Chapter 1

Introduction

Each year, pneumonia claims the lives of hundreds of thousands of people and is the top cause of death in children and the elderly. Pneumonia risk factors include smoking, drinking, having surgery, having asthma, having a damaged immune system, and being over 65. The mortality rate of pneumonia may be lowered by early detection and timely treatment. Chest X-rays are frequently used to diagnose pneumonia by competent specialists, but in recent years, a shortage of medical professionals and an increase in pneumonia patients have made treatment more challenging.This paper suggests a method for automatically detecting pneumonia utilising chest X-ray pictures and ensemble models that are based on deep learning. By utilising the pre-trained models and merging them with a specially created CNN model, training time is cut down and accuracy is increased.

1.1 Background and Motivation

The development of computer systems that can carry out tasks that traditionally require human intelligence is referred to as artificial intelligence (AI). It is a vast field that includes several subfields like computer vision, robotics, natural language processing, and machine learning. Since its inception in the middle of the 20th century, artificial intelligence has made considerable strides.

The great potential of AI to revolutionize a wide range of businesses and areas serves as the driving force behind research and study in this field. Automation of monotonous work, improved decision-making and the extraction of useful insights from massive volumes of data are all possible thanks to AI technologies. This has caused it to be widely used in industries like entertainment, banking, manufacturing, transportation, and healthcare.

AI systems can analyze medical images, spot patterns, and help with disease diagnosis in the healthcare industry. Additionally, they can optimize treatment plans, forecast patient outcomes, and enhance all aspects of healthcare delivery. AI

algorithms in finance can assess risk, analyze market patterns, and automate trading plans. They can help improve cyber security defenses and detect fraud.

Big data's introduction and improvements in processing power have accelerated the development of AI. Artificial intelligence (AI) systems have the capacity to process and analyze enormous volumes of data, producing insightful forecasts and enabling more efficient decision-making. The growing accessibility of AI frameworks and technologies has also facilitated the creation of AI solutions by academics and industry professionals.

Furthermore, it is impossible to ignore how AI will affect society. AI creates ethical, legal, and social issues as technology becomes increasingly ingrained in our daily lives. Further investigation and study of the possible risks and benefits of AI have been motivated by worries about privacy, algorithmic prejudice, job displacement, and the ethical usage of AI systems.

Studying AI's ideas, algorithms, and applications is essential given its quick development and revolutionary potential. Researchers, technologists, and politicians can effectively exploit AI's capabilities and manage the issues that occur by having a solid understanding of it. AI has the ability to spur innovation, increase productivity, and improve the quality of life for both people and societies as a whole through research and development.

If not identified and treated right once, pneumonia is a respiratory infection that can result in serious illness and even death. A timely and correct diagnosis of pneumonia is essential for successful patient care and better results. Traditional techniques of diagnosing pneumonia entail radiologists manually interpreting chest X-rays, which can be time-consuming and prone to inaccuracy.

In recent years, there has been an increase in interest in automating the diagnosis of pneumonia from medical pictures, particularly chest X-rays, using artificial intelligence and image processing techniques. These cutting-edge tools have

the potential to improve pneumonia diagnostics' precision, effectiveness, and accessibility.

Applying AI and image processing to the identification of pneumonia is motivated by a number of factors:

a. Rising Pneumonia Cases: Millions of people around the world contract pneumonia each year, a common respiratory ailment. Rapid and precise pneumonia case detection can greatly enhance patient outcomes while lessening the strain on healthcare systems.
b. Radiologist Workload: Radiologists interpret medical images, such as chest X-rays used to diagnose pneumonia. However, there are difficulties in timely and appropriate interpretation due to the rise in imaging tests and the shortage of radiologists. Radiologists may receive assistance from automated pneumonia detection technologies, which may also lighten their workload and boost productivity.
c. Objective and Standardized Diagnosis: Pneumonia identification can be standardized by using image processing and AI algorithms, reducing inter-observer variability and arbitrary interpretations. This reliability of the diagnosis can improve the standard and dependability of patient care.
d. Early Recognition and Action: Early identification of pneumonia allows for early intervention, which results in prompt treatment and better patient results. Chest X-rays can be promptly analyzed by AI-based systems, helping medical personnel find pneumonia cases that may have gone unnoticed or need immediate attention.
e. Accessibility and Resource-Limited Environments: Pneumonia affects resource-limited environments disproportionately, because access to specialized medical personnel may be constrained. In these situations, AI-powered pneumonia detection devices can be used to help doctors make accurate diagnoses, potentially saving lives and enhancing patient access to care.

