Detection Of Monkeypox Disease Using Computer Vision-Based Transfer Learning Models: A Comparative Study

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APPROVAL

This Project titled "**Detection Of Monkeypox Disease Using Computer Vision-Based Transfer Learning Models: A Comparative Study**", submitted by MD Mizanur Rahman, ID No: 191-15-2525 and Md.Nahiduzzaman, ID No: 191-15-2661 to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 1 February 2023.

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We hereby declare that, this project has been done by us under the supervision of **Amatul Bushra, Assistant Professor, Department of CSE** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

The world is now concern about monkeypox where the world is still infected by the deadly covid-19 virus. Monkeypox is not as infectious as covid-19 but it is a contagious disease. Monkeypox cases are being reported in many different countries in recent time . It is assumed that world will be facing another pandemic due to monkeypox if necessary precautions are not taken. Monkeypox transmitted through human to human or animal to human or animal to animal directly (physical contact: sex, skin to skin touch) or indirectly. It will be catastrophic if community transmission takes place. Artificial Intelligence(AI) has great improvement on image processing . It extracts unique features from the image. Machine learning has been used on the medical purpose by image diagnosis like cancer detection, covid detection. It is also used for classification. Monkeypox eruptive phase includes maculopapular rash on the skin. But it is difficult to identify because rash can be appeared for many reasons. Also monkeypox and smallpox lesions are quite similar so it makes more difficult to distinguish for doctors which one is it. Medical test such as PCR needed to identify monkeypox which is costly. Machine Learning provides some algorithms for image processing and classification. As skin lesion occurs due to monkeypox, monkeypox can be detected by image diagnosis in the early stage. People can then do tests to confirm monkeypox. Thus, Community transmission can be lessened and unnecessary cost for PCR or other diagnosis will be saved by adopting such machine learning application. We used MSLD dataset and deep learning algorithms: MobileNet, InceptionResNet-V2 and DenseNet-201 to classify into monkeypox and Others. We developed a CNN model SkinNet-9 for monkeypox detection. MobileNet and DenseNet-201 gave the best accuracy of 95.42% among these algorithms.

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LIST OF ABBREVIATIONS

ML	Machine Learning
DL	Deep Learning
MSLD	Monkeypox Skin Lesion Dataset
TP	True Positive
TN	True Negative
FP	False Positive
FN	False Negative
CDC	Centers for Disease Control and Prevention
CNN	Convolutional Neural Network
WHO	World Health Organization
FPR	False Positive Rate
FNR	False Negative Rate
MAE	Mean Absolute Error
RMSE	Root Mean Square Error

CHAPTER 1

INTRODUCTION

1.1 Introduction

The world is still suffering from the effects of covid-19 . Where people are recovering from the effect of the pandemic covid, another challenge is ahead of them which is Monkeypox. Recently several cases were reported of Monkeypox in 2022.Although Monkeypox is not so deadly as Covid but it can be global issue if community transmission occurs. The name Monkeypox came from the similarities in Monkeypox and two other pox virus Cowpox and Smallpox. It is also first discovered in a monkey's body in 1958 in a laboratory which is in Copenhagen, Denmark.[1]

The disease caused by the virus zoonotic Orthopoxvirus. The infectious Monkeypox is a member of genus Orthopoxvirus and family Poxviridae. Monkeypox is Contagious disease. Usually the virus itself transmitted through physical contact, animal bites.[1]It usually transmitted animals to animals such animals like Monkey, rats. Human to human transmission can be occurred also. The early stage symptoms of Monkeypox infected are fever, body ache, fatigue. Its eruptive phase includes maculopapular rash mostly on the skin of legs and arms. Two types of variants are known till now of Monkeypox one is Central Africa Clade and the second one is West Africa clade.[10]

Firstly, Monkeypox was detected only in animals specially in Monkeys. First case was an infected monkey in 1958. There was no record of human infection of Monkeypox until 1970. In 1970, A 9-month-old boy in Democratic Republic of the Congo was detected with Monkeypox virus during a smallpox eradication program. The boy was suffering from fever and later rash was seen mostly in the arms and legs. [10] Mostly infected human was young children then. Monkeypox usually was African disease , more specificly it was found in Central and Western Africa.[10] The first case of

Monkeypox infection outside Africa was in United states transmitted by rodents to dogs and then virus transmitted from dogs to humans in 2003.[10] The number of Monkeypox patients rose from 50 to 5000 from the year of 1990 to 2020.[1] Recently In 2022 several cases of Monkeypox were reported in several countries. Men who are gay(had sex with another man) was infected with Monkeypox mostly in a list of Monkeypox infected patient in 2022.[10]According to the WHO (World Health Organization) report from 1 January 2022 to 22 June 2022, there are 3413 confirmed Monkeypox cases in 50 countries and 1 patient died due to Monkeypox infection in Nigeria. Right now, we are facing clade 3 Monkeypox outbreak which derived from the West Africa clade. In 23 July 2022, Seeing the current outbreak of Monkeypox World Health Organization (WHO) has declared global Health emergency.

Till now there is no treatment for monkeypox. Since mokeypox is similar to another pox virus smallpox , treatment given for the smallpox is also being used for treatment of the monkeypox. In addition to being used to treat smallpox, Tecovirimat and Brincidofovir are now being used to treat monkeypox. [11] Although it seems vaccination is a must for monkeypox seeing the current situation. There is no vaccination for Monkeypox. Centers for Disease Control and Prevention (CDC) is developing treatment for the monkeypox.[11]

Early detection of monkeypox can stop the transmission of the monkeypox virus and save the patient's health. But detection of the monkeypox is difficult due to rashes can be found for various reasons. As it is difficult to distinguish monkeypox and smallpox rashes. A dermatologist can observe the symptoms and swab the lesion on the patient skin and send the swab to the lab for PCR. Polymerase Chain Reaction test can confirm the presence the monkeypox virus.[12]

Figure 1.1.1 Monkeypox Skin Lesion

Artificial Intelligence is a main focus to the world. With the help of AI image processing becomes productive and the result are more accurate. Machine Learning is a sub division of AI which has been used for various disease detection like cancer detection, lung disease, covid detection, plants and fruit's various disease with the quality of ML to image processing. Data mining is a subfield of Machine learning which provides pre-trained model for image processing. As the monkeypox virus breaks out recently, There is not much images of Monkeypox. As a result, pre-trained DL method is being used to achieve optimal accuracy. Md Manjurul Ahsan, et al. [1] achieved 97±1:8% and 88±0:8% accuracy for two study using transfer learning approach. Chiranjibi Sitaula, et al.[2] employed 13 pre-trained deep learning methods to identify monkeypox, comparing them to discover the most effective method. Abdelaziz A. Abdelhamid,et al.[3] developed two method namely PSOBER and SCBER using transfer learning approach with average accuracy of 98.8%. Korhan Deniz AKIN et al.[5] used 12 diffferent CNN models where MobileNetV2 shows best accuracy of 98.25%. Keep tracking to these works, every author used deep learning models for detecting monkeypox.

1.2 Motivation

Recently the number of monkeypox patient is increasing all over the world. Though at first monkeypox was seen only in animals since 1970. Then it transmits to human but there was no large number of monkeypox infection cases back then. It was usually a West and Central African disease. But it started spreading all over the world. The monkeypox patient rose from 50 to 5000 within 10 years from 1990 to 2000. According to the WHO, there were 3413 confirmed monkeypox cases from 50 countries all over the world and 1 death reported due to monkeypox from January 1 to June 22 of 2022. It became a global concern now.

Monkeypox prime symptom is rashes all over the body specially in arms and legs along with the other symptoms such as fever, body ache, chills. It is difficult to know if it is monkeypox due to its similarities with other pox virus like smallpox. Also, rashes can be appeared for many reasons so it is not possible to determine monkeypox seeing the rashes. PCR test is needed to confirm monkeypox infection.

Although monkeypox is not deadly as covid-19 but it will effect the world catastrophically. Monkeypox is a contagious virus. It transmits animal to animal, animals to human through physical contact or from things of infected people or animals. The world's economy is still weak due to the pandemic covid 19. If community transmission of monkeypox occurs the world will have to face another pandemic.

As Artificial Intelligence has made significant improvement in image processing. Doctors are also adapting methods/ applications of machine learning for medical diagnosis. Image are processed to detect many diseases. As rashes appears due to monkeypox, skin lesion images can be processed to detect monkeypox in early stage. We look forward to build a model to detect monkeypox simply using images of the skin lesion. Early stage detection can reduce the transmission of the monkeypox virus and we can stop the world from facing another pandemic. Also unnecessary PCR test will not be needed.

1.3 Rationale Of The Study

AI or ML is being used in many fields of research by the researchers. Image processing uaing ML models have brought a new era of research. Deep learning aalgorithm extracts specific features from the image. Many researcher have worked with image processing using ML methods. Medical organizations has also adopted image processing method for medical diagnosis. Some major works in medical research which need to be mentioned are cancer detection, covid detection, heart disease detection etc. Also image processing used in agriculture such as paddy leaf disease, rice disease and many more crops disease detection.

Monkeypox discovered many years ago but it didn't spread that much to attract researchers attention. But recently monkeypox breaks out significantly which attracted researchers attention. As this event occurred recently there is not much of work of monkeypox detection. Another reason for fewer work of monkeypox is that there were no publicly available dataset. So, there are limited number of dataset available online in this time and the number of data is not much. As a result, to find better outcome researchers have used deep learning algorithms in different datasets and have found different results. We will also use deep learning model in a online available dataset.

Monkeypox is contagious virus.It can transmits to human, animal by coming in physical contact of a infected human or animal. One can get infected by indirect contact with the virus also. So, people can get other people infected without his/her knowledge. This makes monkeypox dangerous for the world.

In 2022, From January 1 to June 22 3413 people got infected with monkeypox virus and one died with monkeypox according to WHO. So, percentage of death is not much or can be ignored but it transmits easily which can't be over seen. This will effect one's physical health and economy of the world.

So we aimed to use a DL model to detect monkeypox with better accuracy than previous work. People will be able to detect monkeypox by simply processing skin lesion image

appeared due to monkeypox at a early stage. As a result it will reduce the transmission of monkeypox virus.

We focused to compare previously used algorithm and models we have used to detect monkeypox with the same dataset.

