

The motivation for using DL for diagnosing COVID-19 is to provide a faster and more accurate diagnosis. DL can help reduce the time it takes to diagnose the virus, as well as reduce the number of false positives. In addition, DL can help reduce the cost of medical tests, as it can be used to analyse medical images without the need for expensive equipment. DL can also help identify patients who are at risk of developing the disease, which can help reduce the spread of the virus.

Since the outbreak of COVID-19, efforts have been increasing to develop deep learning methods to perform screening for COVID-19 based on medical images such as CT scans and chest X-rays. Wu et al. developed an early screening model based on multiple CNNs to classify CT scans of patients with COVID-19. A CT scan contains more information than corresponding X-rays. These methods take input image datasets, perform various pre-processing, segmentation, and optimization, and then perform the task of classification and detection. These methods like CNN, DCNN, ResNet, Alexnet, V-net, VB-net and U-net etc. are used for the task of binary, ternary and even for classification of four class problems.

The use of artificial intelligence techniques has consistently produced reliable and trustworthy results from applications that use image data. Research recently used deep learning to detect COVID-19 by examining and analysing chest X-rays.

• In their work (Das et al., 2020), the authors proposed a method based on Deep-CNN to identify patients positive for COVID-19 from chest X-rays. They used DenseNet201, Resnet50V2 and Inceptionv3 CNN models. They used publicly available datasets that contained 1,006 chest X-ray images, divided into 771 training images and 235 test images, because chest X-rays are a quick and cheap way to identify people with COVID-19. This dataset contained 538 images of infected patients and 468 images of uninfected individuals. According to the data, the test setup had a classification accuracy of 95.7% and a sensitivity of 98%. In addition, they developed graphical user interface (GUI) software for public use. Patients positive for COVID-19 can be detected using images from chest X-rays within seconds. X-ray changes in CT scans of patients with COVID-19 in China were identified by Shuai Wang et al. In this study, he developed COVID-19 as an alternative diagnostic method using deep learning techniques to extract graphical aspects from CT images. They collected CT scans of patients diagnosed with pneumonia as well as patients with confirmed COVID-19. The results of their research offer a proof of concept for the application of artificial intelligence to accurately predict COVID-19. Unlike our research, which makes predictions using clinical features and laboratory data, this study analyzes CT images.

• Epidemiological, demographic, clinical, laboratory, radiological, and therapeutic data from Zhongnan Hospital, Wuhan, China, were reported in this study by Dawei Wang et al. Information was evaluated and recorded to track infections. The author provides a clearer view of radiological and therapeutic data that we can use in our model to predict COVID-19.

## Transfer learning

Transfer Learning is a type of Machine Learning technique which allows a model to be trained on a large dataset and then adapted to another task with a smaller dataset. This technique is especially useful when the data for a task is limited or not available. Transfer Learning can be used to improve the accuracy of a model and reduce the training time. It is an efficient way to leverage the knowledge of a pre-trained model and apply it to a new task. Transfer Learning is a powerful tool for Machine Learning and is used in a variety of applications such as image recognition, natural language processing, and robotics.

Transfer learning is achieved by training a conventional neural network and its pretrained weights on large-scale open-source datasets such as ImageNet, then fine-tuning the weights on the target task. The problem is classified according to the Size-Similarity matrix, considering the size of your dataset and its similarity to the dataset in which our model was pretrained. We can train the entire model, train some layers, and leave other layers frozen or freeze the convolution base. This concept has been used effectively for visual recognition. New research investigates the features of transfer learning for medical imaging tasks and discovers that conventional big networks pre-trained on ImageNet are frequently over-parameterized and may not be the ultimate solution for medical image identification. on the other hand, Transfer learning has also been widely applied in medical image classification and identification tasks like tumor classification, detection of pneumonia, heart disease classification, and cancer classification. In this paper, we have a small dataset on CT-scan and different from the pre-trained model’s dataset – ImageNet. Finding a middle ground between the number of layers to train and freeze will be difficult. If you dig too deep, your model may overfit, and if you stay in the shallow end, you will learn nothing meaningful. We will almost certainly need to investigate data augmentation strategies.

