UTILIZING ADVANCED MACHINE LEARNING TECHNOLOGIES FOR DETAILED ECZEMA DIAGNOSIS AND ASSESSMENT

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Project Proposal Report

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DECLARATION

I declare that this is my own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by any other person except where the acknowledgement is made in the text.

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22/Aug/2024

Date

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ABSTRACT

Atopic dermatitis (commonly known as eczema) is a chronic inflammatory skin disease with an increasing prevalence globally, which affects people physically and psychologically. Because the diagnosis and disease severity assessment of atopic dermatitis are subject to traditional subjective clinical evaluations, there is a risk that treatment outcomes will be inconsistent across different patients. Machine learning combined with advanced image analysis techniques is increasing the opportunity for standardization and accuracy in analyzing discrete changes. “DermaScope AI” will be a novel app based on the results in this study, which aims to provide accurate and rapid diagnosis for severity of atopic dermatitis by employing machine learning techniques. Through automatizing clinical images analysis and matching the assessments with predefined metrics, “DermaScope AI” seeks to improve patient care and clinical decision making. Our study aims to change the way in which we approach atopic dermatitis, providing a nimble and adaptable care model that can be implemented across different healthcare platforms offering a practical solution, ultimately improving the lives of those affected by this chronic condition.

Keywords – Eczema, Atopic dermatitis, Machine learning, Deep learning, Severity assessment

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LIST OF ABBREVIATIONS

Abbreviation	Description
AI	Artificial Intelligence
ML	Machine Learning
DL	Deep Learning
AD	Atopic Dermatitis
CNN	Convolutional Neural Network
GLCM	Gray Level Co-occurrence Matrix
SVM	Support Vector Machine
EASI	Eczema Area and Severity Index
SCORAD	SCORing Atopic Dermatitis
XAI	Explainable Artificial Intelligence
UI	User Interface
UX	User Experience
IDE	Integrated Development Environment
HTML	HyperText Markup Language
CSS	Cascading Style Sheets
REST	Representational State Transfer
API	Application Programming Interface

1. INTRODUCTION

Eczema is a skin condition that causes inflamed, itchy, and red patches to appear on the skin. It is a multifactorial disorder that involves genetic and environmental influences, resulting in an overzealous immune response as well as skin barrier dysfunction. Eczema displays itself in characteristic patterns of inflammation, with the face, neck and hands frequently involved, as well as the flexural regions such as inside elbow creases or behind knees.

Atopic dermatitis (AD) is the most prevalent form of eczema found globally as well in Sri Lankan adults and children. It causes rashes, pain, and sleep disturbances and is accompanied by severe itch. Itching is a common ailment that becomes chronic and causes discomfort, damaging the skin barrier which may ultimately increase susceptibility to further maladies. It is a very common condition, which often starts in childhood and sometimes lasts into the adult stage that it becomes a major concern for both persons as well as healthcare systems together [1].

The high prevalence of AD and associated symptomatology highlight the importance that heath care providers need to pay special attention in this specific type of eczema. Apart from its physical disease burden, it also causes psychological and social consequences which add to the suffering of patients in terms of quality-of-life. Therefore, successful diagnosis and severity evaluation are essential for the management of atopic dermatitis to minimize its long-term consequences while improving quality of life.

The disease generally presents with a relapsing and remitting course, from mild discomfort to incapacitating skin lesions. In clinical practice, these approaches rely on the use of emollients and topical corticosteroids with a particular focus towards barrier optimization and reduction in inflammation respectively. The chronicity of eczema frequently results in suffering, both physically and mentally, including sleep impairment, anxiety, and social disruption.

Figure 1.1: Eczema on arm, which has red, inflamed patches

Figure 1.2: Red, inflamed, and possibly scaly patches of eczema on the face

The accurate diagnosis of the most common type of eczema, atopic dermatitis and accurate severity assessment are key components for optimal management intervention. At present, most diagnostic tools and assessments rely on subjective clinical evaluations conducted by dermatologists. Results are likely to be delayed and variably based on the visual inspection methods chosen, or patient history. As a result, there is growing demand for accurate, objective and cost-effective tools for identification and monitoring of eczema among patients that can be accessed in either clinical or non-clinical settings.

2. BACKGROUND AND LITERATURE SURVEY

2.1 Background Literature

The recent advancements in deep learning and various other state-of-the-art machine learning algorithms have paved way to the development of novel computer aided diagnosis system that are able to alleviate human subjectivity at diagnosing eczema more accurately as well as determining it into correct classes along with gauging its severity. Using machine learning to study vast collections of skin pictures can help in recognizing patterns and features that scream eczema, making it a highly prospective diagnostic. In eczema diagnosis, Convolutional Neural Networks (CNNs) have become an especially powerful method for automatic skin lesion classification and severity assessment. CNN could replace the prior process to save time, reduce subjectivity in clinical scales that demand expertise experience from evaluators. Thus, it becomes more efficient comparative novel diagnostic tool over traditional approaches which are slower with high range of variability due to evaluator interpretation. These models are helpful for clinicians as well as the patients.

Many studies have implemented machine learning in diagnosing and assessing the severity of eczema. In particular, the use of image processing methods such as Gray Level Co-occurrence Matrix (GLCM) and machine learning models including Support Vector Machines (SVM), to correctly classify images with specific types as atopic dermatitis, contact dermatitis or nummular dermatitis has already reached a significant level of accuracy. Moreover, the application of U-Net architectures to segment eczema lesions from skin scans has been able to identify lesion delineation, necessary for an adequate reading on disease severity. This progress holds great promise for integration of machine learning in the routine practice of dermatology, leading to personalized and more reliable therapy delivery against eczema.

The novel application, "DermaScope AI," uses proprietary machine learning capabilities to optimize current atopic dermatitis diagnosis. With this atopic dermatitis application, it is possible to detect the condition of the skin that causes atopy correctly by using skin image data. A cutting-edge solution compared to traditional diagnostic techniques, "DermaScope AI" streamlines the diagnosis procedure with a significant amount of time saving and accessibility, especially in areas which do not have enough availability for dermatologists. This solution further illustrates machine learnings vital role in driving more effective, efficient eczema care, a generalizable and objective tool for both clinicians as well as patients with an atopic emphasis.