In academic and clinical settings, the use of image processing and AI algorithms for pneumonia identification has yielded encouraging results. Chest X-rays can be analyzed for signs of pneumonia using machine learning algorithms, deep learning

models, and computer vision techniques, which can also offer automated diagnostic support.

Overall, the necessity for an accurate, quick, and accessible diagnosis, improving patient outcomes, lowering radiologist workload, and addressing healthcare difficulties in places with limited resources are the background and driving forces behind using image processing and AI in pneumonia detection. These technologies could revolutionize the way pneumonia is diagnosed and help treat this potentially fatal respiratory infection more successfully.

1.2 Problem Statement

There is an urgent need to address the ethical and accountability issues related to AI systems as artificial intelligence (AI) develops and permeates more and more fields. A growing amount of worry is being expressed about potential biases, a lack of transparency, and the possibility of unexpected effects in AI algorithms, despite the major advantages AI offers, such as enhanced decision-making and automation. The fairness, accountability, and openness of AI systems are seriously questioned by these challenges, especially when applied to delicate industries like banking, healthcare, and criminal justice. The widespread adoption and responsible usage of AI technology are hampered by the absence of reliable frameworks and rules for assuring ethical AI development and deployment.

In order to address biases, improve accountability, and increase transparency in AI algorithms, as well as to promote trust and the ethical use of AI across a variety of domains, this thesis aims to investigate the ethical challenges posed by AI systems. It also develops frameworks for responsible AI development and proposes strategies to do so.

The precise and prompt diagnosis of pneumonia, a common and sometimes fatal respiratory illness, is essential for successful treatment. The manual interpretation of chest X-rays, a common way of diagnosing pneumonia, takes time and is prone to human mistake, which can cause delays in treatment. Through automated analysis of chest X-ray pictures, the development of image processing techniques and

improvements in artificial intelligence present a chance to improve pneumonia detection. The creation of reliable algorithms that can correctly detect pneumonia from other lung diseases, recognize anomalies associated with pneumonia in X-ray pictures, and handle changes in image quality and patient demographics are among the hurdles that still need to be overcome. Furthermore, in order to earn the confidence and acceptance of doctors, the interpretability and explicability of AI models in the context of pneumonia detection must be addressed. This thesis aims to address these issues by creating an effective and reliable pneumonia detection system using image processing techniques, enhancing the accuracy and effectiveness of diagnosis, and offering insightful information on the interpretability and explainability of AI models for pneumonia detection, ultimately assisting in the early detection and prompt intervention of pneumonia patients.

1.3 Objectives

The objectives in a thesis on pneumonia detection using image processing can vary based on the specific research focus and methodology. However, here are some general objectives that could be included:

a. To review the literature already in existence on machine learning models, image processing algorithms, and methods for detecting pneumonia in chest X-rays.
b. To compile and curate a large dataset of chest X-ray pictures with a variety of demographics and image quality differences, including both pneumonia-positive and pneumonia-negative instances.
c. To create and refine image processing methods for improving and preprocessing chest X-ray pictures in order to increase the precision and dependability of pneumonia identification.
d. To investigate and put into practice convolutional neural networks (CNNs), a type of machine learning method, for automated pneumonia identification utilizing processed chest X-ray pictures.
e. To assess and contrast the accuracy, sensitivity, specificity, and computational efficiency of various image processing and machine learning algorithms.

