

Faculty of Information Technology

***Computer Science Department***

***Artificial Intelligence***

Mobile Skin Condition Diagnosis Using Neural Networks

Graduation Project (1) Report

Prepared by:

|  |  |
| --- | --- |
| **Students Name** | **Student ID** |
| **Hasan Al-Zubaidi** | **202010045** |
| **Yara Al-Thahabi** | **201910717** |
| **Obada Muqbel** | **202010367** |
|  |  |

Supervised by:

Laith W. Al Shehab

**To obtain**

**BSc in Artificial Intelligence**

1 / 2023

Group No.: AI-23-1-1-**5**

Copyright © 2023-2024 - All rights reserved.

Middle East University

|  |
| --- |
| Declaration **إقرار الملكية** |
| Declaration  We hereby acknowledge that the work presented in this document report and the ideas based upon are the group members own unless stated otherwise and properly cited in text and referenced at the end of the document.   |  |  |  |  | | --- | --- | --- | --- | | Date | Signature | Students Name | Student ID | |  |  | Hasan Al-Zubaidi | 202010045 | |  |  | Yara Al-Thahabi | 201910717 | |  |  | Obada Muqbel | 202010367 | |  |  |  |  | |
|  |

|  |
| --- |
| Supervisor Approval **موافقة المشرف** |
| **APPROVAL FOR SUBMISSION**  I certify that this project report entitled “**MOBILE SKIN CONDITION DIAGNOSIS USING NEURAL NETWORKS**” was prepared by **………** has met the required standard for submission in partial fulfillment of the requirements for the degree of Bachelor of Science in Artificial Intelligence at MEU.  Approved by  Signature: ……...……..………………………..................  Supervisor: Dr…..…….…………………………………  Date: ……………..……………………………………… |
|  |

Table of Contents

[Declaration 2](#_Toc153200405)

[Supervisor Approval 3](#_Toc153200406)

[Acknowledgement 5](#_Toc153200407)

[Abstract (English) 6](#_Toc153200408)

[Abstract (Arabic) 7](#_Toc153200409)

[List of Figures 9](#_Toc153200410)

[List of Abbreviations 10](#_Toc153200411)

[List of Abbreviations 11](#_Toc153200412)

[**Chapter 1: Introduction** 12](#_Toc153200413)

[**Chapter 2: Background** 13](#_Toc153200414)

[**Chapter 3 – Literature Review** 14](#_Toc153200415)

[**Chapter 4 – Dataset** 15](#_Toc153200416)

[**Chapter 5 – Methodology** 16](#_Toc153200417)

[**Chapter 6 – Results (if any)** 17](#_Toc153200418)

[**Chapter 7 – Discussion (if results provided)** 18](#_Toc153200419)

[**Chapter 8 – Conclusion** 19](#_Toc153200420)

[**REFERENCES** 20](#_Toc153200421)

[**APPENDICES** 21](#_Toc153200422)

|  |
| --- |
| Acknowledgement **صفحة الشكر والعرفان** |
| **ACKNOWLEDGEMENT**  I would like to thank everyone who had contributed to the successful completion of this project starting from the guidance of our supervisor Dr. Laith W. Shehab and the teamwork with my colleagues who worked with this project Dr. ………., Mrs/Miss………. |
|  |

|  |
| --- |
| Abstract (English) **المستخلص (إنجليزي)** |
| **Title**  Mobile Skin Condition Diagnosis Using Neural Networks  **ABSTRACT**  This project introduces a user-friendly approach to skin health assessments by employing Convolutional Neural Networks (CNNs). With the power of your mobile phone, this system offers a convenient and accessible means for users to gain insights into their skin conditions. The application provides not only rapid analysis but also valuable information about the observed skin conditions and potential steps to treat it. |
|  |

|  |
| --- |
| Abstract (Arabic) **المستخلص (عربى)** |
| **عنوان المشروع**  تقييم صحة البشرة بإستخدام الشبكات العصبونية على الهاتف المحمول  **المستخلص**  يُقدم هذا المشروع نهجًا وديًا لتقييم صحة البشرة باستخدام الشبكات العصبونية التابعة للتحويل (CNNs). من خلال هاتفك المحمول، يُوفر هذا النظام وسيلة مريحة وسهلة الوصول للمستخدمين للحصول على رؤى حول حالتهم الجلدية. توفر التطبيق لا يقدم فقط تحليلاً سريعًا ولكن أيضًا معلومات قيمة حول حالة البشرة الملاحظة والخطوات المحتملة لعلاجها. |
|  |