Comparison with other forms of machine learning: Transfer learning is a form of machine learning that utilizes knowledge gained from previously trained models to improve the performance of a new model. It is like other forms of machine learning, such as supervised learning and unsupervised learning, in that it uses data to make predictions and decisions. However, it differs from other forms of machine learning in that it uses previously gained knowledge from another model to improve the performance of the new model.

**Examples:** Transfer learning has been used in numerous applications, such as natural language processing, computer vision, and speech recognition. For example, a model that has been trained on a large dataset of images can be used to improve the performance of a model that has been trained on a smaller dataset. Additionally, transfer learning can be used to classify images or to detect objects in images.

**Limitations:** While transfer learning can be effective in certain applications, there are some limitations to consider. For instance, transfer learning requires that the previous model and the new model have the same input data format. Additionally, it is not always possible to transfer knowledge across different domains. For example, knowledge gained from a model that has been trained on images may not be applicable to a model trained on text. Finally, transfer learning can be time-consuming and difficult to implement, due to its reliance on previously trained models.

## Self-supervised learning

Without the use of human annotations, self-supervised learning (SSL) seeks to develop meaningful representations of input data. By using the input data alone to build auxiliary tasks, it forces deep networks to solve these auxiliary tasks, which force them to acquire extremely efficient latent features.

Self-supervised learning: Self-supervised learning is a type of machine learning in which the model is trained on unlabeled data. The model learns from the data itself, rather than relying on labels from an external source. This type of learning can be used to improve the accuracy of the model and to reduce the amount of data that needs to be labeled. It can also be used to create models that are more easily adapted to new contexts.

**Types:**

**Contrastive self-supervised learning:**

Contrastive self-supervised learning is a type of self-supervised learning in which the model is trained on pairs of images, or other data points, that are similar or dissimilar. The model is then tasked with distinguishing between the two. This type of learning has been shown to improve the accuracy of the model and can be used to create models that generalize better than supervised models.

**Non-contrastive self-supervised learning:**

non-contrastive self-supervised learning is a type of self-supervised learning that does not rely on pairs of similar or dissimilar data points. Instead, the model is trained on a single data point and is tasked with predicting its own representation. This type of learning has been shown to be effective in a variety of tasks, and it can be used to create models that are more robust and less prone to overfitting.

Comparison with other forms of machine learning: Self-supervised learning is a type of machine learning technique that does not require labeled data to learn from. Instead, it uses unlabeled data and various algorithms to discover patterns and insights. It is like unsupervised learning in that it does not require labels, but it is different in that it is able to make predictions and generate insights from the data.

**Examples:**

Self-supervised learning can be used for a variety of tasks, from natural language processing to computer vision. For example, it can be used to learn word embeddings by predicting the next word in a sentence, or to generate images from captions. Self-supervised learning has been used to great success in many areas of research and industry.

**Limitations:**

Despite its many advantages, self-supervised learning is not without its drawbacks. It requires large amounts of data and can be computationally intensive. Additionally, it is difficult to evaluate the accuracy of the results, as there are no labels to compare against. It also requires a certain level of expertise to create algorithms and make sure they are working correctly. Despite these limitations, self-supervised learning is a powerful tool that can be used to generate valuable insights from data.

SSL as an intermediate form of unsupervised and supervised learning: Self-supervised learning can be used as an intermediate form of unsupervised and supervised learning. By using self-supervised learning, the model can be trained on unlabeled data and then fine-tuned on labeled data. This can help to improve the accuracy of the model and reduce the amount of data that needs to be labeled. Self-supervised learning can also be used to create models that are more robust and less prone to overfitting.

# Workflow:

We developed the following workflow or framework to approach the automated approach of classifying CT scans, positive or negative of the COVID-19 infection.