f. To look into the interpretability and explicability of the AI models that have been constructed to identify pneumonia, including information on the features and patterns that the models use to make decisions.
g. To evaluate the performance of the created pneumonia detection system to that of established techniques and professional interpretations using an independent test dataset.
h. Working with healthcare professionals to evaluate the clinical impact and utility of the created pneumonia detection system, taking into account elements like time savings, accuracy, and the potential to enhance patient outcomes.
i. To put out suggestions for the deployment and integration of the developed pneumonia detection system in clinical practice while taking ethical, legal, and regulatory considerations into account.
j. Through publishing research findings through scholarly papers and giving presentations at conferences or symposiums, to add to the body of knowledge in pneumonia detection using image processing.

The objectives in a thesis on artificial intelligence can vary widely depending on the specific focus and scope of the research. However, here are some general objectives that could be included:

a. To carry out a thorough analysis of the existing literature on artificial intelligence, taking into account all of its numerous subfields, methods, and applications in order to build a strong theoretical base.
b. To recognize and assess the existing issues and constraints affecting the creation and use of artificial intelligence techniques, such as biases, interpretability issues, data privacy issues, and ethical issues.
c. To create and put into use brand-new artificial intelligence techniques or algorithms that deal with a certain issue or inquiry, showcasing creativity and development in the discipline.
d. To plan and execute experiments or simulations to assess the functionality, accuracy, and efficiency of the suggested artificial intelligence methods, contrasting them with industry standards or best practices.

e. To show how the generated artificial intelligence models or algorithms can be used to solve complicated problems by applying them to real-world datasets or scenarios.
f. To analyze and explain the outcomes from the simulations or experiments, giving information on the benefits, drawbacks, and implications of the suggested artificial intelligence methods.
g. To investigate and suggest methods for enhancing the fairness, transparency, and interpretability of AI models while addressing issues with bias, responsibility, and reliability.
h. To look into the moral implications and societal effects of AI applications, stressing potential dangers, difficulties, and moral standards for ethical AI research and use.
i. To advance artificial intelligence understanding by presenting research findings at conferences and symposiums and spreading them through academic publications.
j. To make suggestions for the future development and use of artificial intelligence techniques, taking into account possible areas for improvement, additional study, and useful implications.

1.4 Scope & Limitations

The scope and limitations of pneumonia detection using image processing should outline the boundaries of the research and highlight any potential constraints or challenges. Here are some the scope and limitations for medical image analysis in machine learning application for pneumonia detection using Deep-CNN multimodal & transfer learning model.

Scope:

a. The thesis focuses on pneumonia detection using image processing techniques specifically applied to chest X-ray images.
b. The study includes the development and evaluation of image preprocessing techniques for enhancing the quality and clarity of chest X-ray images.
c. Machine learning algorithms, such as convolutional neural networks (CNNs), are utilized for automated pneumonia detection based on processed chest X-ray images.

d. The thesis explores the interpretability and explainability of the developed AI models to provide insights into the decision-making process.
e. The research investigates the performance of the developed pneumonia detection system using an independent test dataset and compares it against established methods and expert interpretations.
f. Collaboration with healthcare professionals is undertaken to assess the clinical impact and utility of the developed system, considering factors such as accuracy, time-saving, and potential for improving patient outcomes.
g. The research includes the development and implementation of artificial intelligence algorithms, models, or systems to solve a specific problem or address a research question.
h. The study explores the theoretical foundations and existing literature relevant to the chosen subfield or application of artificial intelligence.
i. The thesis may involve data collection, preprocessing, and feature extraction for training and evaluating artificial intelligence models.
j. Performance evaluation and comparison against benchmark datasets or existing approaches are conducted to assess the effectiveness and efficiency of the developed artificial intelligence methods.
k. The research investigates the interpretability, explainability, and fairness of the developed artificial intelligence models, addressing ethical considerations and potential biases.
l. This thesis involves real-world experiments, simulations, or applications to demonstrate the practical applicability and potential impact of the developed artificial intelligence techniques.

