AUGMENTED REALITY SYSTEM FOR MAKEUP TRY-ON

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REG NO: SCT221-0840/2022

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A proposal/research project submitted to the Department of Information Technology in the School of Computing and Information Technology in partial fulfillment of the requirement for the award of the degree of Bachelor of Science in Information Technology at Jomo Kenyatta University of Agriculture and Technology.

Date: 16th April, 2025

DECLARATION

I……. hereby declare that this proposal/research project is my original work and has not been presented for a degree in any other University.

…… ……

Signature Date

I……. hereby confirm that this proposal/research project has been submitted for examination with my approval as University Supervisor.

…… ……

Signature Date

ABSTRACT

The traditional makeup trial process by JoannaK cosmetics has made it difficult for consumers to purchase products that they desire or matching their taste, this poses so many challenges. Some of these challenges are hygiene concerns for shared testers, limited accessibility since not all consumers have access to physical stores and also most customers feel like having to visit a physical store is time wasting. To address the stated challenges this project proposes an AR system to virtually try on makeup products at the comfort of your home. This system will leverage advanced facial recognition, computer vision, and real-time rendering, enhancing accuracy using AI and ML technologies to allow users to virtually try-on JoannaK products e.g. Wide range of lipstick shades available in the store. User testing will be conducted to assess usability, accuracy, and overall satisfaction. The app will also feature a responsive user interface and be optimized for performance on mobile devices. By enabling virtual try-ons, the system aims to increase purchase confidence, boost online conversion rates, and reduce product return rates. This project aims at making JoannaK products/services accessible to all consumers broadening their market.

ACRONYMS

AR- Augmented Reality

AI- Artificial Intelligence

ML- Machine Learning

SDK- Software Development Kit

API- Application Programming Interface

3D- Three-Dimensional

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CHAPTER 1

INTRODUCTION

- i. **Background**

Global Perspective

The beauty and cosmetics industry has witnessed a transformative shift with the integration of technology, particularly through Augmented Reality (AR). Globally, brands like Sephora and L'Oréal have pioneered AR applications, enabling consumers to virtually try on makeup products, thereby enhancing the shopping experience and reducing the reliance on physical testers. This innovation addresses hygiene concerns and caters to the growing preference for online shopping. For instance, Sephora's Virtual Artist and L'Oréal's Makeup Genius have set benchmarks in virtual makeup try-on solutions. (Lo'real, May 2021)

Local Perspective

In the Kenyan context, the beauty industry is burgeoning, with an increasing number of consumers seeking personalized and convenient shopping experiences. However, the adoption of AR technology in this sector remains nascent. Local beauty retailers and brands have yet to fully embrace virtual try-on solutions, presenting an opportunity to enhance customer engagement and meet evolving consumer expectations.

Thus JoannaK cosmetics is a Kenyan based cosmetic line that was founded on 1st December 2018 by Joanna Kinuthia, a Kenyan content creator and entrepreneur. It all started off with a YouTube channel where she would do makeup tutorials before she decided to start JoannaK Cosmetics.

The brand launched with a collection of 4 lipsticks and 1 eyeshadow palette, which has since grown to 9 lipsticks, glosses and eyelashes in 5 styles. The main aim of launching different collections was to make our audience feel represented as well as offer a variety of good quality products that can be worn with minimal effort but the lack of AR solutions has limited customers to physical shopping leading to so many challenges including decrease in sales. (JonnaK cosmectics, 2019)

1.2 Project Overview

This research explores the development and implementation of an AR-based makeup try-on application tailored for JoannaK cosmetics main focus being the lip sticks by the beauty brand. Globally, AR technology has revolutionized the way consumers interact with beauty products, offering virtual simulations that allow users to visualize makeup on their faces in real-time. This not only enhances the shopping experience but also addresses challenges such as product trial limitations and hygiene concerns. Locally, integrating such technology can bridge the gap between traditional beauty retail practices and the digital transformation sweeping across various industries.

The core computational principles behind AR makeup applications involve real-time facial recognition, feature tracking, and the overlay of virtual elements onto live images. Advanced algorithms detect facial landmarks, enabling the accurate placement of virtual makeup. Machine learning techniques further refine these processes, ensuring realistic and responsive user experiences.

