Skin Disease Detection app

Name: Aryan Gupta

Date: 14.01.2024

Abstract:

Machine Learning (ML) outputs often have a mysterious fog surrounding them. A fog that must be demystified for the widespread adoption of ML. The main objective of this report is to use ML to provide not only an accessible and rapid diagnosis tool but also one that reaches a high degree of explainability. This report defines and contextualizes the need for a skin disease detection app in rural India. Looks at competing apps and businesses to identify the business gap. The identified business model is centred around referring diagnosed patients to specialised dermatologists and partnering with insurance companies to provide treatment if necessary. The report also details the limitations of such an approach, regulations to be faced and an abstract concept generation and development process.

1.0 Introduction

Dermatology refers to the study, diagnosis, and management of health conditions that affect that primarily affect the skin, nails and hair. The field has seen proliferated exponential growth over the past half-decade, riding the growingly health-cautious public. Dermatological expenses in 2023 make up 53% of total medical bills, a remarkable rise from a measly 3% just 3 years ago (Shastri & Parikh, 2023).

Concerning more serious diseases, the World Health Organisation, WHO, reports as of 2020 over 1.5 million cases of skin cancer diagnosis and over 120,000 skin cancer-associated deaths (WHO, 2022). The rise in infections and pharma sales can largely be attributed to global warming, unprecedented climate shifts, compounding pollution and lifestyle changes.

Many such risk factors for skin diseases being well documented in conjunction with the advancement and the mass adoption of smartphones, have made apps an easy, cheap and viable source of diagnosis. Furthermore, the revolution of automation brought forward by Artificial Intelligence (AI) and the selective application of this tool in dermatology is the primary focus of this report.

1.1 Problem Statement

Provide an accessible, easy-to-use and understandable skin diagnosis app utilising deep learning in regions where there is a paucity of resources and dermatological expertise. Additional features could include tracking of symptoms and response to treatment.

The key aim entails an Explainable AI implementation - aims to open the "black box" of ML. Explain why the underlying reasoning behind the model output.

1.2 Market Need Assessment

1.2.1 Insight into the Indian Derma Landscape:

Indian population is fast approaching the 1.5 billion mark and has surpassed China as the most populace country in the world. What is perhaps more pertinent is that the United Nations (UN) projects that due to the very young nature of the Indian population will continue to grow until 2060, as shown by the graph below.