2.2 Literature Survey

Nisar et al. [2] worked with supervised machine learning methods for segmenting and categorizing eczema lesions. Supervised machine learning methods can improve the accuracy and efficiency of clinical assessments for identification or severity assessment where they have been developed. Researchers have successfully segmented and categorized eczema skin lesions with a high level of accuracy through the employment of SVM and CNN algorithms. Such techniques are especially useful in clinical situations where conventional methods can result in time constraints and subjectivity. These machine learning models could be a major advance in leading the dermatologic diagnosis to avoid errors which harm patient care as they are capable of reliably identifying multiple types of eczema.

Jardeleza et al. [3] proposed an algorithm combining GLCM and SVM in the detection of several forms of typical eczemas (atopic dermatitis, contact dermatitis and nummular dermatitis). In the study, researchers created a prototype system that was able to obtain photos of skin and eczema locations as well as benchmarking accurately what kind of type dermatitis patients suffered from. This system, with an accuracy of 83.33%, is very useful in regions where access to highly trained dermatologists would seem difficult as the earlier and more accurate diagnosis could dramatically impact treatment outcomes. In this specific case, the mixture of GLCM and SVM demonstrates that machine learning can provide reliable diagnostic tools also to be easily understandable by everyone.

Junayed et al. [4] successfully introduced EczemaNet, to achieve high accuracy in classification of different types of eczema diseases. CNN has demonstrated an impressive performance in classifying various eczema conditions. Many still call for deep learning model as EczemaNet, a deep CNN-based model specifically developed to handle the difficulty of telling eczemas apart from each other. Trained on a large set of annotated eczema photos, the model was more accurate and provided qualitatively consolidated classification results over previous models. The ability of EczemaNet to make accurate and actionable diagnoses may not only aid clinical decision-making but also suggest the potential adoption of such models into routine dermatological practice, which could lead to notable time and accuracy gains.

Attar et al. [5] explored the use of digital camera images for automatic identification and objective assessment of eczema severity in an automated manner to advance the process of evaluating eczema. Through the utilization of advanced image processing methods, these systems are able to programmatically detect areas where there is eczema and then grade severity scores for each area based on specific clinical criteria. All automated assessments were validated for their accuracy and reliability against the opinions of board-certified dermatologists. Results indicate that the systems can achieve equivalent levels of

performance besides saving medical staff time. Automatic systems also ensure the objectiveness and uniformity of assessments that are crucial for tracking the disease progression and tailoring treatment plans.

Nisar et al. [6] successfully applied a modified U-Net network for skin lesion segmentation in eczema within the image. It has shown much better results than prior pixel-based classification. This is useful for medical image segmentation tasks since U-Net was designed to address complex lesion shapes and varying scales sizes. This is particularly valuable for dermatologists who will be able to identify the exact lesion by using those highly precise boundaries of eczema-affected regions drawn with U-Net in this case. This specificity is important to later detection and treatment planning for patients ensuring that an accurate diagnosis of the skin condition diseases they have.

Outside the progress of segmentation and classification, a recent avenue for investigation has been how to close this loop with mobile applications or real-time diagnostic systems integrating these machine learning models. The integration aims to make these valuable diagnostic tools more accessible for patients and their health care providers by allowing examinations and continuous monitoring of eczema diseases at home or during planned visits. The systems help patients to engage and abide by their treatment plans giving responses that are as rapid, so they immediately get feedback on the areas which they need answers. Such advancements signify a paradigm shift in eczema care, as these widespread technologies and advanced deep learning approaches could entirely change how the disease is diagnosed and monitored both within clinical settings as well as beyond. This growing body of research underlines the importance of interdisciplinary collaboration to develop robust care models that are not only effective, but also scalable and feasible for patients.

Research Paper	Technique Used	Focus	Primary Insight
Automatic Segmentation and Classification of Eczema Skin Lesions Using Supervised Learning	Supervised Learning (SVM, CNNs)	Automatic segmentation and classification of eczema skin lesions.	High accuracy and efficiency in segmenting and classifying eczema types.
Detection of Common Types of Eczema Using Gray Level Co-occurrence Matrix and Support Vector Machine	GLCM for Feature Extraction, SVM for Classification	Detection and classification of common types of eczema (atopic, contact, nummular).	Achieved 83.33% accuracy in classifying eczema types, beneficial in regions with limited dermatologist access.
EczemaNet: A Deep CNN-Based Eczema Diseases Classification	Deep CNN (EczemaNet)	High-accuracy classification of various eczema diseases.	Significantly improved classification accuracy and robustness, aiding in efficient clinical diagnosis.
Reliable Detection of Eczema Areas for Fully Automated Assessment of Eczema Severity	Advanced Image Processing Techniques for Segmentation and Severity Assessment	Automated detection of eczema-affected areas and severity assessment.	Comparable accuracy to expert dermatologists, providing objective and consistent severity assessments.
Segmentation of Eczema Skin Lesions Using U-Net	U-Net Architecture for Segmentation	Accurate segmentation of eczema skin lesions.	Outperformed traditional segmentation methods, offering precise lesion identification.

Table 2.1: Overview of existing methods and technologies

3. RESEARCH GAP

The reviewed research articles represent remarkable evolution in the diagnosis, classification and severity scoring of eczema with machine learning (ML) and deep neural networks. Nevertheless, there are several major evident gaps that need to be filled in order to improve the accuracy, generalizability and clinical relevance of these methods specifically with regard to atopic dermatitis as attested by a high number of studies mentioned within this framework.

This is a difficulty of segmentations as different lesion shapes are challenging. Despite U-Net has shown promise for recognizing eczematous areas, it remains challenging to accurately segment non-contouring irregularly shaped lesions Such model performance might suffer when encountering a larger degree of variations in lesion shape and color intensity, leading to less precise results with segmentation. Therefore, this issue requires more advanced solutions for lesion identification or the integration of context to improve detection accuracy.

In addition, there is a lack in the research of automated and real-time eczema severity assessment techniques. They have developed a number of automated systems, which are not necessarily aligned completely with clinical severity assessment systems such as SCORing Atopic Dermatitis (SCORAD) or Area and Severity Index (EASI) and often impractical for real-time deployment. An entirely automated severity assessment tool working on established clinical criteria, which can provide consistent real-time classification of the progress of illness and reflection needs modifying treatment recommendations.