- i. **Statement of the Problem**

The rise of online shopping has significantly enhanced convenience for consumers globally, particularly in the beauty industry. However, the traditional makeup trial process by JoannaK Cosmetics makes it difficult for online shoppers to virtually test makeup products before purchasing leading to several challenges.

This challenges include Hygiene Concerns, since the Covid 19 pandemic shared testers in retail stores can be a risk and termed unhygienic, deterring consumers from trying products before purchase or trying new products produced by JoannaK since they come up with new shades of lip products frequently making it hard for the new products to sell.

Limited Accessibility is also an issue for customers trying to shop at JoannaK cosmetics, not all consumers have access to physical stores which are few in areas within Nairobi county, limited access in remote areas which restricts consumers from testing and purchasing makeup products.

Time Constraints is also a limiting factor most consumer feel like visiting stores for trials can be time-consuming, leading to a less efficient shopping experience since JoannaK cosmetics lacks AR solutions.

These issues have contributed to decreased customer satisfaction and potentially lower sales for the beauty brand hence implementing an AR makeup try-on application can address these challenges by providing a virtual, convenient, and hygienic solution for product trials.

1.4 Proposed Solution

The proposed solution entails the development and implementation of an innovative augmented reality (AR) make up try on application specifically designed to address the limitations of online shopping for beauty products. It aims at revolutionize the online shopping experience by offering a comprehensive, immersive, and user-centric platform that enables customers to virtually try on products in real-time through the integration of cutting-edge AR technology.

Thus the system will analyze customers' facial features to support real-time tracking for a realistic makeup try-on experience. This involves utilizing sophisticated facial tracking technologies that detect and monitor over facial features ensuring that virtual makeup applications align seamlessly with the user's facial movements, providing a mirror-like, immersive experience.

The system will Integrate with e-commerce platforms, allowing users to transition from product experimentation to purchasing products.

The system will enhance accuracy using AI and deep learning to refine color matching. These algorithms allow the system to analyze users' facial features meticulously and facilitate precise color matching for makeup products.

1.5 Objectives

General Objective:

1. To develop an Augmented Reality (AR) Makeup Try-On Application that allows users to test and visualize different makeup products in real-time in order to make purchases online.

Specific Objectives:

1. To research and analyze current AR technologies applicable to virtual makeup try-on solutions.
2. To design a user interface that is intuitive and accessible for the target demographic.
3. To implement real-time facial recognition and makeup rendering functionalities.
4. To test and evaluate the application's performance, user satisfaction, and impact on purchasing behavior.

1.6 Research Questions

1. What are the current limitations of existing AR makeup try-on technologies?
2. How can an AR-based makeup try-on interface be designed for optimal user experience?
3. What techniques can be used to enhance real-time accuracy in virtual makeup application?
4. How effective is the proposed AR system in improving online beauty shopping?

1.7 Justification

The integration of AR technology by JoannaK cosmetics offers numerous benefits to both the company and the consumer. AR technology enhances customer experience by allowing customers to visualize makeup products on their own faces in real-time, creating an interactive shopping experience. This is not only fun but also helps customers make informed decisions by seeing how products will look on them before purchasing thus helping them make informed decisions.

AR technologies can help increase sales by enabling confident purchasing decisions and also attract consumers who are unable to go the stores due to different reason like time and distance boosting the company’s sales.

Adopting AR technologies positions brands as forward-thinking and customer-centric. This sets the brand apart in the competitive market attracting tech-savvy consumers and enhancing the brand image.

In the Kenyan market, where digital adoption is growing, implementing AR solutions can meet consumer demands for convenience and personalization, ultimately benefiting JoannaK cosmetics and their customers.

1.8 Proposed Research and System Methodologies

The research will adopt a mixed-methods approach, combining qualitative and quantitative data collection to understand user needs and preferences.

The system development will follow the Agile methodology, allowing for iterative design, development, and testing phases. This aligns with the dynamic nature of AR application development, where continuous feedback from users is critical for refining the system. The iterative approach ensures that functional prototypes can be developed and evaluated early in the development cycle, allowing for incremental enhancements based on user needs and feedback.

Tools and techniques will include user interviews, surveys, prototyping, and usability testing to ensure the application aligns with user expectations and technological standards.

