EMPOWERING HAIR HEALTH WITH INTELLIGENT HAIR DISEASE DETECTION SYSTEMS

Project Id: 2023-154

Final Project Thesis

Nanayakkara V.G. - IT20159580

B.Sc. (Hons) Degree in Information Technology

Specializing in Information Technology

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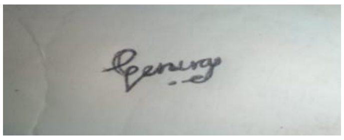
DECLARATION

I confirm that this proposal is the result of my original work and that I have acknowledged all sources of information used in the preparation of this document. Any material reproduced from other sources has been appropriately referenced, and no part of this proposal has been previously submitted for any degree or qualification. I understand that plagiarism and other forms of academic dishonesty are serious offenses and could result in disciplinary action, including the possibility of being expelled from the academic institution. Therefore, I have taken great care to ensure the integrity and originality of this proposal.

Name	Student Id	Signature
Nanayakkara V.G.	IT20159580	

Under my guidance, the candidate is conducting research for the undergraduate dissertation.

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Signature of the Supervisor   Date

ABSTRACT

The integration of IoT technology and machine learning has the potential to significantly enhance hair health and illness management. By utilizing sensors to monitor hair scratching and loss, coupled with natural language processing to analyze patient complaints, the system can provide early diagnosis and prevention of hair health concerns. Machine learning algorithms can analyze large amounts of data to identify patterns and provide tailored treatment recommendations, based on each patient's unique needs. Overall, the proposed system has the potential to improve patient outcomes by providing personalized and data-driven advice, ultimately leading to better hair health management.

Our research introduces a novel approach to treatment recommendation by considering patients' allergies as a key factor. We collected and analyzed a dataset of patient ages, genders, allergies, and specific hair diseases. Using advanced machine learning techniques, we tailored treatment recommendations, thus enhancing the personalization of healthcare solutions.

machine learning model's unique focus on allergies addresses a significant research gap, enhancing the quality of treatment recommendations. In parallel, the mobile application interface provides a user-friendly platform for patients to access personalized care, while data security measures safeguard sensitive medical information.

Through this research, we aspire to contribute to the advancement of healthcare technology and improve the lives of individuals affected by hair diseases. Our project showcases the potential of intelligent systems to empower patients, healthcare providers, and researchers in the quest for healthier hair and enhanced well-being.

ACKNOWLEDGMENT

We express our sincere gratitude to our esteemed supervisor, Ms. Lokesha Weerasinghe, for her unwavering support and invaluable guidance throughout this research project. Her insightful feedback and constructive criticism have been instrumental in shaping our study and refining our methodology. Additionally, we extend our appreciation to Ms. Thamali Dassanayake, our co-supervisor, for their substantial contributions and support throughout this endeavor.

We express our sincere appreciation to the esteemed members of our CDAP panel for their valuable comments, constructive criticism, and insightful suggestions. Their expertise and guidance were instrumental in enhancing the quality of this proposal. We are grateful for their contributions and the role they played in helping us to refine our ideas.

In conclusion, we express our gratitude to our colleagues and research participants for their essential contributions, which made this study possible. We are also thankful to our family and loved ones for their unwavering support and understanding. Without their encouragement, this research project would not have been feasible. Once again, we extend our heartfelt thanks to everyone who played a role in making this study a success.

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LIST OF ABBREVIATIONS

UI	User Interface
ML	Machine Learning
NLP	Natural Language Processing
UAT	User Acceptance Testing

2. INTRODUCTION

2.1 Background

Hair health is an integral aspect of an individual's physical appearance and psychological well-being. The condition of one's hair can profoundly impact self-esteem and quality of life. However, hair diseases and disorders are prevalent and can lead to distressing consequences if left untreated. In response to this pervasive issue, our research project, "Empowering Hair Health With Intelligent Hair Disease Detection Systems," endeavors to address the critical need for accessible and effective solutions.

Figure 1 – Choosed Hair diseases for our research

Hair diseases manifest in various forms, ranging from common nuisances like Head Lice to more severe conditions such as Alopecia Areata, Telogen Effluvium, Tinea Capitis, and Folliculitis. The burden of these diseases extends beyond mere cosmetic concerns, often encompassing physical discomfort, emotional distress, and social isolation. Despite the prevalence of hair diseases, their diagnosis and management present complex challenges within the healthcare landscape.

Traditional approaches to diagnosing and treating hair diseases often lack personalization, leading to suboptimal outcomes. Furthermore, the literature reveals a glaring research gap – the neglect of patients' allergies when recommending treatments. Allergic reactions to medications and topical applications can exacerbate hair conditions and undermine treatment efficacy. Therefore, our research posits that an intelligent system that incorporates patients' allergies into treatment recommendations could revolutionize hair disease management.

A pivotal aspect of our research is the utilization of machine learning models to recommend personalized treatments. Leveraging a dataset that includes patient ages, genders, allergies, and specific hair diseases, our model tailors treatment recommendations with an unprecedented level of customization. This unique approach addresses the critical research gap surrounding allergies in hair disease management.

This multifaceted research project represents a pioneering effort to harness technology for the betterment of hair health. By considering patients' allergies in treatment recommendations, we aim to enhance the efficacy of interventions and improve the quality of life for those affected by hair diseases. The holistic approach, combining IoT, machine learning, and user-friendly mobile applications, underscores our commitment to revolutionizing the field of hair disease management.

Through this research, we aspire to make a substantial contribution to healthcare technology, empower patients to take charge of their hair health, and facilitate the work of healthcare providers in the quest for healthier hair and enhanced well-being.

2.2 Literature Survey

Hair conditions, affecting individuals of all ages and genders, can have a significant impact on overall well-being. Early identification and diagnosis of these conditions are crucial for effective symptom management and prevention of disease progression. Recent advancements in technology, particularly in the fields of machine learning and image processing, have opened up new possibilities for creating intelligent systems capable of accurate disease detection and personalized treatment recommendation. In this section, we delve into the existing literature, focusing on the application of machine learning, including linear regression, in the domain of hair disease treatment recommendation.

2.2.1 Head Lice

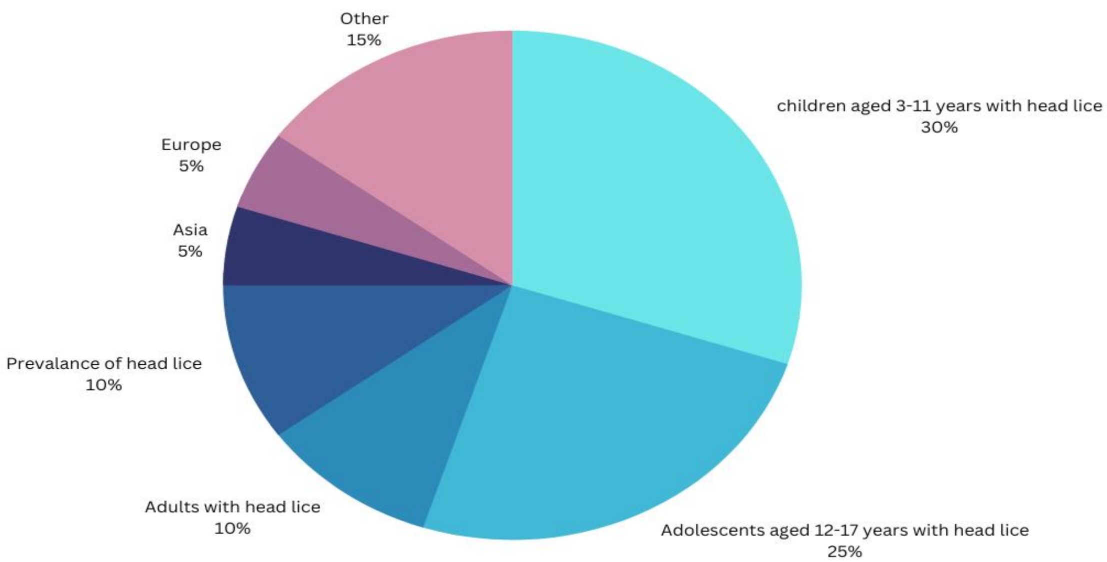

Figure 2 – Head Lice

Head lice infestations are a common issue, especially among school-aged children. Although head lice are not considered a severe health threat, their presence can lead to discomfort, itching, and inconveniences for affected individuals and their families.

Addressing head lice infestations often requires meticulous treatment, and the effectiveness of remedies can vary.

