A Mini Project Report on

Nail Disease Detection Using Image Processing And Machine Learning Techniques

Submitted to

Department of Computer Science
School of Computer Sciences

By

Sumant Kumar
22PGMCA36
MCA III Semester

Under the Guidance of

Dr. Gururaj Mukarambi
Senior Assistant Professor
Department of Computer Science

Central University of Karnataka
Kadaganchi, Kalaburagi - 585367, INDIA
January 29, 2024

ಕರ್ನಾಟಕ ಕೇಂದ್ರೀಯ ವಿಶ್ವವಿದ್ಯಾಲಯ
कर्नाटक केंद्रीय विश्वविद्यालय
CENTRAL UNIVERSITY OF KARNATAKA
(Established by an Act of the Parliament in 2009)
Kadaganchi, Kalaburagi – 585367, INDIA, Website: www.cuk.ac.in
Block No.17, CUK Campus
Dept. of Computer Science
School of Computer Sciences
Email: hodcs@cuk.ac.in

CERTIFICATE

This is to certify that the mini project report entitled **Nail Disease Detection Using Image Processing And Machine Learning Techniques** submitted by **Sumant Kumar** bearing Registration Number: **22PGMCA36**, studying in MCA III Semester, to the Department of Computer Science, Central University of Karnataka, Kadaganchi, Kalaburagi, is a record of the original project work carried out by him under my guidance and supervision during the IV semester of MCA program. The work embodied in this project report has not been submitted fully or in part any where else.

Guide
Dr. Gururaj Mukarambi
Senior Assistant Professor
Dept. of Computer Science

Head
Dept. of Computer Science
School of Computer Science

DECLARATION

I hereby declare that the work embodied in this project report entitled **Nail Disease Detection Using Image Processing And Machine Learning Techniques**, submitted to Department of Computer Science, Central University of Karnataka, Kadaganchi, Kalaburagi is a record of my original project work carried out by me in the Department of Computer Science, Central University of Karnataka, Kadaganchi, Kalaburagi, under the guidance of **Dr. Gururaj Mukarambi** , and that the full of part of this project report has not been submitted to this or any other University or Institute.

Place: Kadaganchi
Date: January 29, 2024

Sumant Kumar
MCA III Semester
Central University of Karnataka
Kadaganchi, Kalaburagi

Acknowledgements

I would like to express my sincere gratitude to the Central University of Karnataka, for their support and guidance in the completion of this project. I am particularly grateful to the Honorable Vice-Chancellor, Professor Battu Satyanarayana, for his vision and leadership.

I would also like to thank the Dean and Head of School of Computer Science, Prof. Srikantaiah K C for their encouragement and support.

I would like to extend my heartfelt appreciation to my guide **Dr. Gururaj Mukarambi** for his valuable insights, suggestions and guidance. Their expertise and insights have greatly contributed to the successful completion of this work.

I am grateful to the faculty members of the Department of Computer Science, Prof. R S Hegadi, Dr.P.M. Kamble, Dr.Kagale Madhuri R, Ms. Shilpa Sthavarikmath, Dr. Sukanya S. Gaikwad, Mr. Parasuram J. C., Mrs. Poornima E. G. for their valuable guidance, support, and encouragement throughout the course of this project.

Furthermore, I would like to acknowledge my fellow classmates and friends for their camaraderie, motivation, and intellectual discussions, which have enriched my learning experience and provided a supportive environment for academic growth.

Last but not least, I would like to express my deepest gratitude to my family for their unwavering love, understanding, and encouragement throughout my academic journey. Their constant support has been the driving force behind my achievements.

Place: Kadaganchi
Date: January 29, 2024

Sumant Kumar
MCA III Semester
Central University of Karnataka
Kadaganchi, Kalaburagi

Contents

1 Introduction **1**

1.1 Background . . . 2
1.2 Motivation . . . 3
1.3 Existing System . . . 4
1.4 Proposed System . . . 4

2 Literature Survey **6**

3 Problem Definition and Objectives **10**

4 Implementation **13**

4.1 Hardware Specifications . . . 13
4.2 Software Specifications . . . 13
4.3 Methodology . . . 14

5 Results and Discussion **21**

5.1 Experiment . . . 21
5.2 Performance Metrics . . . 22
5.3 Results and Analysis . . . 23

6 Conclusion and Future Work **27**

7 References **29**

List of Figures

1.1 Eight Common Nail Disease 2
1.2 Nail Abnormalities 3
1.3 Finger Relation with Body Parts 3

4.1 Flow Diagram of Proposed Work 14
4.2 Nail Image Overview 15
4.3 Feature Vector 18
4.4 Use Case Diagram 20
4.5 Hugging Face Interface 20