1.4 Research Questions

Research starts with a thought, a question which should be answered. So typically our research starts with a question and many other question came with it while we thought of the work. These questions can be the overview of our work. The following questions came in our mind while doing our research work

- Why choose monkeypox as our research work?
- Why do we need monkeypox detection system?
- What work has been done with monkeypox detection by other researchers?
- How will we collect our data?
- Why are we using online available dataset?
- What method will we apply in our dataset?
- Why will we use machine learning?
- What kind of machine learning we will use?
- Why use transfer learning approach?
- What algorithms will we use in our dataset?

To find those above mentioned question's answers we have studied some of the research work about monkeypox and monkeypox detection by other researchers. We shall discuss about some quantitative and qualitative research work in monkeypox in the next part of our report. These studies enhanced our work productively. We have learned about monkeypox more broadly and realized the importance of monkeypox detection system.

As a result we have focused on detecting monkeypox disease in this research work by processing skin lesion images appeared due to monkeypox. We have also noticed which algorithms used in which dataset in previous research works. We have also studied some other image processing works with DL models along with monkeypox detection in order to select a algorithm which will perform better in a dataset.

By analyzing some of the monkeypox related research work, we have selected a dataset which seem to be better for our work. We had to choose a dataset from publicly available dataset on Kaggle because monkeypox image data is not available free for everyone. The dataset we have selected for our work is called ‘Monkeypox Skin Lesion Image Dataset’ which we will discuss more in the next part. This dataset is available publicly on Kaggle.

1.5 Expected Output

Monkeypox is not deadly but the problem it possess that is spreading of the monkeypox virus. It spread is much quicker and easier. One can get infected with monkeypox virus with direct or indirect contact of the monkeypox virus. After the monkeypox recent outbreak image processing for monkeypox detection has started. The expected outcome of our work are:

- Monkeypox detection with pre-trained deep learning models
- Build a new CNN model
- Achieve higher accuracy than previous works
- Detect monkeypox at a early stage of the disease using image classification
- Stop the community transmission of monkeypox

The expected outcome of our work is to detect monkeypox with less data loss and better accuracy. With early stage of detection will contribute to stopping community transmission of monkeypox virus. Thus, stopping a new pandemic.

1.6 Project Management and Finance

There are a couple restrictions through this project that we hope to get past in the future. We employed feature selection approaches and fewer classifiers that we would like to work in the future.

Finance: Our research project finance by Daffodil International University.

1.7 Report Layout

We introduced our research project in chapter 1 of the book. We have discussed basics of our thesis paper. Brief information of the mokeypox virus is discussed and how it is dangerous to the world is also explained. We have also explained our motivation and objective of our thesis in this chapter. An outline of our work is also given in this section and how / where will we collect our data. We have also talked about our method of work and potential outcome of this thesis paper in short.

We discussed the context of our study in the second chapter. We attempted to discuss the rationale for selecting this subject for our thesis. We have mentioned the current state of the monkeypox infection in the world. Also, we have mentioned the challenges and difficulties that we assuming to face.

The third chapter, it is the heart/brain of our work. In this section we firstly described about the method we are going to use in our work. A description of our dataset is given here. We briefly discussed about the selection of our algorithms, the algorithms work process. We shade light to the implementations process of our work in this section.

Chapter 4 is the Experimental Result and discussion section. In this part we discussed our gained knowledge from the work process and experimental outcomes are given here. We have given descriptive analysis of the experiment outcome in this chapter. The outcome for the different algorithms and summary of the results for different algorithms.

In this chapter 5, We focused on the previous works on the Monkeypox Skin Lesion Dataset which is also the dataset we are using. We studied the previous works and compare their outcomes with our works.

In the chapter 6, It is the final chapter of our work report. In this chapter the overview of our whole work is given. The total summary of our thesis and study is described in this section. Also, the implications of our work and also the effect of our work is talked here. The future work is also discussed in this section.

CHAPTER 2
BACKGROUND

2.1 Preliminaries/Terminologies

The monkeypox virus is the cause of the unusual disorder known as monkeypox.

The name "monkeypox" was originally used in 1958 when outbreaks of a disorder resembling the pox appeared in monkeys kept for research. Since the Democratic Republic of the Congo (DRC) identified the first human case of the virus in 1970, the virus has been discovered in a number of central and western African nations. The majority of cases were recorded from Nigeria and the DRC before 2022.

A monkeypox outbreak that followed the importation of rodents from Africa was noted in the US in 2003. Cases of both people and prairie dogs kept as pets were reported. Following contact with an infected animal, all human infections were treated successfully.

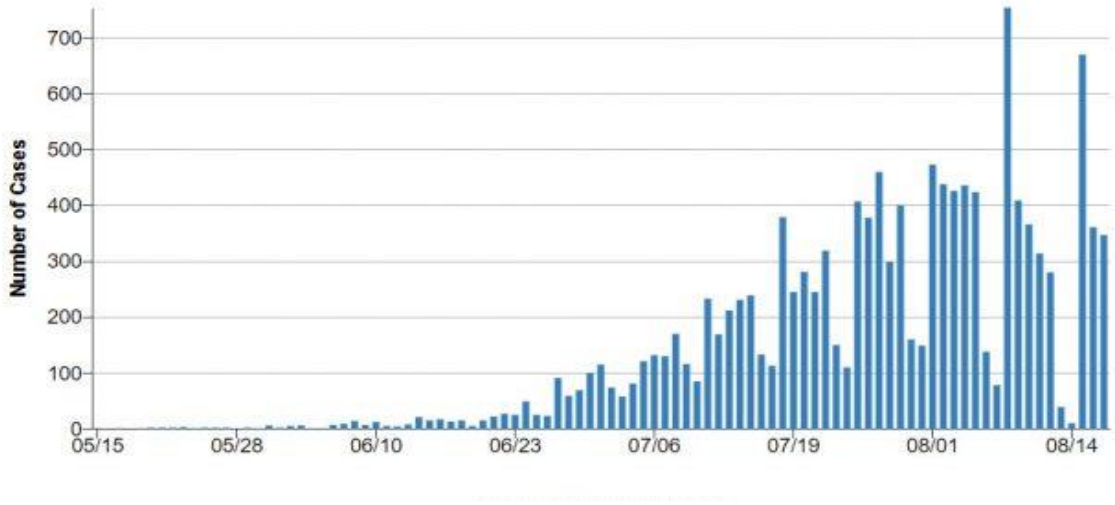

Figure 2.1.1 Monkeypox Case Reported in 2022 according to CDC

The figure shows the monkeypox case reported from May to August 2022 according to CDC.

Since May 2022, a number of countries—including the UK—that generally do not have monkeypox virus in animal or human populations have reported cases of the illness. The geographic distribution of cases of confirmed monkeypox between January and September 2022.

Table 2.1.1 Confirmed cases of monkeypox by WHO region from January 2022 to 15 June 2022, data as of 15 June 2022 1700 CEST

Region	Country	Confirmed	Probable	Deaths
	Cameroon	3		
	Central African Republic	8		
	Congo	2		
	Democratic Republic of the Congo	10		
	Ghana	5		
	Nigeria	36		1
Americas	Argentina	3		
	Brazil	5		
	Canada	159		
	Mexico	5		
	United States of America	72		
	Venezuela (Bolivarian Republic of)	1		
Eastern Mediterranean	Morocco	1		
	United Arab Emirates	13		
European	Austria	4		
	Belgium	52		
	Czechia	6		
	Denmark	7		
	Finland	3		
	France	125		
	Georgia	1		
	Germany	263		
	Greece	2		
	Hungary	5		
	Iceland	3		
	Ireland	14		
	Israel	5		
	Italy	68		
	Latvia	2		
	Malta	2		
	Netherlands	80		
	Norway	2		
	Poland	3		
	Portugal	241		
	Romania	3		
	Slovenia	7		
	Spain	313		
	Sweden	10		
	Switzerland	28		
	The United Kingdom	524		
Western Pacific	Australia	7	1	
Cumulative	**42 countries**	**2103**	**1**	**1**

The confirmed cases of monkeypox by WHO area from January 2022 to June 15th are displayed in the following table. Confirmed cases are those that have had the monkeypox virus in a lab confirmed, albeit they may also include instances with merely orthopoxvirus confirmation. Data were gathered from the CDC and are current as of September 12, 2022.

People do not contract monkeypox very frequently.

Close contact with an infected animal (rodents are thought to be the main animal reservoir for transmission to humans), person, or item contaminated with the virus can result in the spread of monkeypox. Animals in the UK have not been found to have monkeypox.

The respiratory system, mucosal membranes, or even invisible skin breaks allow the virus to enter the body (eyes, nose, or mouth).

The amount of time between coming into touch with an infected person and the onset of the first symptoms is known as the incubation period. Monkeypox takes between 5 and 21 days to incubate.

Most patients with monkeypox infection recover within a few weeks because it is typically a self-limiting condition. However, some people can experience serious illness.

2.2 Related Works

Though monkeypox discovered many years ago but it did not spread that much then to attract people attention. Recently, after covid pandemic monkeypox infected patient number increased significantly all over the world which pulled peoples attention. As a result there is not much work of Monkeypox detection using deep learning models. A few work is completed using deep learning to classify images of monkeypox.

Md Manjurul Ahsan, et al. [1] shows As there are image based diagnoses for cancer detection, covid detection similarly monkeypox can be diagnosed as it infected the human

skin. There are no publicly available dataset so they developed “Monkeypox22” dataset which is available publicly on github. Using a modified VGG16 model, they found accuracy of 97±1:8% (AUC = 97.2) and 88±0:8% (AUC = 0.867) for Studies One and Two, respectively.

Chiranjibi Sitaula, et al.[2] claims They tested 13 various pre-trained deep learning (DL) models to recognize the monkeypox virus. Best performing DL methods are ensembled to improve the performance.The mean F1-score, Accuracy, Precision, and Recall for the ensemble technique are 85.44%, 85.47%, 85.40%, and 87.13%. The second-best performance is also provided by the Xception DL model (F1-score: 85.02%, Accuracy: 86.51%, Recall: 85.14% and Precision: 85.01%).