“DermaScope AI” is a novel way of doing that. It has been designed to bridge these gaps, targeting only for the diagnosis and severity assessment in atopic dermatitis. Focusing on this type of eczema, “DermaScope AI” aims to deliver a highly precise and effective tool that is purpose-built for the characteristics found within atopic dermatitis leading to improved diagnostic accuracy as well as standardization.

An integral part of the proposed solution is to aid in improving explainability or interpret-ability of model. “DermaScope AI” will utilize Explainable Artificial Intelligence (XAI), which is used to increase the transparency and interpretability of predictions in deep learning models, reducing ambiguity by revealing hidden patterns within a model. Not only does this give accurate predictions, but also builds the reasoning behind these to clinicians which can lead to trust from them and facilitate integration of technology in clinical workflows.

The other important part of the proposed strategy is to make models more robust. The study will aim to harden the models against shifting patient demographics, illumination and picture quality. By training the

models on a wider dataset and performance enhancing methods like data augmentation, domain adaptation ensure models will generalize well across many situations. This is to make the system more robust in clinical practice.

Furthermore, an adaptive multi-scale attention mechanism will be implemented to deal with the difficulties in segmenting complex performed lesion shapes and varied image sizes within atopic dermatitis. This would allow the model to attend to important sections of the image at varying scales hence enhancing segmentation and severity assessment which is more accurate especially when lesion borders appear irregular or ill-defined.

In summary, to fill these gaps specifically “DermaScope AI” is built with extra features for a better overall comprehensive tool that can be used reliably and accurately in clinics too as part of managing patients who have atopic dermatitis. This comprehensive approach is expected to significantly enhance patient outcomes across a wide range of settings.

Feature / Gap	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**	**Proposed Solution**
Incorporate advanced deep learning techniques	Yes	No	Yes	Yes	Yes	Yes
Enhanced explainability	No	No	No	No	No	Yes
Improved robustness	Yes	No	Yes	Yes	Yes	Yes
Eczema severity assessment	No	No	No	Yes	No	Yes
Incorporation of attention mechanisms	No	No	No	No	No	Yes
Integrated system	No	No	No	No	No	Yes
Report generation	No	No	No	No	No	Yes
Progress analysis	No	No	No	No	No	Yes

Table 3.1: Comparison of the features addressed by the previous research studies

4. RESEARCH PROBLEM

Eczema (atopic dermatitis) is a common, chronic, relapsing inflammatory skin condition that affects up to 10% of the population worldwide. It leads to intense physical discomfort of itching, redness and thickening skin, overall diminishing quality of life due to the pain it causes those affected. Atopic dermatitis is the most common among all eczema that is commonly encountered in clinical settings. Correctly identifying atopic dermatitis and quantifying its severity represent the first important steps to manage this disease properly while personalizing treatment strategies as much as possible.

The diagnostic process for eczema, and particularly atopic dermatitis, is a clinically based one that depends on observation by trained medical personnel. This approach consists in the physical assessments of eczema, such as redness (erythema, inflammation), thickness (induration, papulation, swelling), scratching (excoriation), and lichenification (lined skin, furrowing, prurigo nodules) as part of the EASI scores. The EASI score is a quantitative and standardized instrument, which assesses the severity of eczema in terms that reflect both the extent as well as clinical intensity of these features. Whilst a common practice, this method is inherently subjective due to the reliance on clinician judgement and experience [7].

This has subjective element and allows room for differences in diagnosis, especially grade of severity of atopic dermatitis. Variation in clinician interpretation of the severity of a given condition could certainly lead to disparate treatment decisions and patient outcomes. In addition, manual evaluation in the case of eczema wrongly not only requires time but substantial manpower and is considered as one of hurdles into opportunities for busy clinical settings towards accuracy top priority.

Furthermore, these methods do not capitalize on the enabling power of developments in medical technology and data science to aid eczema diagnosis and management with greater precision and consistency. We cannot assume that all meaningful changes to the condition are visible and so for situations where assessment occurs via purely invasive visual inspection, we rely on inspectors having a level of detection ability left largely undefined. Thus, innovative strategies specifically targeting atopic dermatitis can and should enhance or replace traditional means of assessing atopic dermatitis severity in a more objective, reproducible and efficient manner.

5. RESEARCH OBJECTIVES

5.1 Main Objective

As the main objective our investigation, we will be developing a new whole system for advanced diagnostic and severity evaluation with machine learning in atopic dermatitis. “DermaScope AI” is aimed at overcoming challenges associated with subjective traditional methods and aims to provide an objective, faster, and more accurate tool for aiding clinical judgment to better patient outcomes.

“DermaScope AI” will focus on the exact diagnosis as well as a detailed severity assessment of atopic dermatitis, one of the most common forms of eczema. However, the most cutting-edge developments in machine learning will assist this system, primarily on image analysis and pattern recognition. We aim at detecting properly the severity of allergen mediated eczema by observing clinical symptoms that are criteria included in elaborate diagnostic definitions. Integrating these cutting-edge technologies will enable “DermaScope AI” to deliver a deeper and detailed analysis, supporting healthcare professionals in making more data-driven decisions about patient care. We conclude that such an analysis will allow them to in turn refine and personalize treatment paradigms even further than already done.

Another important functionality of “DermaScope AI” is its ability to track and update a comprehensive patient profile, as this will highlight crucial aspects with respect to the condition relatedness, past treatments availed, and monitoring progress done. This personalized process guarantees that the assessment is based not only on the general criteria for atopic dermatitis, but also on the own characteristics or necessities of each patient. This would help to log the condition in a more accurate way which can be watched over time, identified early before it reaches acute degrees and treated at correct levels.

Overall, this study will lead to the creation of an AI-based solution for atopic dermatitis treatment called “DermaScope AI”. It will improve the accuracy of diagnoses and enhance clinical assessment, providing a more objective method for evaluating. Ultimately, this will improve care journey for the patient population presenting with a chronic disease like diabetes. The end goal is to improve the patient being of those who, based on their status and eligibility for recommended genetic testing, receive assessments in a timely manner with attention to accuracy such that appropriate treatments may be provided.