5.1 Classes of Nail Dataset 22
5.2 Random Forest Model Confusion Matrix 24
5.3 KNN Confusion Matrix 24
5.4 SVM Confusion Matrix 25
5.5 Naive Bayes Confusion Matrix 25

Chapter 1

Introduction

The project aims to develop an automated system capable of identifying nail diseases with high accuracy. It involves collecting a substantial dataset of nail images labeled with corresponding disease conditions, preprocessing the images for better machine learning model performance, and designing and training a model to classify the diseases. This approach can be particularly useful for early detection and management of nail conditions, thus improving patient outcomes and reducing healthcare costs. Furthermore, with the global increase in telemedicine and remote health monitoring, such automated tools could be particularly appealing for patients in areas with limited access to dermatologists or for continuous monitoring and follow-up of chronic conditions. The project seeks not to replace clinicians but to provide a reliable and efficient tool that could support healthcare professionals in making rapid and accurate diagnoses, improving the service delivery for individuals with nail diseases.

Figure 1.1: Eight Common Nail Disease

1.1 Background

Nail disease detection is an important area in dermatology as it can be indicative of various health conditions, ranging from local nail infections to systemic diseases. The clinical diagnosis of nail diseases is often performed by dermatologists through visual inspection, which requires a high level of expertise and can be subjective. The demand for automatic detection arises from the need for a consistent, accessible, and less resource-intensive method to diagnose nail diseases.

With the advent of digital imaging technology and the widespread use of smartphones, it has become feasible to obtain high-resolution images of nails with relative ease. These images provide an opportunity for the application of image processing and machine learning techniques to assist in the detection of nail diseases. The integration of these technologies aims to supplement the clinicians' diagnostic capabilities, providing a second opinion, and potentially offering a preliminary screening tool that can be accessed by patients themselves.

Category	Nail Abnormality
Dematosis	Onycholysis, splinter haemorrhage, Darier's disease ,alopecia
Change in shape	Clubbing , koilonychia
Change in surface	Bau's lines, meruhrcke's line, leuonychia
Change in color	Terry's nails, linday's nails, red lunula ,splinter haemorrhage ,yellow nail syndrome

Figure 1.2: Nail Abnormalities

Finger name	Organ
The thumb	Brain,excretory system and reproductive system
Index finger	Liver,gall bladder or nervous system
Middle finger	Heart and circulatory system
Ring finger	Reproductive and the hormonal system
Little finger	Digestive system

Figure 1.3: Finger Relation with Body Parts

1.2 Motivation

The motivation behind this project is to harness the potential of modern technology to improve healthcare and early disease detection. Nails, often overlooked, hold critical information about an individual's health. By developing an automated system that can analyze nail images, we aim to empower both healthcare professionals and individuals to identify and address nail-related diseases promptly. This project seeks to bridge the gap between traditional diagnostic methods and cutting-edge computer vision techniques, offering a convenient and accessible solution for better health outcomes.

1.3 Existing System

The current system for diagnosing nail-related diseases primarily relies on manual inspection by dermatologists and medical professionals. While effective, this approach has limitations:

- **Time Consuming:** It can be time-consuming and may lead to delayed diagnoses.
- **Expertise:** Expertise is needed to identify subtle and complex patterns associated with nail diseases.
- **Accessibility:** using magnifying glass for examination of the skin
- **Biopsy:** Accessibility to dermatologists may be limited in some regions, causing delays in diagnosis and treatment.

1.4 Proposed System

The goal is to create an automated system that not only complements the expertise of medical professionals but also promotes proactive nail health management for individuals. By doing so, we aim to improve overall healthcare outcomes and increase awareness of the significance of nail health in the context of broader well-being. Proposed system offers a transformative solution:

- **Disease Detection:** Utilizes machine learning and image processing techniques to analyze nail images for disease detection.Empowers both healthcare professionals and individuals to monitor nail health conveniently

- **Early Detection:** Provides early and accurate identification of nail conditions, aiding in timely medical intervention.

- **User-friendly Interface:** Offers a user-friendly interface for easy nail image capture and real-time diagnostic results.

- **Accessibility:** Enhances accessibility to nail health assessments, making it a valuable tool for remote health monitoring.

Chapter 2

Literature Survey

There are several papers which are proposed on image-processing and machine learning based detection of nail diseases. I have reviewed the various techniques mentioned in the literature.

Mrs. D. Nithya (Mar 2019) proposed system "Nail Based Disease Analysis At Earlier Stage Using Median Filter In Image Processing" takes image of nail and then segment the image. They had focused on image recognition based on color analysis. They had used median filter for removal of impulse noise (also called as binary noise) and Support Vector Machine for classification.