Abdelaziz A. Abdelhamid,et al.[3] proposed two algorithms to improve accuracy of the monkeypox image classification. The parameter optimization techniques for multilayer neural networks are based on meta-heuristic optimization, whereas the feature extraction and feature selection procedures are based on transfer learning. The average classification accuracy was 98.8%. The Wilcoxon signed-rank test and ANOVA were used to statistically evaluate the relevance and effectiveness of the proposed approach. A collection of visual representations of the results was created in order to prove the validity and effectiveness of the suggested algorithms even further.

Veysel Harun Sahin et al.[4] suggested developing an Android app that uses a deep learning algorithm to identify monkeypox using a smartphone camera. An image dataset containing skin lesion photos of individuals with monkeypox and other skin lesions was used to train a deep learning algorithm. The algorithm with best accuracy was recreated after running in matlab and then trained with TensorFlow. The program was used on 3 different devices, with average inference times of 197 ms, 91 ms, and 138 ms being reported. The suggested system MobileNetv2 has an image classification accuracy of 91.11%.

Korhan Deniz AKIN et al.[5], a decision support system built on convolutional neural networks (CNNs) and aided by explainable artificial intelligence (xAI) was developed. The

572 photos in the data set, which was used for this work, are divided into two classes, such as Normal and Monkeypox. For the classification of monkeypox and normal skin, 12 different CNN models were utilized. In a comparison analysis, the MobileNet V2 model performed the best, with accuracy, sensitivity, specificity, and F1-Scores of 98.25, 96.5, and 100 respectively. For explainable artificial intelligence, this paradigm was utilized.

Kristi L.Koenig et al.[6], In order to facilitate the early identification and care of patients suspected of having monkeypox in 2022, this research presents a unique Identify-Isolate-Inform Tool. This study investigates the known One Health components of monkeypox in addition to offering a novel, condensed, fact-based Identify-Isolate-Inform Tool for frontline physicians in the early diagnosis and care of patients under investigation for monkeypox in 2022.

Shams Nafisa Ali et al.[7] mentioned monkeypox can be difficult to diagnose clinically in its early stages since it resembles both chickenpox and measles. If there are sufficient training examples available, deep learning approaches have been demonstrated to be useful in the automated detection of skin lesions. The "Monkeypox Skin Lesion Dataset (MSLD)," This was initially created as part of the present endeavor and displays pictures of skin lesions caused by measles, chickenpox, and monkeypox. In this study, a 3-fold cross-validation experiment is set up, and the sample size is extended through data augmentation. In the second stage, deep learning models like VGG-16, ResNet50, and InceptionV3 that have already been trained are used to classify ailments like monkeypox. With a score of 82:96 (4:57%), ResNet50 achieves the highest overall accuracy, followed by VGG16 (81:48 (6:87%)), and the ensemble system (79:26 (1:05%)).

Sourav Kumar Patnaik et al.[8] presents a method for using deep learning to automatically predict different skin conditions using a variety of computer vision-based methodologies. The system makes use of three image recognition architectures, InceptionV3, InceptionResNet-V2, and MobileNet, which have been modified for usage in applications for skin diseases. These models have been pre trained to identify photos in up to 1000 classifications, including pandas, parrots, and others. The following factors were taken into

account when creating the framework after creating the testing procedures. The modules include: -

1) A module for feature extraction.

2) Module for training.

3) Validation and testing.

Due to the fact that the prior models created for this application could only accurately predict up to six different skin diseases. By using deep learning algorithms, we can predict up to 20 diseases with an accuracy rate of 88%.

Md. Ashiqul Islam et al.[9] dealt with one class of healthy leaves and four classes of diseased leaves (Leaf smut, Brown spot, Leaf blast, and Leaf blight). For classification, the VGG-19, ResNet-101, Inception-Resnet-V2 and Xception deep learning CNN models were utilized. Inception-Resnet-V2 outperformed the other models, with an accuracy of 92.68%. In terms of testing accuracy, the ResNet-101 network came in second with 91.52%.

Md. Enamul Haque et al. [13] used convolutional block attention module(CBAM) with deep learning algorithms on the MSLD dataset for monkeypox detection. It focuses on the relevant portion of feature maps. The Xception-CBAM model gave better accuracy than other used algorithms with 83.89% accuracy.
The following table shows the future works and limitations of the related works

Table 2.2.1 Limitations and Future works of Related works

Author	Limitations and Future
Md Manjurul Ahsan, et al. [1]	They mentioned that their dataset consist of limited samples and collected from open source rather from a specific hospital and

	clinic. Suggested to update the dataset continuously with new Monkeypox infected patients. Also evaluate the proposed VGG16 model on imbalanced data and compare performances.
Chiranjibi Sitaula, et al.[2]	They mentioned that their dataset comparatively smaller and employed pre-trained models, which provide a challenge if implemented in a memory-constrained environment. Dataset can be improved and novel lightweight DL model can be a solution for the second problem.
Abdelaziz A. Abdelhamid,et al.[3]	Their dataset comparatively smaller They mentioned to evaluating the suggested approach using a sizable dataset and engineering optimization problems to clearly define its benefits and drawbacks.
Veysel Harun Sahin et al.[4]	They mentioned that they use only tools provided by the android studio where framework like React Natïve,Flutter and KMM can be used to developed application for multiple platforms. In future, multi-platform frameworks and PWAs can be used to solve problems and improve dataset

Korhan Deniz Akin et al.[5]	They used Monkeypox Skin Images Dataset (MSID) consisting of 572 images which is very few for a dataset. Dataset can be improved for a better outcome.
Shams Nafisa Ali et al.[7]	The used MSLD dataset contains fewer original image. Further number of data can be increached and more model can be used to automatic detection.
Sourav Kumar Patnaik et al.[8]	They mentioned that their model can be improved to make it a standard model for various skin disease detection.
Md. Ashiqul Islam et al.[9]	They work with only four type of disease and the dataset was smaller. They mentioned work can be done with other disease also and other deep learning models. Also modified models can be adopt to reduce complexities
Md. Enamul Haque et al.[13]	They mentioned that the used dataset has very few original image .so the wish to build a optimized model and use a larger dataset.

2.3 Comparative Analysis and Summary

Our work on this project focuses on various methods that are readily available in the community. Four different algorithms were utilized in total. The Monkeypox data set has been used as our main data set in this instance. It will enable us to distinguish between various pictures, such as smallpox, chickenpox, and monkeypox. This indicates that the labels are of the same type and class. By using algorithms we find out exact monkeypox disease from different types of disease. Our major language of preference was Python, and our feature extraction processes made advantage of deep learning techniques.

2.4 Scope of the Problem

Monkeypox virus is related to the smallpox and chickenpox viruses, but neither is usually severe and is a rare disease. Since then, isolated cases have been reported in 10 African countries, including Nigeria, where 172 suspected and 61 confirmed cases were recorded in 2017, the largest number of cases. Outbreak recorded. From the age of 21 he was 75% male until the age of 40. The monkeypox virus can spread when a person is close to an infected person, animal, or object. It is possible for viruses to enter the body through the mouth, eyes, nose, and open wounds.One to three days after the fever first occurs, people commonly develop a rash on their face that spreads to other parts of their bodies, such as the palms of their hands and soles of their feet. The severity of monkeypox varies. West Africa has seen some recorded deaths.

The section of the article where an image is the input and a proper result can determine whether or not there is monkeypox. A person will be able to ascertain using the provided method whether or not the person whose data was input has monkeypox. The system can adapt recommendations and offer pertinent solutions that address the topic's main problem because it has been trained by a large number of inputs.

One specific goal of our thesis is to develop a notion. A theory that can satisfy the needs of everyone who is or could be interested in learning about monkeypox. A theory that uses

a computationally efficient image-based model. An excellent objective where this effort can benefit everyone worldwide.

Our main goal is to find monkeypox before it progresses to an untreatable stage or a point when a person is confused about the name of the disease.

2.5 Challenges

In this section the most important part is data collection. For getting the best performance of detection, you must use clear pictures.

During our work on this project, we faced challenges like

- Data collection
- Dataset selection
- Data preprocessing
- Selecting method for our work
- Selection of best algorithms
- Looking for data collection sources
- Sources for build a model
- Data validation

This project's objective is to develop a model that, when applied to the images from the dataset, can calculate the severity of monkeypox that affected individuals have experienced. Like exact images of monkeypox, chickenpox, smallpox and images preprocessing, exact detection of monkeypox is a job that has a reputation for being difficult because of the complexity of various images. To find monkeypox from different classes of image like chickenpox, monkeypox and smallpox is too difficult because of the variety of images.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Research Subject and Instrumentation

To build mathematical models and make predictions based on previous data or information, machine learning employs a variety of methods. ML provides with frameworks for classification of images. Image classification model has important implications on the medical sector. Deep learning which is a subset of ML is a neural network. Deep learning models extract features from the data. It consists of some layers which extract important information from the images. CNN stands for Convolutional Neural Network which is used for deep learning that finds important patterns from the input data and used for classification of the data. We have used Monkeypox Skin Lesion Dataset (MSLD) for our work. The dataset contains two classes of data; one class is monkeypox and the other one is labelled as others. Others labelled contains chickenpox and measles images. As for the dataset, our model contains two classes such as monkeypox and others.

The basic model of our work is shown on the figure: 3.1.1. Firstly we selected the dataset and collected it from the Kaggle. The data is preprocessed for applying the transfer learning pre-trained models. The dataset is ready to use the deep learning algorithms after the pre-processing. The models will then be trained and tested using the augmented data. Finally we will test the model. Thus the model will provide different measurements on the basis of our command such as accuracy, precision, Recall, F1 score.

It is important to pre-process the data for a deep learning model if the dataset is not pre-processed. Pre-trained models needs the all image in the same resolution. So firstly we pre-processed our data to fed the deep learning models.