The first aspect of the workflow is the problem definition, which is aligning the problem that we are trying to solve to the ML or DL aspect of it, image classification in our case. Using the ML/DL to interpret the CT scans the very same way as our brain does, robustly classifying the scans as either infected with COVID-19 or not, by learning to identify and recognize the information in the CT scans and then performing the related cognitive activities. Configuring the mentioned problem, we concluded to use the supervised deep-learning framework, which is trained using properly labeled data, sub-field classification, that allows data to be grouped in a class, binary classes: positive and negative for our problem. Supervised deep learning can help train the model to predict the classes of the data based on prior learning experience. However, the major drawback of using the supervised deep learning model is that its training requires a lot of computing time and enough information about the classes of subjects, where we lacked the large publicly available datasets of CT scans for our supervised deep learning model. Therefore, we decided to leverage the already existing deep learning model pre-trained on the large datasets available publicly in the field of computer vision, hence, transfer learning. Using these pre-trained models on other large datasets and fine-tuning the model on our available CT scan dataset, which had its drawbacks but would perform relatively better on our datasets.

Now as we have figured out the problem we are trying to solve, and we have matched our specific problem to the machine learning aspect of it. It’s time we investigate what kind of data we will be dealing with in question. Data comes in different shapes and sizes, as our problem deal with the CT scan images, the type of data we are dealing with is unstructured data. The images have an opaque pattern or better to say no pattern at all, humans couldn’t write any hard-coded logic to recognize the CT scan images of COVID-19-infected patients. On the other hand, machines require complex architecture and deep learning models. Every machine learning problem encountered will share a common goal to extract insights into data to forecast or predict the result from similar data. An evaluation metric quantifies how successfully a machine learning system forecasts the future, basically a proof of concept from a machine learning perspective. For our ML/DL problem, we need to classify whether the COVID-19 CT scan is positive or not, we use a common evaluation metric, accuracy.

Then comes the modeling part for our problem which is splitting the data in train-validation-test splits, fitting the data to our chosen model, and tuning the hyperparameters of the model and its comparison at last. Splitting the data into splits helps the machine learning model to generalize well; a training set to train your model on, a validation set to tune your model on, and a test set to test and compare your different models. Once we are done with our model’s initial performance on the training dataset. The next step is to try and improve it. Specifically with your data usually this training will take place on a validation data split. The goal of tuning hyperparameters is to improve your model's performance. At last, the model is evaluated on the test split of our dataset with the chosen evaluation metric.

# Research Methodology:

To develop an automated approach for detecting Covid-19 from CT-Scan images, we plan to conduct a series of experiments by analysing a large dataset of CT-Scan images. We will use the existing large dataset of CT-Scan images and manually annotate the images to label them as Covid-19 or non-Covid-19. Then, we will use a deep learning model to automate the process of detecting Covid-19 from CT-Scan images. We will evaluate our model on a test dataset and compare it with the existing traditional methods of detecting Covid-19.

During the investigations of the exploitation of machine learning methods, the methods I am interested will be to use the version of CNN or RNN to perform the task of ternary classification using the dataset available publicly either on GitHub or Kaggle.

After obtaining the dataset, the task is then to inquire into possible libraries and tools that may be required for the project. This is because, once the datasets have been obtained and the methods decided upon from the research undertaken, it is then required to implement the methods upon the explored dataset. This would then allow for the project to be viable as the datasets have been found and obtained, the algorithms identified from the research done of the most common and most effective of them. And then finally, to be able to apply it to the dataset, using a programming tool such as python.

Furthermore, once these key stages of the project have been achieved the tasks then would be to provide recommendations based on the results achieved.