Vipra Sharma in 2015 proposed system for disease detection by analysing finger nail colour and texture takes back side of palm region and then segment the image. The segmented image is the actual nail region. They have analysed the nail colour and texture and compare these values with the predefined values for healthy nails and diagnose the result. For this experiment they only processed the image having format GIF, JPEG, PNG, TIFF etc.

Hardik Pandit (2013) proposed the model of nail colour analysis. In this experiment they scan back side of human palm then extract nail region from cropped image of palm by RGB component analysis in which algorithm was designed which gives average as well as pixel by pixel nail colour for each finger. For the comparison they took 50 reference images per colour. After calculating arithmetic mean they fixed a reference colour. For the identification of stage of a disease they fixed a percentage of pixels with given colour in all nails.

In Pravin S. Ambad & A. S. Shirsat at el. “An image analysis System to detect skin diseases” has proposed a system for early identification of skin problem using statistical analysis and ad boost classifier. Their research mainly focused on early identification of skin cancer symptoms based on statistical analysis with correlation algorithms.

Kumuda N S presented a method for segmentation of fingernails and differentiate them as distinct nail parts; fingernail plate with lunula and distal free edge of nail plate. In the research work, concentrated on fixed area of the fingernail plate plus lunula, as it remains unchanged in structure, where as the distal nail edge extends and changes in structure over a period of time. Proposed method is of two stages. In first stage, color image is converted to gray scale and contrast enhancement is applied using adaptive histogram equalization. In second stage, perform segmentation using watershed method that exercises maxima and minima properties of marker controlled watershed principles. In order to verify the results of the algorithm, constructed a confusion matrix where evaluation has been done with ground truth. Additionally, the segmented object's from both the methods was considered for quality metrics assessmenting. Similarity and accuracy between the ground truth and watershed result is 84 percentage correctness for fingernail plate.Initial fingernail segmentation results are promising,supporting its use for biometric application.

In Li-sheng Wei, Quan Gan, and Tao ji at el. "Skin Disease recognition method based on image color and texture features" has proposed a model based on feature extraction of image using color texture and using segmentation and SVM on it to identify the disease.

Sujath R (2017) proposed leaf disease detection. In this experiment, the input image is first converted from RGB to HSI and then they perform k-means clustering algorithm and Support vector machine which is statistical learning based solver for accurate detection of leaf disease.

In R. Yasir, M S I Nibir and N. Ahmed at el. "A skin disease detection system for financially unstable people in developing countries" has proposed a system for detection of disease which could be implemented on mobile devices as well as computer using desktop application based upon computer vision technique.

In R Sumithra, M Suhilb and D S guruc at el., “Segmentation and classification of skin lesion for disease diagnosis” has proposed a model for segmentation and classification a skin disease using SVM and KNN algorithms.

In Rahat Yasir, Md. Ashiqur Rahman and Nova Ahmed at el. “Dermatological Disease detection using image processing and artificial neural network” has used various kind of different image processing algorithms for feature extraction and feed forwarding using artificial neural network for training and testing the model. The system works on two parts, in the first part the feature extraction has been taken place based upon the color texture and in the second stage the classifier identifies the possible disease.

Chapter 3

Problem Definition and Objectives

The problem at hand is the development of an innovative and non-invasive system for the early detection and classification of nail-related diseases using machine learning (ML) and image processing techniques. While dermatologists and medical professionals are skilled at diagnosing these conditions, there is a significant opportunity to augment their expertise with an automated tool that can assist in the early recognition of nail diseases. This system aims to address several challenges:

- Variability in Nail Abnormalities: Nail diseases present in various ways, making it challenging to identify specific conditions based on visual inspection alone. ML and DL techniques can learn to recognize subtle and complex patterns associated with different diseases.

- Early Detection: Many nail-related diseases can progress over time, potentially leading to severe health consequences if left untreated. Early detection is crucial for prompt medical intervention and improved treatment outcomes.

- Accessibility and Convenience: An automated system that can analyze nail images offers the advantage of accessibility and convenience. Users can capture or upload nail images for analysis, making it suitable for both healthcare professionals and individuals concerned about their nail health.

- Multi-Disease Classification: Nail disorders encompass a wide range of conditions, from fungal infections to autoimmune disorders. The system should be designed to classify and distinguish between various diseases, providing users with specific diagnostic information.

By developing this project it is aimed to develop dedicated system that can take high resolution images of nail and diagnose it using Machine Learning algorithms. Through the utilization of machine learning and image processing techniques, the objectives are:

- Enhanced objectivity and accuracy: When compared to human-based techniques, the use of machine learning models trained on sizable datasets of tagged nail photos may enhance the objectivity and accuracy of disease detection.

- Enhanced efficiency and accessibility: A machine learning-based system would offer a simple tool for preliminary nail disease screening, which might alleviate the workload for medical professionals and expand access to diagnostic resources in underprivileged areas.