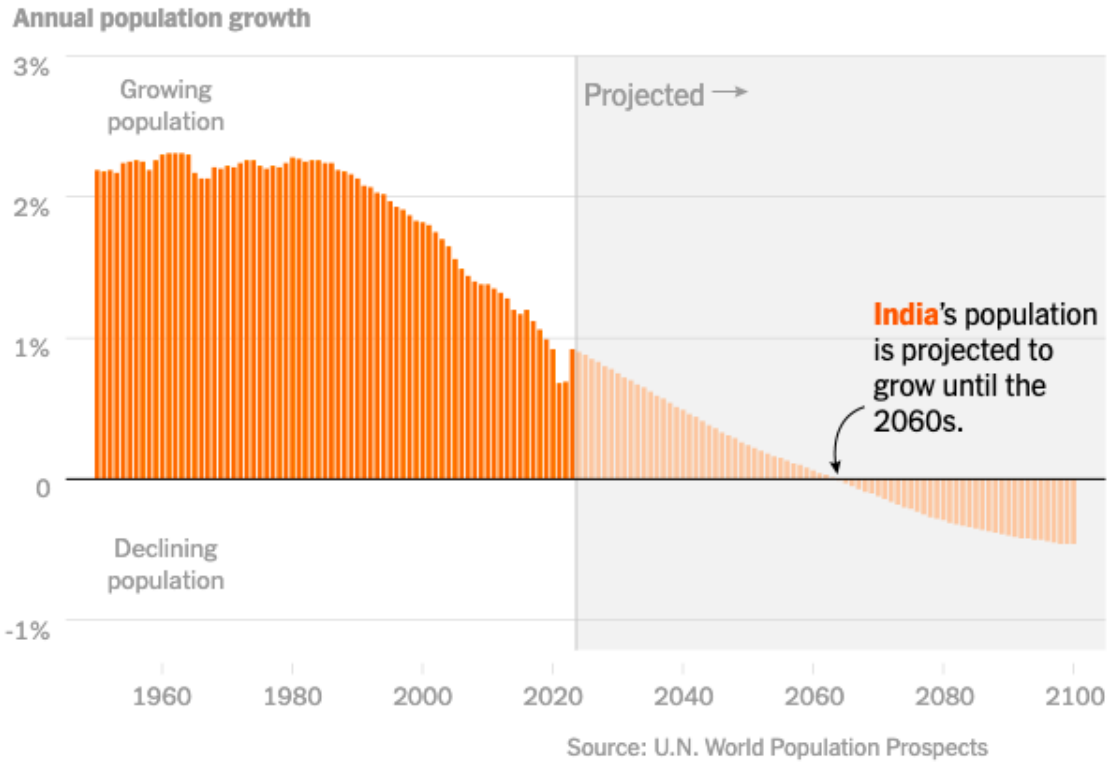

Figure 1: Continued growth of the Indian population (Travelli & Cai, 2023)

With these figures mind, India is host to only approximately 11,000 skin care specialists country-wide, this leaves less than one dermatologist for more than 100,000 people (Mesko, 2023). In India particularly, the space of dermatology is often overlooked with, with most people in suburban and rural areas lacking either the necessary knowledge or resources to identify potential skin risks.

1.2.2 Executive Summary:

India, with its vast population and diverse healthcare challenges, presents a significant market need for innovative solutions in the medical field. Dermatological conditions are prevalent, and access to specialized healthcare can be limited in many regions. A dermatological diagnosis app leveraging deep learning (AI) technology can address these challenges by providing accessible and accurate skin condition assessments. This market need assessment aims to explore the potential for such an app in India.

1.2.3 Market Overview:

1. Prevalence of Skin Disorders:
    - India faces a high prevalence of dermatological conditions due to factors such as climate, pollution, and genetic predisposition.
        - For example, it is no secret that excessive UVR (UltraViolet radiation) is a proven factor that damages DNA and causes cancer.

        - Early and excessive sun exposure in childhood and adolescence markedly increases the odds of skin cancer in adulthood (WHO, 2022).
        - According to an assessment of the UV index in Kerala of the last 18 years 2004-2022, 46% of the readings fall in the high category (8-10) and 33% fall in the extreme category (>11) (Nambudiri, 2024).
    - The lack of dermatologists in remote areas exacerbates the need for accessible diagnostic tools.

2. Limited Accessibility to Dermatologists:
    - Rural and semi-urban areas often lack adequate dermatological healthcare infrastructure, leading to delayed diagnoses and treatment.
    - Urban areas also experience long waiting times for dermatologist appointments.

3. Increasing Smartphone Penetration:
    - India has witnessed a notable increase in smartphone usage, even in rural regions, providing a platform for health-related apps to thrive.
    - A dermatological diagnosis app can leverage this trend to reach a large user base.

1.2.4 Deep Learning in Dermatology:

1. Accuracy and Speed:
    - Deep learning algorithms excel in image recognition and analysis, providing high accuracy in dermatological diagnosis.
    - Quick assessments can lead to early detection and early intervention.

2. Continuous Learning and Improvement:
    - AI algorithms can continuously learn from new data, ensuring that the app's diagnostic capabilities improve over time.
    - This feature addresses the dynamic nature of skin conditions.

3. User-Friendly Interface:
    - A well-designed app with an intuitive interface can empower users to conduct self-assessments easily and regularly.
    - Features such as image uploading, symptom tracking and post-treatment response tracking enhance user engagement.

4. Personalization:
    - Utilising optimised deep learning models allows a personalized experience regarding symptom detection and further steps to be undertaken.

1.2.5 Challenge = Opportunity:

1. Cultural Sensitivity:
    - Cultural diversity in India requires the app to be sensitive to various skin types, colours, and cultural practices.
    - The deep learning algorithm must be trained on a diverse dataset to ensure inclusivity.
    - Furthermore, skin colour diversification adds an element of inaccuracy within models. Studies show skin disease detection ML models focused on Asians perform markedly worse than those focused on Caucasians (Chan et al., 2020).

2. Data Security and Privacy:
    - User data security and privacy concerns are paramount. Adherence to data protection regulations is essential for user trust.
    - Implementing robust encryption and secure data storage practices is crucial.

3. Integration with the Healthcare Ecosystem:
    - Collaboration with existing healthcare systems and professionals is key for a comprehensive patient care approach.
    - The app can act as a triage tool, referring severe cases to dermatologists for further evaluation.