5.2 Sub Objectives

Sub Objective 1: To Develop an Accurate Machine Learning Model for Diagnosis

The project aims to build an advanced machine learning model to make a correct prediction of atopic dermatitis based on clinical images. The pretrained model will be further fine-tuned to detect and read certain signals of the disease, using clinical diagnostic criteria EASI score in mind. Automation of this process is then expected to result in more consistent and objective diagnoses, with the goal being a higher standardization of patient assessment making it easier for clinicians to provide good care. This new development could change the pathway to diagnosis for atopic dermatitis, making it quicker and more dependable and less reliant on clinical impression so that a patient can get an accurate treatment option.

Sub Objective 2: To Implement a Detailed Severity Assessment Framework

This project efforts to design a meticulous and reliable framework under “DermaScope AI” exclusively for evaluating the severity of atopic dermatitis. The framework will assess a wide range of clinical indicators that contribute to the severity of atopic dermatitis (such as erythema, induration and lichenification). The goal of such a framework is to facilitate better diagnostic and treatment decisions by clinicians. It can enable detailed and subtle evaluation of disease severity, a foundation that supports the development of individualized treatment plans for patients. These personalized therapy concentrates treatments for effectiveness and patient experience which enhances individual outcomes by identifying the appropriate care each patient needs based upon their clinical characteristics.

Sub Objective 2: To Integrate an Attention Mechanism with Explainable AI for Enhanced Diagnostic Accuracy

This sub-objective aims at embedding an attention mechanism in the machine learning model implemented on “DermaScope AI”, to further improve its diagnosis of atopic dermatitis. The attention mechanism will help the model to focus, rather than ignore complex regions of interest from clinical images such as major areas with erythema or lichenification which are necessary parts for diagnosing disease. Through this, the diagnostic process is more rigorous and aligned with clinical practice as it guides which parts of data are essential to every model feature.

Also, this sub-objective is to integrate Explainable AI (XAI) techniques with the model so that users can interpret how the decision-making process of it being transparent. Using XAI, the model will return visualizations and explanations of where in the image is contributing to diagnosis and severity so on. The users can see why and how a diagnosis is reached. We convinced that a compound unit of AI and XAI along with the incorporation attention mechanism not only boost diagnostic accuracy but also in terms adoption of AI clinical as tool since clinician are served by provision more interpretable about available tools.

Sub Objective 4: To Implement Progress Tracking for Atopic Dermatitis Management

This sub-objective aims to create a comprehensive progress monitoring feature in “DermaScope AI” which can constantly track the patient's response to treatment enabling clinicians to detect changes (positive or negative). Therefore, they can administer therapy appropriately. By keeping tabs on progress analysis, the clinicians can make real-time adjustments to treatment plans, helping patients receive the best possible care while their strategy continues to be fine-tuned.

6. METHODOLOGY

The development of “DermaScope AI” is made by a process and steps designed to build an accurate tool for mobile and desktop atopic dermatitis diagnostic and disease evaluation. The stages of the methodology are as follows.

In the first phase of the project, high-quality clinical images of patients with atopic dermatitis will be collected from a broad mixed patient population. All these images are sourced from publicly available secondary datasets and will represent different extremes and stages in atopic dermatitis.

Once the data is collected, it will undergo pre-processing the data to make it consistent and ready for use. This might be re-sizing images, normalizing pixel values, or simply performing data augmentation to add variety and resiliency in the behavior of our training set. This is essential to a well simulated dataset, where rotation, flip of images will be their color adjustments all property which would help to improve the machine learning model.

Next, a machine learning model will be implemented which can identify and diagnose eczema using the preprocessed dataset. The model will use more sophisticated image analysis and pattern recognition techniques. The model will be trained to identify characteristic clinical signs of atopic dermatitis (most commonly erythema, induration and lichenification). The training will be an iterative process, mean testing and adjusting hyperparameters to get the best performance out of model.

Advanced severity of the disease assessment methodology will be embedded within “DermaScope AI” after a successful modelling exercise. The system will provide a framework for the assessment of atopic dermatitis severity according to the results of model-based identification and interpretation based on clinical features. The extent and intensity of symptomatic level, as noted by the system will be categorized into three categories as mild, moderate, and severe. The framework will be based on the EASI scoring standard that “DermaScope AI” uses, meaning the ratings conveyed from this model agree with contemporary clinical methodologies. This alignment will develop the tool, making it easy to adopt across diverse clinical settings and equip healthcare professionals with a robust way of assessing the disease severity.

The progress tracking module is one of the important elements of “DermaScope AI”. Patient response to treatment will be continuously monitored by the system. Providers will also get a full report on the course of illness, helping them to adapt care delivery as disease progresses. Feedback is important to maintain a continuous monitoring of the patient for having their optimal and effective treatment.

“DermaScope AI” will be further adapted for clinical use with a feature that allows users to generate and maintain their own patient profiles. The differential of atopic dermatitis will capture comprehensive data on each patient's condition that contains an assessment for the level and severity, previous treatments received, along with a longitudinal tracker. These profiles will be updated automatically by the system on an ongoing basis with each new assessment, allowing health care professionals to follow individual patients over time. This ongoing surveillance of disease activity will enable more tailored and dynamic treatment approaches, in turn providing an enhanced quality care.

To make the system “DermaScope AI” user-friendly and accessible, it will have an intuitive interface with a convenient to use design. The interface will be conducive to easy access, ensuring that health care providers of all technological capabilities are able to use it. Large scale usability tests will be conducted on the interface, so that it may be perfected and modified to fit into end-user use cases.

After all components are integrated, the system will undergo the testing phase. This phase includes the determination of accuracy, reliability and robustness of “DermaScope AI” in various clinical scenarios and populations. These are being done to ensure that the tool stays regular and can be trusted with real-world results. These will then be remediated, and the system iterated upon with test user feedback. The end result will be validated and clinically useful version for use in dermatology settings.

The final step of the methodology is to launch the prototype “DermaScope AI”. The prototype will undergo further evaluation and refinement in a clinical environment that simulates actual use. The phase gathers data from the real-world on the efficacy of a tool, to make final adjustments before broad adoption. Ultimately, the goal is for “DermaScope AI” to be a trusted bedside tool used routinely in clinical medical practice for diagnosing and evaluating disease severity of atopic dermatitis with great accuracy leading clinicians to better choice therapy strategies that will lead improved patient outcomes.