- Early identification and action: Improved patient outcomes and prompt action can be achieved by quicker and more precise identification of possibly malignant disease.

- User-friendly Interface: Offers a user-friendly interface for easy nail image capture and real-time diagnostic results.

Chapter 4

Implementation

4.1 Hardware Specifications

- Processor: i5 or above.
- Memory : Minimum 8GB.
- GPU : Minimum 2 GB.

4.2 Software Specifications

- Operating System: Windows 10 and above
- Languages : Python
- IDE : Jupyter Notebook(preferred), VS code

4.3 Methodology

Methodologies used during project development process are sets of rules and processes that define how you manage a project. They help you plan, execute, monitor, and control the project activities and deliverables. Different methodologies have different advantages and disadvantages, depending on the nature, scope, and goals of the project.

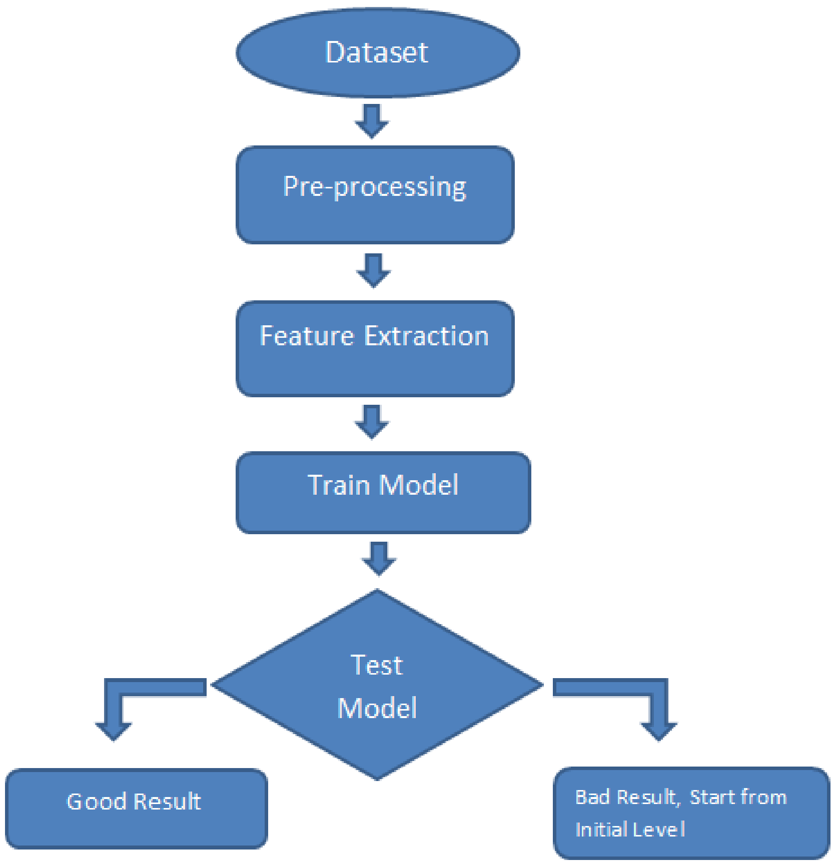

Figure 4.1: Flow Diagram of Proposed Work

The methodology for developing this project involved several steps and technologies.

The following outlines the methodology employed in the project:

- **Technology Selection**

  Python was chosen as the primary technologies for building the project. Python is a strong language when it comes to statistical programming. Python served as the core programming language, while many libraries such as glob, sci-kit learn, sk-image, matplotlib, etc. were used for the accomplishment of the project. Jupyter notebook and google colab was used as the IDE for the development of this project.

- **Image Acquisition and Preprocessing**

Figure 4.2: Nail Image Overview

  - **Ambiguous Image Removal:** The dataset initially contained a variety of images, some of which were deemed ambiguous for the purpose of disease detection. These included images with unclear focus, improper lighting, or mixed image. Ambiguous images were systematically removed to enhance the overall quality of the dataset.

  - **Nail Region Extraction:** To isolate the nail region for analysis, a manual extraction process (cropping) was implemented. This involved segmenting the nail region from the finger image and retaining only the relevant nail portion. This step is crucial for focusing the algorithm on the area of interest and improving the accuracy of disease detection.
  - **Image Resizing:** Image resizing was performed to achieve uniformity, ensuring that all images are of the same dimensions 128*128. This step not only simplifies the computational process but also facilitates efficient model training.

- **Feature Development :-** The project development began by building machine learning algorithms that can read and analyse images based on features extracted from them.