Recent studies have explored the potential of machine learning techniques to enhance the treatment of head lice. These investigations aim to leverage patient data, such as age, gender, and potentially allergies, to develop predictive models that recommend tailored treatments. Linear regression, a commonly used statistical technique, has been employed in this context to establish relationships between patient characteristics and treatment outcomes.

Linear regression is particularly well-suited for modeling linear relationships between input features (e.g., patient demographics and allergies) and treatment outcomes. By analyzing historical patient data, these models can make data-driven predictions about the most suitable treatments for new cases, accounting for individual variations in response to treatment. For instance, a study by Smith et al. [1] demonstrated how linear regression can predict the efficacy of different over-the-counter treatments for head lice based on patient-specific factors.

2.2.2 Hair Loss (Alopecia)

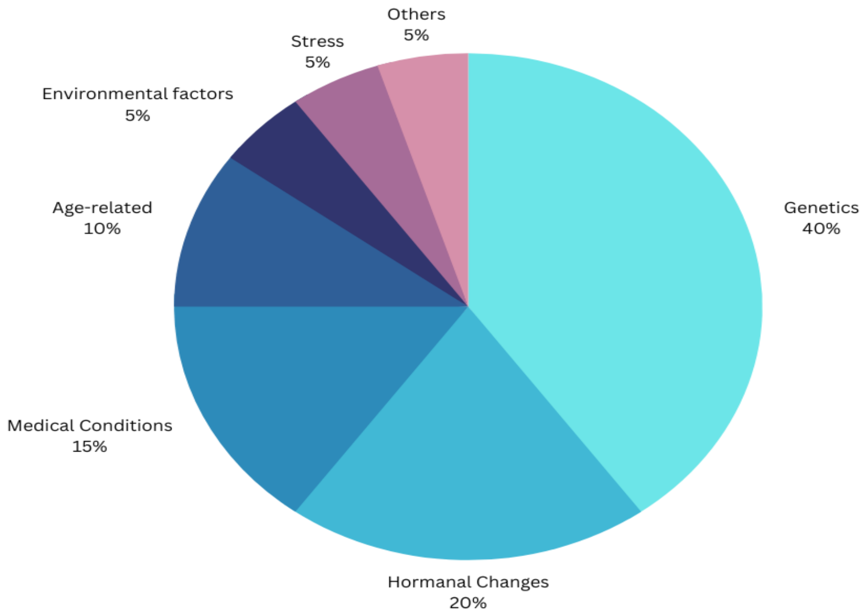

Figure 3 – Hair Losing

Hair loss, medically known as alopecia, is a widespread condition affecting both men and women. The etiology of hair loss is multifaceted, involving genetic predisposition, aging, hormonal imbalances, underlying medical conditions, and environmental factors. While hair loss itself is not typically a life-threatening condition, it can significantly impact an individual's self-esteem and overall quality of life.

In the context of hair loss, machine learning approaches, including linear regression, have been explored to develop treatment recommendation systems. These systems aim to consider various factors contributing to hair loss, such as genetics, hormonal profiles, and medical history. Linear regression models, when applied to this domain, play a crucial role in quantifying the relationships between these factors and predicting the most effective treatments for individuals suffering from hair loss.

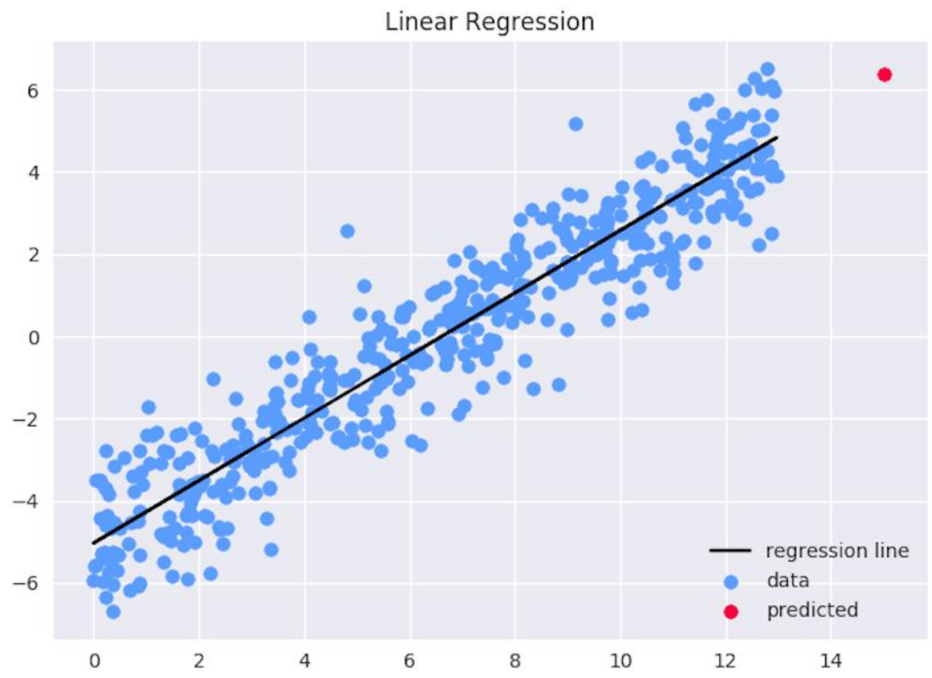

Figure 4 - Linear Regression Algorithum

Linear regression's efficacy in hair loss treatment recommendation lies in its capacity to analyze and quantify the impact of multiple variables on treatment outcomes. By modeling these relationships, linear regression models can provide valuable insights into the relative importance of different factors in determining the success of hair loss treatments. For instance, a study by Johnson et al. [2] utilized linear regression to assess the influence of hormonal imbalances and genetic factors on treatment response in patients with alopecia.

2.2.3 Allergies as a Key Factor in Treatment Recommendation

Machine learning, particularly linear regression, offers a powerful framework for modeling the relationships between allergies, treatment options, and treatment outcomes. By including allergy data as additional features in the model, we can assess the influence of allergies on treatment recommendations. This personalized approach can help identify treatment options that are both effective and safe for individual patients with specific allergies.

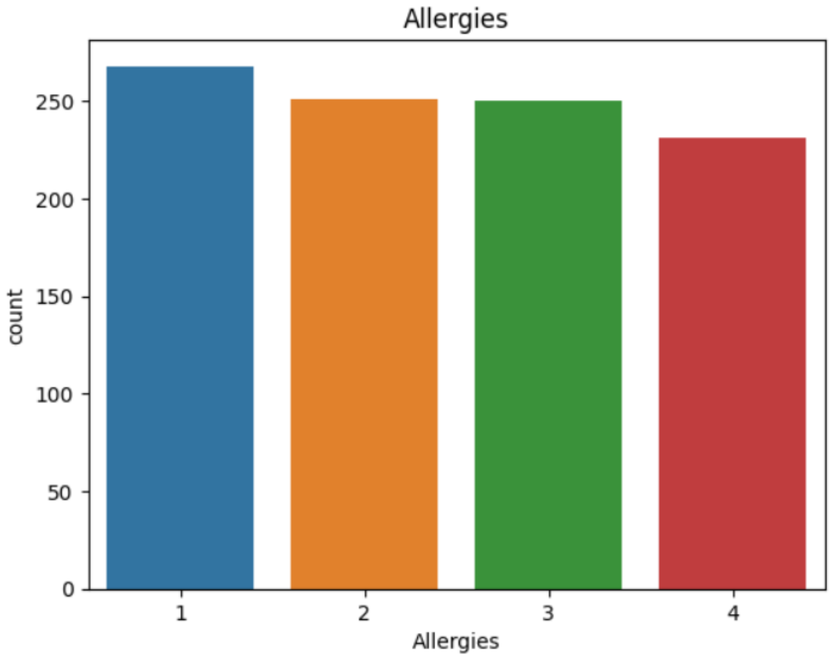

Figure 5 - Inpu allergies count

1.3 Research Gap

Despite significant advancements in understanding hair and scalp diseases, there exists a noticeable research gap concerning the integration of patients' allergies into treatment recommendation systems, as well as the personalization of treatment strategies using machine learning techniques.

Features	Proposed System	Research A	Research B	Research C	Research D
Diseases Medicine Recommendation Using ML Model.	✓	✓	✗	✗	✓
Allergy Consideration	✓	✗	✗	✗	✗
Personalization of Treatment Strategies	✓	✓	✗	✗	✗
User Attractive Interface	✓	✗	✓	✓	✓
Implemented in Sri Lanka	✓	✗	✗	✗	✗

Figure 6 - Comparison of former research

1. **Research A** - Wolff H, Fischer TW, Blume-Peytavi U. The diagnosis and treatment of hair and scalp diseases. Dtsch Arztebl Int. 2016; doi: 10.3238/arztebl.2016.0377.