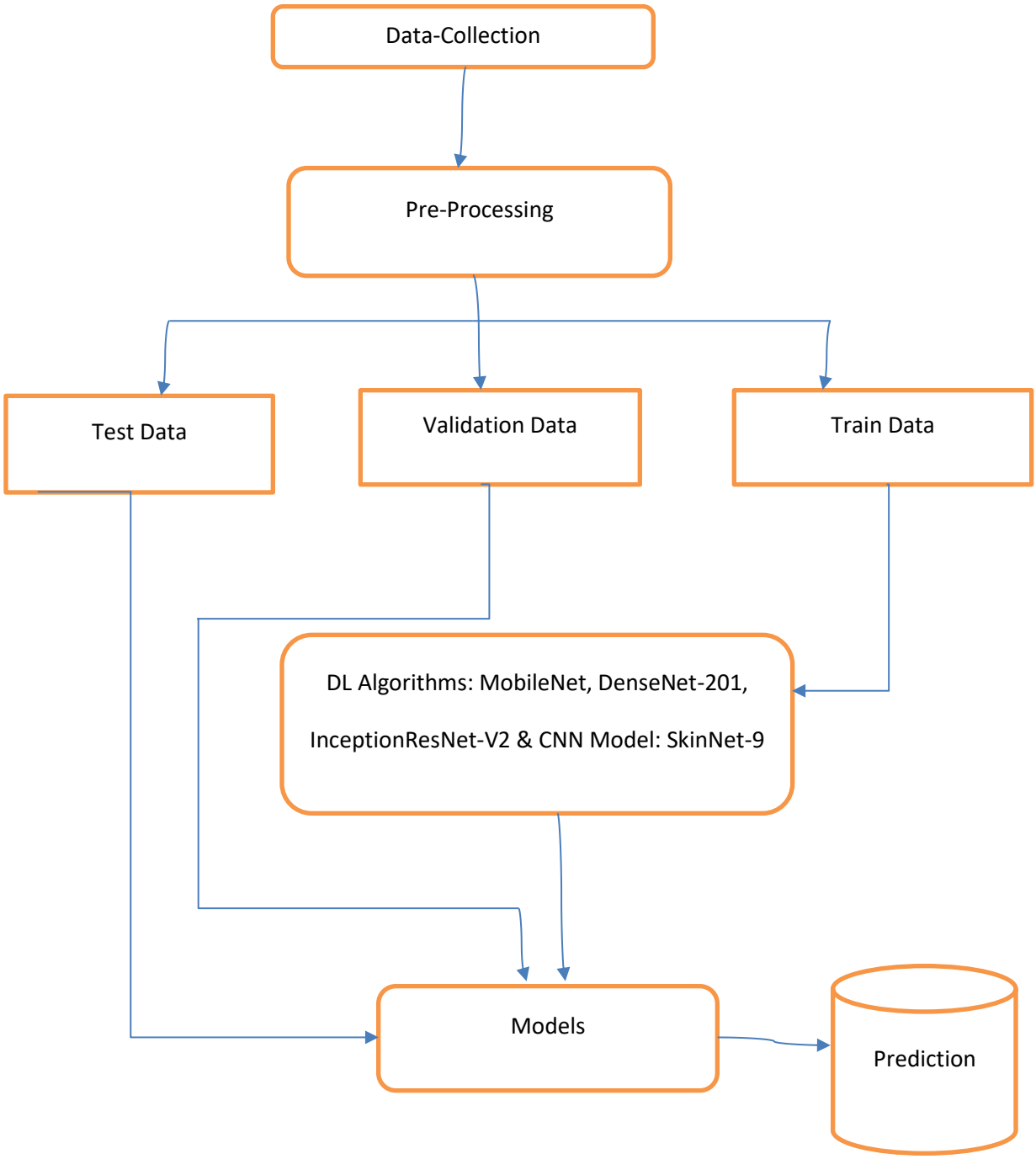

Figure 3.1.1 Basic model of our work

Our main goal is to detect monkeypox from skin lesion images. To achieve our goal we have used our ML knowledge and applied DL transfer learning pre-trained models in the dataset. In order to complete our work, we used different tools, software's and libraries available on the coding environment on the basis of our needs.

Machine Learning

Computers can learn autonomously from historical data thanks to a new technology known as machine learning. To build mathematical models and make predictions based on previous data or information, machine learning employs a variety of methods. It is currently used for a wide range of applications, including voice recognition, recommender systems, spam filtering, social auto-tagging, image identification, and voice recognition. We also have computers or other robots that carry out our orders in the real world, and we are accompanied by people whose capacity for learning allows them to learn from their experiences. A machine-learning method uses prediction models it has constructed based on previous data to forecast the outcome when it receives new data. The amount of information used determines the accuracy of the predicted outcome, as it is easier to create a model that accurately predicts the outcome with a larger data set. Take a difficult problem that calls for some predictions.If we simply feed it basic algorithms with data, the machine will build logic on the basis of the data and predict the output, so we won't have to write any code. Machine learning has altered our perspective on the problem. It used in classification of images. Also, DL is a subset of ML which search for patterns in the images and classify them by the patterns.

CNN Model

An exceptional class of multi-facet brain network called a "convolutional brain organization" is made to perceive fractal math straightforwardly from pixel pictures with practically zero pre-handling. The architecture of its artificial neural network is one of a kind. Convolutional neural networks have advanced computer vision issues to the cutting edge by utilizing a portion of the characteristics of the visual cortex. The convolution layer and the pooling layer are the two most fundamental components of convolutional neural

networks. For a particular PC vision issue, there are almost endless ways of gathering these layers notwithstanding their effortlessness. A deep neural network's convolutional layers and other parts are simple to comprehend. In fact, it's hard to use convolutional neural networks because it's hard to make model structures that use these fundamental parts to their full potential. Convolutional neural networks are extremely popular because of their architecture and because it is not necessary to extract features. By converging images and filters into invariant features that are then transmitted to the subsequent layer, the system acquires the ability to extract features. In order to produce increasingly abstract and occlusion-invariant features, the features of the subsequent layer are combined with a variety of filters. Until the final feature is obtained, this procedure is repeated. The most frequently used convolutional neural network designs are LeNet, AlexNet, ZFNet, GoogLeNet, and VGGNet. These are now been widely used for image classification and the reason is to achieve higher accuracy.

Table 3.1.1 Tools used for our work

Package	Description
Python	A high-level programming language is Python. There are numerous sophisticated built-in functions. It is popular for application development for it’s high-level built structure which is dynamic binding and dynamic typing. It is more popular as it is simple and it’s syntax are easy, code is easily understandable. Python is widely used for the ML. The reason is that it’s available libraries that makes easy to

	implement ML and also for the visualizations options.
Google CoLab	Google Colab or Colaboratory is a programming environment. It is a publicly available, free of cost product by Google Research. It provides free libraries for various computation, Visualization process. So it used for machine learning especially.
JupyterLab	A web-based interactive development environment for code, notebooks, and data is called JupyterLab. JupyterLab consists a flexible interface that allows the users to arrange and configure workflows in data science, Machine Learning and scientific computing.

In order to implement our model, we used some python libraries. The used libraries in our work:

TensorFlow: TensorFlow is a library which is used for fast numerical computation. It usually makes ML and developing neural networks faster and easier. It can be also used to develop deep learning models. TensorFlow makes it simpler to train models, collect data, serve predictions, and improve future outcomes.

Pandas: Pandas is a popular library for quantitative analysis. The library has some functions for make changes to the data such as analyzing, cleaning, exploring and manipulating the data. It applies statistical theories to the dataset and gives a conclusion.

Matplotlib: Matplotlib is usually used to create different plot types. Matplotlib can be embedded in JupyterLab. It is used to visualize static, animated and interactive plots in python. It can make interactive figures which can be zoomed, updated.

Numpy: Numpy mainly works with arrays. A Python package called Numpy enables users to build sizable, multidimensional matrices. and arrays and allow the user to operate many high-level mathematical functions on the arrays. Numpy provides arrays which is faster than python lists

Seaborn: Seaborn is actually matplotlib based python library used to visualization of data in python. It's high level interface is used to make the statistical graphics more informative and attractive.

3.2 Data Collection Procedure/Dataset Utilized

Data Collection

Since monkeypox breaks out recently in human recently there is not much work of monkeypox detection. Few of the study has been done and some publicly available dataset has been developed. [1][8] We have used Monkeypox Skin Lesion Dataset (MSLD) publicly available dataset for classifying human monkeypox in Kaggle. [8] The dataset consist of monkeypox and other images. Other lesion image data is either chickenpox or measles.

Figure 3.2.1 Monkeypox Skin Lesion Original Image

The following figure 3.2.1 shows the original images of monkeypox skin lesion image from MSLD dataset.

MSLD was developed by collecting image from online portals, publicly available case reports or websites. They preferred manual searching over auto web scrapping to distinguish monkeypox and other lesion image. Also, data were cross checked using Google Reverse Image search. The dataset has 3 folders original image, fold1, augmented images. Original image folder has 228 image consisting of 102 monkeypox lesion and 126 other lesion images. After adopting different augmentation method on original images monkeypox image increase to 1428 and other image increases to 1764.

Figure 3.2.2 Others Skin Lesion Original Image

The figure illustrates the original other images example from MSLD dataset.
Then these images were kept in the folder for augmented images. Testing, validation, and training sets of the original images were created. Augmentation method only applied to the training and validation set. These training, testing and validation set were stored in fold1. The dataset divided into 70:20:10 for training, testing and validation set. Thus fold1 was used to train, validate and test the model.

The following 3.2.1 table shows the dataset state before the augmentation process applied on the MSLD dataset.

Table 3.2.1 Monkeypox Skin Lesion Dataset before augmentation

Class	Original Image	Unique Patients
Monkeypox	102	55
Non-Monkeypox	126	107
Total	228	162

Data Augmentation:

Data augmentation is used to improve the performance of the model , increase the dataset and achieve a better experimental outcome. The original images were only 228 of monkeypox, chickenpox and measles in the Monkeypox Skin Lesion Dataset.

This number is not enough to gain a expected outcome using machine learning. So the creator of the dataset MSLD used various augmentation method to increase the number of data. These methods slightly alters the existing data and make copies of those altered data. Augmentation methods applied in the dataset MSLD are translation, shear, rotation, hue, reflection, jitter, saturation, brightness, contrast, scaling and noise.

Augmentation were applied only on the training and validation set. The number of data rose up to 1428 of monkeypox image and 1764 of non-monkeypox image.

The following 3.2.3 figure shows the augmented image of monkeypox skin lesion from MSLD dataset.

The following 3.2.4 figure shows the augmented image of others skin lesion from MSLD dataset.