  - **Gabor Feature Extraction:** Gabor filters are widely used in image processing for texture analysis. In the project of nail disease detection, Gabor filtering was employed to extract texture features from the nail images. This involved convolving the images with a set of Gabor kernels at multiple scales and orientations. The resulting Gabor responses capture the textural patterns specific to various nail conditions, enhancing the discriminative power of the feature set. The Gabor filter function is defined as:

$$G(x, y; \lambda, \theta, \psi, \sigma, \gamma) = \exp\left(-\frac{x'^2 + \gamma^2 y'^2}{2\sigma^2}\right) \cos\left(2\pi \frac{x'}{\lambda} + \psi\right) \tag{4.1}$$

where;

$$x' = x \cos\theta + y \sin\theta,$$

$$y' = -x \sin\theta + y \cos\theta.$$

- **Gaussian Filtering:** Gaussian filtering is a smoothing technique that helps in reducing high-frequency noise in images. In the context of this project, Gaussian filtering was applied to the nail images to achieve a more uniform and visually consistent representation. By smoothing out variations in pixel intensities. The 2D Gaussian filter function is defined as:

$$G(x, y) = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{x^2 + y^2}{2\sigma^2}\right) \tag{4.2}$$

  where x and y are the distances from the origin in the horizontal and vertical axes, σ is the standard deviation of the Gaussian distribution.

- **Variance Filtering:** Variance filtering was utilized to capture the spatial variability in pixel intensities within the nail images. This technique involves computing the local variance in pixel values over the image. Areas with high variance indicate regions of significant intensity variations, which can be indicative of certain features related to nail diseases. The variance filter function is defined as:

$$\mathrm{Var}(X) = \frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2 \tag{4.3}$$

where;

* X is the set of pixel values in the neighborhood,
* N is the number of pixels in the neighborhood,
* x_i is the value of the i-th pixel,
* μ is the mean of the pixel values in the neighborhood.

- **Integration of Features:** The features extracted through Gabor, sobel, Gaussian filtering, and variance filtering were integrated into a comprehensive feature vector for each nail image. This concatenated feature vector serves as the input for subsequent stages of the project, including model training and disease classification.

```
[88] image_features
```

	Pixel_Value	Gaussian s5	Sobel	Gabor1	Gabor2	Gabor3	Gabor4	Gabor5	Gabor6	Gabor7	...
0	0.056763	0.588235	0.000000	0.0	0.0	1.000000	0.694118	1.000000	0.509804	0.843137	...
1	0.059867	0.588235	0.000000	0.0	0.0	1.000000	0.733333	1.000000	0.537255	0.890196	...
2	0.084257	0.588235	0.000000	0.0	0.0	1.000000	1.000000	1.000000	0.756863	1.000000	...
3	0.056319	0.588235	0.000000	0.0	0.0	1.000000	0.690196	1.000000	0.505882	0.839216	...
4	0.059867	0.588235	0.000000	0.0	0.0	1.000000	0.733333	1.000000	0.537255	0.890196	...
...	...	...	...	...	...	...	...	...	...	...	...
4816891	0.030599	0.274510	0.023529	0.0	0.0	0.698039	0.360784	0.505882	0.266667	0.415686	...
4816892	0.031042	0.274510	0.023529	0.0	0.0	0.701961	0.364706	0.505882	0.266667	0.415686	...
4816893	0.025721	0.274510	0.015686	0.0	0.0	0.643137	0.317647	0.462745	0.223529	0.380392	...
4816894	0.026608	0.274510	0.015686	0.0	0.0	0.662745	0.325490	0.478431	0.231373	0.392157	...
4816895	0.027494	0.274510	0.015686	0.0	0.0	0.678431	0.337255	0.490196	0.239216	0.407843	...

4816896 rows × 36 columns

...	Gabor24	Gabor25	Gabor26	Gabor27	Gabor28	Gabor29	Gabor30	Gabor31	Gabor32	Variance s5
...	0.352941	0.0	0.0	1.0	1.0	0.003922	0.003922	0.184314	0.094118	0.250980
...	0.372549	0.0	0.0	1.0	1.0	0.003922	0.000000	0.192157	0.094118	0.478431
...	0.525490	0.0	0.0	1.0	1.0	0.003922	0.003922	0.274510	0.133333	0.203922
...	0.349020	0.0	0.0	1.0	1.0	0.003922	0.000000	0.180392	0.090196	0.282353
...	0.372549	0.0	0.0	1.0	1.0	0.003922	0.000000	0.192157	0.094118	0.525490
...	...	...	...	...	...	...	...	...	...	...
...	0.200000	0.0	0.0	1.0	1.0	0.031373	0.047059	0.098039	0.066667	0.086275
...	0.200000	0.0	0.0	1.0	1.0	0.039216	0.050980	0.101961	0.066667	0.082353
...	0.152941	0.0	0.0	1.0	1.0	0.000000	0.000000	0.101961	0.023529	0.078431
...	0.160784	0.0	0.0	1.0	1.0	0.000000	0.000000	0.109804	0.027451	0.078431
...	0.164706	0.0	0.0	1.0	1.0	0.000000	0.000000	0.113725	0.031373	0.074510

