# DIABETES PREDICTION BY USING ACANTHOSIS NIGRICANS IMAGES

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**Declaration**

# Declaration

"I declare that this is our 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 our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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| Name | Student ID | Signature |
|---|---|---|
| Sangavi.G | IT21069772 |  |

The above candidate is carrying out research for the undergraduate Dissertation under my supervision.

29/12/2024

Signature of the supervisor

Date

## Abstract

Diabetes mellitus presents a global health challenge, necessitating proactive measures for early detection and intervention to mitigate complications. This proposal advocates for a machine learning-based solution within the "Decoding Diabetes" app framework to identify diabetes risk through neck acanthosis nigricans (AN) analysis. Leveraging advancements in machine learning and image processing, this solution aims to democratize access to diabetes risk assessment, fostering early awareness and intervention. The project outlines a multidisciplinary approach, encompassing expertise in machine learning, healthcare, and user interface design. Through data gathering, past research analysis, and rigorous testing, the project aims to address challenges, develop a user-friendly app, and evaluate usability across diverse populations. The primary objective is to enable diabetes detection using home-captured neck images, supported by secondary objectives including machine learning model development and mobile application design. By bridging gaps in accessibility, awareness, and non-invasive screening, the project seeks to enhance early detection, empower individuals, and contribute to improved health outcomes globally.

**Keywords:** Diabetes, Acanthosis nigricans, Machine learning, Image processing, CNN

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## Introduction

Diabetes mellitus, a chronic metabolic disorder characterized by elevated blood sugar levels, poses a significant global health challenge. With its prevalence steadily rising worldwide, diabetic detection and intervention are paramount for effective management and prevention of complications. One visible manifestation associated with diabetes risk is acanthosis nigricans (AN), a dermatological condition characterized by dark, velvety patches of skin, often found in body folds such as the neck[4].

In response to the growing need for accessible and proactive healthcare solutions, we propose the development of a machine learning-based model aimed at identifying diabetes risk through the analysis of images depicting neck acanthosis nigricans. This initiative aligns with the broader objectives of promoting early awareness and facilitating timely intervention to mitigate the burden of diabetes-related complications[2].

The envisioned solution, integrated within the framework of the "Decoding Diabetes" app, leverages advancements in machine learning and image processing technologies to empower individuals with the capability to assess their diabetes risk from the comfort of their homes. By harnessing the wealth of information embedded within images of AN, coupled with robust algorithmic frameworks, the proposed model seeks to provide users with actionable insights regarding their potential diabetes risk status[6].

Through a user-friendly interface and seamless integration into existing healthcare infrastructures, our solution aims to democratize access to diabetes risk assessment tools, catering to diverse demographics and facilitating early detection among populations that may face barriers to traditional healthcare services. By prompting proactive engagement and fostering a culture of preventive healthcare, we envision contributing to improved health outcomes and reduced healthcare disparities on a global scale.

This proposal outlines the methodology, technical approach, and anticipated outcomes of the project, underscoring its potential to catalyze positive changes in diabetes management and prevention efforts. With a multidisciplinary team comprising expertise in machine

learning, healthcare, and user interface design, we are poised to embark on this transformative journey toward a future where early detection is synonymous with effective diabetes care.

## Background Literature

A comprehensive review of previous systems and studies will be conducted to identify successful approaches and lessons learned in diabetes prediction using image analysis, particularly focusing on neck images and acanthosis nigricans (AN). This analysis helped to guide the design and implementation of the proposed system by providing insights into effective methodologies, potential challenges, and areas for improvement based on previous research and existing systems.

### Acanthosis Nigricans (AN) as a Marker of Diabetes Risk

A substantial body of research establishes a strong association between AN and increased risk of developing diabetes, particularly type 2 diabetes mellitus (T2DM) [1][2]. Studies report a prevalence of AN ranging from 40% to 74% in individuals with T2DM, significantly higher compared to healthy controls [2][3]. This association stems from the underlying pathophysiology of both conditions. Diabetes often coincides with insulin resistance, a state where cells become less responsive to insulin's effects on blood sugar regulation. AN arises due to the binding of high insulin levels to specific receptors on skin cells, leading to increased growth and pigmentation, manifesting as the characteristic dark, velvety patches [4].