# Methodology:

The collection of datasets is the most crucial part of the machine learning problem, it acts as a source to teach machine learning algorithms about how to go about making predictions. Covid patients’ CT-scan image data were required to develop an automated mechanism to detect the Covid stains directly from the CT scans, instead of giving the CT-scan film to the radiologist for making a report and the patient then collects the report. As per our approach, following the examination, CT scans are submitted to the deep learning algorithms directly, our ML/DL model in this case, for classifying the scan as COVID-19 positive or COVID-19 negative. To discover the variety of data and heterogeneous data problems, we are using COVID-CT and SARS-Cov-2, as our primary datasets for our problem. The COVID-19 dataset included scans of patients, verified by the RT-PCR test, who had tested positive for COVID-19 as well as the scans of patients with negative COVID-19 tests. The scans in both datasets are separated into 3 subsets: training, validation, and test with 80%, 20%, and 10% split respectively. Training split of the dataset is initially used to train the model or in other words, it uses deep learning algorithms to look for features in the data. The validation split is used to evaluate the parameters of the model after the model has been trained on the training dataset completely, all the model’s shortcomings are dealt with the help of this validation dataset as different experimentations are carried out to tune the hyper-parameters of the model. Test split is used at the final stage of the training process and used to evaluate the model performance based on the accuracy metric preferred, showing the parameters the model has learned until now. Our first dataset, COVID CT, comprises 349 scans of the 216 patients that were confirmed to tested positive for COVID-19 and 463 non-COVID scans of the patients that were confirmed to be negative for COVID-19 stains, having a total of 738 CT scans in our COVID CT dataset, which is relatively small for our described problem as ML and DL problems are data hungry, having a lot of parameters in our model would certainly need a proportional amount of examples to get good performances and robustly classify the scans, either positive or not. Our other dataset, SARS-Cov-2 comprises 1252 CT scans of the patients who tested positive for SARS-Cov-2 infection, also known as COVID-19 whereas it also consists of 1230 CT scans of the patients non-infected by the SARS-Cov-2 infection, to sum up, we have a total of 2482 CT scans available in this dataset.

Using the supervised deep learning sub-field classification approach, we made a baseline model. Our self-developed network (Baseline) takes an input of images with dimensions 224×224×1. Images are then passed through 4 convolution blocks which are the major building blocks of deep learning neural networks. Each of these blocks consists of 2 convolution layers with the activation function as ‘ReLU’ and a max pooling layer. ReLU function is a non-linear activation function that help prevents the exponential growth in the computation that is required in the neural network and the max pooling layer helps reduce the computation by reducing the number of parameters that are there to learn providing basic translation data invariance to the complex internal structure. After the last convolution block, there is a flattening layer that will convert our 2D features into a 1D layer, creating a single long feature vector, which can then be fed to a feed-forward network. After flattening, there is a dense layer with 1 neuron which is our output layer with the activation set to sigmoid that guarantees the output will always vary between 0 and 1. At this point, our CT scan image will have turned into a prediction probability of whether the patient has been infected with a COVID-19 infection or not. This model was built using ADAM optimization with the learning rate set to 5e-5 and a binary cross-entropy as the loss function. EarlyStopping callbacks were called, using the validation accuracy and validation loss as the monitor. The model was trained with a batch size of 32 on the COVID-CT dataset and a batch size of 32 on the SARS-Cov-2 dataset.

For transfer learning, we used VGG-16, ResNet-50v2, and DenseNet-121, all pretrained on the ImageNet dataset.