Figure 4.3: Feature Vector

- **Classifier Selection**

  Four diverse classifiers were chosen for the task of nail disease classification:

  - **Support Vector Machine:** SVM is a powerful supervised learning algorithm suitable for both binary and multiclass classification. It identifies a hyperplane in a high-dimensional space that best separates classes.
  - **Random Forest:** Random Forest is an ensemble learning method that constructs multiple decision trees during training. It outputs the mode of the classes for classification.
  - **k-Nearest Neighbors:** KNN is a non-parametric, instance-based learning algorithm that classifies new instances based on their similarity to existing instances in the training dataset. It is known for simplicity and effectiveness in capturing local patterns.
  - **Naive Bayes:** Naive Bayes classifiers are a collection of classification algorithms based on Bayes' Theorem, these classifiers are widely utilized for their simplicity and efficiency in machine learning.

- **Deployment**

  Hugging Face is a platform that offers a user-friendly interface for deploying, sharing, and utilizing machine learning models. This enables easy sharing and access to the models by other developers and stakeholders.

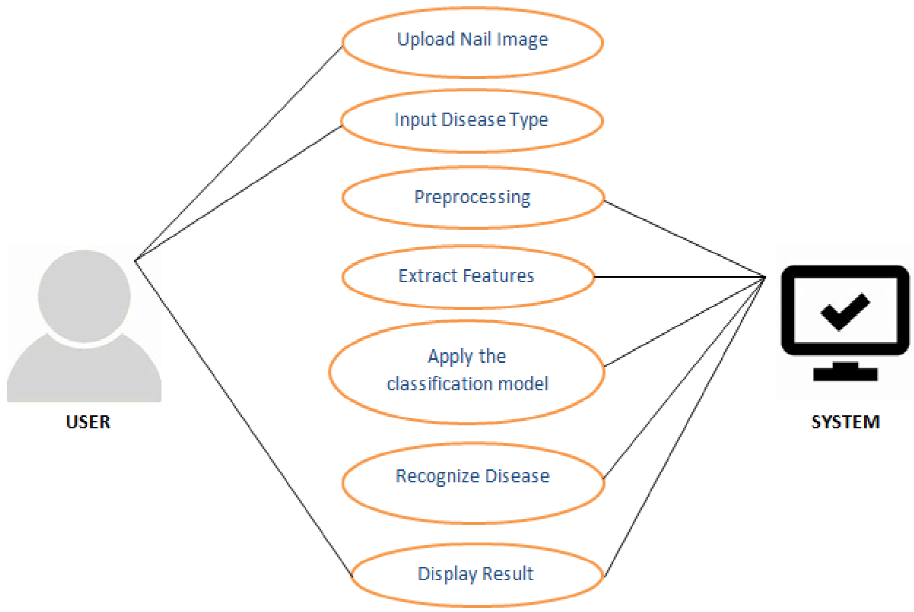

Figure 4.4: Use Case Diagram

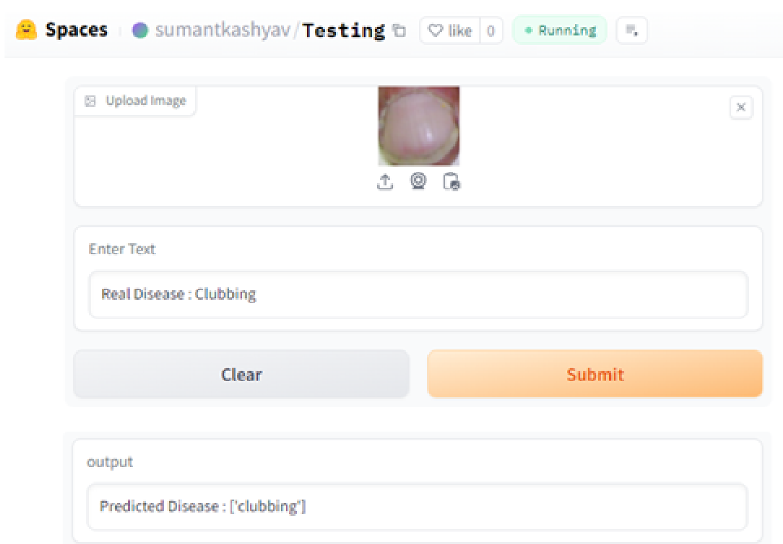

Figure 4.5: Hugging Face Interface

Chapter 5

Results and Discussion

5.1 Experiment

All the tasks were implemented on Jupyter notebook IDE and Google Colab. The technology used was Python. Python being the core programming language along with many useful and efficient libraries worked wonder for this project.

