

HERIOT-WATT UNIVERSITY

FINAL YEAR DISSERTATION

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# Automated Diagnosis of COVID-19 using Medical Imagery

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for the honours degree of Bachelor of Science*

*in the*

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# Declaration of Authorship

I, **Alister George Luiz**, confirm that this work submitted for assessment is my own and is expressed in my own words. Any uses made within it of the works of other authors in any form (e.g., ideas, equations, figures, text, tables, programs) are properly acknowledged at any point of their use. A list of the references employed is included.

Signed: **Alister George Luiz**

Date: **November 26, 2020**

*"The only limit to our realization of tomorrow will be our doubts of today."*

Franklin D. Roosevelt

# Abstract

The Coronavirus Disease (COVID-19), ever since its inception in late 2019 has spread all across the world and as a result, led to an increased burden on healthcare professionals due to the urgent need for rapid disease diagnosis and effectuating quarantine protocols.

Currently, the Real-Time Reverse Transcription Polymerase Chain Reaction (RT-PCR) test recommended by the World Health Organization (WHO) remains the front runner in terms of COVID-19 diagnosis when compared to other testing mechanisms. But there involve serious downsides to using this test as a primary diagnosis tool, a few of them include the shortage in RT-PCR test kits, delays in receiving test results (up to 2 days), but most importantly the low accuracy rate of COVID-19 detection.

The primary objective of this project is to develop a fully automated framework minimizing human to human interaction to rapidly diagnose patients with COVID-19 using medical imagery such as Chest X-ray's or CT scan's applying deep learning techniques and therefore, achieve a much higher accuracy rate compared to the traditional RT-PCR test ultimately reducing the workload on healthcare professionals.

**Keywords:** COVID-19, SARS-CoV-2, Chest X-ray, Chest CT, Medical Image Classification, Deep Learning, Convolutional Neural Networks, Transfer Learning

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# List of Abbreviations

<b>COVID-19</b>	<b>Coronavirus Disease 2019</b>
<b>SARS-CoV-2</b>	<b>Severe Acute Respiratory Syndrome Coronavirus 2</b>
<b>RT-PCR</b>	<b>Reverse Transcription Polymerase Chain Reaction</b>
<b>CT</b>	<b>Computed Tomography</b>
<b>CNN</b>	<b>Convolutional Neural Network</b>
<b>WHO</b>	<b>World Health Organization</b>

## Chapter 1

# Introduction

COVID-19, which was declared a global pandemic by the World Health Organization on March 11, 2020, has affected millions of lives worldwide in terms of both health and finances and have also had a severe global economic impact.

With over a million tests carried out on average daily across the world for diagnosing patients with COVID-19 ([Daily COVID-19 Tests 2020](#)), it is therefore the need of the hour to alleviate the burden on healthcare professionals who conducts these diagnoses on a day-to-day basis, and more importantly, minimize the exposure rate between patients and healthcare professionals.

### 1.1 Aim

This project aims to **automate the diagnoses of COVID-19 with medical imagery using Deep Learning**. The main focus being to achieve the highest diagnostic accuracy possible, minimizing the false-negative rate, which, if not accounted for may have adverse real-world implications. We also intent to compare the usage of X-rays vs CT scans in this project considering the limitations in terms of the equipment available on medical facilities, radiation exposure, and the results obtained in both cases.

The overall goal of this project is to develop a framework that enables highly accurate rapid diagnoses of COVID-19, all while providing a safer environment for healthcare professionals by minimizing the rate of exposure and following quarantine protocols therefore curbing the spread of COVID-19.

## 1.2 Objectives

The objective of this project is to develop a framework that rapidly diagnoses patients with COVID-19 with medical imagery and thereby provide assistance to healthcare professionals.

These are the primary objectives for this thesis:

- Analyse X-ray and CT imaging features of COVID-19.
- Build a deep learning model which diagnoses patients with COVID-19 using chest X-rays.
- Test the accuracy of the proposed COVID-19 diagnoses model by comparing with other similar models implemented previously.
- Develop a deep learning API which can be used by healthcare professionals and medical facilities to diagnose COVID-19.
- Optionally, build a deep learning model which diagnoses patients with COVID-19 using chest CT scans and compare the accuracy and results obtained from both models respectively.