4. Importance of Explainability:
    - A key current limitation of ML in the field of healthcare is the lack of explainability (Chan et al., 2020).
    - For a healthcare app to flourish in less resourceful regions, this is a necessary gap to cover. Since incentivizing medical action must have a strong reasoning motivating it.

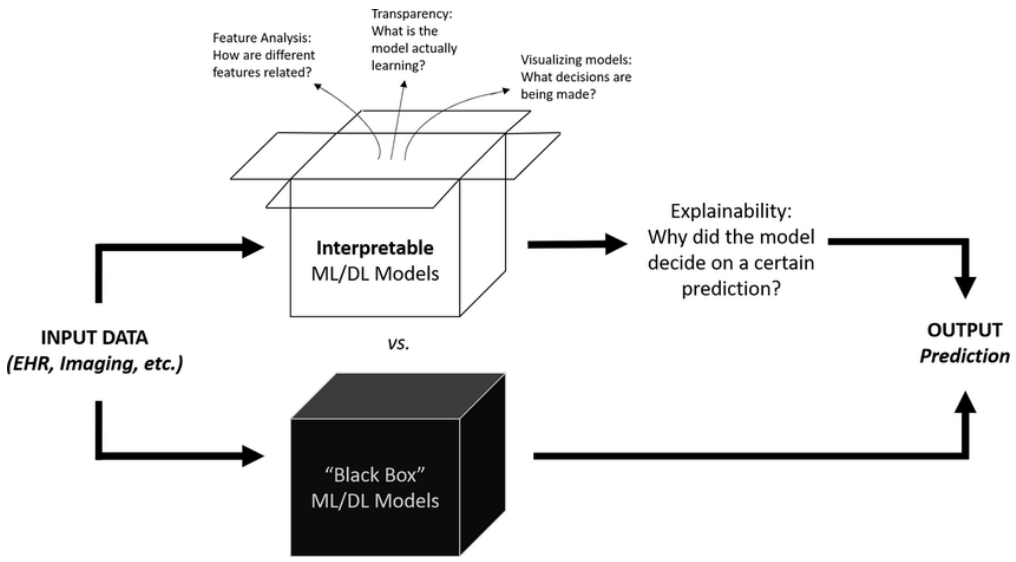

Figure 2: Black box AI vs Explainable AI (Hui et al., 2021)

2.0 Target Specifications and Characterization

A. Demographic:

- Age Group: The primary target audience comprises individuals between the ages of 18 to 60, as skin conditions can affect people across a broad age range.

- Technological Literacy: The app aims to cater to users with varying levels of technological proficiency. Hence, the interface ought to be user-friendly, allowing those with basic smartphone knowledge to navigate easily.
    - This is taken further by talking about a significant market gap giving detailed explanations behind the symptom diagnostic conclusion.

- Geographic Location: The app targets users across urban, semi-urban, and rural areas of India, acknowledging the diverse healthcare needs across different regions.

- Socioeconomic Status: To ensure inclusivity, the app should be accessible to users from diverse socioeconomic backgrounds. This includes both urban and rural populations.

B. Demographic Considerations:

- Gender Inclusivity: The app should be designed to address the dermatological concerns of all genders, considering the diverse skin conditions and cosmetic concerns.

- Cultural Sensitivity: Given the diverse population in India, the app should account for various skin tones, types, and cultural practices. The AI algorithm must be trained on a dataset that represents this diversity.

C. User Behaviour and Preferences:

- Health Consciousness: Target users who are health-conscious and proactive about monitoring and addressing their skin health.

- Privacy Concerns: Users are likely to be cautious about sharing personal health data. The app will prioritize robust data security measures and transparent privacy policies.

- Desire for Quick Access: Given the potential lack of immediate access to dermatologists, the app's target users value quick and convenient solutions for skin condition assessments.

D. Healthcare Engagement:

- Existing Dermatology Patients: The app can be designed to assist existing dermatology patients in monitoring their conditions between regular appointments, fostering continuous care.

- Underserved Populations: Target individuals who lack easy access to dermatological services, including those in remote areas where dermatologists are scarce.