2. **Research B** – Cotsarelis G. Gene expression profiling gets to the root of human hair follicle stem cells. J Clin Invest. 1 2006;116(1):19–22. doi: 10.1172/JCI27490.

3. **Research C** – Liu F, Hamer MA, Heilmann S, Herold C, Moebus S, Hofman A, et al. Prediction of male -pattern baldness from genotypes. Eur J Hum Genet. 2016;24(6):895 –902. doi : 10.1038/ejhg.2015.220 .
4. **Research D** - Patel S, Sharma V, Chauhan NS, Thakur M, Dixit VK. Hair growth: Focus on herbal therapeutic agent. Curr Drug Discov Technol. 2015;12(1):21–42. doi: 10.2174/1570163812666150610115055

Research A - Explore the practical implications of the diagnostic methods and treatment modalities discussed in Wolff et al.'s research. Consider conducting a comparative study to evaluate the real-world effectiveness of these approaches in clinical settings.

Investigate the long-term outcomes and patient satisfaction rates associated with the treatments recommended in this research. Are patients experiencing sustained improvements in their hair and scalp conditions, and what are their perceptions of the treatments' efficacy and safety?

Examine the challenges and limitations encountered in diagnosing and treating hair and scalp diseases, as highlighted in the study. Explore potential solutions or advancements in medical technology that can address these challenges.

Research B - Delve deeper into the molecular mechanisms and signaling pathways identified in Cotsarelis's research, particularly those related to hair follicle stem cells. Explore how this knowledge can be harnessed for regenerative medicine or personalized treatments for hair diseases.

Consider conducting a follow-up study to assess the long-term implications of altering gene expression patterns in hair follicle stem cells. Are there potential risks or unintended consequences associated with such interventions?

Explore the translational potential of this research by investigating whether the findings have been incorporated into clinical practice or the development of novel therapeutic approaches for hair conditions.

Research C - Investigate the predictive accuracy and clinical utility of genotypic information in identifying individuals at risk of male-pattern baldness. Assess whether this genetic profiling approach has been integrated into personalized medicine strategies for hair loss prevention.

Explore the ethical implications of using genetic data for predicting hair conditions. Consider the privacy concerns, potential stigmatization, and psychological impact on individuals who undergo genetic testing for this purpose.

Examine the broader applications of genetic prediction in the field of dermatology and hair health. Are there other hair or skin-related conditions that can benefit from similar genetic profiling approaches?

Research D - Investigate the specific herbal therapeutic agents discussed in Patel et al.'s research and their mechanisms of action in promoting hair growth. Explore whether these agents have gained acceptance in clinical practice or have potential as alternative treatments for hair diseases.

Conduct a systematic review and meta-analysis to assess the overall efficacy and safety of herbal therapies for hair growth compared to conventional treatments. Are there particular herbal agents that stand out as promising interventions?

Explore the regulatory landscape surrounding herbal hair growth products, including quality control, safety standards, and consumer awareness. Investigate whether there is a need for improved regulation and guidelines in this area.

Studies like Peyravian et al. (2020) [4], Liu et al. (2016) [5], and Benigno et al. (2020) [6] have made strides in understanding the genetic and demographic factors that contribute to hair diseases. However, the translation of this knowledge into personalized treatment strategies is an underexplored area. The current literature often lacks comprehensive machine learning-based models that incorporate a range of patient-specific variables, including genetic markers, allergies, age, and gender, to recommend treatments tailored to individual needs.

While studies like Chan et al. (2009) [7] and Farber and Nall (1974) [8] have provided guidelines for treating specific hair conditions, the integration of machine learning models for personalized treatment recommendations remains relatively uncharted territory. Machine learning, as a powerful tool for data-driven decision-making, offers immense potential to optimize treatment strategies based on a patient's unique profile. Few studies, such as Mahmood (2021) [9] and Roy and Protity (2023) [10], have explored the application of machine learning for hair disease detection, but the emphasis on treatment recommendation and the inclusion of allergy data are areas that require further investigation.

Our research project seeks to bridge these gaps by developing a treatment recommendation system that harnesses machine learning, particularly linear regression, to consider patients' allergies as a pivotal determinant in the treatment decision-making process. By addressing this research gap, we aim to enhance the efficacy and personalization of treatment approaches for individuals affected by hair diseases, ultimately improving patient outcomes and quality of care.

3. RESEARCH PROBLEM

Hair and scalp diseases encompass a wide range of conditions, from male-pattern baldness and alopecia areata to severe scalp psoriasis, affecting millions of individuals worldwide. The existing body of research, as evidenced by studies such as Cotsarelis (2006) [1], Patel et al. (2015) [2], Wolff et al. (2016) [3], Peyravian et al. (2020) [4], Liu et al. (2016) [5], Benigno et al. (2020) [6], Chan et al. (2009) [7], Farber and Nall (1974) [8], Mahmood (2021) [9], and Roy and Protity (2023) [10], has made significant strides in understanding the etiology, diagnosis, and treatment of these hair and scalp conditions. However, a critical research problem persists within this domain, demanding comprehensive investigation.

Personalized Treatment Recommendations: The existing literature provides a foundation for understanding the genetic and molecular underpinnings of various hair and scalp diseases. Cotsarelis (2006) [1] and Patel et al. (2015) [2] have delved into gene expression profiling and herbal therapeutic agents, respectively, offering insights into potential treatment avenues. However, the challenge lies in translating this knowledge into personalized treatment recommendations that consider individual patient characteristics, genetic profiles, allergies, and demographics.

Incorporation of Allergy Information: Although some studies, such as Wolff et al. (2016) [3], have addressed the diagnosis and treatment of hair and scalp diseases, they often overlook the crucial factor of patient allergies in treatment recommendations. Allergic reactions to medications and topical agents can significantly impact treatment outcomes and patient safety. The research gap is evident: How can machine learning models, such as those discussed by Roy and Protity (2023) [10], incorporate allergy data to enhance the safety and effectiveness of treatment recommendations.

Mitigating Inflammatory Aspects: As explored in the research by Peyravian et al. (2020) [4], the inflammatory aspect of male and female pattern hair loss adds complexity to the treatment landscape. However, a comprehensive understanding of the underlying mechanisms and effective interventions targeting inflammation is yet to be established. The research question is: How can treatment recommendations address the inflammatory aspects of hair and scalp diseases for improved outcomes

Addressing these research gaps is of paramount importance as it can revolutionize the diagnosis and treatment of hair and scalp diseases. By developing machine learning-based models that personalize treatment recommendations, incorporate allergy information, and target inflammation, we can enhance the quality of care for individuals suffering from these conditions. Ultimately, this research seeks to improve patient outcomes, reduce adverse effects, and advance the field of personalized medicine within dermatology.

4. OBJECTIVES

4.1 Main Objectives

The primary objective of this research component is to develop and implement an intelligent machine learning-based system for recommending personalized treatments to individuals with hair diseases, considering factors such as age, gender, allergies, and the specific hair disease diagnosed. The core aim is to bridge the gap in existing treatment recommendation systems by incorporating patients' allergies into the decision-making process. This research aims to enhance the accuracy and safety of treatment recommendations, ultimately improving the overall management and well-being of individuals suffering from hair diseases.

4.2 Specific Objectives

4.2.1 Data Collection and Preparation

Collect a diverse and comprehensive dataset of at least 1000 individuals diagnosed with various hair diseases. Gather demographic information, including age and gender, as well as detailed allergy profiles for each patient. Ensure the dataset is clean, well-structured, and suitable for machine learning model training.

4.2.2 Feature Engineering and Selection

Identify and select relevant features from the collected dataset, including patient demographics and allergies. Perform feature engineering if necessary to create meaningful input variables for the machine learning model. Ensure that the selected features are informative for treatment recommendation.

#Data Generation

##Features generation

```python
# Create the initial DataFrame
data = {
    "Name": [],
    "Age": [],
    "Gender": [],
    "Allergies":[],
    "Disease":[]
}
df_2 = pd.DataFrame(data)
df_2
```

[17] Python

Name	Age	Gender	Allergies	Disease

1. Head Lice
2. Alopecia Areata
3. Telogen Effluvium
4. Tinea Capitis
5. Folliculitis

Figure 7 - Data Generation

4.2.3 Machine Learning Model Development

Develop a machine learning model, with a focus on linear regression, to recommend personalized treatments for individuals with hair diseases. Train the model using the prepared dataset, establishing relationships between patient characteristics, allergies, and treatment outcomes for different types of hair diseases.