## 1.3 Manuscript Organization

This manuscript contains 6 sections, starting with a comprehensive **Introduction** of the main objectives of this project. This is followed by the **Literature Review** section which aims to synthesize and sum up relevant research and implementations previously conducted in this same field. The next section **Requirements Analysis** conducts a detailed study on the use cases of this project and identifies user requirements and labels their priority. An additional section **Design** has also been included, which demonstrates the pipeline and the workflow of the proposed model. Following this is a section for **Evaluation Strategy** which specifies the analysis and assessment that needs to be administered for this project. The last section is dedicated to **Project Management** which provides a detailed schedule that must be strictly adhered to, in order to ensure the success of this project, as well as examining the risks involved and the ethical, legal and, social issues pertaining to this project.

## Chapter 2

# Literature Review

A comprehensive analysis of the existing research and methodologies pertaining to COVID-19 detection using medical imagery and deep learning models have been provided in this section.

### 2.1 The COVID-19 Pandemic Era

Coronavirus disease (COVID-19) is a highly contagious respiratory disease caused by the newly discovered coronavirus. The virus mainly spreads through the discharge of saliva droplets when an infected person coughs or sneezes (World Health Organization, [2020a](#)). A brief description of the novel coronavirus and its spread across the world is discussed in the following section.

#### 2.1.1 Rise of the Global Pandemic

COVID-19 which is now officially declared as a global pandemic by the WHO was initially discovered in late 2019 emerging from Wuhan, People's Republic of China. A media statement was released by the Wuhan Municipal Health Commission confirming multiple cases of "Viral Pneumonia from an unknown cause" on December 31<sup>st</sup> 2019 (Wuhan Municipal Health Commission, [2020](#)).

On January 7<sup>th</sup> 2020, this unknown disease was identified as the novel coronavirus by the WHO. Three days later, the first known death caused by the coronavirus was reported (World Health Organization, [2020b](#)). The spread of the virus continued rapidly within China and on January 20<sup>th</sup> 2020, WHO reports the first confirmed cases outside China in

Thailand, Japan, and South Korea. The very next day The United States reports its first confirmed coronavirus case (Edwards, 2020a).

Following these set of events saw the introduction of quarantine protocols via lockdowns. Starting with Wuhan, many other cities across the world also adopted the same orders to suspend the spread of the coronavirus. This prompted the WHO to declare the outbreak a global public health emergency (Edwards, 2020b).

Within the span of a month, the death toll from COVID-19 surpassed that of SARS and the WHO gives the official name for the disease caused by the coronavirus "COVID-19" (Mucari, Chow, and Murphy, 2020). The adverse effects of COVID-19 on various industries and the stock market began to show.

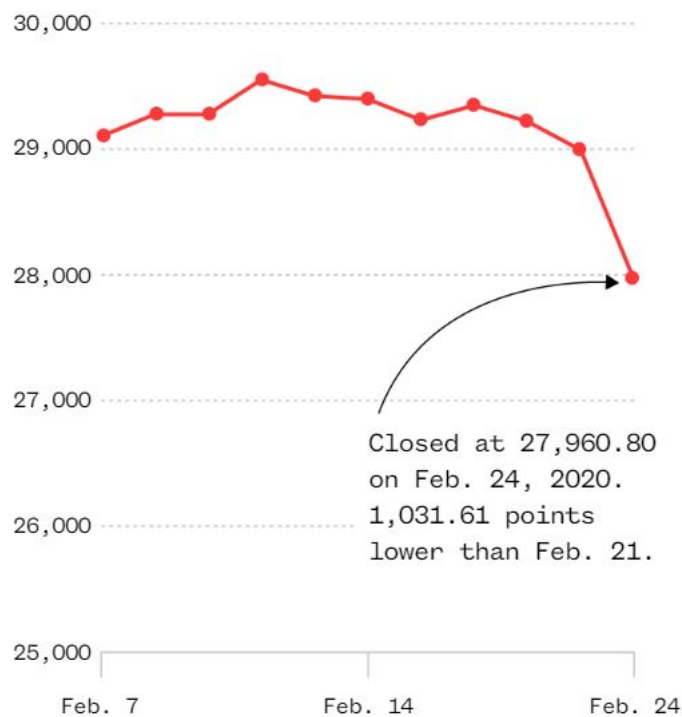


FIGURE 2.1: Dow Jones Industrial Average experienced the worst day in two years. (White and Bayly, 2020)

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