3.0 Benchmarking Alternate Products

For all the reasons stated throughout this report, dermatology has become an attractive space for app innovation. A study in 2017, reported a total of 526 dermatological mobile apps which corresponded to an 80.8% growth since 2014 (Flaten et al., 2018). Hence it is important to look over at the noteworthy available market alternatives as per (Mesko, 2023).

- CureSkin:
    - Targeted operating location: India
    - Features: Provides personalized skincare solutions using AI. Allows users to submit images of their skin conditions for analysis.
    - Strength: The app claims to offer customized treatment plans based on AI analysis and consultations with dermatologists.
    - Consideration: The effectiveness of features like tracking treatment progress and reminders for medication vary with individual use. Promotes its own product line.
    - Languages: 3 Indian Languages – Hindi, Kannada and Telugu only
- FirstDerm:
    - Targeted operating location: Global
    - Features: Offers remote dermatology consultations and skin condition information.
    - Strength: Access to dermatologists for consultation
    - Consideration: May require a fee for consultations
    - AI usage: Limited
    - Languages: 6 global languages
- Skin Vision:
    - Targeted operating location: Europe predominantly
    - Features: Provides skin cancer risk assessment using AI.
    - Strength: Focus on early detection of skin cancer
    - Consideration: Requires a subscription for full access.
    - Languages: English, Dutch and German only
- DermEngine:
    - Targeted operating location: Global
    - Features: Offers AI-driven skin imaging and analysis.

    - Strengths: Focus on skin imaging and AI analysis, Anytime (24/7)
    - Consideration: May cater more to healthcare providers
    - Languages: English, French, Italian, Spanish and Portuguese only
- Ping An Good Doctor:
    - Targeted operating location: China
    - Features: Comprehensive healthcare app including dermatology services.
    - Strengths: Part of a larger telemedicine platform.
    - Consideration: Not a specialist app - More expansive than dedicated dermatology apps as they tackle a host of non- skin related conditions.
    - Languages: Chinese only

Healthcare gap in Dermatology in India: Explainable deep-learning based AI early-diagnostic (detection) app that has high explainability of outputs to dedicated for India, to address the cultural and linguistic diversity. Additionally, serving as a link between users, healthcare specialists and insurance institutions.

4. Applicable Regulations (Government and Environmental)

Developing and deploying a dermatological diagnosis app using deep learning in India requires adherence to several regulations, encompassing both government and environmental considerations. Ensuring compliance with these regulations throughout the business venture is not only a legal requirement but also essential for building trust with users and stakeholders. Key applicable regulations include (Das et al., 2023):

A. Data Protection and Privacy:

- Personal Data Protection Bill (PDPB): India is in the process of enacting comprehensive data protection legislation. The PDPB aims to regulate the processing of personal data and impose obligations on entities handling such data. Compliance with this law is critical to ensure the protection of user health data.

- General Data Protection Regulation (GDPR): If the app processes data of users residing in the European Union, compliance with GDPR is necessary. Even though it's an EU regulation, its extraterritorial scope affects businesses worldwide.

B. Health Data Regulations:

- Electronic Health Records (EHR) Standards: Ensure compliance with any national and/or state-level standards for electronic health records as the app will be storing and managing user health-related information.

- Medical Council of India (MCI) Guidelines: Since the app aims to collaborate with dermatological professionals, it must adhere to guidelines set by the Medical Council of India to maintain ethical standards in healthcare practice.

C. Drug and Cosmetic Act:

- Central Drugs Standard Control Organization (CDSCO): The app might provide information related to pharmaceutical products, it should comply with the regulations governed by CDSCO under the Drug and Cosmetic Act.

D. Telemedicine Guidelines:

- Telemedicine Practice Guidelines: The Ministry of Health and Family Welfare in India has released guidelines for telemedicine. The app will involve virtual consultations, hence adherence to these guidelines is critical.

E. Cybersecurity Regulations:

- Indian Computer Emergency Response Team (CERT-In): Dealing with sensitive health data means compliance with cybersecurity regulations is necessary to protect user data from cyber threats. CERT-In provides guidelines and standards for information security.

F. Ethical AI and Algorithmic Transparency:

- NITI Aayog's AI Policy Framework: The National Institution for Transforming India (NITI Aayog) has detailed the guidelines on ethical AI. App developers should ensure transparency in algorithms, fairness, and accountability in AI systems.