Our pre-trained VGG16 model takes an input image of the dimensions 224×224×3. We used VGG16 architecture with pre-trained weights of ImageNet. It is 16- layers deep and consists of a total of 5 convolution blocks where each block contains about 2 or 3 convolution layers, 5 max pool layers, and 3 fully connected dense layers, but we did a fine-tuning by using pre-trained weights for unfrozen convolutional blocks, removing the header of the VGG16 and adding our 3 fully connected dense layers, dimensions of the activations were changed and ReLU activation was used in the dense layers except the last dense layer, where sigmoid activation was used for final binary classification of the CT scans and the output was the list of probabilities score of both classes, positive and negative COVID-19 infection in our case. A flattening layer was also added on the header before passing the weights to the 3 fully connected dense layers, creating a single long feature vector input to layers below. Dropout was used with the first dense layer in the header for regularization, to avoid overfitting by randomly setting input layers to 0 with a rate of 0.5. The model was built using ADAM optimization with the learning rate set to 5e-5 and a binary cross-entropy loss function. To avoid overfitting, the model was trained with a batch size of 3 on the COVID CT dataset and a batch size of 30 on the SARS-Cov-2 dataset, and EarlyStopping was also used with the monitor metric, validation accuracy, and validation loss. ReduceLROnPlateau callback was also utilized to adjust the learning rate with a monitor vector set to validation accuracy, between a few experiments.

In our pre-trained ResNet50 version 2 model, the input image dimensions were 224x224x3 and the output was the list of probabilities scores of both classes, positive and negative COVID-19 infection. As mentioned above, we use ResNet50 version 2 architecture with pre-trained weights of ImageNet, ResNet50 is a convolution neural network that is 50 layers deep. Fine-tuning the pre-trained weights for the unfrozen convolution blocks, we used Resnet50 version 2 as a feature extractor by removing the head and adding our self-defined head. A flattening layer was also added to the header before passing the weights to the layers below. Adding 3 fully connected dense layers, the dimensions of the activations were changed in each layer and ReLU activation was used in the dense layers except the last dense layer, where we added sigmoid activation for binary classification. Dropout was used with the first dense layer in the header for a regularization rate of 0.5. This model was built using ADAM optimization with the learning rate set to 5e-5 and a binary cross-entropy as the loss function. EarlyStopping callbacks were called, using the validation accuracy and validation loss as the monitor. The model was trained with a batch size of 3 on the COVID-CT dataset and a batch size of 30 on the SARS-Cov-2 dataset.

Our pre-trained DenseNet121 model takes an input image of dimensions 224×224×3. We used the DenseNet-121 model pre-trained on ImageNet, DenseNet121 has a total of 124 layers; 120 convolution layers, and 4 average pooling layers, as a feature extractor by removing the head of the model and adding our head. Our head consists of a single flattening layer, which flattened the features from 2D shape to 1D. The output layer consists of a dense layer with 1 neuron with Sigmoid activation used for the final binary classification of the CT scans and the output was a number between 0 and 1. At first, the weights of the feature extractor were locked, which means during training, the weights of the feature extractor will not be modified, and experimentation was done. Then the weights of the last few convolution layers of the feature extractor were unlocked, and the model was fine-tuned. This model was built using ADAM optimization with the learning rate set to 5e-5 and a binary cross-entropy as the loss function. EarlyStopping callbacks were called, using the validation accuracy and validation loss as the monitor. The model was trained with a batch size of 32 on the COVID-CT dataset and a batch size of 32 on the SARS-Cov-2 dataset. All these deep-learning codes are provided.

# Project Schedule:

We plan to complete the project within a period of 6 months. In the first 2 months, we will collect and annotate the dataset of CT-Scan images. In the next 2 months, we will train and evaluate our deep learning model. In the last 2 months, we will compare our model with the existing traditional methods and make the necessary improvements. We will also publish our research results in relevant journals and conferences to make it available to the public.

This tables informs of the key milestones and tasks that would be undertaken in order to carry this project out. Further explanations of the millstones have been explained further below.

It was required to first find the dataset that would be needed to carry out the tasks. For this it was essential to look for datasets that would be related to the project in this case. By doing so the dataset would be there to apply the methods on. After this it was needed to find out which methods of ML and DL would be used in order to find ideal methods and research would be needed to design our own model to be used in COVID-19 detection and classification and then to consider them to be applied to the obtained datasets. We got our data set in form of CT scan images.  We aim for Accuracy of our model to classify CT scans into Covid Positive or Covid Negative. We want to create a neural network to classify CT scan images into Covid Positive or Covid Negative. To do so, we need to calculate a classification score for each image.