6.1 System Architecture Diagram

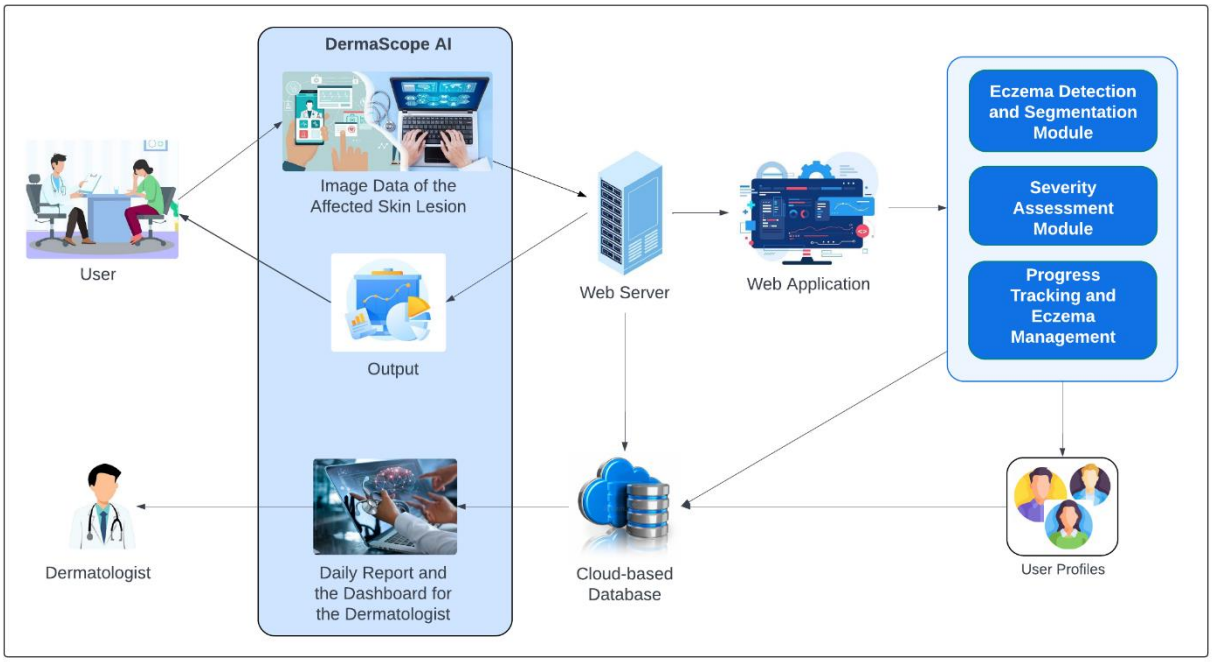

Figure 6.1: Individual component system architecture diagram

The system architecture for "DermaScope AI" is designed to facilitate the accurate diagnosis and severity assessment of atopic dermatitis through an integrated, AI-driven approach. The workflow starts with the patient (user) uploading an image of a skin lesion and then it gets analyzed by core "DermaScope AI" system. It deploys an eczema detection and segmentation module to automatically detect and segment the eczematous regions in the images. After segmentation, the severity assessment module processes clinical signs like erythema (redness), induration (hardening of the skin) and lichenification. The pre-processed results, which are the diagnosis and severity identification results of patients, are stored in a server-side web application to allow communication between AI system part at client-side with the web application interface. Patient data and all results generated are backed up in a database, making it possible for safekeeping and management.

The system includes keeping user profiles that store extensive details about a patient's condition, diagnosis, severity assessment, and treatment history. This industry leading eczema management and progress tracker module constantly monitors the patient's status, adding new data to their profile and keeping track of them over time. This makes the healthcare providers can change a treatment plan as need be. This allows

diagnostic report outputs like daily reports from “DermaScope AI” on the dedicated dashboard to be offered in real time to dermatologists, providing everything they need for a rational prescribing decision. The web app serves as the UI for patients to see their progress results and updated profiles. On the dermatologist’s end, it will allow access to comprehensive dashboards showing detailed reports of each patient's condition in real-time. In the end, “DermaScope AI” system can increase both objectiveness and accuracy of eczema diagnosis to patients and healthcare professionals having measurable tools for better disease management.

7. PROJECT REQUIREMENTS

7.1 Functional Requirements

- The application should allow a user to upload affected skin lesion images at high resolution and process the uploaded images.
- The application should be able to identify and segment eczema-affected regions from the input images with a system that uses advanced machine learning techniques.
- The application should offer an end-to-end analysis of the severity of atopic dermatitis using user-friendly dashboards for healthcare providers.
- An application is required to establish its personalized profile for each user, which allows the user-centered service provider to save various information like severity evaluation, treatment history or progress assessment.
- The application must assess the severity of atopic dermatitis based on clinical indicators and established criteria.
- The progress of users' conditions over time needs to be monitored by the app with updated assessment data into a user profile and ongoing monitoring.

7.2 Non-Functional Requirements

- **Reliability**

The “DermaScope AI” app under consideration would enable dermatologists and other healthcare providers to diagnose atopic dermatitis while also assessing its severity. Therefore, “DermaScope AI” has to be good enough, because if the results are incorrect and patients get mis-treated on false identification by tool this could be disaster in patient outcomes. To ensure the reliability of the application, it has to undergo intensive testing, specifically validation of its machine learning models so that it keeps delivering reliable results.

- **Security**

As the “DermaScope AI” application will have to deal with the patients’ sensitive data, to prevent them from being tampered with or getting leaked to unauthorized access and breaches, security has become the topmost concern with data. The application is going to introduce common security practices for better overall safety. Crucially, the system will not retain images of patients. Once the analysis has been performed, all images will be removed to avoid storing any private visual data. It helps minimize data breaches and makes sure people's privacy is kept to the highest standard.

- **Availability**

“DermaScope AI” provides timely and accurate diagnoses of atopic dermatitis for healthcare professionals who can trust the tool is available 24/7. Downtime could slow time-sensitive assessments and patient care. The app is designed with robust mechanisms to ensure high availability, reducing the chances of disruptions. The same extensive testing will also help confirm readiness of the app for a public launch.

- **Usability**

The application has to be extremely user-friendly, as people that will use “DermaScope AI” are the patients and the healthcare providers, and they have different levels of expertise with technology. It will have a user-friendly UI, allowing each user to navigate easily into their respective tasks and use the system with minimal effort. Insert key features, such as a clean navigation bar, clear visual indicators and design that scales down

well with smaller devices to make the application more user friendly. This design will center around user experience to ensure widespread use in clinical environments.