G. Accessibility Standards:

- Web Content Accessibility Guidelines (WCAG): As a health-related app, to ensure that it is accessible to all individuals it must be considerate of users with disabilities by following WCAG standards. This would include considerations for users with visual or auditory impairments.

H. Consumer Protection Laws:

- Consumer Protection Act: Adhere to consumer protection laws to ensure fair and transparent practices, including providing accurate information about the app's capabilities and limitations.

5. Applicable Constraints

A. Technical Expertise: Developing and implementing deep learning algorithms requires specialized technical expertise in AI, machine learning, and image recognition.

B. Data limitations: A detailed and extensive health dataset is necessary to develop an accurate and result-explainable model. Creating, obtaining the necessary permissions and meeting necessary regulations for handling sensitive confidential health data will be tricky. Poorly labelled data will also lead to the outputs reflecting those biases and inaccuracies. Additionally to meet the explainability requirement the data must be labelled at the physician level.

C. Legal expertise: The extensive list of healthcare-related regulations means it might be necessary to consult legal experts to ensure adherence.

D. Model accuracy measure: Such a metric is especially tricky considering the app seeks to explain conclusions drawn to a high degree.

E. Accessibility features: Multilingual Support is necessary to reflect and cater to the linguistic diversity in India, making the app accessible to a wider audience. Especially necessary since a large target audience lies in rural regions. Poor connectivity and networks in these areas mean the app would need to be optimized for low bandwidth, ensuring usability in regions with limited internet connectivity.

6. Business Model

Integration with Healthcare Providers:

- Physician Collaboration: The app should facilitate collaboration with dermatologists and other healthcare providers. This means the app is not a replacement but a complement to traditional healthcare services.
- Referral System: Incorporate a seamless referral system for cases that require in-person consultations, ensuring a holistic approach to healthcare.

Integration of Insurance firms:

- Work with local Insurance firms: Allow firms to identify high-risk patients adding to their profile when getting insurance. Allows patients to identify firms that can support their treatment if necessary based on professional diagnosis. Furthermore, it would allow them to maximise their usage of their current plans if applicable at an earlier stage of treatment.

10. Concept Generation and Development

A. Market Research – Expanding on the current report:

- Identify the current landscape of dermatological diagnosis apps in India.
- Understand user needs, pain points, and preferences.
- Analyse competitors and existing solutions to identify gaps.

B. Define Objectives:

- Clearly define the objectives of the app, such as early detection, accessibility, or remote consultations.
- Identify specific dermatological conditions the app will focus on.

C. Detailed User/Consumer Survey:

- Create detailed user personas to understand the characteristics, preferences, and challenges of potential users in India.

D. Ideation Sessions:

- Conduct brainstorming sessions with a multidisciplinary team, including AI experts, UX/UI designers, dermatologists and legal experts.
- Problem-Solution Fit: Addressing problems identified
- The interdisciplinary approach encourages diverse perspectives to generate a wide range of ideas.

E. User-Friendly Design:

- Develop ideas for a user-friendly interface that accommodates users with varying levels of tech literacy.
- Ensure the design is culturally sensitive and inclusive of diverse populations in India.

F. AI Algorithm Integration:

- Explore different deep-learning algorithms for dermatological image analysis.
- Consider continuous learning mechanisms to improve accuracy over time.
- Focus on Explainable AI to maximise healthcare transparency

G. Collaboration with Healthcare Professionals:

- Identify exact opportunities for collaboration with dermatologists and/or other healthcare providers.
- Develop features that facilitate seamless communication between users and healthcare professionals.

H. Data Security and Privacy:

- Devise strategies to address data security and privacy concerns.
- Consider encryption, secure storage, and compliance with the relevant regulations mentioned.

I. Multilingual Support:

- Ensure the app supports multiple languages to address the linguistic diversity in India.

J. Offline Functionality:

- Look into app functionality in areas with limited internet connectivity.

K. Pilot Testing:

- Develop a prototype of the app to conduct pilot testing with a selected small user group.
- Gather feedback to refine the concept based on user experiences.

L. Productization

- Stabilize the model for the use case. Then scale the model and data collection to an open (not curated) bigger user base.
- Check for outliers

M. Iterative Refinement:

- Continuously improvement of the app based on user feedback, technological advancements, and changes in the healthcare landscape.