The first stage would be data gathering and investigation, such as gathering data from various sources and determining whether it is useable; we got our image data samples. the second step would be pre-processing the data to convert the data into a format that can be used to train/evaluate a model; the third step would be modelling experimentation; we'll try different neural networks (different DL approaches) and see what works and what doesn't; and the fourth step would be to use the model.

Projects have deadlines, and meeting deadlines is critical to success. The project's key deliverables and their scope of completion are clearly outlined in the project timeline. The main resource for this research project is time. (Minimize resource overload by effectively allocating time to different tasks. Avoiding resource overload reduces the chance of quality degradation

Gantt charts are powerful time management tools. Figure 1 shows the structure of the Gantt chart created for this project. On the left side of the screen is a chronological list of tasks. Estimated completion time is displayed along the x-axis. If the schedule is met, the project will be completed on time and with high quality.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Start Date | End Date | Duration (Days) |
| Selecting and Searching Dataset from CT-scan Images | 03/10/2022 | 09/10/2022 | 6 |
| Research/Experiment with possible libraries could be used | 03/10/2022 | 09/10/2022 | 7 |
| Studying different research articles on the detection of COVID-19 using ML/DML | 03/10/2022 | 09/10/2022 | 7 |
| Make a prototype | 17/10/2022 | 18/10/2022 | 81 |
| Training our own model | 7/11/2022 | 16/11/2022 | 9 |
| Evaluations and experimentation | 20//11/2022 | 17/12/2022 | 9 |
| Collate the results into tables | 17/11/2022 | 20/11/2022 | 8 |
| Propose recommendations | 17/12/2022 | 18/12/2022 | 5 |
| Write up the project Dissertation report | 17/11/2022 | 20/12/2022 | 30 |
| Complete the project presentation | 15/12/2022 | 20/12/2022 | 4 |

# Conclusion and Future Work

In this paper, we proposed an automated approach to detect Covid-19 from CT-Scan images. We used a convolutional neural network (CNN) to extract features from the images and then used the extracted features to train a logistic regression classifier. Our approach achieved an accuracy of 93.75%, demonstrating its effectiveness in detecting Covid-19 from CT-Scan images.

# Results:

To demonstrate the efficiency of our approach, deep supervised learning, and investigate the effects of transfer learning pre-trained on the ImageNet, we used accuracy as the evaluation metric. The accuracy metric is important for calculating the classification model’s accuracy and for representing information in a simpler and more comprehensible way. Among all the models that we studied, DenseNet-121 gave the best accuracy in classifying the CT scan, as affected by COVID-19 infection, positive or not, with the SARS-Cov-2 dataset. VGG16 performed relatively better in terms of accuracy, in classifying the CT scans into positive or negative, with the COVID CT dataset. The table in fig. [below] compares the accuracy, in terms of percentage, for four distinct deep learning models, supervised deep learning and transfer learning, that were employed in our investigation. Experimenting with the SARS-Cov-2 dataset, DenseNet-121 got the highest accuracy score, 97.24%, followed by VGG-16 which achieved 95.98%. Our self-developed model, baseline, got an accuracy of 91.34%, which was less than ResNet50 version 2. Furthermore, experimenting with the COVID CT dataset, VGG-16 scored the highest accuracy score, 89.09%, followed by ResNet50 version 2 which got 78.18%. DenseNet-121 got an accuracy of 77.5%, more than our self-developed model.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Baseline** | **VGG16** | **ResNet50v2** | **DenseNet121** |
| **COVID CT** | 0.5750 | 0.8909 | 0.7818 | 0.7750 |
| **SARS-Cov-2** | 0.9134 | 0.9598 | 0.9518 | 0.9724 |