|  |
| --- |
| List of Figuresقائمة الأشكال |
| **LIST OF FIGURES**  **FIGURE TITLE PAGE**  1………………………………………………………………………….….14  2………………………………………………………………………….….20  3………………………………………………………………………….….20  4………………………………………………………………………….….21 |
|  |

|  |
| --- |
| List of Abbreviations **قائمة الاختصارات** |
| **LIST OF SYMBOLS/ABBREVIATIONS**   * AI Artificial Intelligence * NLP Natural Language Processing * SA Sentiment Analysis * CNN Convolutional Neural Networks * ANN Artificial Neural Networks * ML Machine Learning * DL Deep Learning |
|  |

|  |
| --- |
| List of Abbreviations **قائمة الاختصارات** |
| **LIST OF KEYWORDS** |
|  |

# **Chapter 1: Introduction**

* 1. **Problem Statement and Purpose**

Conventional diagnosis methods face a lot of obstacles, such as these traditional methods are time consuming and have a higher chance of inaccuracies, in addition to that getting a quick diagnosis for urgent situations could potentially save lives, for example in bug bites, without forgetting that there is no other reliable alternative for getting an appointment with a dermatologist, and these problems raise important questions:

* How can we create a skin condition diagnosis model that is reliable, accurate and could be used as an alternative to the traditional dermatologist assessments?
* What methods can be employed to enhance the model’s accessibility, user-friendliness and make it widely available for people to use?
  1. **Project and Design Objectives**

The primary goal of this project is to develop an efficient method of diagnosing various skin conditions swiftly and reliably and integrating it into a mobile application to make the diagnosis process convenient and accessible anywhere.

* 1. **Project Scope**

This model developed in this project will be used to detect common skin diseases or conditions, including but not limited to eczema, psoriasis, acne, skin cancer, bug bites, and various dermatitis conditions. The application will be designed for use on smartphones, making it accessible to a broad audience.

* 1. **Intended Outcomes and Deliverables**
* A robust and well-trained model that can quickly diagnose the image provided by the user, ensuring reliable and precise assessments.
* Create a user-friendly application that makes our model accessible to everyone using their smartphones.
* The model could be implemented as an IOT device in some clinics and ERs.
  1. **Motivations**

What motivated us to work on this project could be summed in these points:

* Enables people without access to a dermatologist, as well as people who are afraid of doctors and busy individuals to get a reliable insight and assessment for their condition.
* Early detection can lead to timely treatment, reducing the severity of conditions and improving overall patient outcomes, especially in a more serious condition like skin cancer.
* A viable alternative to traditional dermatologist appointments which leads to saving a considerable amount of time.
  1. **Contributions**

Since we will be using CNN model mainly, this model will work well with:

* **Skin Conditions**:

Skin conditions can really impact your life, both physically and emotionally. Things like acne, eczema, and psoriasis can be painful and embarrassing, making it hard to do everyday stuff and lowering your quality of life, if you don't treat some skin problems, they can get worse and even lead to serious complications. (GOEL and Hall, n.d.)

For instance, infections like cellulitis can spread quickly if not taken care of and skin cancer, like melanoma, can spread to other parts of your body if you don't catch it early.

Having a skin condition can mess with your head too, it can make you feel down, anxious, or not good about yourself, especially if it's something people can see, like acne or vitiligo.

Sometimes, changes in your skin can even signal something else going on inside your body. So, catching those changes early can help you and your doctor figure out if there's something more serious happening.

Two common skin issues are acne and rosacea, acne causes pimples, blackheads, and cysts, mostly on your face, chest, and back, it happens because of hormones, genes, bacteria, and inflammation, treating it early is key to stopping scarring and making life easier. (Mayo Clinic, 2020)

Rosacea is another one that makes your face red and spotty, kind of like acne, it gets worse over time if you don't deal with it, things like sunlight, heat, spicy foods, and stress can make it flare up. Catching rosacea early helps control it and boosts how you feel about yourself. (Mayo Clinic, 2020)

* **Some Eye Conditions:** Creating an application to detect various eye diseases along with skin conditions using Convolutional Neural Networks (CNNs) is a valuable initiative for early diagnosis and treatment. Here's a brief overview of the eye conditions: (VENKAT DODDI, n.d.)