For the purpose of our study on nail diseases, we utilized two primary sources for our dataset. The first part of our dataset, focusing on various nail diseases, was obtained from Kaggle, a well-known platform for data science and machine learning. To complement the disease dataset and create a balanced study, we curated a dataset of healthy nails. This dataset was compiled through a meticulous process where images of healthy nails were gathered and verified. The creation of this dataset was driven by the necessity to have a control group in our study, which is essential for accurate comparison and analysis.

This dataset contains 120 images across nine different classes. It is further split into training and test datasets. The training dataset comprises 98 images, while the test dataset contains 22 images.

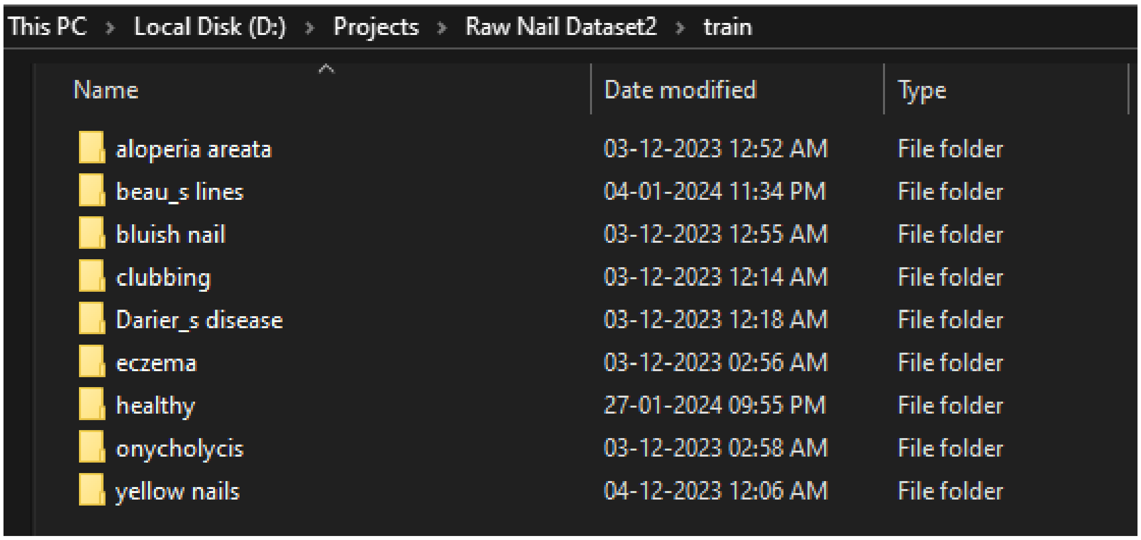

Figure 5.1: Classes of Nail Dataset

5.2 Performance Metrics

Accuracy: Accuracy is defined as the proportion of the properly recognized positives samples and the total number of predicted positive samples.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \tag{5.1}$$

Precision: Precision is defined as the proportion of the properly recognized positive samples and the total number of predicted positive samples.

$$Precision = \frac{TP}{TP + FP} \tag{5.2}$$

Recall: The recall is defined as the proportion of the total number of properly recognized positive samples classified correctly.

$$Recall = \frac{TP}{TP + FN} \tag{5.3}$$

F1-Score: The F1 score is the weighted average that returns a single value by combining precision and recall.

$$F1 = \frac{2 * Precision * Recall}{Precision + Recall} \tag{5.4}$$

5.3 Results and Analysis

In this project on nail disease classification, four different classifiers were implemented: Random Forest, Support Vector Machine (SVM), Naive Bayes, and K-Nearest Neighbors (KNN). Each classifier's performance was evaluated based on its accuracy in classifying the test dataset.

In addition to accuracy metrics, confusion matrices for each classifier were also generated. These matrices provide a detailed insight into the classification performance, highlighting not only the overall accuracy but also the specific instances of true positives, true negatives, false positives, and false negatives.

The observed accuracies were as follows:

- **Random Forest:** Random Forest achieved the highest accuracy of 86 percentage.

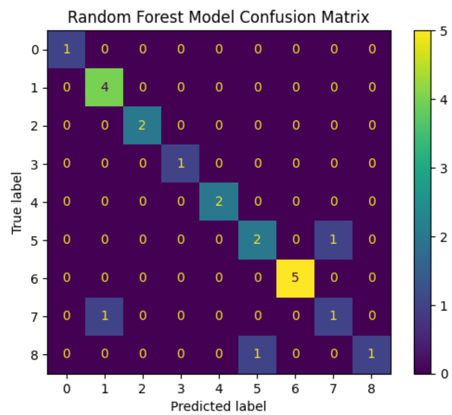

Figure 5.2: Random Forest Model Confusion Matrix

- **k-Nearest Neighbors:** KNN yielded an accuracy of 77 percentage.