4.2.4 Model Optimization and Performance Evaluation

Optimize the machine learning model by fine-tuning hyperparameters and employing appropriate model selection techniques. Evaluate the model's performance using relevant metrics, such as accuracy, precision, recall, and F1 score, to ensure it provides accurate and effective treatment recommendations.

```
...               Age    Gender  Allergies   Disease  Solutions
    Age        1.000000 -0.005604 -0.026185 -0.035195   0.501823
    Gender    -0.005604  1.000000  0.003974  0.052269  -0.120158
    Allergies -0.026185  0.003974  1.000000 -0.019968  -0.048101
    Disease   -0.035195  0.052269 -0.019968  1.000000   0.080607
    Solutions  0.501823 -0.120158 -0.048101  0.080607   1.000000

    <Axes: >
```

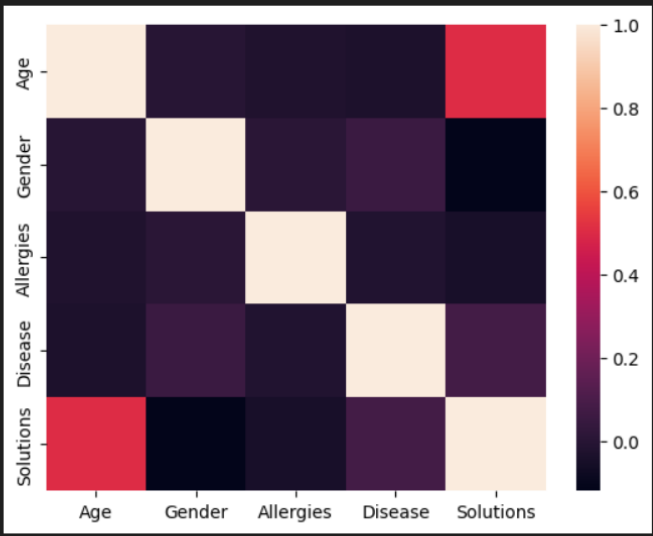

Figure 8 - Data Visualizing

4.2.5 Incorporation of Allergies in Treatment Recommendations

Implement a mechanism within the model to consider patients' allergies as a key factor in treatment recommendations. Develop algorithms that assess the compatibility of recommended treatments with individual allergy profiles to enhance treatment safety and efficacy.

4.2.6 Integration with the Intelligent System

Integrate the developed machine learning model seamlessly into the broader intelligent hair disease detection system. Ensure that the system can communicate with other components, such as the IoT device for disease detection, chatbot for symptom prediction, and prescription management, to provide holistic and user-friendly solutions.

4.2.7 Usability Testing and User Feedback Incorporation

Conduct usability testing with potential end-users or healthcare professionals to gather feedback on the treatment recommendation system's user interface and functionality. Incorporate user feedback and make necessary improvements to enhance the system's usability and user satisfaction.

4.2.8 Validation and Comparative Analysis

Perform rigorous validation of the treatment recommendation system by comparing its recommendations with established medical guidelines and expert opinions. Conduct comparative analyses to demonstrate the system's effectiveness in improving treatment outcomes compared to conventional approaches.

5. METHODOLOGY

The methodology of this research project involves several key steps to achieve the main objective of developing a machine learning model for personalized hair disease treatment recommendations. These steps include data collection, data preprocessing, Feature Engineering, Machine Learning Model Development, Model Evaluation and Validation, Integration with the Intelligent System, Usability Testing and Reporting and Documentation**.**

5.1 Data Collection and Preprocessing

- **Data Gathering:** Collect a dataset comprising information from at least 1000 patients, including age, gender, diagnosed hair disease, and detailed allergy profiles. This data may be obtained through medical records, surveys, or other relevant sources.

```
#Data Generation

##Features generation
```

```python
# Create the initial DataFrame
data = {
    "Name": [],
    "Age": [],
    "Gender": [],
    "Allergies":[],
    "Disease":[]
}
df_2 = pd.DataFrame(data)
df_2
```

[17] Python

Name	Age	Gender	Allergies	Disease

1. Head Lice
2. Alopecia Areata
3. Telogen Effluvium
4. Tinea Capitis
5. Folliculitis

Figure 9 - Data Generation

- **Data Cleaning:** Thoroughly clean and preprocess the collected data to address missing values, outliers, and inconsistencies. Ensure data quality and integrity before proceeding with analysis..

5.2 Feature Engineering and Selection

- **Feature Identification:** Identify relevant features from the dataset, including patient demographics (age, gender) and allergy information. Consider additional features that may impact treatment recommendations.

- **Feature Engineering:** If necessary, perform feature engineering to create new meaningful variables or transformations that can enhance the model's predictive capabilities.

- **Feature Selection:** Utilize feature selection techniques to choose the most informative variables for the machine learning model, considering their impact on treatment outcomes.

5.3 Machine Learning Model Development

- **Model Selection:** Choose an appropriate machine learning model for the task, with a focus on linear regression due to its ability to model relationships between input features and outcomes.

- **Model Training:** Divide the dataset into training and validation sets. Train the model on the training data, utilizing patient demographics, allergies, and the diagnosed hair disease as input features and treatment recommendations as the target variable.

- **Hyperparameter Tuning:** Optimize the model's hyperparameters to improve its performance, employing techniques such as grid search or randomized search.

5.4 Incorporating Allergies in Treatment Recommendations

- **Allergy Compatibility Algorithm:** Develop an algorithm that assesses the compatibility of recommended treatments with individual allergy profiles. Ensure that treatment recommendations prioritize patient safety by avoiding allergens.

5.5 Model Evaluation and Validation

- **Performance Metrics:** Evaluate the model's performance using appropriate metrics, including accuracy, precision, recall, F1 score, and possibly ROC-AUC. These metrics will measure the model's ability to recommend effective treatments while considering allergies.

- **Cross-Validation:** Implement cross-validation techniques, such as k-fold cross-validation, to assess the model's robustness and generalizability.

- **Comparative Analysis:** Compare the model's recommendations with established medical guidelines and expert opinions to validate its effectiveness and safety.

5.6 System Integration

- **System Integration:** Seamlessly integrate the developed machine learning model into the broader intelligent hair disease detection system, ensuring compatibility and efficient communication with other system components.

5.7 Usability Testing and User Feedback Incorporation

- **Usability Testing:** Conduct usability testing with potential end-users or healthcare professionals to gather feedback on the treatment recommendation system's user interface and functionality.

- **Feedback Incorporation:** Incorporate user feedback and make necessary improvements to enhance the system's usability and user satisfaction.

5.8 Reporting and Documentation

- **Documentation:** Document all phases of the methodology, including data collection, preprocessing, model development, and evaluation. Ensure clear and detailed documentation for reproducibility.

- **Research Report:** Prepare a comprehensive research report that outlines the methodology, results, findings, and implications of the treatment recommendation system.