### Leveraging Machine Learning for Diabetes Risk Assessment

The field of artificial intelligence (AI) has witnessed significant advancements in machine learning (ML) algorithms, particularly in the realm of medical imaging

analysis. Researchers have explored the potential of utilizing ML models for diabetes risk assessment using various modalities, including retinal fundus images [5]. Notably, studies have begun investigating the feasibility of employing ML for AN detection in images [6]. A study by Yu et al. (2020) demonstrated the efficacy of a deep learning model in accurately diagnosing AN from dermoscopic images, achieving an area under the ROC curve (AUC) of 0.94 [6].

**Current Challenges and Limitations**

While the initial research on utilizing AN image for diabetes risk assessment through ML shows promise, certain challenges need to be addressed.

**Limited Data Availability**

Training robust and reliable ML models necessitates substantial amounts of labeled data. Gathering a diverse and extensive dataset of AN images, encompassing various severities and demographics, is crucial for model generalizability and effectiveness.

**Addressing Confounding Factors**

Several medical conditions, including obesity and polycystic ovary syndrome (PCOS), can also present with AN. ML models need to be refined to distinguish between AN arising from insulin resistance, which is indicative of heightened diabetes risk, and AN associated with other etiologies.

The use of AN images for diabetes risk assessment through ML models holds significant potential. By harnessing the strengths of AI and addressing current limitations, this approach could pave the way for accessible and early detection of diabetes risk, enabling timely intervention and improved health outcomes. Future research should focus on overcoming existing challenges, and refining algorithms of this technology in healthcare settings.

## Research Gap

### Limited Home-Based Solutions

The absence of accessible home-based diabetes diagnostic tools for the general user population indicates a gap in the market for convenient and user-friendly solutions that individuals can utilize in the comfort of their own homes. Currently, individuals often rely on medical facilities or clinics for diabetes testing, which may not always be convenient or accessible. Home-based solutions could empower users to monitor their health more regularly and conveniently, leading to earlier detection and management of diabetes.

### Lack of Diverse Indicators

Conventional diabetes diagnostic methods often focus on blood glucose levels and traditional risk factors such as weight and family history. However, there are additional indicators that could be valuable for predicting diabetes risk, such as neck circumference images, foot ulcers, infected nails, and retinal images. These unconventional indicators may provide valuable insights into a person's risk of developing diabetes, especially when combined with other clinical data. Incorporating these diverse indicators into diabetes prediction models could enhance the accuracy of early detection and improve overall health outcomes.

### User-Friendly Gap

Many existing tools for diabetes screening and management lack a user-friendly interface, which can hinder widespread adoption among diverse user populations. A user-friendly interface is essential for ensuring that individuals of all ages and technological literacy levels can easily navigate and utilize diabetes diagnostic tools. By designing intuitive interfaces and incorporating features such as clear instructions, visual aids, and

personalized feedback, developers can bridge the user-friendly gap and promote greater engagement with diabetes screening and management tools.

**Delayed Detection**

The absence of early, comprehensive screening tools contributes to delayed diabetes detection, limiting opportunities for proactive management. Early detection of diabetes is crucial for initiating timely interventions and preventing complications associated with the condition. Comprehensive screening tools that incorporate diverse indicators and are accessible for home use could facilitate earlier detection and empower individuals to take proactive steps towards managing their health. By addressing the gap in early detection, healthcare providers can improve outcomes for individuals with diabetes and reduce the burden on healthcare systems.

| | Research Paper A (Doi:10.1001/jamanetworkopen.2018.3896) | Research Paper B (Doi:10.1001/archdermatol.2007.27) | Research Paper C (DOI: 10.4103/cdrp.cdrp_14_23) | **Proposed System** |
|---|---|---|---|---|
| **Global Prevalence of Diabetes** | ✓ | ✓ | ✓ | ✓ |
| **Historical Perspective** | ✓ | ✓ | ✓ | ✓ |
| **Acanthosis nigricans of neck images** | ✗ | ✗ | ✓ | ✓ |
| **Telemedicine Standards** | ✓ | ✗ | ✗ | ✓ |
| **Definition and Prevalence of Diabetics by Acanthosis nigricans of neck** | ✓ | ✗ | ✗ | ✓ |

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*Figure 1 Research gap*

## Research Problem

- **Limited accessibility and convenience of traditional blood tests**

  Traditional blood tests for diabetes typically require individuals to visit a healthcare facility or clinic, which can be inconvenient and time-consuming. This requirement may deter some individuals from undergoing regular screening for diabetes, especially those with busy schedules or mobility limitations. Additionally, access to healthcare facilities may be limited in certain geographical areas or for individuals with financial constraints. As a result, many people may not receive timely diabetes screening, leading to undiagnosed or poorly managed diabetes.