Figure 3.2.3 Monkeypox Skin Lesion Augmented Images

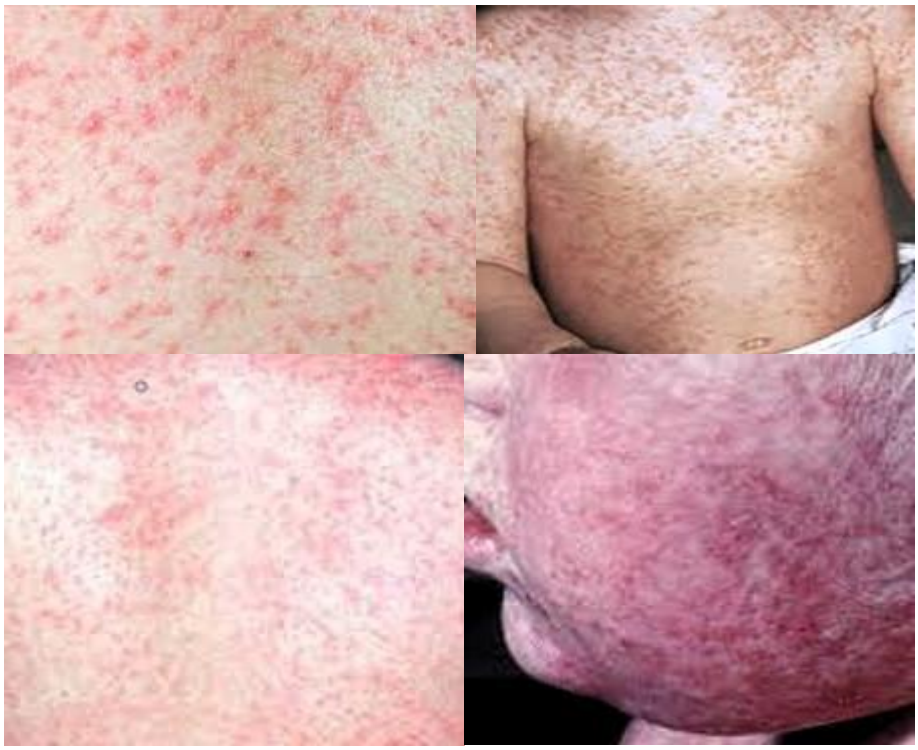

Figure 3.2.4 Others Skin Lesion Augmented Image

The following 3.2.2 table shows the state of MSLD dataset after augmentation.

Table 3.2.2 MSLD Dataset after augmentation

Class	Original Image	Augmented Image
Monkeypox	102	1428
Non-Monkeypox	126	1764
Total	228	3192

3.3 Statistical Analysis

3.3.1 Image Classification

In recent years, fields like machine learning, as well as its subdivisions, deep learning, and neural networks, have made significant progress due to the increasing volatility, necessity, and applicability of artificial intelligence. For training, you need tools and software like classifiers, which take in a lot of data, look at it, and find useful characteristics. In a digital image, the classification process groups all of the pixels into one of several groups. In the classification process, multi-spectral data are frequently utilized, with each pixel's spectral pattern serving as the numerical classification value. The identification and description of image features in terms of the actual floor object they represent as a distinct gray level is the goal of image categorization. Most likely, picture order is the most important aspect of advanced picture handling. The classification of images has been a crucial task in the field of computer vision due to the difficulty of object identification. The process of classifying images into one of a number of previously established categories is referred to as "image classification." one that can potentially be divided into n distinct classes. Manually examining and classifying a large number of photos can take time; As a result, using computer vision to automate the entire process would be extremely beneficial. The development of autonomous vehicles is yet another excellent illustration of how picture

categorization is utilized in practice. We need classification models to achieve the highest level of accuracy because of the applications, such as automatic feature organization, holistic picture and video webpages, visual search for improved product visibility, important visual databases, facial detection and image on social media, and many others.

3.3.2 Structure for Classification of Images

- Pre-processing of images: This method aims to increase the amount of image data (elements) available to computer vision models by enhancing key image features and reducing undesirable distortions. Reading the image, resizing it, and adding data are all part of the image pre-processing steps.

- Object detection: The process of localizing an object by segmenting the image and locating the target object is known as detection.

- Extraction of features and training: Statistics are used in this crucial step to identify the most intriguing patterns in the image. The model will use these characteristics to differentiate between classes in the future. They may be unique to a particular class. Model training is the process by which the model is trained on the features in the dataset.

- The item's classification: This phase divides any new items into predetermined categories by employing an appropriate classification algorithm that contrasts the dealing with the target patterns.

3.3.3 Customize Dataset

In our dataset, there was a folder named fold1 which has 3 folders of train,test and val. These three folders each has also two subfolders named Monkeypox and others. Firstly we combined the all monkeypox images from these three monkeypox subfolders and stored in a subfolder named Monkeypox within a split folder. Similarly we combined the others images from the others subfolders and stored them into the newly created subfolder others

within the split folder. We split the data into 70:20:10 for sequentially train, test and validate the model.

3.4 Proposed Methodology/Applied Mechanism

3.4.1 Data Pre-processing

Data is important for a better accuracy in ML. The result will greatly depend on the data provided to the ML model. So to increase the accuracy, data need to be pre-processed. We used ImageDataGenerator. It is used to augment the input data. Makes random transformations on the images. We rescaled the data by 1./255. Images will randomly transform by shearing and zooming by the range of 0.2. Horizontal and vertical flip is used to flipping the images randomly horizontally and vertically. By the brightness range of (0.4, 0.7), images will make random transformations. We set the resolution of the images to 224×224×3.

3.4.2 Training, Validation and Testing Data

Firstly, we used transfer learning pre-trained models. The models were trained on a ImageNet dataset. Pre-trained models are used to achieve a better accuracy with its transfer learning. Thus, these models take training set as input and finds the pattern. Then the model is validate using a separate dataset from the training set to look how the model is working on the data. Finally, the model is tested with data and the model classify the data with the pattern it founds from the training data.

3.4.3 Measurement

- Accuracy: Accuracy is a metric that generally describes how well the model performs across all classes. This is needed when all categories are of equal importance. It is calculated as the ratio between the number of correct predictions and the total number of predictions.

$$Accuracy = \frac{TP + TN}{TP + FN + TN + FP}$$

- F1-Score: The consonant normal of review and accuracy is utilized to work out the F1 score. Keep in mind that the harmonic average is used in place of the arithmetic mean, which is used more often. It frequently helps when figuring up an average rate. For the F1 score, we calculate the mean of the precision and recall. Given that they are both rates, it makes sense to apply the symmetrical average. The formula for the F1 score is demonstrated here:

$$F1\ score = \frac{2 \times Precision \times Recall}{Precision + Recall}$$

- Precision: The accuracy of successful predictions is one sign of a deep learning model's effectiveness. Divide the total number of genuine positive predictions by the total number of correct positive predictions to determine precision. For instance, in a model of customer attrition, precision is the percentage of all consumers whose cancellation of subscriptions the model accurately predicted would occur as opposed to the actual consumers who actually did so.

  The ratio of correctly diagnosed positive instances to all samples that were classified as positive, whether correctly or wrongly, serves as a measure of the precision. The precision of the model is how well it determines whether a sample is positive.

$$Precision = \frac{TP}{TP + FP}$$

- Recall: The proportion of positive cases correctly identified as positive compared to all positive cases determines the number of instances recalled. Recall measures

the model's capacity to recognize positive samples. The recall rises as more positive cases are discovered. The recall is calculated by dividing the total number of positive cases by the percentage of cases correctly classified as positive. Recall is a measure of a model's capacity to recognize positive samples. Positive samples are discovered more frequently when recall is higher.

$$Recall = \frac{TP}{TP + FN}$$

- Specificity: The ability of the algorithm or model to accurately predict a true negative for each category that is available is known as specificity. It is also referred to as the true negative rate in literature. Formally, the equation below can be used to figure it out.

$$Specificity = \frac{TN}{TN + FP}$$

- False Positive Rate: The formula for determining is FP/FP+TN, FP indicates how many false positives there are, TN indicates how many true negatives there are.The probability that a false alarm will sound is: that even if the actual value is negative, a positive result will be returned.

$$FPR = \frac{FP}{TN + FP}$$

- False Negative Rate: The misleading negative rate is the level of importance tests that neglected to dismiss the invalid speculation regardless of whether it was really false. A false negative is an outcome where the negative class is predicted incorrectly by the model.

$$FNR = \frac{FN}{TP + FN}$$

- Mean Absolute Error: MAE is the measure of a model's evaluation statistic in regression analysis. The average of each prediction error's actual values over all instances of the test set is the mean percentage error of this model with regard to the test set.

$$MAE = \frac{|(Yi - Yp)|}{N}$$

Yi=actual value

Yp=predicted value

N=number of observations/ rows

- Root Mean Square Error: The average of each prediction error's actual values over all instances of the test set is the mean percentage error of this model with regard to the test set. It illustrates how forecasts and actual values are separated by the Euclidean distance. You must first determine the leftover for every data point, its norm, and its mean before you can get the square root error (RMSE). Since it necessitates and makes use of real measurements at each projected data point, RMSE is frequently utilized in supervised learning techniques.
  The expression for the root mean square error is

$$\text{RMSE} = \sqrt{\frac{\sum (y_i - y_p)^2}{n}}$$

y_i = actual value
y_p = predicted value
n = number of observations/rows

3.4.4 Classification Model

- SkinNet-9

  We build a Convolutional Neural Network (CNN) model in deep learning. Our model is a sequential model. We used keras library to build the model. We have used four blocks in our model. Every block is consisting of two layers. One layer is the 2D convolutional layer and the other one is 2D maxpool layer. Maxpool layer comes after the convolutional layer. The batch size is 32 in the convolutional layer. We have set the kernel size into (5,5). So, the filter matrix of our model is (5×5).