Limitations:

a. The study relies on the availability and quality of the chest X-ray dataset used for training and evaluation, which may be limited in terms of diversity and size.
b. The research is limited to chest X-ray images and does not consider other medical imaging modalities or diagnostic techniques for pneumonia detection.
c. The study assumes that chest X-ray images provided are properly labeled and accurately diagnosed by medical experts, which may introduce inherent biases or uncertainties in the dataset.

d. The research does not address other respiratory diseases or abnormalities that may coexist with or mimic pneumonia in chest X-ray images.
e. The thesis does not consider the real-time or online application of the pneumonia detection system, focusing primarily on offline analysis and evaluation.
f. The study does not explore the implementation of the developed system in different healthcare settings or consider potential challenges related to infrastructure, compatibility, or scalability.
g. The research may be limited by the availability and quality of data, which can impact the performance and generalizability of the artificial intelligence models.
h. Time and computational resource constraints may limit the complexity or scale of the artificial intelligence models or the size of the datasets used.
i. The thesis may not encompass all aspects of the chosen subfield or application of artificial intelligence, but rather focuses on specific techniques or algorithms.
j. The study may not consider the social, legal, or economic implications of the developed artificial intelligence systems beyond their technical performance.
k. The research may be limited to specific hardware or software environments, which may affect the reproducibility or transferability of the developed artificial intelligence methods.
l. The thesis may not address all potential challenges or limitations associated with the application of artificial intelligence, but rather focus on specific aspects within the chosen scope.

It is important to acknowledge these limitations and justify any constraints imposed by the scope to ensure the research findings are valid and reliable within the defined boundaries.

1.5 Thesis Structure

The introduction gives a succinct summary of the subject and its importance. The introduction introduces artificial intelligence and its expanding impact on modern civilization. The thesis's goal, to look at how AI affects society, is highlighted in the introduction, along with the study's goals. The journey of our research will reflect in

this thesis with the structure included with Major heads like Introduction, Literature review, Methodology, Experimental Results and Analysis, Conclusion and Future work. The structure of the thesis may be considered with the mentioned major points of our research process.

Pneumonia has been identified as a major cause of mortality, accounting for 14% of fatalities in children under the age of 5 and 740,180 recorded paediatric deaths in 2019 [40]. A high-grade fever with cramps, rapid breathing, shortness of breath, chest discomfort while coughing, a rapid heartbeat, feeling incredibly exhausted or weak, nausea and vomiting, diarrhoea, seizures, etc. are among the symptoms. Patients who have severe symptoms may lose their appetite, feel physically uncomfortable, cough up blood, or develop cyanosis. There are several different ways that pneumonia can be spread.