- **Low public awareness and understanding of diabetes symptoms**

  There is often a lack of public awareness and understanding of diabetes symptoms, particularly in the early stages of the disease when symptoms may be subtle or go unnoticed. Many individuals may not recognize the signs of diabetes, such as increased thirst, frequent urination, fatigue, and blurred vision. Consequently, individuals may delay seeking medical attention until complications arise or the disease has progressed to a more advanced stage. Improving public awareness and education about diabetes symptoms and risk factors is crucial for promoting early detection and intervention.

- **Lack of a non-invasive, home-based screening method for diabetes**

  Currently, there is a lack of non-invasive, home-based screening methods for diabetes that are accessible and convenient for the general population. Traditional screening methods often involve invasive procedures such as blood tests, which may be uncomfortable or inconvenient for some individuals. A non-invasive

home-based screening method would enable individuals to monitor their diabetes risk or status in the comfort of their own homes, without the need for clinic visits or blood draws. Such a method could increase participation in diabetes screening programs and facilitate earlier detection and management of the disease.

Addressing these challenges requires the development and implementation of innovative solutions that prioritize accessibility, convenience, and user-friendliness. This may involve the creation of non-invasive home-based screening technologies, as well as initiatives to raise public awareness and education about diabetes prevention, symptoms, and management. Additionally, efforts to improve access to healthcare services and promote regular diabetes screening among at-risk populations are essential for reducing the burden of diabetes and its associated complications.

## Objectives

### Main Objective

Diabetes Detection with Home-Captured Neck Images**.** This project aims to develop and evaluate a non-invasive, home-based system for diabetes detection using images of the user's neck captured with a smartphone camera.

### Specific Objective

1. To detect early diabetes.
2. To develop algorithms for precise diabetes risk prediction using neck image features.
3. To design user-friendly app for neck image capture, ML analysis, and diabetes risk feedback.
4. To evaluate system usability across diverse populations.