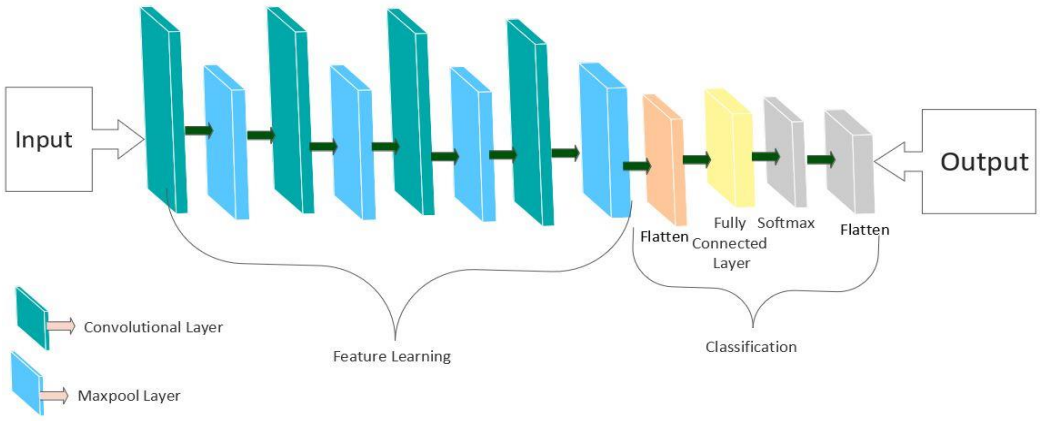

Figure 3.4.1 Basic architecture of SkinNet-9

The activation function we used in our model is ReLu. ReLu stands for Rectified Linear Activation. It works well in our model. We used a flatten layer. It makes the connection between convolutional and dense layer. Then we used dense layer with 1024 output size. We have used a dropout of 0.5 in our model. We have selected two class as our work is to classify image into two classes. So we have used 'Softmax' as activation function for classification.

In the next step, We declared our optimizer, learning rate and loss. 'Adam' is the optimizer we have used. We tried different optimizer but it seems suitable more.

Adam adjust the learning rate. We have set the learning rate to 0.001 in our CNN model. Learning rate fix the optimal weights calculation for the model. So small learning rate leads to more optimal weights but it will take more time to calculate weight. Then we have used 'categorical_crossentropy' as loss function.

We tried to see the other possibilities by using different parameters in different functions, using different activation functions. We have also tried to see the accuracy by adding or reducing layers.

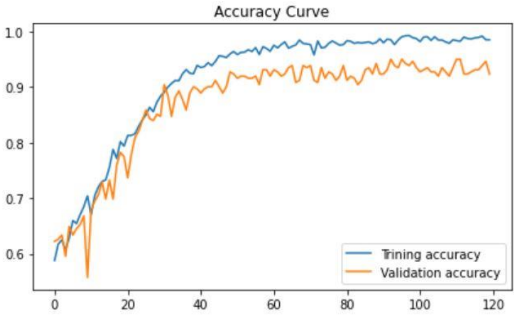

Figure 3.4.2 Accuracy curve of SkinNet-9

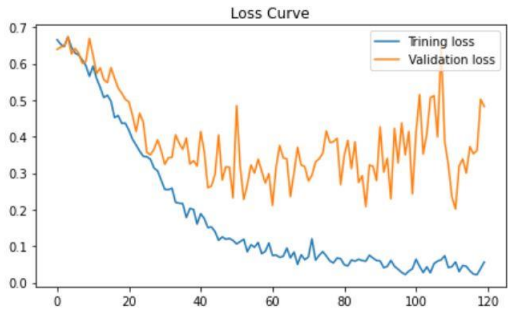

Figure 3.4.3 Loss curve of SkinNet-9

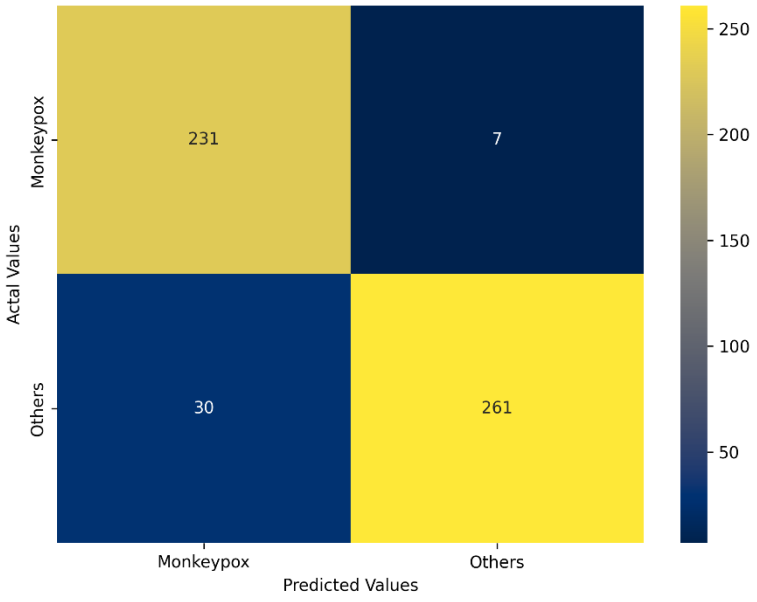

Figure 3.4.4 Confusion matrix of SkinNet-9

- MobileNet

  The MobileNet model is, as its name indicates, the first mobile computer vision system in TensorFlow. It is created with mobile apps in mind.MobileNet employs depth-wise segmented convolutions. The number of parameters is drastically reduced when compared to a network with typical convolution layers at a similar depth within nets. Compact deep neural systems have been created as a result.

  The creation of a depthwise special solution requires two processes.

  i.Convolution along the depth

  ii.Convolution along a point

  This offers us an extraordinary spot to begin while preparing our classifiers, which are tiny and incredibly fast. Google made the MobileNet subclass of CNN open-source.

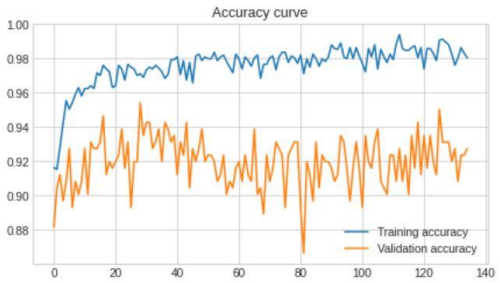

Figure 3.4.5 Accuracy curve of MobileNet

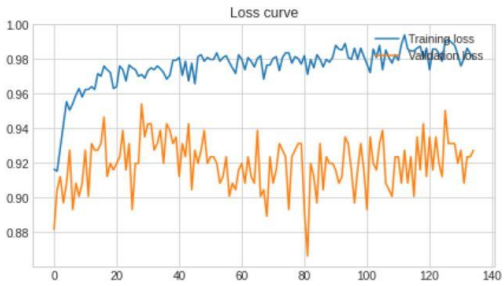

Figure 3.4.6 Loss curve of MobileNet

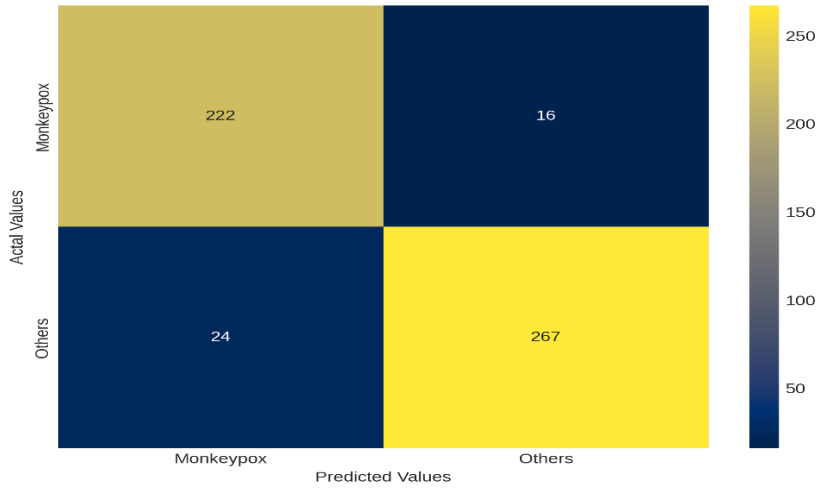

Figure 3.4.7 Confusion matrix of MobileNet

- DenseNet-201

  DenseNet-201 is the name of a neural network convolutional with 201 layers.A pre-trained model variant of the network which has been learnt from the more than one million photographs is included in the ImageNet database. The pre-trained model network is capable of classifying images into more than a thousand distinct item categories, including animals, pencils, keyboards, mouse, and many others. As a result, this model can learn a lot from a wide range of images and consequently represent a wide range of features.The network accepts images that are 224 by 224 pixels in size.

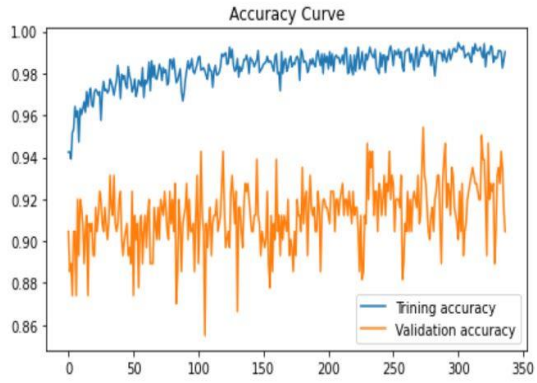

Figure 3.4.8 Accuracy curve of DenseNet-201

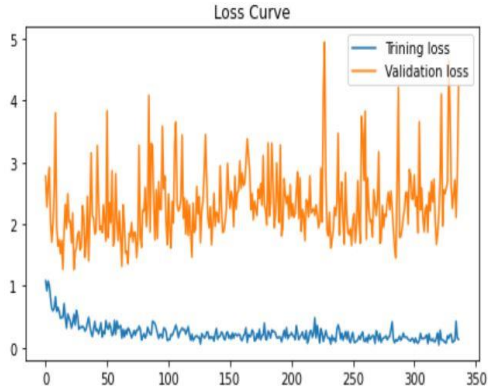

Figure 3.4.9 Loss curve of DenseNet-201

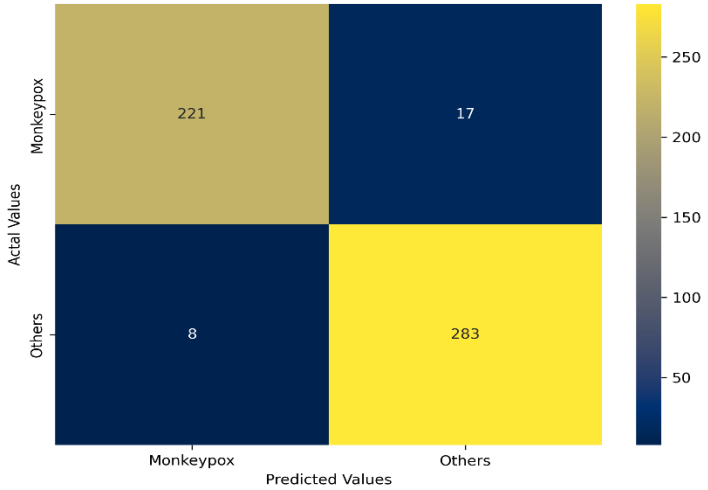

Figure 3.4.10 Confusion matrix of DenseNet-201

- Inception-ResNet-V2

  A CNN named Inception-ResNet-V2 was trained with more than 1 million pictures, collected from image databases. The 164-layer network is capable of classifying images into more than a thousand distinct item categories, including animals, pencils, keyboards, mouse, and many others. As a result, this model can learn a lot from a wide range of images and consequently represent a wide range of features. This model is based on a combination of inception structure and residual connection. Convolutional filters of different sizes are connected in the block of this model with residual connections. These connections reduce training time.