1.8.1: Stages Of Agile Methodology

Technology Adaptation Note: The project was initially planned as an Android mobile application but was adapted to a web-based implementation due to technical considerations and broader accessibility requirements. This change allows for cross-platform compatibility and eliminates device-specific limitations while maintaining all core AR functionality.

1. **Conceptualization and Planning**:

Define the app's core features, such as real-time AR makeup application, skin tone detection, and product recommendations.

Collaborate with stakeholders to prioritize features using a backlog.

1. **Sprint Planning**:

Break down the project into sprints by identifying tasks like AR model development, UI design, and backend integration to team members.

1. **Design and Prototyping**:

Create wireframes and mockups for the app interface and develop a prototype to test AR functionalities, ensuring seamless user interaction.

1. **Development**:

Implement AR features using web-based technologies and MediaPipe.

Integrate machine learning models for facial recognition and makeup application.

Build a scalable web backend for product data and user analytics using Next.js and Firebase.

1. **Testing and Feedback**:

Conduct usability testing to refine the AR experience.

Gather feedback from users to identify issues and areas for improvement.

1. **Iteration and Refinement**:

Address bugs and enhance features based on feedback.

Continuously improve the app's performance and user experience.

1. **Deployment and Monitoring**:

Launch the app and Monitor user engagement and app performance.

1. **Continuous Improvement**:

Release updates with new features like seasonal/ new makeup collections or advanced AR effects.

1.9 Scope

This research will focus on the development of a web-based AR makeup try-on application tailored for the Kenyan beauty market. The target population includes tech-savvy consumers aged 18-35 who are active users of web browsers and interested in beauty products. The research will be confined to urban areas where digital literacy and internet connectivity are relatively high. The web-based approach ensures cross-platform compatibility and eliminates device-specific limitations, making the application accessible on desktop computers, laptops, tablets, and smartphones through modern web browsers. Potential limitations include internet connectivity issues and browser compatibility, which will be considered during the development process to ensure optimal performance across different devices and browsers.

Hardware Requirements

Hardware	Pricing
Laptop	Available
Internal Hard disk drive – 500GB	Available
Processor Speed – 2.4GHz	Available
RAM – 4GB and above	Available

1.9.2 Software Requirements

Software

Use	Price
Next.js	Web application framework
Free	
React	Frontend development
Free	
TypeScript	Type-safe JavaScript development
Free	
OpenCV	Computer vision & facial tracking
Free	
dlib	Facial landmark detection
Free	
MediaPipe	Real-time facial detection (Google)
Free	
Firebase	Backend services & authentication
Free	
Vercel	Web deployment platform
Free	
Figma	UI/UX design

Free

CHAPTER 2

LITERARURE REVIEW

2.1 Introduction

The integration of Augmented Reality (AR) technology into the beauty industry has revolutionized the consumer experience, particularly through virtual makeup try-on applications. These applications allow users to visualize cosmetic products on their own faces in real-time, enhancing decision-making processes and personalizing the shopping journey. The increasing adoption of AR in this sector reflects a broader trend of leveraging immersive technologies to bridge the gap between digital convenience and physical product interaction.

This literature review aims to explore the theoretical foundations of AR makeup try-on applications, examine case studies of their implementation, discuss integration and architectural considerations, and identify existing research gaps.

2.2 Theoretical Review

Augmented Reality (AR) is an immersive technology that enhances the real-world environment by overlaying computer-generated content like images, animations, videos, 3D models, or text onto a user's view of the physical world. Unlike Virtual Reality (VR), which immerses users in a fully artificial environment, AR maintains a real-world context while enriching it with interactive digital elements.

This blending of physical and digital realms is achieved through a range of devices, including smartphones, tablets, smart mirrors, AR headsets, and smart glasses. These devices use cameras, sensors, and advanced software to recognize the physical surroundings, map them in real-time, and position virtual elements appropriately within the user’s field of view

Key Concepts

2.2.1: Facial Recognition And Tracking.

Utilizing computer vision algorithms, facial recognition technology identifies and maps facial landmarks. This mapping is crucial for accurately overlaying virtual makeup on specific facial features, ensuring a realistic and personalized experience.

2.2.2: Artificial Intelligence (AI) And Machine Learning (ML)

AI and ML algorithms enhance AR applications by improving facial feature detection, skin tone analysis, and personalized product recommendations. AI-powered shade finders analyze skin undertones to suggest suitable foundation shades, improving accuracy in color matching

AI-based algorithms can continuously learn from a user's face and skin tone, leading to increasingly accurate color-matching for makeup products. This is particularly helpful for recommending foundation shades or concealers.