# Methodology

## System Diagram

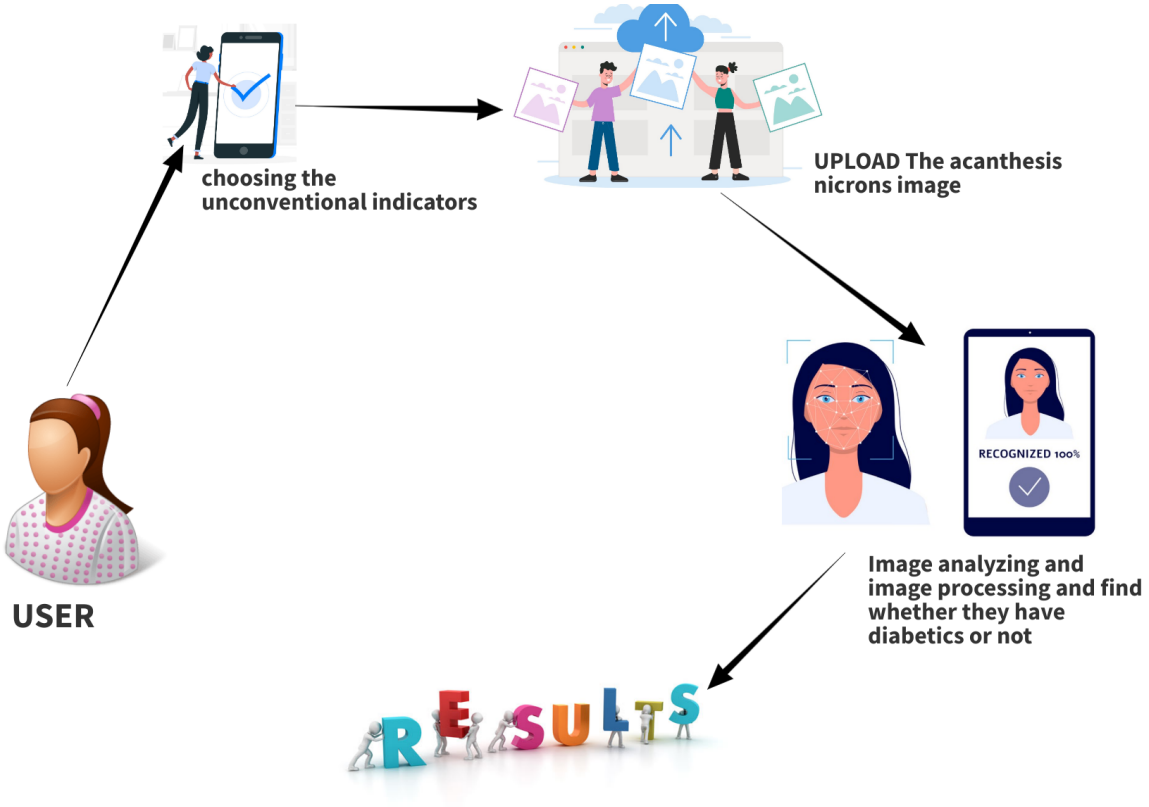


*Figure 2 Individual System Architectue*

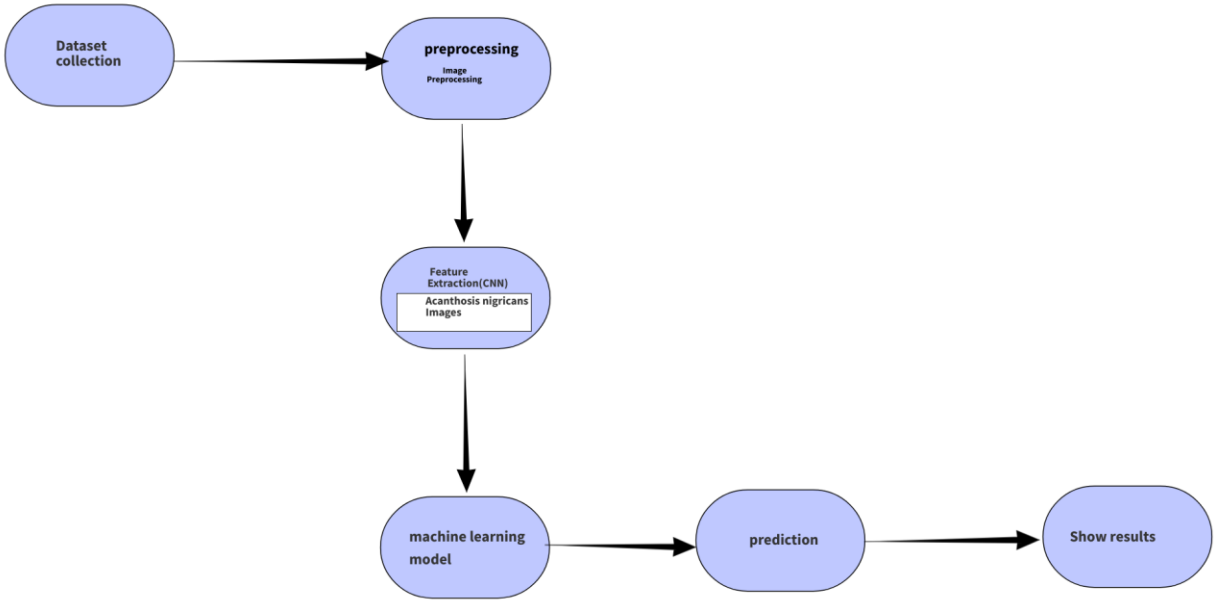


*Figure 3 Individual system diagram!*

## Description of Personal and Facilities

The research proposal aims to investigate the efficacy of using acanthosis nigricans images for predicting diabetes onset. This interdisciplinary undertaking will involve medical professionals, data scientists, software engineers, and ethics experts. Medical professionals, including doctors and dermatologists, will provide clinical expertise and access to patients for image acquisition. Data science will develop machine learning algorithms to analyze the images and identify predictive patterns. Software knowledge will design and implement software applications for image analysis and data management. Additionally, data annotation will ensure accurate labeling of images, while ethics and privacy experts will ensure compliance with regulatory requirements. The proposal underscores the importance of powerful data storage, regulatory compliance infrastructure, and collaborative environments to foster innovative research and develop effective diabetes prediction models using acanthosis nigricans images.