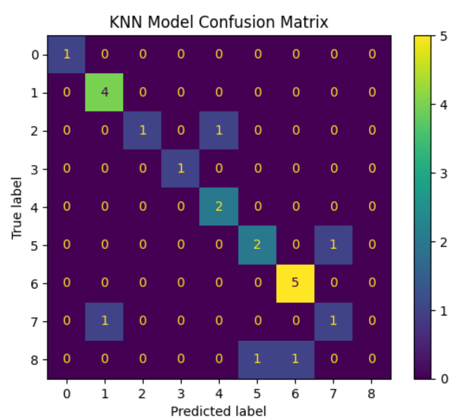

Figure 5.3: KNN Confusion Matrix

- **Support Vector Machine:** SVM Reported an accuracy of 40 percentage.

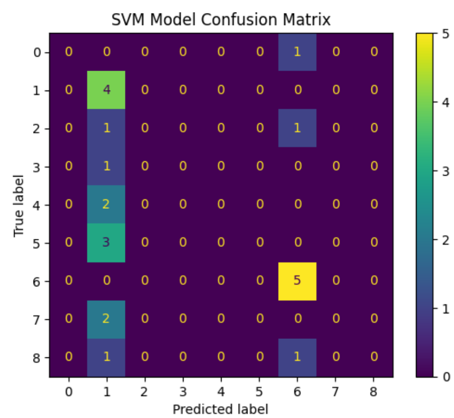

Figure 5.4: SVM Confusion Matrix

- **Naive Bayes:** Multinomial Naive Bayes also recorded an accuracy of 40 percentage.

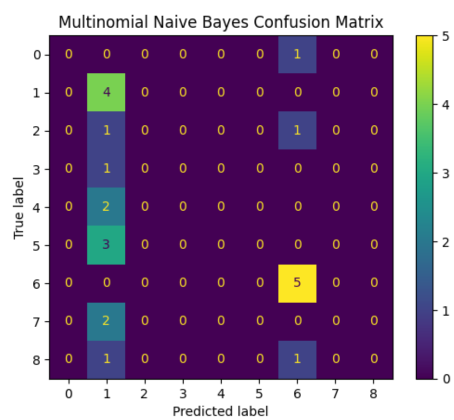

Figure 5.5: Naive Bayes Confusion Matrix

The comparative analysis clearly indicates that the Random Forest classifier outperforms the others in the context of this specific dataset and task. Its superior accuracy suggests a better capability at handling the variability and features within the nail disease dataset. The lower performance of the SVM and Naive Bayes classifiers may be attributed to the specific characteristics of the dataset or the intrinsic nature of these algorithms. Further investigation into the confusion matrices reveals specific areas where each model excels or falls short, providing valuable insights for further model refinement and research direction.

The analysis underscores the importance of choosing an appropriate machine learning model based on the dataset characteristics and the problem at hand. The results from the Random Forest model, in particular, demonstrate its robustness and effectiveness in the context of nail disease classification.

Chapter 6

Conclusion and Future Work

Health is a critical aspect for Human life. Identification of human health conditions and accurately predicting the symptoms of the diseases is useful work for the society. For these a new system is designed based on Digital Image Processing and nail-color analysis. Nail colors are used for the disease detection. It helps in recognizing disease of the person and minimizes the cost of the diagnosis of diseases. This detection system makes easy for doctors to give correct treatment to patients. Hence, this system can be useful in healthcare domain, especially in routine checkups. So, the diseases could be able to get caught in their initial stages.

Expanding the dataset size will be a pivotal step in improving the robustness and generalization capabilities of the Nail Disease Detection model. The inclusion of a more diverse set of images, spanning various demographics and conditions, will contribute to better model performance and a more comprehensive understanding of nail diseases. To further enhance the model's robustness, exploring alternative feature extraction strategies is essential. Techniques beyond Gabor filtering, median filtering, Gaussian filtering, and variance filtering should be considered. Deep learning-based feature extraction methods, such as convolutional neural networks (CNNs) or auto-encoders, could be explored for their ability to automatically learn relevant features from raw image data.

The initiative has shown the enormous potential of technology in transforming early cancer by investigating the application of machine learning algorithms to detect nail disease. Through the utilization of algorithms trained on extensive datasets, noteworthy progress is achieved in pursuit of improved objectivity and accuracy, the machine learning models outperformed human subjectivity and potential bias in the classification of nail disease, achieving outstanding accuracy. The created system may lessen the burden on medical practitioners and enable patients to take a proactive approach to their nail health.

Chapter 7

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