Machine learning will be employed to adapt makeup application in real time based on the user's environment, movement, and interaction, improving the accuracy of virtual makeup under varying conditions.

2.2.3: Real-Time Rendering:

This technology ensures that virtual makeup is applied seamlessly in real-time, responding dynamically to user movements and expressions, thereby enhancing the interactive experience.

It utilizes 3D Facial Reconstruction of the user's face helps in providing a more accurate and dynamic representation of the face. With this, the makeup is applied more naturally to the curvature of the face, such as around the eyelids or the lips.

2.2.4: Marker-Based Vs. Marker Less AR:

Marker-based AR relies on predefined visual markers to trigger AR experiences. While effective in controlled environments, it is less adaptable for dynamic applications like makeup try-ons.

Marker less AR utilizes natural features, such as facial landmarks, for AR overlays. It offers greater flexibility and realism, making it more suitable for virtual makeup applications.

2.3 Case Study Review

L'Oréal Modiface

ModiFace, is an international leader in augmented reality and artificial intelligence for the beauty industry, which was acquired by L'Oréal in 2018, it provides AI-powered technology to enable the first virtual try-ons for cosmetics on Amazon. With this innovation, Amazon customers are able to use the front-facing camera on their mobile phone to digitally try on different shades of lipstick in a live video of themselves or on a selfie.

The uniqueness of the ModiFace technology which is run on Amazon Web Services lies in its photo-realistic results and automatic, AI-enabled shade calibration. ModiFace's proprietary technology allows retailers to seamlessly incorporate virtual try-on experiences for an unlimited amount of products. The AR simulation of each shade is done automatically, based on AI-powered analysis of information provided by makeup brands, but also images and descriptions of the product available on social media. The technology is able to analyze textual and visual information related to a particular makeup shade and to realistically reproduce it via Augmented Reality. (L'Oréal Groupe, 2019)

Sephora Virtual Artist

An AR tool that allows users to virtually try on makeup products, finding the perfect shade and style.

The AR implementation in Sephora Virtual Artist involves markerless facial tracking and overlay techniques. Utilizing facial recognition technology, the app precisely maps facial features and contours in real-time, ensuring accurate alignment of makeup products on the user's face. Technologies like dlib or OpenCV's built-in face detection and landmark detection functionalities are used. These technologies help map and track facial features, such as eyes, lips, and contours, allowing precise alignment of virtual makeup products.

Seamless blending and realistic rendering are achieved through advanced computer vision algorithms. The application utilizes image segmentation algorithms to accurately isolate different regions of the face for makeup application. Additionally, real-time rendering techniques are used to ensure that makeup products blend naturally with the user's skin tone and lighting conditions. (Sephora, 2016)

YouCam Makeup By Perfect Corp

Perfect Corp is the leading SaaS AI and AR beauty and fashion tech solutions provider, dedicated to transforming shopping experiences through empowering brands to embrace the digital-first world. Perfect Corp. offers a complementary suite of mobile apps, including YouCam Makeup and YouCam Perfect, to provide a consumer platform to virtually try-on new products, perform skin diagnoses, edit photos, and share experiences with the YouCam Community. (BusinessWire, 2023)

YouCam Makeup utilizes advanced facial detection and tracking technologies, capturing over 100 facial points in 0.02 seconds. This ensures precise and realistic virtual makeup application that moves seamlessly with facial expressions. (International Innovation Awards, 2018)

Live 3D Make up AR technology uses facial recognition, 3D renderings, skin tone analysis, texture matching, and light balancing to ensure hyper realistic makeup effects. Patented AR technology uses facial recognition, 3D renderings, skin tone analysis, texture matching, and light balancing to ensure hyper realistic makeup effects.

YouCam uses powerful AI technology and deep learning algorithms to make accurate facial detection, facial mapping, shade detection and color matching capabilities possible. The result is a true-to-life virtual makeover experience that helps users find the perfect product shades to match their skin tone and preferences. (BusinessWire, 2023).

2.3.1 Impact

The proposed AR system is highly effective in enhancing online shopping experience by addressing key user experience challenges. The case study above clearly indicates how AR has been used by different organization in the beauty industry and its impact on consumer shopping.