- **Scalability**

Demand may scale rapidly as “DermaScope AI” becomes more widely used, especially post-public-release and the application must still perform consistently without any delay. For that, scalability is an important element to be able to scale up with high network traffic and increasing number of users. “DermaScope AI” utilizes tactics in its design to help load handling increased over time gracefully such that it will continue as fast, reliable and efficient even as network traffic increases and the user base grows.

7.3 Personal Requirements

- **Guidance from supervisors on the eczema and data science domains**

It requires interdisciplinary expertise, with the knowledge of dermatology (specifically eczema) with advanced data science. The supervision of mentors who are experts in these areas is also crucial to assure robust scientific and methodological quality. External supervisors will offer expertise in the clinical characteristics of eczema, advising on appropriate indicators and that should be used as targets by AI models to reflect actual diagnostic practice prevalent in the real world. In the same way, technical guiding on machine learning data processing and model development will be provided through the main supervisor, co-supervisor as well as members of the evaluation panel to guarantee that expert input is received for every aspect related with building a responsible AI system fitting best practice in data science.

- **Understanding the specific area of each domain to proceed with the selected research area**

In the context of the chosen research area, integration requires a comprehensive understanding in both dermatology and data science fields to be effective. With eczema being such a vast field, it is paramount to be aware of the various forms of dermatitis present including atopic profile and how do these criterions fit into clinical presentations, diagnosis, and severity thresholds. In the case of data science, one should be familiar with ML algorithm, image processing technique, and evaluating the models through AI. This will also help us to establish a connection between these two fields and lead to the “DermaScope AI” system being clinically relevant as well technically robust. This provides security to ensure that as the project advances, the patients with atopic dermatitis face less stringent challenges of diagnosis and management.

7.4 Expected Test Cases

In the development and implementation of "DermaScope AI", rigorous testing will be conducted to ensure the accuracy, reliability, and usability of the system. The key test cases expected for this research project are as follows.

i. Image uploading and preprocessing test

Objective	To confirm the system accepts, processes and prepares uploaded images for analysis correctly.
Test Case	Upload images in different formats (JPEG, PNG) and resolutions. Make sure the system properly processes these images by using resizing and normalizing, applied some data augmentation techniques.
Expected Outcome	The system should successfully upload, preprocess, and standardize all images without errors.

Table 7.1: Test case 1

ii. Eczema detection and segmentation test

Objective	To validate the accuracy of the model in recognizing and segmenting eczema regions within images uploaded.
Test Case	Use a set of test images with known eczema-affected regions. Compare the segmented output generated by the system with the actual outputs validated by the dermatologists.
Expected Outcome	The system needs to have the ability of accurately identifying and segmenting eczematous region with high accuracy.

Table 7.2: Test case 2

iii. Severity assessment test

Objective	To assess the system's ability to accurately evaluate the severity of atopic dermatitis based on clinical indicators.
Test Case	Input images with varying degrees of severity (mild, moderate, severe). Verify that the system classifies the severity correctly in alignment with the signs which are considered in the EASI score.
Expected Outcome	The system should accurately classify the severity of the eczema condition according to the predefined categories.

Table 7.3: Test case 3

iv. User profile management test

Objective	To ensure that the system correctly creates, updates, and maintains user profiles with detailed information.
Test Case	Create new user profiles and input assessment data. Verify that the system updates profiles with new data after each assessment and maintains the integrity of the information over time.
Expected Outcome	User profiles should be accurately created, updated, and reflect all relevant data without loss or corruption of information.

Table 7.4: Test case 4

v. Progress tracking and reporting test

Objective	To validate the system's ability to track the progress of a patient's condition and generate accurate reports.
Test Case	Simulate a series of assessments over time for a patient. Verify that the system tracks changes in severity, updates the user profile accordingly, and generates comprehensive progress reports.
Expected Outcome	The system should accurately track progress, update profiles, and produce detailed, accurate reports on the patient's condition over time.

Table 7.5: Test case 5

vi. Web application interface test

Objective	To evaluate the usability and functionality of the web-based application interface for both patients and healthcare providers.
Test Case	Test all interactive elements of the web application, including navigation, dashboard functionality, and report viewing. Assess the UI's responsiveness and ease of use across different devices (desktop, tablet, smartphone).
Expected Outcome	The web application should be fully functional, easy to navigate, and responsive across all tested devices, with all features accessible and operating as intended.

Table 7.6: Test case 6

8. COMMERCIALIZATION

The launch of “DermaScope AI” offers an important point for the change in eczema diagnosis and management in clinical practice. “DermaScope AI”, an advanced accurate diagnostic supplemental tool powered by artificial intelligence that helps in refining diagnostic precision to further specialistic path of treatment and addresses serious need deriving from the field of dermatology. Intended for commercialization, this medical product line is targeted at dermatology clinics and hospitals, healthcare providers that specialize in these skin conditions. The system can also be linked to telemedicine platforms, allowing for an even wider reach and use in areas with little access, mostly sub-dermatological care.

As for the commercialization of “DermaScope AI”, a subscription-based model can be used by having healthcare providers and institutions pay a periodic fee which will give them continued access to its diagnostic and management functions. Such a model also will provide users with unlimited access to the latest advances in AI-driven dermatology, and real-time updates as needed.

“DermaScope AI,” based on advanced machine learning technologies and trending toward precision medicine, particularly in personalized patient care, may redefine the dermatology paradigm. Furthermore, we plan to proactively market the system through campaigns such as attending medical conferences, meeting with healthcare key opinion leaders, and delivering clinical case studies that demonstrate its real-world effectiveness. The development of this “DermaScope AI” application will lead to an improvement in diagnosis accuracy and diagnostic efficiency. The application will be able to help millions globally through AI-based analysis, ultimately creating a significant positive impact on healthcare.

9. SOFTWARE SPECIFICATIONS

The development of the “DermaScope AI” project will utilize a comprehensive set of software tools and technologies to ensure robustness, scalability, and security. The detailed software specifications for the project are as follows.