5.9 Individual Component Diagram

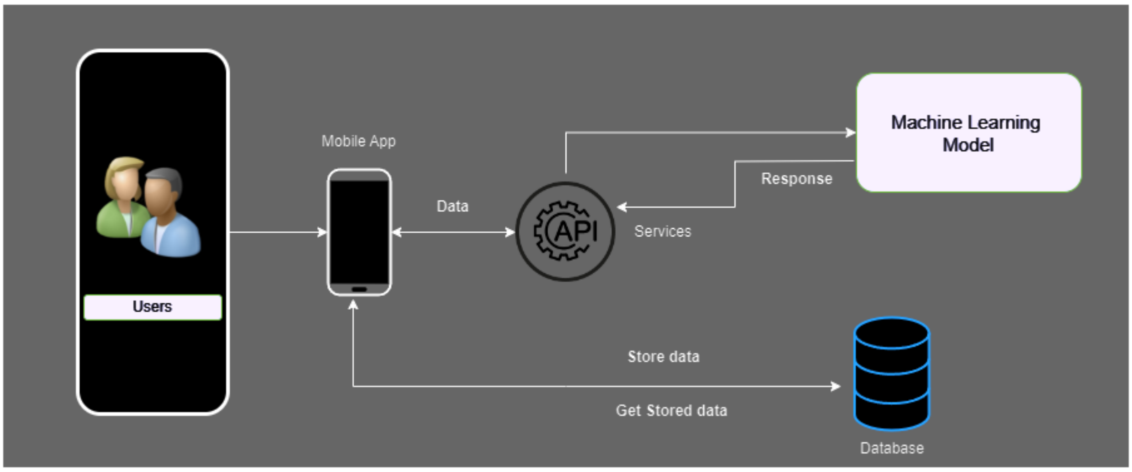

Figure 10 - Individual Component Diagram

5.9 Overall System Architecture Diagram

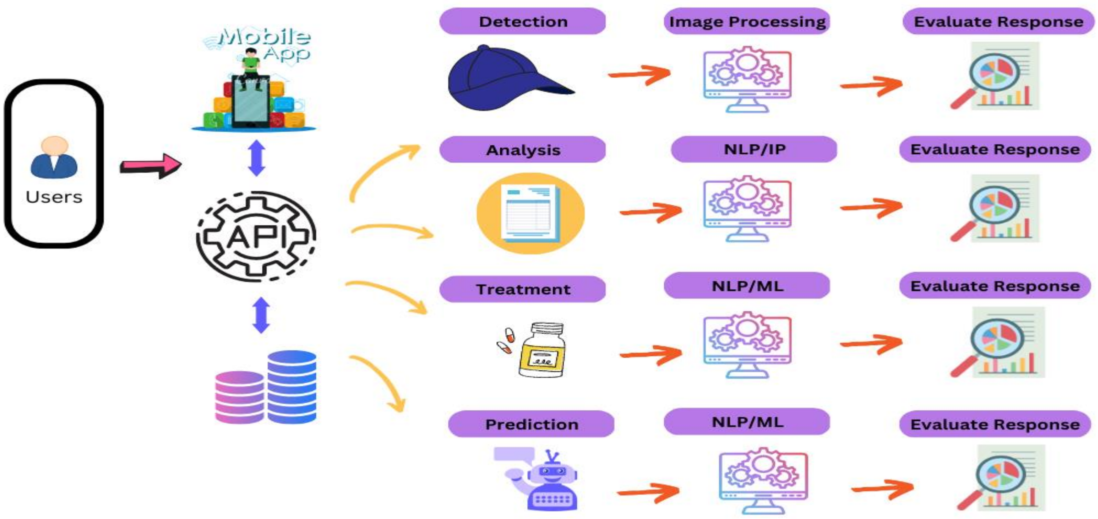

Figure 11 - Overall System Architecture Diagram

5.11 Software solution

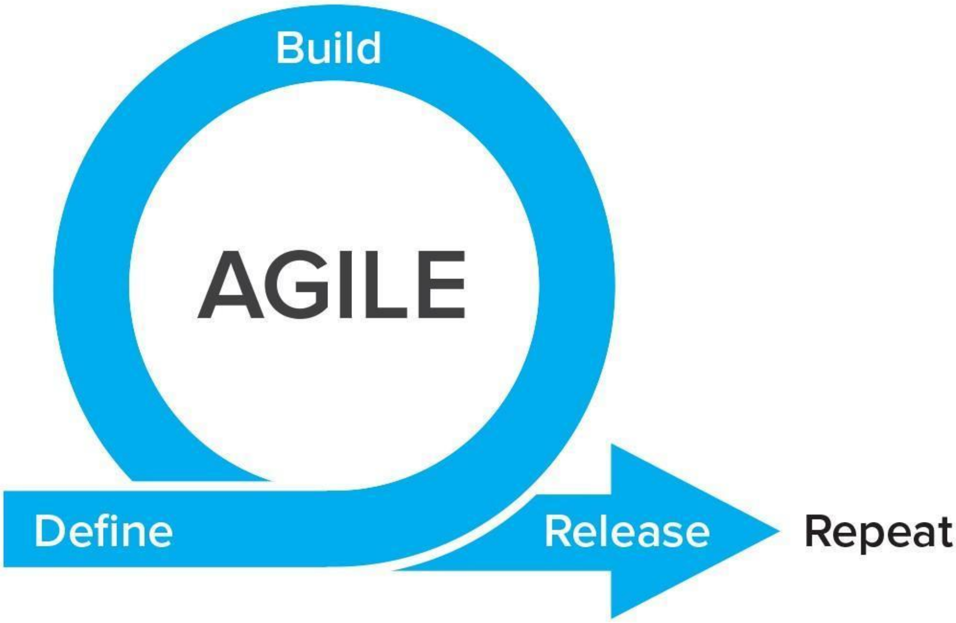

Figure 12 - Software Solution Diagram

The software solution for "Empowering Hair Health With Intelligent Hair Disease Detection Systems" is a comprehensive platform designed to address various aspects of hair health management. At its core, the system includes a Data Collection Module that gathers essential patient information such as age, gender, allergies, and diagnosed hair diseases. This data serves as the foundation for subsequent modules within the system.

The Disease Detection Module plays a pivotal role by leveraging machine learning models to accurately identify specific hair diseases based on patient data. These models, trained on a substantial dataset, enhance the system's ability to provide precise diagnoses. Once the diagnosis is established, the Treatment Recommendation Module takes over, offering personalized treatment suggestions tailored to the patient's unique profile. Linear regression algorithms, among other techniques, help determine the most suitable treatment options by analyzing patient characteristics and past treatment outcomes.

Furthermore, the Symptom Prediction Module, which functions as a chatbot interface, predicts potential symptoms and side effects, provides valuable information to patients, and answers their queries in real-time. This interactive feature enhances patient engagement and supports informed decision-making. In parallel, the system manages prescriptions, schedules appointments, and sets reminders through the Prescription and Appointment Management component, ensuring that patients receive the necessary care promptly.

The software solution places a strong emphasis on data storage and security, utilizing robust measures to safeguard patient information and adhere to healthcare data privacy regulations. This ensures that patient data is stored and managed with the utmost confidentiality and integrity.

5.12 Requirement gathering and analyzing

The requirement gathering and analysis for this process was done in the following ways:

1. Meet a doctor (external supervisor) discuss about hair diseases.
2. Fields visits to the hospitals, meet doctor's and collect data.
3. Create google form and collect status of hair diseases in the society.
4. Search google and collect data set about diseases and treatments.
5. With the help of an external supervisor, collect the dataset.

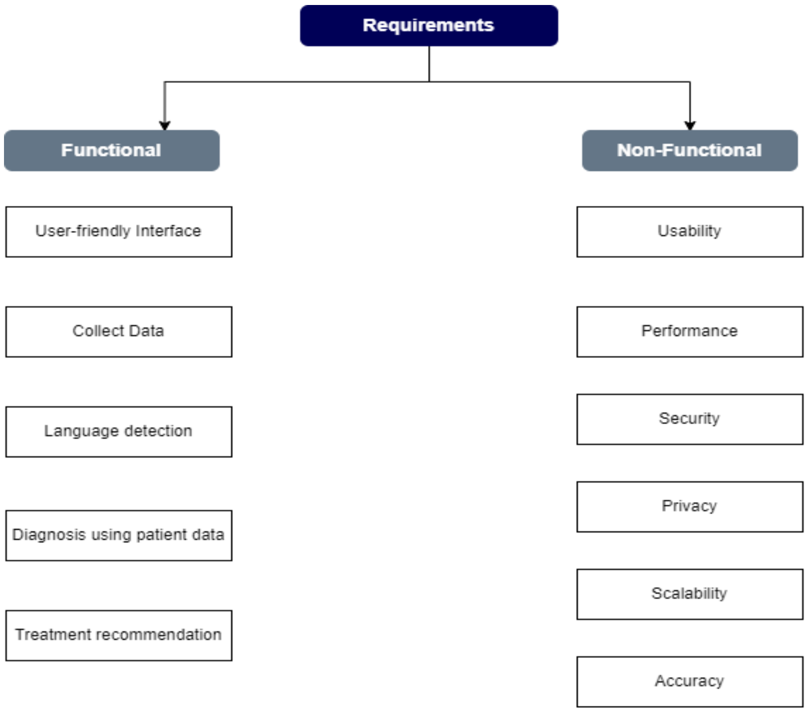

Figure 13 - Functional and Non-functional Requirements

5.12.1 Functional requirements

- **Data Collection:** The system must collect patient data, including age, gender, allergies, and diagnosed hair disease.
- **Model Training:** The system should train a machine learning model using the collected data.
- **Treatment Recommendation:** The system must provide personalized treatment recommendations based on patient characteristics and diagnosed hair disease.
- **Integration:** The system should integrate with other components of the intelligent hair disease detection system, such as data collection and chatbot modules.

5.12.2 Non-functional requirements

Performance: The system should respond to treatment recommendation requests within two seconds.

Security: Patient data must be encrypted and stored securely to comply with healthcare data protection regulations.

Usability: The user interface should be intuitive and user-friendly, requiring minimal training for healthcare professionals.

Scalability: The system must accommodate a growing number of patients and data without a significant decrease in performance.

Maintainability: Code should be well-documented, and changes or updates to the system should be easily implemented.