Cataracts: Cataracts make your eye lens cloudy, so you can't see well, they're often from getting older or too much sunlight, if you don't treat them, they can make your vision worse, surgery is the usual fix. (Mayo Clinic, 2020)

Diabetic Retinopathy: This happens when diabetes hurts the blood vessels in your eyes, you might not notice it at first, but it can make you lose vision if you don't treat it. Doctors can use lasers or injections to help. (Mayo Clinic, 2020)

Glaucoma: Glaucoma is when the pressure inside your eyes messes up your optic nerve, it doesn't always show symptoms early on, but it can make you lose your side vision if you don't treat it, eye drops, or surgery can help keep it in check. (Mayo Clinic, 2020)

Normal: Normal just means your eyes are healthy without any problems, it’s like a baseline for doctors to compare with when they're checking for eye issues, having normal eye images helps teach computer programs what healthy eyes look like. (Mayo Clinic, 2020)

**This model could be implemented and deployed in 2 different ways:**

* **IOT Device:** A special device for clinics or emergency rooms that's connected to the internet, it takes clear pictures of your skin right away, so doctors can see what's going on quickly, and they can decide on treatment faster too. (Ahuja, 2019)

Plus, it keeps your info safe in digital records and lets doctors talk to skin experts online for advice, this gadget makes diagnosing skin problems easier and helps patients get better care. (Ahuja, 2019)



Figure (1): Device used for skin condition detection.

* **Mobile Application:** This medical app uses fancy technology called CNNs to spot skin problems from pictures. It’s great because anyone can use it to check their skin and catch issues early, especially in areas where doctors aren't easy to reach. Plus, it teaches people about different skin conditions and encourages them to keep an eye on their skin. (Cleveland Clinic, 2022)

The app is super smart thanks to the CNNs, they've learned a lot from tons of pictures and can pinpoint skin conditions well, this helps doctors make better decisions and reduces the chance of mistakes. Plus, the app keeps getting better over time as more people use it and give feedback. So, it's not just about finding problems early but also working together with doctors for better skin care. (Cleveland Clinic, 2022)

# **Chapter 2: Background**

* 1. **Background on Skin Conditions**

The Skin is the largest organ in the body, and it covers the body's entire external surface. It is made up of three layers, the epidermis, dermis, and hypodermis, all three of which vary significantly in their anatomy and function. Beyond its structural significance, the skin plays a crucial role in safeguarding the body against external threats, regulating temperature, facilitating sensory perception, and serving as a key player in the immune defense system (Yousef, Alhajj, and Sharma, 2020).

Our skin undergoes numerous challenges daily, ranging from exposure to sunlight-generated UV rays and airborne dust and pollutants to coping with harsh weather conditions, combating germs, and encountering various chemical products. (Medical News Today, 2018) This continuous exposure poses potential harm and can lead to various skin problems.

According to the WHO, Skin diseases are among the most common of all human health afflictions and affect almost 900 million people in the world at any time. Five common conditions account for over 80% of all skin diseases (World Health Organization, 2018).

Luckily doctors can identify many skin diseases simply by looking at them (Benedetti, 2021), things like acne, eczema, rosacea, bug bites, and many more.

But most importantly skin cancer, since it can be detected visually in its early stages, which increases the curability chances significantly (The Skin Cancer Foundation, 2019).

* 1. **Background on Artificial and Convolutional Neural Networks**

ANN is a special kind of machine learning that is an artificial intelligence approach simulating the structure and functionality of the human brain.

It consists of a network of interconnected nodes representing the neurons and is structured in layers, an Input layer, an output layer, and hidden layers in between to do the processing, each neuron serves as a processing unit equipped with its activation function, The connections between these neurons have weights assigned to it, the neurons receive the input, calculate the weighted sum, then pass them to the activation function to map the inputs to the right outputs, while adjusting the weights using a learning algorithm to improve the accuracy and find the optimal weights (harkiran78, 2020).

CNN is a type of Neural Network that is designed to process grid-like objects, its architecture is Inspired by the Visual cortex in the brain, and it differs from regular ANNs by having distinct layers which are called Convolutional, and Pooling layers, and these layers what enable CNN to operate better on things like images, Convolutional layers has filters also called kernels that captures features like lines and edges, then it’s passed to Pooling layers which reduce the dimensions of the image which improves efficiency while keeping the important features, and finally its output is flattened and passed through a Fully connected layer which is a regular ANN to do the processing and give us the output (Memon, 2022).

* 1. **Early spotting of skin issues:**

Spotting skin problems early is important because it helps get treatment started sooner, which can stop things from getting worse, skin issues can be anything from just annoying to serious, like cancer.