**Requirement Gathering**

The proper data will be collected from the General Hospital of Jaffna. and university of jaffna

## Commercialization

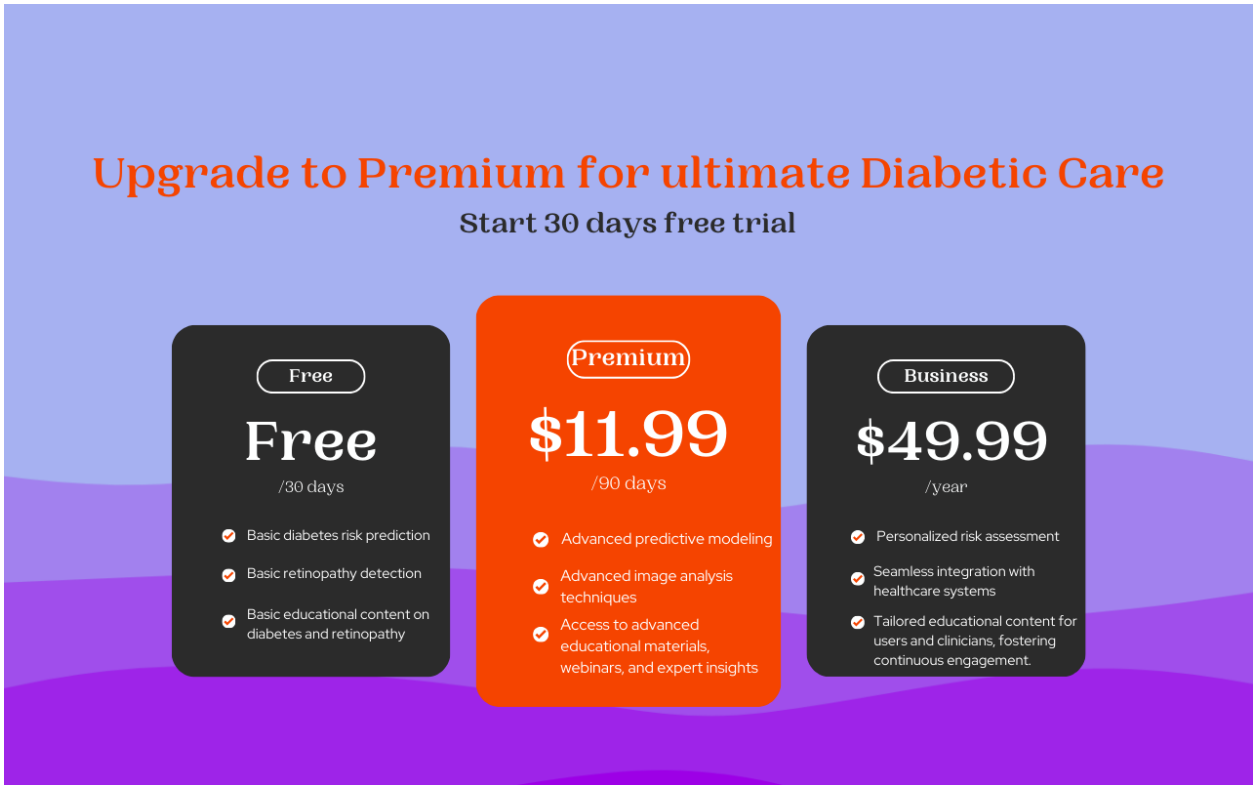


*Figure 4 Commercialization*

The above image shows with three different pricing plans for a diabetic care service. The plans are called Free, Premium, and Business. The Free plan costs nothing and includes basic diabetic risk prediction, basic retinopathy detection, and basic educational content on diabetes and retinopathy. The Premium plan costs $11.99 per month and includes everything in the Free plan, as well as advanced predictive modeling, advanced image analysis techniques, and access to advanced educational materials, webinars, and expert insights. The Business plan costs $49.99 per year and includes everything in the Premium

plan, as well as personalized risk assessment, seamless integration with healthcare systems, tailored educational content for users and clinicians, and continuous engagement.