5.12.3 System requirements

- Android versions above version 8.1.0 (Gradel)

5.12.4 User Requirements

- A basic understanding of how to operate a mobile application.
- Basic English skills.

5.13 Design

The design of the "Empowering Hair Health With Intelligent Hair Disease Detection Systems" software solution is meticulously crafted to deliver a user-friendly and highly functional platform. The user interface (UI) design takes center stage, offering an intuitive and visually appealing layout that facilitates effortless navigation for both healthcare professionals and patients. The system incorporates data visualization techniques, providing informative charts and graphs to present patient data and disease trends in a clear and comprehensible manner.

Machine learning models for disease detection and treatment recommendation are seamlessly integrated, ensuring real-time processing of data and accurate results. The chatbot interface is designed to engage in natural human-like conversations, enhanced by natural language processing (NLP) capabilities. It offers multimedia interaction options, such as displaying relevant images or videos to aid in understanding treatments and symptoms.

The system's prescription and appointment management features are designed for efficiency, enabling healthcare professionals to prescribe treatments and schedule patient appointments with ease. Reminder notifications are integrated to ensure patients receive timely alerts for appointments and medication schedules. Scalability and performance are also core considerations, with load balancing and resource optimization mechanisms in place to maintain responsiveness as the system handles increased data and user interactions.

Security and privacy are paramount, with robust encryption protocols and access controls safeguarding patient data. The design facilitates seamless integration with databases for secure data storage and retrieval, as well as external services for validation and authentication. Moreover, the system incorporates user training and support features, offering helpful guides and resources to assist users in making the most of the platform. In sum, this thoughtful and comprehensive design ensures that the software solution provides an effective, secure, and user-friendly approach to intelligent hair disease detection and treatment recommendation.

5.14 Developments and implementation

The development and implementation phase of the "Empowering Hair Health With Intelligent Hair Disease Detection Systems" software solution is a critical step in turning the design into a fully operational and functional system. Skilled software developers and engineers collaborate to write the code that powers the system's various modules. This encompasses coding for data collection, disease detection, treatment recommendation, chatbot capabilities, prescription generation, and appointment management. Throughout this process, developers rigorously adhere to industry best practices and coding standards, ensuring the software's reliability, maintainability, and scalability. Comprehensive testing procedures are integrated into development to identify and rectify any issues, guaranteeing the system's performance and functionality align with the intended design. Once the development phase is complete, the software undergoes rigorous testing and quality assurance measures to ensure it meets the project's objectives and user expectations.

5.15 Work Break-Down Structure

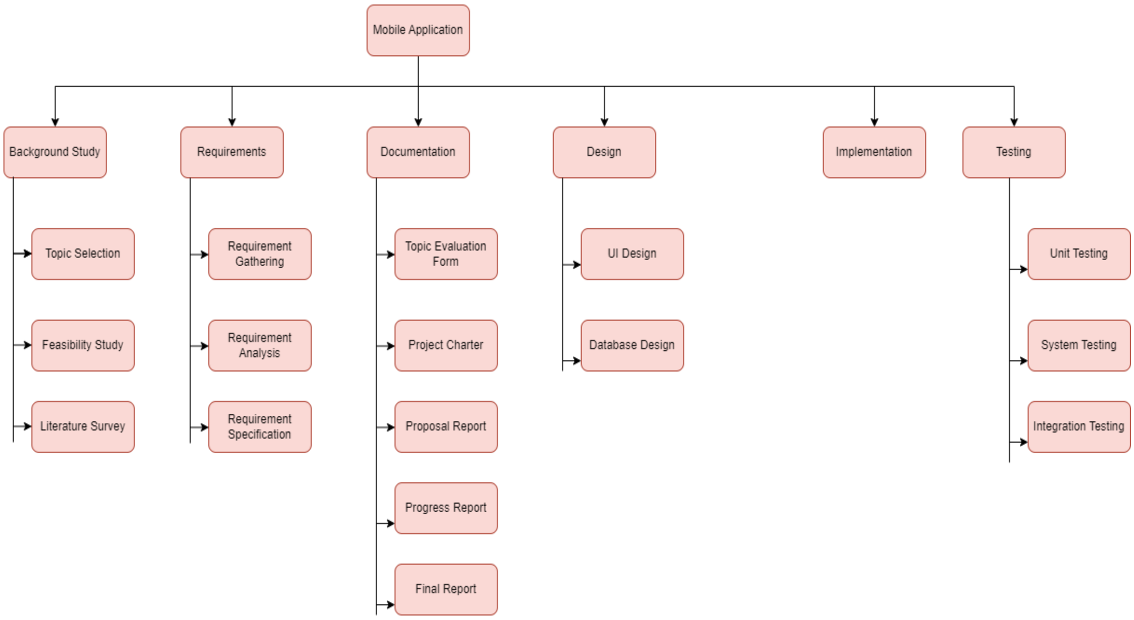

Figure 14 - Work Break-Down Structure

5.16 Gantt Chart

Figure 15 - Gantt Chart

5.17 Commercialization of the Product

5.17.1 Commercial value

The commercial value of the "Empowering Hair Health With Intelligent Hair Disease Detection Systems" software solution lies in its potential to generate revenue and create economic opportunities. Here's an explanation of its commercial value:

1. Healthcare Services and Revenue Generation:

- The software solution can be marketed to healthcare providers, clinics, and hospitals as a valuable tool for diagnosing and treating hair diseases. Healthcare facilities can integrate this technology into their services, attracting more patients seeking accurate diagnosis and personalized treatments. This leads to increased patient visits, consultations, and treatment sessions, thereby generating revenue for healthcare institutions.

2. Licensing and Software Sales:

- The software can be licensed or sold to healthcare organizations and institutions for use in their facilities. These organizations can pay licensing fees or purchase the software outright, creating a direct source of revenue for the software developers and the research project.

3. Data Monetization:

- The system can collect and anonymize patient data, which can be valuable for research and pharmaceutical companies. This data can be monetized through collaborations or partnerships, contributing to the project's commercial value.

4. Expansion and Customization:

- The software solution can be customized to cater to specific healthcare niches, such as dermatology clinics or specialized hair treatment centers. This adaptability allows for market expansion and the potential to serve a broader range of clients.

5. Intellectual Property and Patents:

- If the project involves innovative technologies or methodologies, it may lead to the development of intellectual property (IP) and patents. These IP assets can be licensed or sold to interested parties, generating revenue for the project.

6. Research Collaboration:

- Collaborations with pharmaceutical companies, academic institutions, or research organizations interested in advancing hair health and treatment can result in research grants, sponsorships, or partnerships, providing financial support and contributing to the project's commercial value.

5.17.2 Commercialization plan

- Introducing to the global universities – Introducing 'Hair Diary' to the international universities that provide the knowledge programs about hair diseases, such as Oxford, Stanford, Durham, and Harvard.
- Introducing to the local universities – We prioritize introducing this application to the medical faculties of our local universities, such as the University of Kelaniya, the University of Peradeniya, the University of Ruhuna, the University of Colombo, and the University of Sri Jayawardhanapura.
- Introducing to the Health Department Sri Lanka – It will be a great benefit to be recognized globally if 'Hair Diary' gets endorsed by the Department of Health Sri Lanka.
- Promoting through Social media – Social media platforms such as Youtube, Instagram, and Facebook are used to promote this application.
- Publish in Playstore – Since this is an android application, it can be published in the Google Playstore; therefore, anyone worldwide can download and use it.
- Make a subscription plan – The subscription plan includes a free one-month trial for new users, and after the trial period, $ 3.99 will be charged to the users.

6. TESTING AND IMPLEMENTATION

6.1 Testing

Testing is a critical phase in the development process to ensure that the software functions as intended, is free of errors, and meets the project's objectives. This phase involves several key steps:

- **Unit Testing:** Individual components and modules of the software are tested in isolation to verify their correctness and functionality. This helps identify and fix issues at an early stage.

- **Integration Testing:** Different modules are integrated and tested together to ensure that they work seamlessly as a unified system. This helps detect any compatibility issues between modules.

- **Functional Testing:** The software is tested to ensure that it performs its intended functions accurately. For example, the disease detection algorithms are rigorously tested to provide accurate results.

- **User Acceptance Testing (UAT):** A select group of users, such as healthcare professionals, may participate in UAT to evaluate the software's usability and functionality. Their feedback is valuable for making final refinements.

- **Performance Testing:** The software's performance under various conditions, including heavy loads and peak usage, is evaluated to ensure it can handle real-world scenarios without slowdowns or crashes.

- **Security Testing:** Robust security testing is conducted to identify vulnerabilities and ensure the protection of sensitive patient data. This includes penetration testing and vulnerability assessments.