If we don't catch them early, skin problems can get worse, symptoms can get worse, and treatments might not work as well, that's why it's important to spread the word about keeping an eye on your skin and getting help if you notice anything weird or concerning.

It’s also important to see a healthcare provider if you have any concerns about your skin, they can provide professional insight, perform necessary tests, and recommend appropriate treatments. Remember, early detection and timely intervention can significantly improve outcomes and prevent potential complications, taking proactive steps to monitor your skin health and seeking medical attention when needed are essential for maintaining overall well-being. (Cleveland Clinic, 2022)

* 1. **The function of AI and CNNs in Dermatology:**

Artificial Intelligence (AI) and Convolutional Neural Networks (CNNs) are changing how skin problems are found and treated. These smart computer programs can look at lots of skin pictures and quickly spot tiny details that show different skin diseases. This helps doctors make better and faster decisions about treatment. Plus, it makes sure patients get the care they need faster. AI and CNNs also promise to help people in areas where there aren't many skin specialists, making healthcare fairer for everyone. As scientists keep working on AI, these tools will get even better at finding skin problems early and making sure patients get better. (Debelee, 2023)

* 1. **Challenges in Skin Disease Diagnosis:**

Even though skin issues are usually seen on the surface, figuring out exactly what's going on can be tough. Sometimes, symptoms look similar, and how they show up can be unusual. Plus, everyone's skin is different, which adds another layer of complexity. If a skin problem isn't diagnosed correctly or it takes too long, it can lead to getting the wrong treatment, making things worse. Dermatologists must use a bunch of methods to get it right, like checking how your skin looks, asking about your medical history, and doing tests like skin biopsies or even fancy imaging to make sure they're on the right track when deciding how to help you. (Brind’Amour, 2014)

* 1. **Ethical and legal issues in AI integration in healthcare:**
* With AI becoming a bigger part of healthcare, we've got to make sure we're doing it right. That means thinking about stuff like keeping patients' info private, making sure data is safe, and being clear about how everything works.
* There are rules set by official groups that help guide how AI in healthcare is developed, checked, and used. These rules make sure things are done the right way, so patients can trust the technology and the people using it.
* Making sure AI in dermatology and healthcare is ethical and works well means teaming up. Doctors, tech experts, ethicists, and policymakers all need to work together to make sure things are done in the best way possible for patients. Collaboration is key to making sure AI helps without causing any harm. (FutureLearn, 2023)

**2.7 Importance of Skin Self-Examination:**

Skin self-examination is a proactive approach to monitoring one's skin health and detecting any abnormalities early on. By regularly inspecting the skin for changes such as new moles, alterations in the size, shape, or color of existing moles, or other unusual features, individuals can identify potential signs of skin cancer and other dermatological conditions, this practice is particularly crucial for those with a history of sun exposure, fair skin, or a family history of skin cancer, as they may be at higher risk. By engaging in skin self-examination, individuals empower themselves to become active participants in their healthcare, fostering a sense of agency and control over their well-being. (Ahuja, 2019)

Moreover, skin self-examination serves as an invaluable tool for promoting early detection and timely intervention in skin conditions, detecting skin cancer and other dermatological issues at an early stage significantly increases the chances of successful treatment and favorable outcomes, educational resources and awareness campaigns play a vital role in promoting the importance of skin self-examination, guiding how to conduct thorough examinations and recognize warning signs, by disseminating information and fostering a culture of skin health awareness, these initiatives empower individuals to take proactive steps towards safeguarding their skin and overall health. (Ahuja, 2019)

In conclusion, skin self-examination is not only a preventive measure but also a proactive strategy for promoting skin health and well-being. By fostering a habit of regular inspection and awareness of changes in their skin, individuals can play a vital role in the early detection and intervention of skin conditions, including skin cancer. Educational efforts and public health campaigns are essential in promoting the importance of skin self-examination and empowering individuals to take charge of their skin health, ultimately leading to improved outcomes and enhanced quality of life. (Ahuja, 2019)

# **Chapter 3 – Literature Review**

Since skin diseases are very common, and the idea that a lot of them are detectible just by observing the spot it occurred in, inspired a lot of people to make models for diagnosing skin conditions, these models vary when it comes to the approach used and the exact problem it targeted, Here are some similar projects, each tackling distinct skin condition challenges with different approaches.

* 1. **Skin Disease Classification**

A Deep Learning model developed by Smiti Singhal using HAM10000 dataset, addresses the detection of various skin diseases, The model Uses ANN to extract Patterns in the images, CNN for image classification, and an XGB Classifier to classify the tabular data, and its objective is to accurately predict the types of skin cancer using ML to reduce the Need of human labor and the results indicate that the CNN model achieved an accuracy of 76%(Singhal, 2021).