## Requirements

### a. Functional requirements

Using Convolutional Neural Network (CNN) functions to detect diabetic symptoms from Acanthosis nigricans images involves leveraging the power of deep learning algorithms to analyze and interpret visual data. Acanthosis nigricans is a skin condition often associated with insulin resistance and type 2 diabetes, characterized by dark, velvety patches of skin. By training a CNN model on a dataset of Acanthosis nigricans images along with corresponding diabetic symptom labels, the model can learn to recognize patterns and features indicative of diabetes-related skin manifestations.

- Use of CNN functions to detect diabetic symptoms by using the Acanthosis nigricans images.
- A well-designed UI/UX essential to manage the system.
- Flexible data connection required to generate new feature and solver user requirements.

### b. Non-Functional requirements

The system aims to achieve high accuracy in detecting diabetic symptoms from Acanthosis nigricans images through rigorous testing and validation procedures, while prioritizing usability with a simple and intuitive UI/UX design, ensuring accessibility for users with diverse abilities, and optimizing performance through efficient processing and resource utilization techniques. Regular monitoring and evaluation efforts are conducted to maintain system effectiveness and address any discrepancies promptly, ultimately delivering a reliable and user-centric diabetic symptom detection solution.

**System requirement**

**1.Hardware requirement**

Minimum system requirements of user end device for the client app to work is as follows:

1. Operating system: IOS or Android
2. RAM: 1GB
3. Storage: 300 MB free space
4. Internet connectivity

The minimum system requirement for a back-end server is either Windows or Linux, 8GB of RAM and 30 GB of storage. 200 megabytes of database storage space is sufficient for the implementation phase. These system requirements may increase during use, and these resources should be scaled in that case.

**2.Software Requirements**

VSCode

PyCharm

Google Collab

Jupyter

**3.Technological Requirement**

Conventional Neural Networks (CNN)

Transfer learning (pre-trained deep learning model) – VGG, and ResNet

Ensemble Learning: RandomForest, Gradient Boosting Machines (GBM), AdaBoost

Sparse Representation based Classification

Generative Adversarial Networks (GAN)

Support Vector Machines (SVMs)