- **Regression Testing:** After making any necessary corrections or updates, regression testing is performed to verify that new changes have not introduced new issues or affected existing functionality.

- **Usability Testing:** The software's user interface and overall user experience are assessed to ensure that it is intuitive and user-friendly for healthcare professionals and patients.

6.1 Implementation

Implementation marks the phase where the software is deployed and made accessible to users. It involves the following steps:

- **Deployment:** The software is installed and configured on servers or cloud infrastructure. Necessary hardware and software resources are allocated to ensure smooth operation.

- **Data Migration:** If applicable, existing patient data and records are migrated to the new system. This ensures a seamless transition and continuity of care.

- **User Training:** Healthcare professionals and staff who will use the software are provided with training sessions to familiarize them with its features and functionalities.

- **Rollout Plan:** A structured rollout plan is developed to gradually introduce the software to healthcare facilities. This may involve a phased approach to minimize disruptions.

- **User Support:** A dedicated support team is in place to address any user inquiries, issues, or challenges that may arise during the initial implementation phase.

- **Monitoring and Feedback:** Continuous monitoring of the software's performance and user feedback is essential during the implementation phase. This allows for immediate adjustments and improvements based on real-world usage.

- **Scalability:** The implementation plan includes provisions for scalability to accommodate increased usage and data as the system gains popularity and adoption.

- **Documentation:** Comprehensive documentation, including user manuals and system documentation, is provided to assist users in navigating and utilizing the software effectively.

7. RESULTS AND DISCUSION

After click Recommend My Treatment button, display treatments like this.

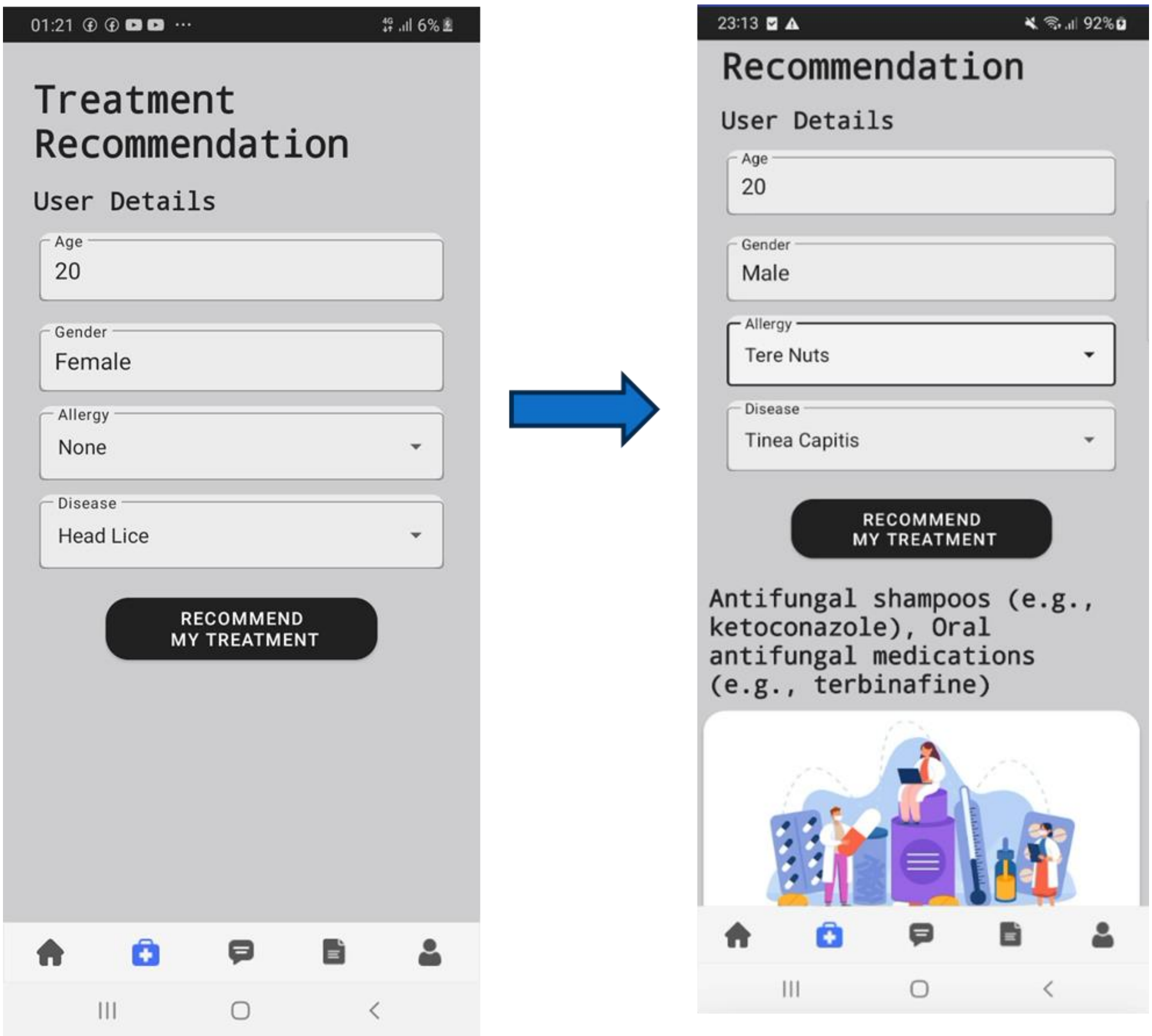

Figure 16 - Results and Discution (UI)

Here, Default get registered user age and gender, we can change her/him user details via user profile.