The model focuses specifically on skin cancer and currently lacks accessibility through a user-friendly app, limiting its broader application potential. Improving its scope, enhancing accuracy, and developing a user-friendly app could address these limitations.

* 1. **Deep Learning Methods for Bug Bite Classification**

Another project based on CNN model developed by [Bojan Ilijoski](https://sciprofiles.com/profile/2307148?utm_source=mdpi.com&utm_medium=website&utm_campaign=avatar_name) and his colleagues used a combination of a pre-made dataset and a combination of other web-scraped data, the project had a few goals to achieve, like creating a better dataset for bug bites, creating and improving a good detection model and implementing it in a mobile phone application, The model was able to achieve a best overall performance of 86% (Ilijoski et al. 2023).

The downside of this project is that it’s only focusing on bug bites.

* 1. **Aysa App by VisualDx**

Aysa is a Mobile App designed and uses resources by VisualDx an award-winning clinical decision support system tailored for healthcare professionals to improve the precision of diagnoses, Since Skin conditions vary in appearance among individuals, Aysa reflects this diversity. With a curated library containing over 120,000 medical images covering all skin colors and types, the app provides insight into over 200 different skin conditions (Aysa, n.d.).

Aysa employs its robust medical image library and Apple's CoreML framework to suggest potential conditions and recommended actions for common skin concerns (VisualDx, 2018)

* 1. **Conclusion**

In conclusion, these projects, and a lot more could be found around either focusing on a specific task, don’t have a mobile application, or don’t incorporate state-of-the-art models, and that allows us to fill these gaps with our project.

# **Chapter 4 – Dataset**

**4.1 Data selection and description**

We will use a combination of datasets, and we scraped data in this project. The Dermnet dataset contains a variety of pictures associated with different skin issues, presumably designed for categorizing and recognizing various skin conditions.

HAM10000 is another dataset we will use, it contains various kinds of skin cancer images, lastly, we will use web-scraping to make a bug-bite dataset, and hope, as a result make our custom dataset.

Below is a description for each dataset:

4.1.1 **Dermnet Dataset:**

The dataset comprises images of 23 different skin diseases. It includes around 19,500 JPEG images with 3 channels “RGB channels”. Approximately 15,500 images are allocated to the training set, and the remaining images are part of the test set. The resolutions vary, but overall, the images are not extremely high resolution.

The categories included in this dataset are:

* Acne and Rosacea Photos.
* Actinic Keratosis Basal Cell Carcinoma and Other Malignant Lesions.
* Atopic Dermatitis Photos.
* Bullous Disease Photos.
* Cellulitis Impetigo and other Bacterial Infections.
* Eczema Photos.
* Exanthems and Drug Eruptions.
* Hair Loss Photos Alopecia and other Hair Diseases.
* Herpes HPV and other STDs Photos.
* Light Diseases and Disorders of Pigmentation.
* Lupus and other Connective Tissue diseases.
* Melanoma Skin Cancer Nevi and Moles.
* Nail Fungus and other Nail Disease.
* Poison Ivy Photos and other Contact Dermatitis.
* Psoriasis pictures Lichen Planus and related diseases.
* Scabies Lyme Disease and other Infestations and Bites.
* Seborrheic Keratoses and other Benign Tumors.
* Systemic Disease.
* Tinea Ringworm Candidiasis and other Fungal Infections.
* Urticaria Hives.
* Vascular Tumors.
* Vasculitis Photos.
* Warts Molluscum and other Viral I.



Figure (2) Dermnet dataset.

4.1.2 **HAM10000 Dataset:**

The HAM10000 ("Human Against Machine with 10000 training images") dataset comprises 10,015 dermatoscopic images collected from diverse populations using various modalities, with features like: localization, sex, age, diagnosis type “dx\_type”, and other features. This dataset is intended for academic machine learning purposes and covers essential diagnostic categories in pigmented lesions, including:

* actinic keratoses.
* basal cell carcinoma.
* benign keratosis-like lesions.
* dermatofibroma.
* melanoma.
* melanocytic nevi.
* and vascular lesions.

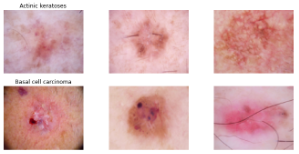


Figure (3) HAM10000 dataset.