11. Final Product Prototype Diagram

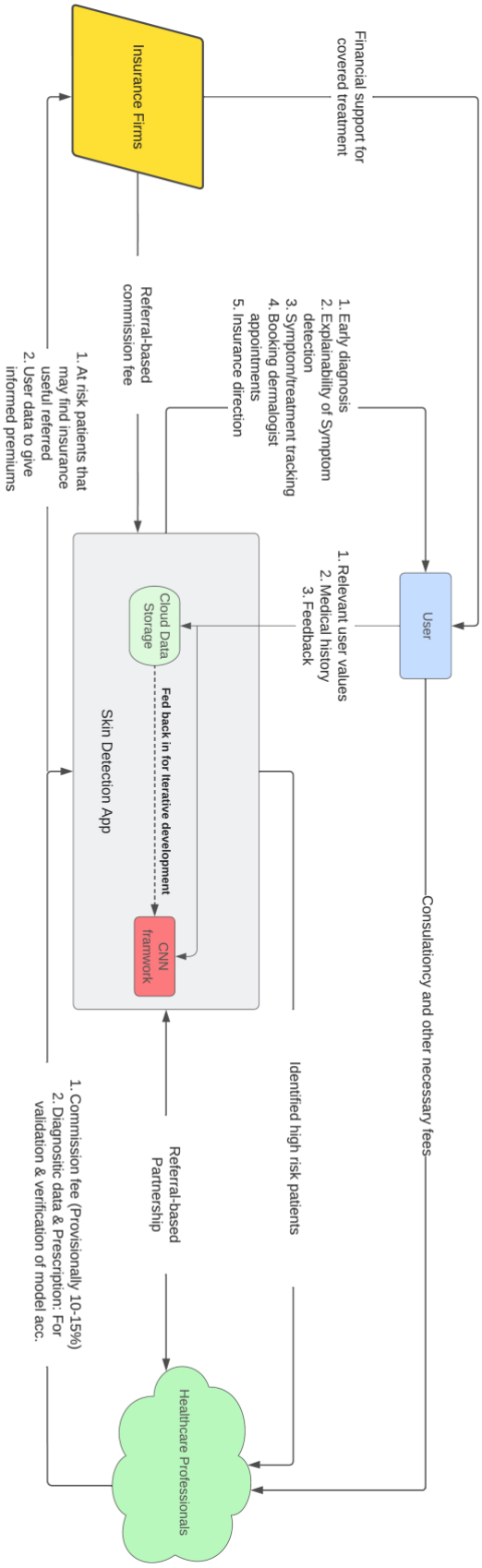

Figure 3: Abstract Business Prototype for Proposed Skin Detection App

12. Product details

A. Data Sources:

- Kaggle: An open-source library and network of online data science projects
    - 1. HAM10000 – Skin cancer dataset: Need to first structure the dataset for further tasks. Total of approximately 10000 training images of lesions.
    - 2. Dermnet – 23 different disease dataset: Well structured, easier to load and work with. The total number of images is approximately 19,500 split into training and test sets of size approximately 15,500 and 4,000 respectively.

B. Algorithms of interest:

As a diagnosis tool, the primary focus lies on Classification based algorithms (Chan et al., 2020):

- Convoluted Neural Networks (CNN): A branch of deep learning that mimics how neurons process information by adding more convolutions to the traditional Artificial neural networks (ANNs). It breaks down the image into its fundamental component pixels. The model proceeds to compare and contrast sub-class features of the input image. Finally pooling information across to classify input image. A branch of CNN called region-based CNN (r-CNN) can hone in on a desired object within the image. This in particular is of crucial importance in skin disease detection using AI.
- k-nearest neighbours (k-NN): Used for data classification and regression based on the number of k neighbours. Can be used to identify at risk patient if their data is close to that of a statistically diagnosed patient (data point).
- Support vector machine (SVM): They are used in data classification by finding a hyperplane to differentiate between groups. Serving a similar role as a classifier to identify at-risk patients based on training data.
- Logistic regression: Several risk factors will be of binary format hence it is worth considering a discriminative model such as logistic regression. It distinguishes between classes such as binary data (true or false).
- Random Forest: A simple yet powerful tool of ensemble learning used for classification that utilises the strength in many approaches to construct several decision trees during training returning the most common denominator. Effective in reducing overfitting to a single curated model.