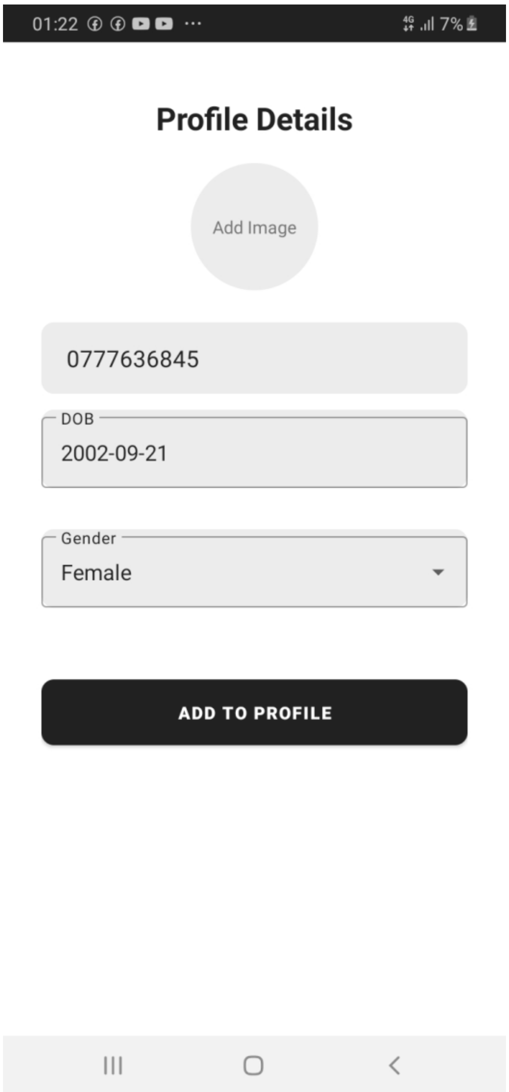

Figure 17 - User Profile page

After click add to profile button, changed user data in recommendation page.

```
Epoch:0 Train_loss: 3.03 Train_accuracy: 0.00 Test_loss: 3.02 Test_accuracy: 0.00
Epoch:500 Train_loss: 2.15 Train_accuracy: 26.12 Test_loss: 2.20 Test_accuracy: 25.00
Epoch:1000 Train_loss: 2.14 Train_accuracy: 26.12 Test_loss: 2.18 Test_accuracy: 25.00
Epoch:1500 Train_loss: 2.13 Train_accuracy: 26.12 Test_loss: 2.18 Test_accuracy: 25.00
Epoch:2000 Train_loss: 2.00 Train_accuracy: 30.12 Test_loss: 2.07 Test_accuracy: 27.50
Epoch:2500 Train_loss: 1.66 Train_accuracy: 39.25 Test_loss: 1.76 Test_accuracy: 36.00
Epoch:3000 Train_loss: 1.55 Train_accuracy: 43.38 Test_loss: 1.65 Test_accuracy: 38.50
Epoch:3500 Train_loss: 1.47 Train_accuracy: 46.88 Test_loss: 1.57 Test_accuracy: 44.00
Epoch:4000 Train_loss: 1.36 Train_accuracy: 51.75 Test_loss: 1.46 Test_accuracy: 50.00
Epoch:4500 Train_loss: 1.20 Train_accuracy: 55.00 Test_loss: 1.41 Test_accuracy: 47.00
Epoch:5000 Train_loss: 0.93 Train_accuracy: 65.88 Test_loss: 0.96 Test_accuracy: 64.50
Epoch:5500 Train_loss: 0.84 Train_accuracy: 68.75 Test_loss: 0.91 Test_accuracy: 68.00
Epoch:6000 Train_loss: 0.78 Train_accuracy: 71.50 Test_loss: 0.83 Test_accuracy: 70.00
Epoch:6500 Train_loss: 0.70 Train_accuracy: 74.38 Test_loss: 0.81 Test_accuracy: 71.00
Epoch:7000 Train_loss: 0.73 Train_accuracy: 72.38 Test_loss: 0.74 Test_accuracy: 74.00
Epoch:7500 Train_loss: 0.69 Train_accuracy: 74.75 Test_loss: 0.77 Test_accuracy: 73.50
Epoch:8000 Train_loss: 0.64 Train_accuracy: 76.88 Test_loss: 0.73 Test_accuracy: 72.00
Epoch:8500 Train_loss: 0.64 Train_accuracy: 77.00 Test_loss: 0.69 Test_accuracy: 74.50
Epoch:9000 Train_loss: 0.61 Train_accuracy: 78.38 Test_loss: 0.65 Test_accuracy: 74.50
Epoch:9500 Train_loss: 0.61 Train_accuracy: 77.75 Test_loss: 0.67 Test_accuracy: 76.50
```

Figure 18 - Test Accuracy

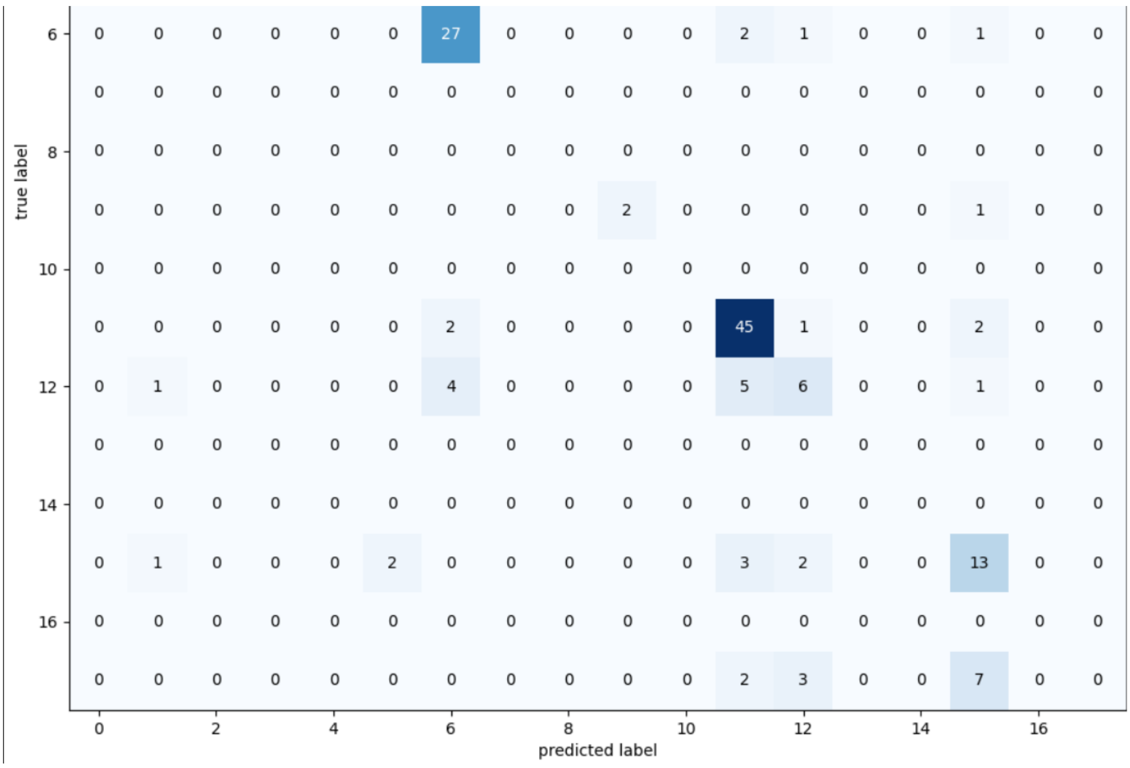

Figure 19 - Accuracy Graph

8. CONCLUSION

the research project on "Empowering Hair Health With Intelligent Hair Disease Detection Systems" represents a significant stride in the field of healthcare technology. Hair conditions affect individuals of all demographics and can have a profound impact on their well-being. Early detection and effective treatment are pivotal in managing these conditions and improving the quality of life for affected individuals.

Through this project, we have explored innovative approaches, including machine learning techniques such as linear regression, to enhance the diagnosis and treatment of hair diseases. The integration of technology, data analysis, and intelligent systems has the potential to revolutionize the way we approach hair health.

The project's specific components, including disease detection using IoT devices, treatment recommendation through machine learning, symptom prediction via chatbots, and prescription management, showcase a holistic approach to addressing the complexities of hair diseases. Notably, the consideration of patient allergies in treatment recommendations represents a crucial research gap that can significantly improve patient outcomes and safety.

Our extensive literature survey has provided insights into the current state of research in various hair conditions, from head lice to alopecia and beyond. Researchers worldwide have made substantial contributions to understanding the underlying factors, diagnostic methods, and treatment options for these conditions. Our project builds upon this knowledge and introduces novel solutions.

The commercialization plan outlines a clear path for bringing our intelligent system to healthcare providers and institutions, with an emphasis on data security, regulatory compliance, and scalability. We recognize the commercial value of our solution in meeting the demands of the healthcare industry and addressing the needs of patients.

In the testing and implementation phases, rigorous quality assurance measures ensure that our software solution is reliable, efficient, and user-friendly. The collaboration with healthcare professionals and the consideration of real-world scenarios have guided the development process, resulting in a robust and practical system.

As we move forward with the implementation of this project, we remain committed to the principles of innovation, accuracy, and patient-centric care. Our software solution has the potential to make a positive impact on countless lives, improving the early detection and management of hair diseases.

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10.APPENDICES

Appendix A

Mobile Application User Interfaces

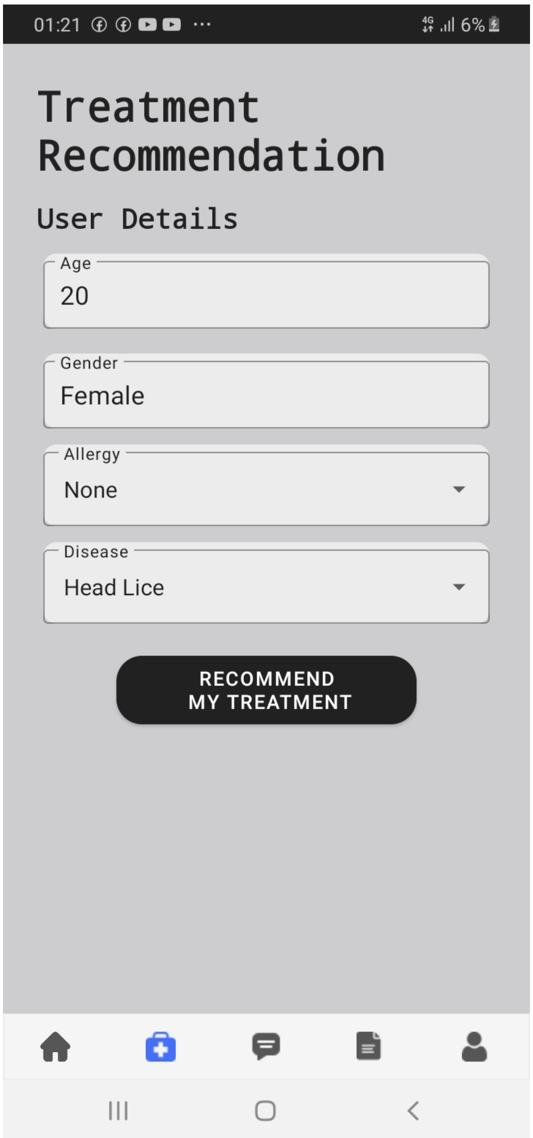

Figure 20 - Treatment page (Before)

Figure 21 - Treatment page (After)