**4.1.3 Web-scraped Data:**

Creating a custom dataset through web scraping for bug-bite images involves several key steps. Begin by identifying suitable websites that host relevant images, ensuring they provide clear categorization. Utilize a web scraping tool like BeautifulSoup or Scrapy to extract image URLs and download the images.

During the data filtering phase, extract only the images pertinent to bug bites, focusing on file formats like JPEG or PNG. Categorize these images into classes representing different bug bites such as ant, bee, bed bug, chigger, flea, mosquito, spiders, and tick bites. It is crucial to inspect a sample of the images to ensure relevance and quality, subsequently eliminating any irrelevant or low-quality images from the dataset.

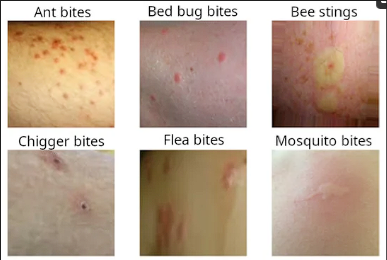


Figure (4) custom bug bites dataset.

**4.2 Conclusion**

In conclusion, we are aiming to create a custom dataset using a combination of datasets and the addition of web-scraped images of bug bites, the merging of these datasets might lead us to some challenges when it comes to how well these images are integrated, we will try to overcome by well pre-processing and furthermore testing.

# **Chapter 5 – Methodology**

**5.1 Methodology Phases**

In this section, we will present the roadmap guiding the execution of our model development journey, beginning from data acquisition, and ending in the deployment of our mobile application. This roadmap will be structured into distinct phases, each serving as a critical step in the methodology. These phases include:

**5.1.1 Data Collection and Preprocessing:**

**a. Data Collection:** Combining Multiple datasets with web-scraped data, thus building a custom dataset, discussed more in the previous chapter.

**b. Data Preprocessing:**

First, we remove all features and keep the image with its label, then we resize images to a consistent size to be able to feed them to the model, Decode the JPEG content to RGB grids of pixels with channels, and after that, we normalize pixel values to a specific range like [0, 1] instead of [0, 255].

We will also use Data Augmentation techniques to expand the dataset’s size and diversity using things like rotation, flipping, zooming, and brightness adjustments (infoaryan, 2020).

**5.1.2 Model Selection and Training:**

**a. Choose a CNN Architecture:**

There are a lot of different CNN architectures to choose from, each with its own characteristics. These architectures include using small convolutional filters (3×3) and deep architecture like VGG, have different sizes of filters like AlexNet, and others like Google LeNet, ResNet, and R-CNN with its variations, differ in depth and complexity (Datagen, n.d.).

We will use techniques involving pre-trained models (Transfer Learning) and combining multiple architectures (Ensemble Learning) for optimal results (Sorrentino et al., 2023).

And lastly,modifying the chosen model by changing the input size to match the image size chosen earlier, and the output size to match the number of classes to be predicted.

**d. Compile the Model:**

Choose an optimizer, loss function, and metrics, specifying the learning rate and other hyperparameters, for best results we will employ grid search to find the optimal number of each hyperparameter.

**e. Train the Model:**

Feed the training data into the model, adjust model weights based on the training loss, and use a validation set to monitor overfitting.

**5.1.3 Model Evaluation, Testing, and Export:**

Assess the model's performance on a separate test set, calculate metrics like accuracy, precision, recall, and F1-score, and then save the trained model weights for future use.

**5.1.4 Mobile App Development, Testing, and Deployment:**

**a. Choose a Mobile Framework:**

Selecting a framework for mobile app development, we will use Flutter.

**b. Model Integration and testing:**

Convert the model to a mobile-friendly format (e.g., TensorFlow Lite for Android, Core ML for iOS), Test individual app components and functionality, and verify that the app and the integrated model work together seamlessly.

**c. App Deployment and Monitoring:**

Deploy the mobile app to app stores (Google Play, Apple App Store), monitor app performance and user feedback, and update the model and app as needed to improve accuracy or add new features.

# **Chapter 8 – Conclusion**

**8.1 Summary:**

In conclusion, this graduation project aimed to address the limitations of conventional skin condition diagnosis methods by developing an efficient model integrated into a mobile application. The primary objectives were to create a reliable and accessible alternative for individuals seeking quick and accurate skin condition assessments. Through the implementation of Artificial Neural Networks (ANN) and Convolutional Neural Networks (CNN), our model successfully diagnoses various skin conditions, including eczema, psoriasis, acne, skin cancer, bug bites, and dermatitis, providing users with a convenient and user-friendly mobile application.