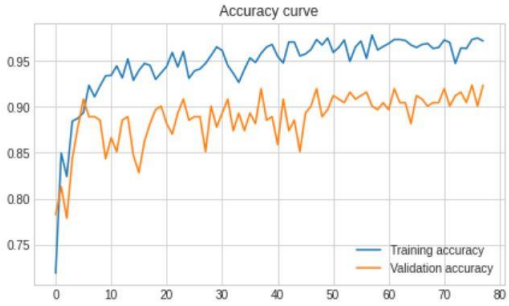

Figure 3.4.11 Accuracy curve of Inception-ResNet-V2

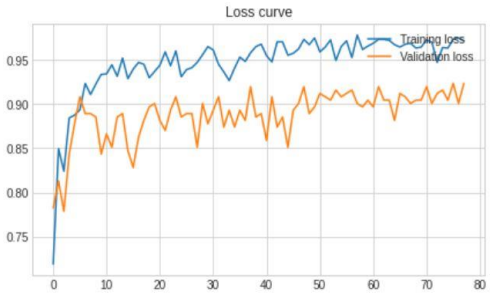

Figure 3.4.12 Loss curve of Inception-ResNet-V2

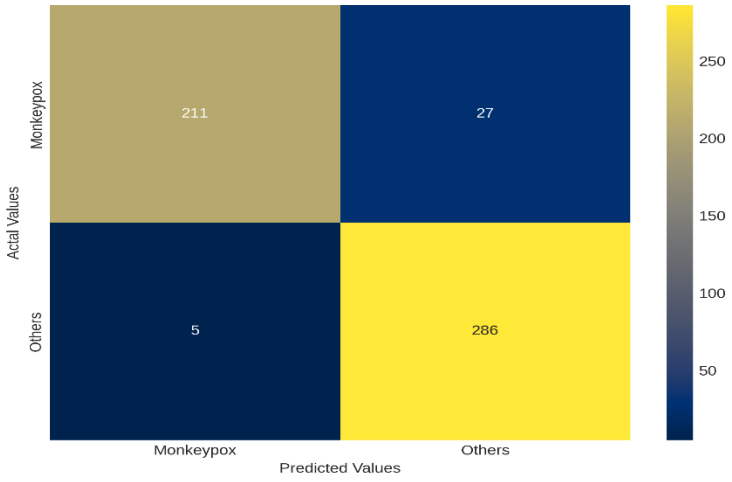

Figure 3.4.13 Confusion matrix of Inception-ResNet-V2

3.5 Implementation Requirements

We have divided our work into four section for implementation of our thesis,

- Data Collection
- Data Pre-process
- Algorithm Implementation
- Result Discussion

We have collected our data from the Kaggle. Customized our dataset as needed to our requirements. Then pre-processed the data using ImageDataGenerator. Also we set the resolution to 224×224×3 for all images as input.

In the next step , we started working with our algorithm implementation. We applied three pre-trained deep learning algorithm. We built a Convolutional Neural Network to apply in our dataset.

After implementing the algorithms, we find some measurements. We compared the accuracy between our applied algorithms and also with the previously used algorithms by the researchers.

CHAPTER 4
EXPERIMENTAL RESULTS AND DISCUSSION

4.1 Experimental Setup

As our work based on a online publicly available dataset MSLD we studied about the previous algorithm which has been used in this dataset. To make our work more productive, we used four algorithms which has not been used in the dataset MSLD and focused on achieving better accuracy than previous research works. Among these four algorithm, three algorithm were pre-trained models which are MobileNet, DenseNet-201 and InceptionResNet-V2. Also We have built a CNN model with some convolutional and maxpool layer. In this chapter, We will describe our experimental outcomes. In 4.2 We will explain our experiment result in detail, Descriptive Analysis is discussed in the 4.2 portion of the chapter and a summary of the total experiment and it's result will be covered in 4.3 portion of this chapter.

4.2 Experimental Results & Analysis

To expect a better outcome, we had to face challenges for choosing dataset and also the method we were going to choose. So we firstly studied about the previously used algorithm on MSLD dataset. We used different methods except the previously used methods. We studied different transfer learning approaches and choose algorithms for our work. We applied different algorithms for a better accuracy . To make our work productive from previous work, we build a model for our work.

In the process of our work, we learned about different image processing techniques, classification methods. To classify image we used python libraries, called function available on the colab. We learned how transfer learning helps to improve the accuracy of

a model. From the previous related works, we learned how deep learning and CNN is good for a small dataset. We used the effective method CNN for a better accuracy.

We used four different algorithms different from the previously used algorithm on the dataset MSLD. The outcome of our experiment has different outputs. We used three available algorithms from our study of the deep learning algorithms. With the help of deep learning and CNN (Convolutional Neural Network) we build our own model in term of finding better output. We used three deep learning algorithms known as MobileNet, DenseNet-201, InceptionResNet-V2 and our own build model SkinNet-9 applied on the Monkeypox Skin Lesion Dataset for automatic human monkeypox disease detection. To evaluate the models on the MSLD dataset in our work we used python libraries and functions to find out some measurement's such as accuracy, precision, Recall, F1 score, False Positive Rate, False Negative Rate, Mean Absolute Error and Root Mean Square Error.

Table 4.2.1 Results from the different models

Classifier	Accuracy (%)	Precision (%)	Recall	F1 score (%)	FPR (%)	FNR (%)	MAE (%)	RMSE (%)
MobileNet	95.42	92.29	92.51	92.40	7.48	7.48	7.56	27.49
DenseNet-201	95.42	95.41	95.05	95.23	4.94	4.94	4.72	21.73
SkinNet-9	95.038	92.94	93.37	93.16	6.62	6.62	6.99	26.44
InceptionResNet-V2	92.36	94.52	93.46	93.99	6.53	6.53	6.04	24.59

We have found 95.42% validation accuracy on epoch 135 and 92.43% test accuracy with MobileNet, 95.42% validation accuracy on epoch 337 and 95.27% test accuracy with DenseNet-201, 92.36% validation accuracy on epoch 78 and 93.95% test accuracy with InceptionResNet-V2, 95.038% validation accuracy on epoch 120 and 93.00% test accuracy with SkinNet-9.

We used four algorithms for the classification of monkeypox and others (chickenpox and Measles) images. Different algorithm shows different results. The accuracy of individual algorithm is different. The results we have found in our work is stated here. The four algorithms that we used are SkinNet-9, MobileNet, DenseNet-201 and InceptionResNet-V2.

4.2.1 Comparison of the works with MSLD dataset

Monkeypox was discovered in 1958. But it didn't spread that much until 2022 to attract the researchers. In 2022, It has been spreading which has became a concern for the world. Research work has been started recently about monkeypox detection. Also another reason for few works of monkeypox detection is that lack of data. Till now Bangladesh has reported no confirm cases for monkeypox infection. So it is almost impossible for us to collect data of monkeypox skin lesion image. As a result, we had to use a publicly available dataset "Monkeypox Skin Lesion Dataset" from Kaggle. Some of the researchers worked with this dataset and they used some deep learning algorithm to detect monkeypox. So, we tried to use four deep learning algorithms except the used algorithms on the MSLD dataset by other researchers.

Image classification using AI has been used in many sectors. It brings a revolution in medical sector. Disease detection using image classification is a popular subject for many researchers. As monkeypox is a recent topic for the research there are not much of a dataset. For our work, we have used MSLD (Monkeypox Skin Lesion Dataset). This dataset has been used in three individual research work. Several deep learning algorithms and

Convolutional Neural Network model used by the researchers in this MSLD dataset. In Veysel Harun Sahin et al.[4] used 6 pre-trained deep learning algorithm. Among them MobileNetv2 and EfficientNetb0 gave best accuracy of 91.11%. Another work using the dataset MSLD in Md. Enamul Haque et al.[13] used convolutional block attention module(CBAM) with deep learning algorithms VGG19, Xception, DenseNet121, EfficientNetB3, and MobileNetV2. With 83.89% accuracy Xception-CBAM gives best accuracy than other algorithms. The developers of the MSLD Shams Nafisa Ali et al.[7] used VGG-16, ResNet50, and InceptionV3 on the dataset. Also used a ensemble system with these algorithms. ResNet50 gives the best outcome with 82:96±4:57% accuracy.

Table 4.2.2 Results of various algorithm in [13]

Algorithm	Accuracy (%)
MobileNetv2-CBAM-Dense	74.07
EfficientNetB3-CBAM-Dense	81.43
VGG19-CBAM-Dense	71.86
Xception-CBAM-Dense	83.89
DenseNet121-CBAM-Dense	78.27

Table 4.2.3 Results of various algorithm in [4]

Algorithm	Accuracy (%)
MobileNetv2	91.11
EfficientNetb0	91.11
ResNet18	73.33
GoogleNet	77.78
ShuffleNet	80.00
NasnetMobile	86.67

Table 4.2.4 Results of various algorithm in [7]

Algorithm	Accuracy (%)
VGG16	81.48±6.87
InceptionV3	74.07±3.78
ResNet50	82.96±4.57
Ensemble	79.26±1.05

Table 4.2.5 Results of various algorithm in this work

Algorithm	Accuracy (%)
MobileNet	95. 42
DenseNet-201	95.42
SkinNet-9	95.038
InceptionResNet-V2	92.36

Table 4.2.6 Comparison between used best model and previous study

Paper	Dataset	Algorithm	Accuracy(%)
[4]	MSLD	MobileNetv2, EfficientNetb0	91.11
[7]	MSLD	ResNet50	82.96±4.57
[13]	MSLD	Xception-CBAM-Dense	83.89
In This Work	**MSLD**	**MobileNet, DenseNet-201**	**95. 42**

Among these works, out of the all used deep learning algorithms on MSLD dataset MobileNetv2 and EfficientNetb0 has given the best experimental outcome. Both provides a accuracy of 91.11%. Other algorithms shows accuracy below 90%. Among the all works including ours, MobileNet and DenseNet-201 which we used gave best accuracy of 95. 42%.