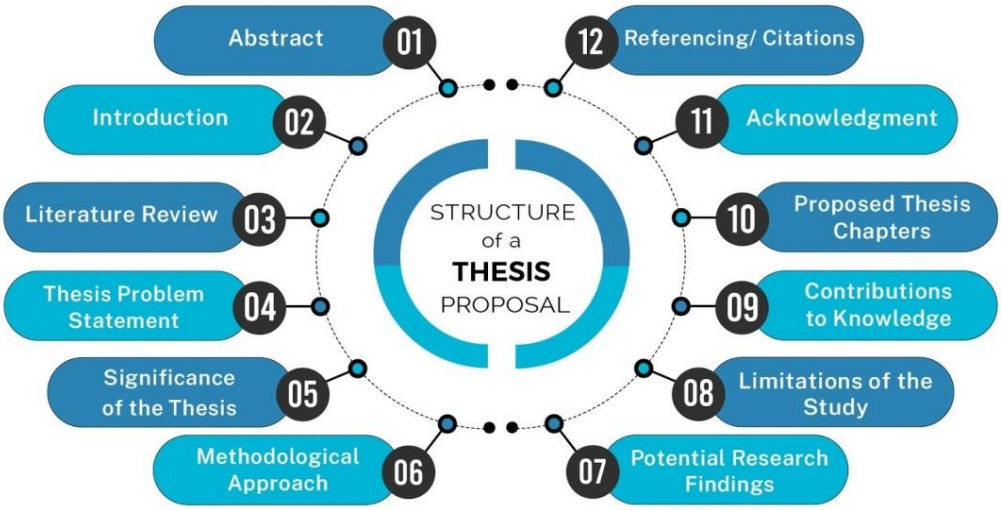

Figure 1.1: Structure of the thesis

When a youngster breathes, bacteria and viruses that are frequently present in their throat or nose could infect their lungs. Airborne droplets from their cough or sneeze can transmit the illness. Pneumonia affects millions of people each year all around the world. It is the third leading cause of death overall. Pneumonia caused 860,373 under-five-year-old deaths in 2016 and 808,694 in 2017. 90,000 kids in Pakistan lose their lives to pneumonia each year. Pneumonia affects families and children all throughout the world, despite being more common in South Asia and Sub-

Saharan Africa. Pneumonia is the second-leading cause of death for children under five in Pakistan, where it is particularly common in nations with high mortality rates. Prior to interventions, there were 14 pneumonia-related deaths for every 1000 children under the age of five in Abbottabad City, Pakistan. According to official autopsy procedures, pneumonia claimed the lives of 44% of young children in a hamlet in Pakistan's Northern Areas between 1988 and 1991. According to a verbal autopsy performed by the "Aga Khan Health Services," Pakistan [41,42,43], pneumonia is still a leading cause of mortality in the Northern Areas for infants and kids between the ages of 1 and 4.

In poor and underdeveloped nations, where squalor, pollution, and unhygienic climate conditions are prevalent, pneumonia is more common. The situation has worsened as a result, and there are not enough medical supplies. Therefore, keeping the disease from progressing to a deadly stage depends greatly on early detection and treatment. It is usual practise to evaluate the lungs radiographically for diagnosis using computed tomography (CT), magnetic resonance imaging (MRI), and radiography (X-rays). The examination of the lungs by X-ray radiography is congenital and typically inexpensive [44]. Infiltrates are the white spots on the pneumonic X-ray that separate a pneumonic condition from a healthy one. Contrarily, the diagnosis of pneumonia using a chest X-ray is prone to subjective variation. Therefore, an automated method of diagnosing pneumonia is required.

As an alternate method of diagnosing pneumonia, X-ray imaging technology has various advantages over traditional testing methods. Among these benefits are its low operating costs, wide availability of X-ray capabilities, non-invasiveness, decreased computational complexity, and equipment simplicity.

In light of the current crisis in global healthcare, X-ray imaging may be a better option for the widespread, easy, affordable, and quick detection of a pandemic, as well as pneumonia, COVID-19, heart failure, bone fracture, and other conditions [45]. Computer-controlled pneumonia detection systems have grown in popularity over the past few years as a tool to improve the effectiveness and reliability of healthcare services. In the context of numerous image analysis applications in the

medical profession, such as tracking, categorization, and classification, deep learning approaches go beyond traditional machine learning methods [46].

A potent artificial intelligence tool called deep learning can assist in resolving challenging computer vision issues [47]. Deep learning models, in particular convolutional neural networks (CNN), are frequently employed for picture categorization tasks [48,49]. These models, which are data-intensive, need a lot of data to perform well, which is challenging for biomedical image classification problems since each image must be identified by qualified medical professionals. There is a remedy for this problem called transfer learning [50]. This method uses the network weights calculated in a model that was trained on a large dataset to solve a problem involving a small dataset.The following contributions are made as a result of the study's use of several pre-trained networks to identify pneumonia in its early stages. In order to classify pneumonia accurately, an ensemble model is created by combining a CNN model with an Inception-V3 that has already been trained. This method explores the impact of transfer learning on model performance.

The effect of artificially increasing data on the precision of deep learning models is examined through data augmentation. For model overfitting, the effect of data augmentation is also investigated. For the purpose of detecting pneumonia, the performance of models is compared between single models and individually created ensemble models. Additionally, a comparison to cutting-edge models is made.