Autoencoders

**4.Libraries**

TensorFlow

Keras

Scikit-learn

PyTorch

## Project Timeline (Gannt Chart)

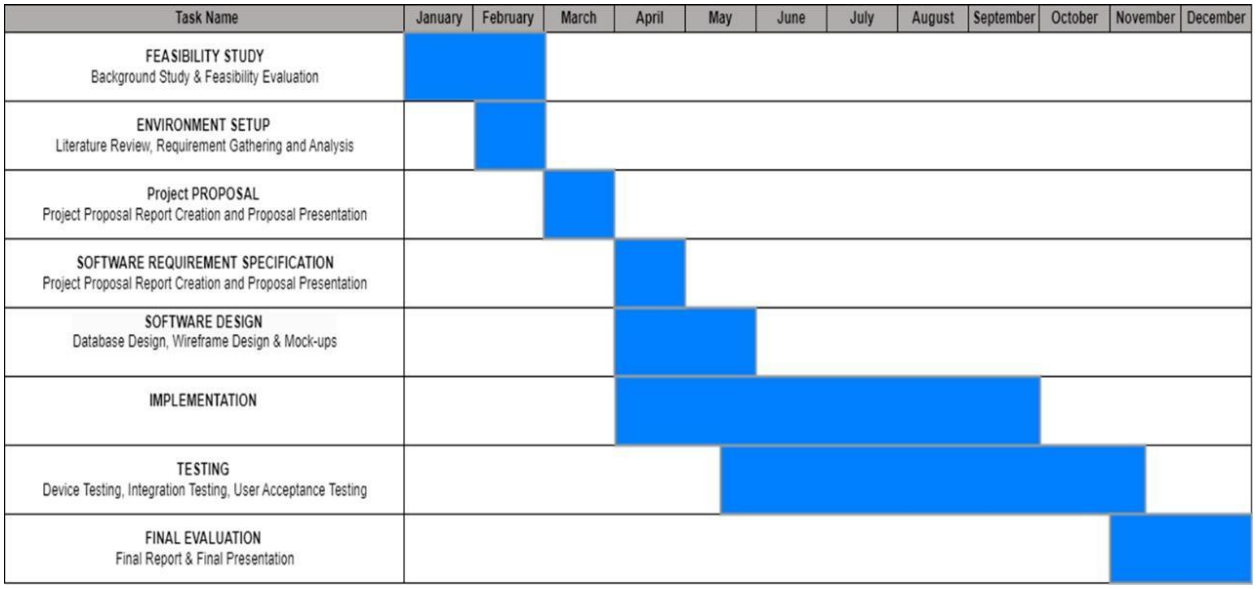


*Figure 5 Gannt's Chart*

## Conclusion

The project aims to develop a machine learning-based system utilizing neck images to predict diabetes risk, integrated into a user-friendly mobile app. Through rigorous evaluation and addressing of challenges, the project seeks to empower users with accessible and proactive healthcare solutions, fostering early detection and improved management of diabetes. Furthermore, by leveraging advancements in artificial intelligence and image processing technologies, the project addresses the critical gap in home-based diabetes screening tools. Traditional methods often require clinic visits and invasive procedures, leading to delays in detection and management. This innovative approach offers a non-invasive and convenient solution, enabling individuals to monitor their diabetes risk from the comfort of their homes. Through the development of a user-friendly mobile application, the project democratizes access to diabetes risk assessment, promoting regular monitoring and proactive intervention.

## References


1. Lakhani, O. J. (2024). Artificial Intelligence in diabetes management and research. Chronicle of Diabetes Research and Practice, 3(1), 5–7. https://doi.org/10.4103/cdrp.cdrp_14_23

2. Novotny, R., Davis, J., Butel, J., Boushey, C. J., Fialkowski, M. K., Nigg, C. R., Braun, K. L., Leon Guerrero, R. T., Coleman, P., Bersamin, A., Areta, A. A., Barber, L. R., Belyeu-Camacho, T., Greenberg, J., Fleming, T., Dela Cruz-Talbert, E., Yamanaka, A., & Wilkens, L. R. (2018). Effect of the children's healthy living program on young child overweight, obesity, and acanthosis nigricans in the US-affiliated Pacific Region. JAMA Network Open, 1(6). https://doi.org/10.1001/jamanetworkopen.2018.3896

3. References and reviews. (1965). JAMA: The Journal of the American Medical Association, 192(4), 148. https://doi.org/10.1001/jama.1965.03080170092046

4. Jeong, M., Sohn, J., Sung, M., & Kang, J. (2024). Improving Medical Reasoning through Retrieval and Self-Reflection with Retrieval-Augmented Large Language Models. arXiv preprint arXiv:2401.15269.

5. Karadağ, A. S., You, Y., Danarti, R., Al-Khuzaei, S., & Chen, W. (2018). Acanthosis nigricans and the metabolic syndrome. *Clinics in Dermatology*, *36*(1), 48–53. https://doi.org/10.1016/j.clindermatol.2017.09.008

6. Stuart, C. A., Gilkison, C. R., Smith, M. M., Bosma, A. M., Keenan, B. S., & Nagamani, M. (1998). Acanthosis nigricans as a risk factor for non-insulin dependent diabetes mellitus. *Clinical Pediatrics*, *37*(2), 73–79. https://doi.org/10.1177/000992289803700203

7. ElSayed, N. A., Aleppo, G., Bannuru, R. R., Bruemmer, D., Collins, B. S., Ekhlaspour, L., Gaglia, J. L., Hilliard, M. E., Johnson, E. L., Khunti, K., Lingvay, I., Matfin, G., McCoy, R. G., Perry, M. L., Pilla, S. J., Polsky, S., Prahalad, P., Pratley, R. E., Segal, A. R., … Gabbay, R. A. (2023). 2. diagnosis and

classification of diabetes: *standards of care in diabetes—2024*. *Diabetes Care*, *47*(Supplement_1). https://doi.org/10.2337/dc24-s002

8. Lakhani, O. J. (2024a). Artificial Intelligence in diabetes management and research. *Chronicle of Diabetes Research and Practice*, *3*(1), 5–7. https://doi.org/10.4103/cdrp.cdrp_14_23