4.3 Discussion

Different algorithms give different results on the dataset. On the other hand, result varies with the dataset such as if anyone made changes in the dataset or uses another dataset with the same algorithm. As we used MSLD dataset, there were two kinds of data, one is original images and augmented images. Result would be different for original and augmented images. We used augmented images for training and validation for achieving higher accuracy. The number of original images were not sufficient for achieving expected outcome in our work. We were looking to gain a higher accuracy than the previous work done on this specific dataset MSLD.

In order to fulfill our purpose, we used four deep learning algorithms in our thesis work. We used two different available deep learning algorithm and for finding a better accuracy built a model using deep learning and CNN. We used four algorithms called SkinNet-9, MobileNet, DenseNet-201 and InceptionResNet-V2 in our MSLD dataset. We found out accuracy, precision and some other measurement for these four algorithms.

A most noticeable point is that the result of the algorithm depend on the characteristics of the dataset. An error containing dataset will provide wrong accuracy and if the characteristics of the dataset changes it will change the prediction of the model. Among the four used algorithm on our dataset MobileNet and DenseNet-201 gives the best accuracy of 95.42%.

The dataset we used is a publicly available dataset on Kaggle named Monkeypox Skin Lesion Dataset. The developer of MSLD opens up a scope for the researchers to work with monkeypox detection using this dataset. Some researchers used the dataset for automatic monkeypox infection detection using some deep learning algorithms. As we also used deep learning and CNN models, we tried to compare the experimental outcomes of ours with previous works. The motto of this comparison is to help the researchers who will further work with monkeypox detection with deep learning models using the MSLD dataset to gain knowledge about selection of algorithm and make improvisation from the previous works.

CHAPTER FIVE

IMPACT ON SOCIETY, ENVIRONMENT AND SUSTAINABILITY

5.1 Impact on Society

The main impact of our study will be on the medical sector, Public health. It will stop a contagious virus from spreading without one's knowledge. It can stop the world from facing another pandemic. Our work could play a major role in medicine. It will be beneficial to society. Because of this, it will have a significant impact on everyone in society. It can make save one's health and save lives. Because, in the field of medicine, a simple picture can easily detect monkeypox in humans.

Public Health: Monkeypox eruptive stage is rashes all over the infected person. It is not a deadly disease but the rashes can take long time to fade away. Some scars can be permanent. These will impact the patient health badly. If it possible to detect monkeypox on first stage, the damage will be much less on the human body.

Mental Health: Monkeypox is a contagious virus. It spreads easily. So the patient can infect another person specifically his/her family easily. Also spreadness of monkeypox can lead the world to another pandemic. We have seen in covid pandemic how people have gone through depression and stress. Another pandemic can bread down the people completely. Early stage detection of monkeypox can stop this pandemic. Thus save peoples mental health.

Economic: If the community transmission of monkeypox occurs, there is a chance of another pandemic in our world. If this happens the economy will collapse again like the previous pandemic. Also PCR test cost can be saved by adopting this study to detect monkeypox.

5.2 Impact on Environment

Using deep learning techniques to identify monkeypox by collecting images from online may not directly affect the environment. However, the development and use of these techniques may have environmental impacts. A few possible ways are discussed below:

Data Storage: Deep learning algorithms require a large number of images. Because of the large number of images, better accuracy can be obtained from a model. That is why it is very important to save the images. This is important for saving energy and material resources. These resources have an impact on the environment. That's why it's important to take steps to minimize potential resource costs.

Harassment of People: Deep learning models require a lot of images. We need real images for collection of images, these images are collected by people. So if these images indicate human identification, then people will be victims of human harassment. That's why it is necessary to take care not to get human identification by this image. Which can bring risk in social sphere.

Energy Consumption: If deep learning techniques require a large amount of computational power, the energy consumption can increase significantly. which can have an environmental impact through greenhouse gas emissions. It is important to account for these effects in the algorithm and take steps to reduce the power consumption of the hardware being used.

All things considered, we realized that deep learning could never have a direct impact on society. However, there may be some indirect effects which if we consider with a little awareness, then these effects will not have much impact. That's why we have to be aware from all sides.

5.3 Ethical Aspects

There are some ethical issues as a result of using deep learning for monkeypox directions by collecting datasets from online which are considered below:

Privacy: In this case, the most important thing is privacy. When we go to detect monkeypox through a picture, we have to use that picture of people. In that case, if people can be identified by pictures, then there will be big problems in the social field. People will look down on him. For this, we have to ensure that the person cannot be identified by that picture and that these dates are completely private.

Accuracy: Another important thing is its accuracy. We are trying to tell by looking at a picture of a rash on a human body whether it is monkey pox or not, if in some way it is predicted as monkeypox and if it is not really monkeypox, then the wrong treatment may cause great damage. That's why it's so important to find the best accuracy .

Bias: The possibility for bias in algorithms for deep learning is a further ethical problem. For instance, skewed predictions may result if the algorithms are trained with data that is not representative of the population. In order to minimize the possibility of bias, it is crucial to make sure that the data utilized to train the algorithms is diverse and representative of the population.

Access: Another ethical issue to consider is deep learning techniques for manic epoxy detection. If the techniques are only for certain groups or individuals, this may cause the detection system to be inequitable. Because it is important to ensure that the techniques are widely used and acceptable to all who can benefit from them.

Responsibility: The final concern is who is in charge of using the results of the deep learning algorithms to detect monkeypox. It is crucial to think about who is in charge of ensuring that the algorithms are used ethically and appropriately and that those who have

been identified as being at risk of contracting monkeypox are given access to the right tools and support.

Finally, the use of deep learning techniques to detect human monkeypox using online data sets raises several ethical issues that must be carefully considered and resolved. It is important to ensure that strategies are developed and used in an ethical and responsible manner. so as to maximize their potential benefits while minimizing any negative impacts.

5.4 Sustainability Plan

To make sure that the use of deep learning techniques for monkeypox detection is sustainable over time, a sustainability plan should take a variety of issues into account. A sustainability strategy should include the following essential components:

Data Privacy and Security: The sustainability of machine learning methods for identifying monkeypox depends on safeguarding the privacy and security of internet data. This entails putting in place suitable security measures to guard against unauthorized access or exploitation of the data, as well as getting the necessary authorization from people before utilizing their data. The potential effects on a person's privacy should also be taken into account if they are determined to be at risk for monkeypox detection based on their online data.

Accuracy and Reliability: Sustainability also depends on ensuring the precision and dependability of deep learning algorithms, which includes comprehensive testing, validation, and continuous algorithm updates as required.

Bias: For the strategies to be effective in the long term, bias in the deep learning algorithms must be reduced. In order to minimize the possibility of bias, this entails making sure that the data used to train the algorithms is diverse and representative of the community. It also involves continuously reviewing and modifying the algorithms as appropriate.

Access: The sustainability of deep learning techniques depends on ensuring that they are widely used and accessible to everyone who may profit from them. This can entail creating plans to make the approaches more affordable or available in regions with scarce resources, or collaborating with entities or people who can aid in their wider dissemination.

Responsibility: The sustainability of deep learning techniques depends on the roles and responsibilities of individuals involved in their development and application being made clear. This can entail formulating precise rules for the moral application of the techniques as well as outlining the duties and responsibilities of individuals in charge of guaranteeing their moral and proper application.

In order to ensure that the use of these techniques is sustainable over time, a sustainability plan for the use of deep learning techniques for identifying monkeypox using social web data should take a variety of things into account. It is possible to guarantee that the approaches are developed and used in a responsible and ethical manner that optimizes their potential benefits while limiting any bad effects by addressing concerns like data privacy, accuracy and dependability, bias, access, and responsibility.

CHAPTER SIX

SUMMARY, CONCLUSION, RECOMMENDATION AND IMPLICATION FOR FUTURE RESEARCH

6.1 Summary of the Study

Through this study, we gained a lot of knowledge about monkeypox. It can take many dire forms at any time. Monkeypox, chicken pox, and smallpox looks very similar, which makes it difficult to recognize monkeypox. We have worked on deep learning models to recognize monkeypox through images. We have built a CNN model to automatic detection of monkeypox. Through a deep learning model, we can identify monkeypox by picture. We have already mentioned that we have collected the combined dataset for monkeypox, chicken pox, and smallpox online. Its images helped train our deep learning and CNN model. As a result, we were able to identify Monkeypox. There were some problems that we solved with pre-processing such as resolution fixing. We have been able to achieve the goals for which we worked. Different algorithms gave us different results.

6.2 Conclusions

Our research findings and methods are excellent, as demonstrated by our work. We believe and hope that this study will benefit future research in this area. We have found scope to work with in the future in this topic. In the future, we are also considering ways to combine algorithms and develop more effective solutions to our study's issues. We will be able to learn more about our field of study thanks to this study. We hope that it will make it easier to identify specific monkeypox and open up new opportunities for technology to assist us in doing so. Our study's outcome was improved by incorporating information from smallpox, chickenpox, and monkeypox. Based on this study, we hope to propose a new method for detecting monkeypox.

6.3 Implication for Further Study

Our own work also has much potential for further study in this area. We have found many ways to make our work better. We want to do this better with our main targets, such as monkeypox detection through pictures. Thus, we can use it through an application. For example, if the application inputs a picture, it can determine whether it is monkeypox or not. We can check this with various pictures by Googling.

Our main goal for future work will be to increase the accuracy of our work. To improve accuracy, we will increasingly rely on various built-in models. We can increase the accuracy by creating our own CNN model. We will collect more data, and accordingly, we will process the data in such a way that our accuracy will greatly increase. We will do further processing as per our specific requirements. We will increase the range of images we are using now. We will increase the dataset by collecting good-quality images. Then we will further process those images to increase their accuracy by using them in our own CNN model.

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