	Tools and Technologies	**Purpose**
Programming languages	Python	Development of machine learning models and backend logic
	JavaScript	Development of the frontend.
	HTML / CSS	Structuring and styling the web application.
Frameworks	TensorFlow / Keras	Build, train, and deploy the model.
	Flask / Django	Backend development, API creation, and managing server-side operations.
	React.js	Frontend development.
Libraries	OpenCV	Image processing tasks.
	Pandas / Numpy	Data manipulation and analysis.
Database	Firebase	Securely store user profiles, progress reports, and analysis results
APIs	REST API	Communication between the frontend, backend, and the database.
Development environment	Visual Studio Code / PyCharm	Primary IDEs
	GitHub	Version controlling

Table 9.1: Tools and technologies

These software specifications are carefully chosen to ensure that “DermaScope AI” is developed with high standards for performance, security, and usability, making it a reliable tool for the diagnosis and management of atopic dermatitis in clinical settings.

10. WORK BREAKDOWN STRUCTURE

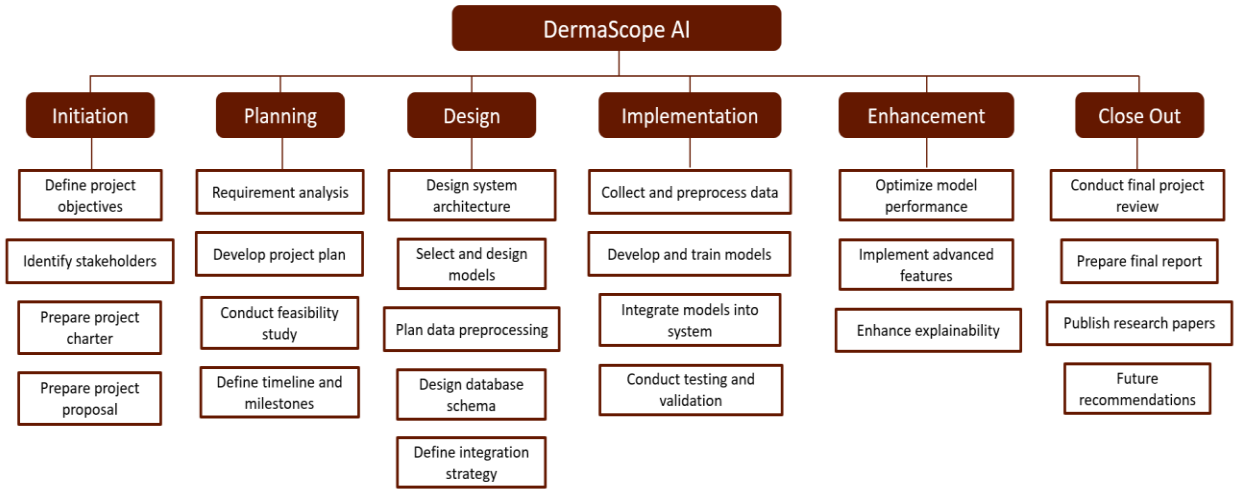

Figure 10.1: Work breakdown structure

The work breakdown structure of "DermaScope AI" is represented as a detailed plan with six important stages as initiation, planning, design, implementation, enhancement, and close out. The initiation phase is where the project groundwork takes place, objectives are defined, and stakeholders are identified with key documents such as proposals and a charter created. Requirements are defined and feasibility studies are done in the planning phase along with the project planning followed by setting up timelines on when specific milestones should be met. The work to be completed during the design phase is creating the system architecture and choosing model methods while also outlining data preprocessing strategies. During the implementation, project implementations will be done, and it involves concepts from data collection to model development all the way through system integration. At the end of it, the system will go through testing and validation stages. The enhancement phase goes on to tune model performance, adopting best-in-class functionality and interpretability wherever possible, so that the system meets exacting standards. After which the close out phase includes a final review, report preparation, publication, and research available for future references. By taking a structured way of working, it ensures that each phase is well planned and implemented to complete the desired outcomes.