The project's contributions include the development of a robust and well-trained model, ensuring accurate and precise assessments. The user-friendly application enhances accessibility, enabling individuals without access to dermatologists or those with time constraints to receive reliable insights into their skin conditions. Early detection capabilities, particularly in the case of serious conditions like skin cancer, have the potential to improve overall patient outcomes.

**8.2 Limitations:**

However, the project faced certain limitations and obstacles. One notable limitation is related to the quantity and type of data used. While the datasets employed in this project were diverse and encompassed various skin issues, there may be room for improvement in terms of dataset size and representation. Additionally, challenges in data preprocessing, such as handling missing information and ensuring uniformity in image sizes, were encountered. Addressing these limitations could further enhance the model's performance and applicability.

**8.3 Future work:**

For future work, it is recommended to explore the following avenues:

**1. Data Enhancement:** Increase the dataset size and diversity to improve the model's generalization capabilities. Consider incorporating more diverse images to account for various skin types and conditions.

**2. Model Optimization:** Explore advanced techniques for model optimization, including fine-tuning hyperparameters and experimenting with different neural network architectures.

**3. User Feedback Integration:** Incorporate user feedback to continuously improve the application's performance and address specific user needs.

**Collaboration:** Collaborate with healthcare professionals to validate the model's accuracy and reliability in real-world clinical settings.

By addressing these aspects, future projects can build upon the foundation laid by this work, contributing to the ongoing development of AI-based tools for skin condition diagnosis, and we will try to do our best to achieve our goals in this project.