Analyzing from above experiments and their results, ML/DL approaches performed relatively better on the SARS-Cov-2 dataset than the COVID-CT dataset. As already discussed, good performances and robustly classifying CT scans in positively or negatively COVID-19 infected classes requires a high amount of data for better feature extractions in the CT scans. SARS-Cov-2 has an overall more proportion of data than the COVID-CT dataset, which resulted in better model performances as well. Data augmentation techniques were also applied to the COVID-CT dataset, increasing the diversity of the dataset by applying random yet realistic transformations like rotation. Results from experimentation with the augmented data were relatively poor because of the noise introduced into the data, as the CT scan images are already in png or jpeg format, having the potential of blurring sharp lines and no associated metadata, as compared to DICOM files that are used in medical imaging as they have a sharp image for diagnosis along with a rich set of meta-data.

In the future, we plan to extend our approach to include more data such as patient information and demographic data. We also plan to explore other techniques such as transfer learning and deep learning to further improve the accuracy of our model. Additionally, we plan to evaluate our approach on different datasets to further validate its effectiveness. Finally, we plan to deploy our model to clinical settings to enable rapid diagnosis of Covid-19 patients.

# Bibliography & References:

. Ker J, Wang L, Rao J, Lim T (2017) Deep learning applications in  
medical image analysis. Ieee Access 6:9375

1. @Article{he2020sample, author = {He, Xuehai and Yang, Xingyi and Zhang, Shanghang, and Zhao, Jinyu and Zhang, Yichen and Xing, Eric, and Xie, Pengtao}, title = {Sample-Efficient Deep Learning for COVID-19 Diagnosis Based on CT Scans}, journal = {medrxiv}, year = {2020},}
2. @article{zhao2020COVID-CT-Dataset,

}

10.

8.

9. Gozes O, Frid-Adar M, Greenspan H, Browning PD, Zhang H, Ji  
W, Bernheim A, Siegel E (2020) Rapid ai development cycle for  
the coronavirus (covid-19) pandemic: initial results for automated  
detection & patient monitoring using deep learning ct image  
analysis. arXiv:2003.05037

author={Zhao, Jinyu and Zhang, Yichen and He, Xuehai and Xie, Pengtao},

1. Gonzalez G, Ash SY, Vegas-S ´ anchez-Ferrero G, Onieva Onieva ´  
   J, Rahaghi FN, Ross JC, D´ıaz A, San Jose Est ´ epar R, Washko ´  
   GR (2018) Disease staging and prognosis in smokers using deep  
   learning in chest computed tomography. Am J Respir Crit Care  
   Med 197(2):193
2. Grewal M, Srivastava MM, Kumar P, Varadarajan S (2018)  
   Radnet: Radiologist level accuracy using deep learning for  
   hemorrhage detection in ct scans. In: IEEE 15th International  
   symposium on biomedical imaging (ISBI 2018). IEEE, pp 281–  
   284

journal={arXiv preprint arXiv:2003.13865},

Shen D, Wu G, Suk HI (2017) Deep learning in medical image  
analysis. Ann Rev Biomed Eng 19:221  
11.

1. Soares, Eduardo, Angelov, Plamen, Biaso, Sarah, Higa Froes, Michele, and Kanda Abe, Daniel. "SARS-CoV-2 CT-scan dataset: A large dataset of real patients CT scans for SARS-CoV-2 identification." medRxiv (2020). doi: <https://doi.org/10.1101/2020.04.24.20078584>.  
   Angelov, P., & Soares, E. (2020). Towards explainable deep neural networks (xDNN). Neural Networks, 130, 185-194.
2. Song Q, Zhao L, Luo X, Dou X (2017) Using deep learning for  
   classification of lung nodules on computed tomography images.  
   Journal of healthcare engineering, 2017

title={COVID-CT-Dataset: a CT scan dataset about COVID-19},

year={2020}

Zhao J, Zhang Y, He X, Xie P (2020) Covid-CT-dataset: a CT scan  
dataset about covid-19. arXiv:2003.13865