11. GANTT CHART

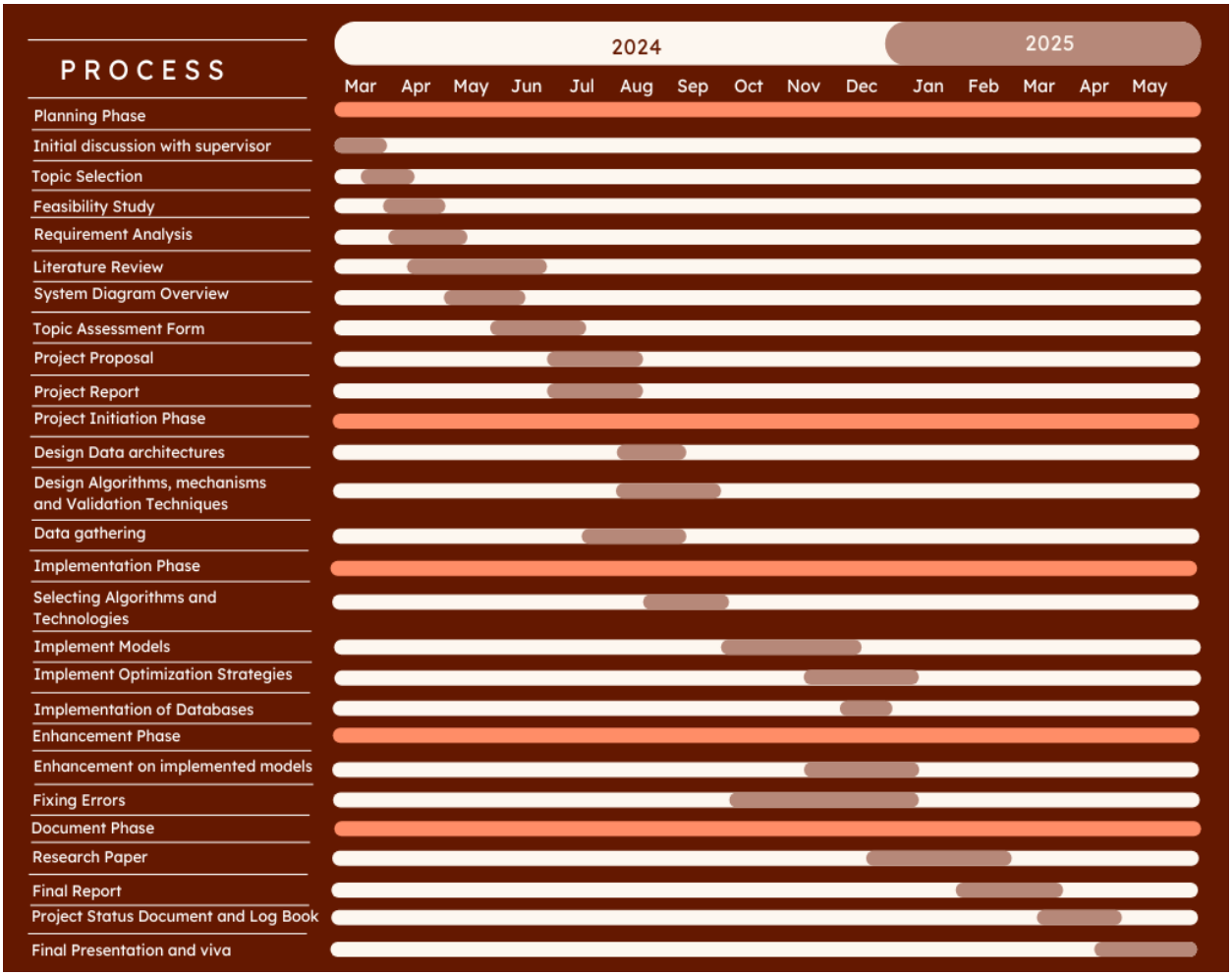

Figure 11.1: Gantt chart

The gantt chart's timeline is from March 2024 to May 2025 showcasing a number of phases and tasks that the project lifecycle constitutes. The first stage starts in March 2024, and it involved initial talks with the supervisor and selecting the topic. After the data collection and preparation phases, there is a period of implementation to select algorithms, implement models and optimization strategies between late 2024 until early 2025. The project ends with the enhancement phase and documentation, where errors are fixed, and enhancements are done. Then the research papers will be prepared, and final report will be written leading to the final presentation and viva by May 2025. This gantt chart is useful to have a high-level view of the timeline and organize all tasks in this research project in an organized sequence.

12. CONCLUSION

The study of the diagnosis and severity assessment of eczema will not only promote research among the dermatologists but also have a great impact in this specific area using advanced machine learning algorithms. This will also address the lack of standards in diagnosis and currently available subjective techniques that limit accuracy by developing “DermaScope AI”, a novel application for eczema diagnostic software to assist clinicians in making more accurate and consistent diagnoses quickly. By capitalizing on leading-edge image analysis in combination with machine learning algorithms, “DermaScope AI” will help standardize the diagnostic evaluation and provide a detailed assessment. The result of this not only improves the accuracy and specificity of diagnostics, but also encourages early detection as well helps guide more appropriate treatment options to deliver better outcomes for patients.

Further, “DermaScope AI” will enable more widespread use of machine learning in dermatology and hence add to a pragmatic adjunct that can be readily implemented into daily clinical practice. The research offers a scalable model for use across various healthcare settings and will open exciting new avenues in the treatment of atopic dermatitis. It will enhance the quality of care and improve the lives of patients who suffer from this skin condition. Altogether, even though it is only at the prototyping stage right now this project already represents a major development in dermatology that could well be helping to recognize and care for many more sufferers of atopic dermatitis all over the globe.

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14. APPENDICES

Figure 14.1: Application logo

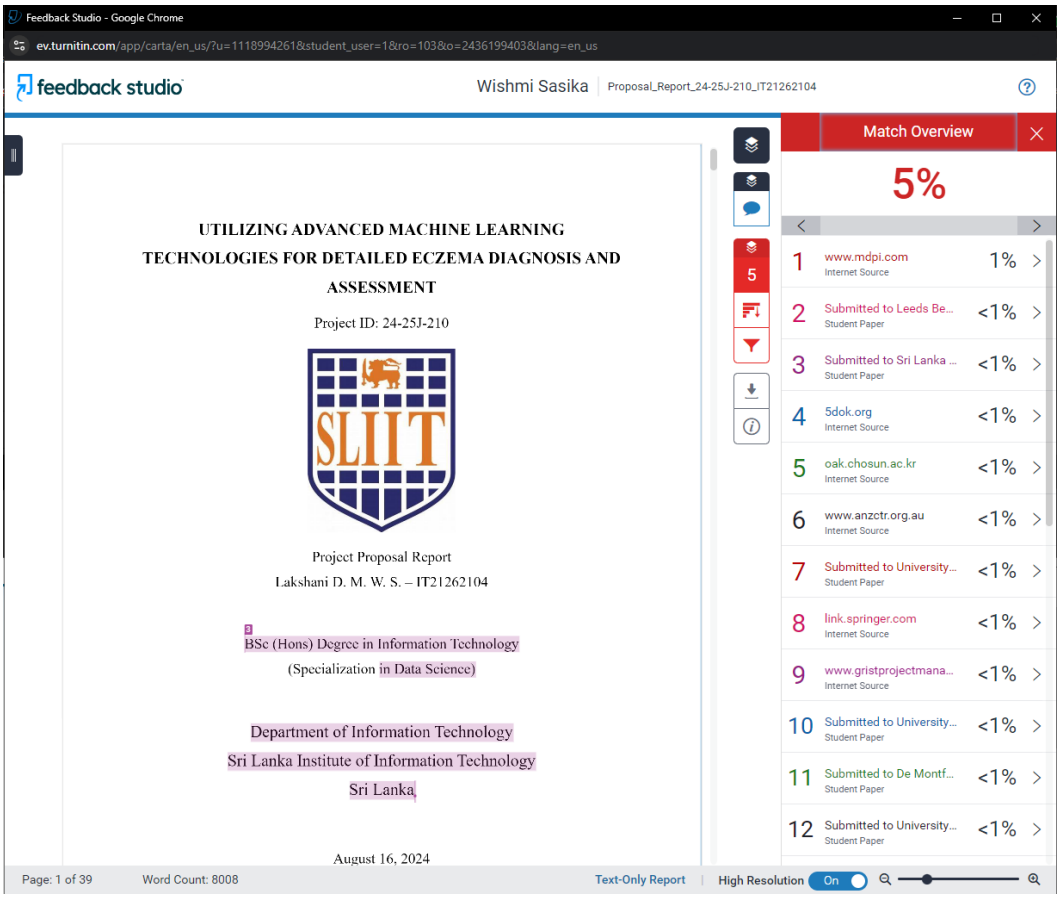

Figure 14.2: Turnitin similarity report