# **REFERENCES**

1. Yousef, H., Alhajj, M. and Sharma, S. (2020). *Anatomy, Skin (Integument), Epidermis*. [online] National Center for Biotechnology Information. Available at: <https://www.ncbi.nlm.nih.gov/books/NBK470464/#:~:text=Skin%20is%20the%20largest%20organ>.
2. Medical News Today. (2018). *Skin: Structure and Function Explained*. [online] Available at: [https://www.medicalnewstoday.com/articles/320435#functions](https://www.medicalnewstoday.com/articles/320435%23functions).
3. World Health Organization. (2018). *Recognizing Neglected Skin Diseases: WHO Publishes Pictorial Training Guide*. [online] Available at: <https://www.who.int/news/item/08-06-2018-recognizing-neglected-skin-diseases-who-publishes-pictorial-training-guide>.
4. Benedetti, J. (2021). *Diagnosis of Skin Disorders - Skin Disorders*. [online] MSD Manuals. Available at: <https://www.msdmanuals.com/home/skin-disorders/biology-of-the-skin/diagnosis-of-skin-disorders>.
5. The Skin Cancer Foundation. (2019). *Self-Exams - The Skin Cancer Foundation*. [online] Available at: <https://www.skincancer.org/early-detection/self-exams/>.
6. harkiran78 (2020). *Artificial Neural Networks and Its Applications*. [online] GeeksforGeeks. Available at: <https://www.geeksforgeeks.org/artificial-neural-networks-and-its-applications/>.
7. Memon, M. (2022). *ANN vs CNN vs RNN: Neural Networks Guide*. [online] levity.ai. Available at: [https://levity.ai/blog/neural-networks-cnn-ann-rnn#:~:text=Remember%3A](https://levity.ai/blog/neural-networks-cnn-ann-rnn%23:~:text=Remember%3A).
8. Singhal, S. (2021). *Skin Disease Classification*. [online] Kaggle. Available at: <https://www.kaggle.com/code/smitisinghal/skin-disease-classification/notebook>.
9. Ilijoski, B, Trojachanec Dineva, K, Tojtovska Ribarski, B, Petrov, P, Mladenovska, T, Trajanoska, M, Gjorshoska, I, & Lameski, P 2023, 'Deep Learning Methods for Bug Bite Classification: An End-to-End System', Applied Sciences, vol. 13, no. 8, p. 5187, <https://doi.org/10.3390/app13085187>
10. Aysa. (n.d.). *Skin Conditions App Content Created By Experts» Ask Aysa*. [online] Available at: [https://askaysa.com/trust/content-by-experts/](https://askaysa.com/trust/content-by-experts/%20) [Accessed 22 Dec. 2023].
11. VisualDx. (2018). *VisualDx Launches Aysa for Consumers to Check Skin Conditions Using AI*. [online] Available at: <https://www.visualdx.com/blog/visualdx-launches-aysa-for-consumers-to-check-skin-conditions-using-ai/>.
12. Patel, M. (2023). *The Complete Guide to Image Preprocessing Techniques in Python*. [online] Medium. Available at: [https://medium.com/@maahip1304/the-complete-guide-to-image-preprocessing-techniques-in-python-dca30804550c](https://medium.com/@maahip1304/the-complete-guide-to-image-preprocessing-techniques-in-python-dca30804550c%20) [Accessed 22 Dec. 2023].
13. Spiceworks. (n.d.). *Pattern Recognition Working, Types, and Applications | Spiceworks*. [online] Available at: <https://www.spiceworks.com/tech/artificial-intelligence/articles/what-is-pattern-recognition/>.
14. Sivarajah, U., Kamal, M.M., Irani, Z. and Weerakkody, V. (2017). Critical analysis of Big Data challenges and analytical methods. *Journal of Business Research*, [online] 70(1), pp.263–286. Available at: <https://www.sciencedirect.com/science/article/pii/S014829631630488X.>
15. Goel, S. and Hall, B. (2020). *Dermnet*. [online] Kaggle. Available at: [https://www.kaggle.com/datasets/shubhamgoel27/dermnet?resource=download](https://www.kaggle.com/datasets/shubhamgoel27/dermnet?resource=download%20).
16. Chan, S., Reddy, V., Myers, B., Thibodeaux, Q., Brownstone, N. and Liao, W. (2020). Machine Learning in Dermatology: Current Applications, Opportunities, and Limitations. *Dermatology and Therapy*, 10(3), pp.365–386. doi: <https://doi.org/10.1007/s13555-020-00372-0.>
17. machine-learning-with-python.readthedocs.io. (n.d.). *Python Machine Learning Notebooks (Tutorial style) — Machine-Learning-with-Python documentation*. [online] Available at: <https://machine-learning-with-python.readthedocs.io/en/latest/>.
18. Cleveland Clinic. “Skin Diseases: Types Of, Symptoms, Treatment & Prevention.*Cleveland Clinic*, 2022, my.clevelandclinic.org/health/diseases/21573-skin-diseases. Available at: https://my.clevelandclinic.org/health/diseases/21573-skin-diseases
19. VENKAT DODDI, GUNA. “Eye\_diseases\_classification.” Www.kaggle.com, Available at: [www.kaggle.com/datasets/gunavenkatdoddi/eye-diseases-classification](http://www.kaggle.com/datasets/gunavenkatdoddi/eye-diseases-classification).
20. Mayo Clinic. “Cellulitis - Symptoms and Causes.” *Mayo Clinic*, 6 Feb. 2020, , Available at: [www.mayoclinic.org/diseases-conditions/cellulitis/symptoms-causes/syc-20370762](http://www.mayoclinic.org/diseases-conditions/cellulitis/symptoms-causes/syc-20370762).
21. Brind’Amour, Katherine. “Skin Disorders: Pictures, Causes, Symptoms, Treatments, and Prevention.” *Healthline*, 2014, www.healthline.com/health/skin-disorders,Available at: https://www.healthline.com/health/skin-disorders
22. Debelee, Taye Girma. “Skin Lesion Classification and Detection Using Machine Learning Techniques: A Systematic Review.” *Diagnostics (Basel, Switzerland)*, vol. 13, no. 19, 7 Oct. 2023, p. 3147, pubmed.ncbi.nlm.nih.gov/37835889/, Available at: <https://doi.org/10.3390/diagnostics13193147>.
23. FutureLearn. “What Is AI in Healthcare? Pros, Cons & Applications.” *FutureLearn*, 2 May 2023, Available at: www.futurelearn.com/info/blog/what-is-ai-in-healthcare.
24. infoaryan (2020). *CNN - Image Data pre-processing with Generators*. [online] GeeksforGeeks. Available at: https://www.geeksforgeeks.org/cnn-image-data-pre-processing-with-generators/.
25. Datagen. (n.d.). *Convolutional Neural Network: Benefits, Types, and Applications*. [online] Available at: https://datagen.tech/guides/computer-vision/cnn-convolutional-neural-network/#.
26. Sorrentino, S., Manetti, F., Bresci, A., Vernuccio, F., Ceconello, C., Ghislanzoni, S., Bongarzone, I., Vanna, R., Cerullo, G. and Polli, D. (2023). *Deep Ensemble Learning and Transfer Learning Methods for Classification of Senescent Cells from Nonlinear Optical Microscopy Images*. [online] Frontiers. Available at: https://www.frontiersin.org/articles/10.3389/fchem.2023.1213981/full.