C. Team required to develop:

- Deep ML engineers
- Healthcare professionals
- Business analyst
- Software engineer

- UI/UX developer
- Cloud engineer
- Big Data Researcher
- Legal expert

D. A structure that makes sense:

The Data Science department reports to the Product (Gavish, 2022)

- Allows the product to be the driver, this structure allows full alignment of goals and desirables. Creates a level of transparency to the product head which helps achieve business outcomes effectively.
- Prerequisite: Linkage between the teams to dumb down the technical jargon. A product head that understands the importance of understanding the underlying infrastructure to an extent.

13. Conclusion

The field of AI as an industry is said to be worth it by 2027. However, the next step in its journey has to be unravelling the bemusing "black-box" magic under the hood. The impact of this next step will be felt most noticeably in the health industry. This process will only be further facilitated with the increasing digitalization and data tracking which will create larger and more detailed datasets. Thereby, paving the way for more complex, more powerful and hopefully more transparent models.

The findings in this report suggest a promising opportunity for a dermatological diagnosis app using deep learning in India. Addressing the healthcare gap in dermatology, especially in underserved areas, can significantly impact early detection and treatment. Successful implementation requires a culturally sensitive, user-friendly, and secure application that integrates with existing healthcare infrastructure. By meeting this criterion, the app has the potential to improve dermatological care accessibility and outcomes across diverse demographics in India.

In conclusion, the accessibility, accuracy and adoption rate of online dermatological diagnosis will only continue to rise. The lack of data and significance of model bias remain relevant boulders. However, the potential for an ever-available, rapid and consistently accurate to the most recent literature. Furthermore, unlike doctors, their labour does not require pay. This would allow us to identify possible complications in dermatology at the earliest notice. The room for scalable growth is all the more reason to be an early adopter in the space of AI disruption in dermatology.

References

(Referencing Style: Havard)

Chan, S. *et al.* (2020) 'Machine learning in dermatology: Current applications, opportunities, and limitations', *Dermatology and Therapy*, 10(3), pp. 365–386. doi:10.1007/s13555-020-00372-0.

Das, F. *et al.* (2023) *Spotlight: The Regulation of Healthcare Providers and professionals in India*, *Lexology*. Available at: https://www.lexology.com/library/detail.aspx?g=4d495335-d8db-4618-a309-3864d7858b94 (Accessed: 14 January 2024).

Flaten, H.K. *et al.* (2018) 'Growth of mobile applications in dermatology - 2017 update', *Dermatology Online Journal*, 24(2). doi:10.5070/d3242038180.

Gavish, Y. (2022) *The step-by-step PM guide to building machine learning based products*, *Medium*. Available at: https://medium.com/@yaelg/product-manager-pm-step-by-step-tutorial-building-machine-learning-products-ffa7817aa8ab (Accessed: 14 January 2024).

Hui, A.T. *et al.* (2021) 'Ethical challenges of Artificial Intelligence in health care: A narrative review', *Ethics in Biology, Engineering and Medicine: An International Journal*, 12(1), pp. 55–71. doi:10.1615/ethicsbiologyengmed.2022041580.

Mesko, B. (2023) *Digital Skin Care: Top 8 dermatology apps*, *The Medical Futurist*. Available at: https://medicalfuturist.com/digital-skin-care-top-8-dermatology-apps/ (Accessed: 14 January 2024).

Nambudiri, S. (2024) *Study: Kerala experiencing alarming rise in UV radiation levels: Kochi News - Times of India*, *The Times of India*. Available at: https://timesofindia.indiatimes.com/city/kochi/study-kerala-experiencing-alarming-rise-in-uv-radiation-levels/articleshow/106683055.cms (Accessed: 14 January 2024).

Shastri, P. and Parikh, N. (2023) *In 3 years, derma products up from 3% to 53% in medical bills: Ahmedabad News - Times of India*, *The Times of India*. Available at: https://timesofindia.indiatimes.com/city/ahmedabad/in-3-years-derma-products-up-from-3-to-53-in-medical-bills/articleshow/99074212.cms (Accessed: 14 January 2024).

Travelli, A. and Cai, W. (2023) *Will this be the 'Indian Century'? Four key questions*, *The New York Times*. Available at: https://www.nytimes.com/interactive/2023/04/19/world/asia/india-china-population.html (Accessed: 14 January 2024).

Ultraviolet radiation (2022) *World Health Organization*. Available at: https://www.who.int/news-room/fact-sheets/detail/ultraviolet-radiation (Accessed: 14 January 2024).