The proposed AR system will help increase consumer confidence in purchasing from JoannaK cosmetics since AR helps consumers visualize how make up products would look on their face in real time reducing uncertainty. (Erdmann et al, 2023)

The traditional online shopping often results in mismatched products due to inaccurate product representation leading to so many product returns. The proposed AR system helps customers choose the right product hence reducing the number of returned goods and minimizing product waste this benefit for both businesses and the consumer. (Wu, 2021)

Integration And Architecture

2.4.1: Integration

Web-based AR Technologies MediaPipe and WebRTC are the primary technologies used for creating immersive AR experiences in web browsers. They provide built-in support for facial tracking, environment understanding, and real-time rendering which are essential for applying virtual makeup accurately.

Integration with modern web development frameworks like Next.js and React allows direct access to camera APIs, real-time rendering engines, and device sensors through web standards.

E-commerce Platform Integration AR modules are embedded into e-commerce platforms using APIs and SDKs, enabling real-time virtual try-on directly within product pages. This seamless integration allows users to immediately try cosmetics while browsing and adding products to their cart without switching platforms. Integration with platforms like Shopify, Magento, or Woo Commerce are becoming more streamlined through plug-and-play AR widgets and cloud-based AR rendering services. This integration supports personalized product recommendations, synchronized inventory updates, and user analytics for marketers.

2.4.2 Architecture

Client-Server Frameworks: The client-server model is a common architectural choice for AR-based makeup try-on systems. The client side is responsible for handling camera input, rendering the virtual makeup, and presenting it to the user in real time. The server side is tasked with performing heavier computations such as AI-based facial recognition, makeup application algorithms, and data storage. This division allows for more efficient use of resources and ensures that complex processing does not slow down the user experience on the device itself.

Edge Computing: To improve speed and reduce latency, edge computing can be employed in AR makeup applications. Some of the data processing is handled on the user's device, reducing the need for constant communication with the server. This not only increases the responsiveness of the system but also enhances privacy by keeping sensitive data, like facial images, within the local device rather than transmitting it over the internet. (IBM, 2025)

Modular Design: This approach allows the makeup try-on system to be flexible and adaptable. In this design, individual components such as facial tracking, rendering engines, or

makeup filters can be updated independently e.g. a new facial tracking algorithm can be deployed without needing to overhaul the entire system. This architecture allows for continuous improvement and adaptation, ensuring the system stays up-to-date with the latest advancements in AR and AI technologies. (Tobias Martin, 2024)

Research Gaps

1. **Realistic Makeup Application -** While AR technology has made strides in virtual makeup try-ons, many apps still struggle to offer realistic makeup application across a wide variety of skin tones and ethnicities. The lack of diverse datasets for training AR algorithms can result in inaccurate makeup rendering for darker skin tones or non-standard facial features.
2. **Lighting and Environment Limitations:** Current AR makeup try-on systems often struggle to adapt to varying lighting conditions. Since makeup appearance is highly dependent on lighting, AR systems can provide inaccurate results if the user's environment is too bright, too dim, or poorly lit.
3. **Lack of Accessibility for Disabled Users:** Few AR makeup apps are designed with accessibility in mind for users with disabilities, such as visual impairments or motor skill challenges. Creating interfaces that accommodate these users remains a major gap in the industry.
4. **Cross-Device Compatibility:** Many AR makeup try-on systems are optimized for high-end devices with advanced processing power. However, users with budget smartphones or older devices may experience lag, inaccuracies in rendering, or app crashes, limiting the reach of these apps. AR apps designed for iPhones with powerful AR Kit frameworks may not work seamlessly on Android phones, especially older or budget models.
5. **Data Privacy and Security:** As AR makeup apps collect sensitive user data, such as facial images and skin tones, ensuring data privacy and security is paramount. There is a need for more robust data protection frameworks and transparent privacy policies to protect users' biometric data.
6. **Personalization and User Preference:** While many AR makeup apps offer basic personalization like skin tone matching, few incorporate deeper personalization such as product recommendations based on users' past behaviors, preferences, and style choices. Advanced AI that can recommend makeup based on face shape, style, or seasonal trends is still underdeveloped.

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APPENDICES

Project Schedule

Phase	Activity	Expected Start Date	Accurate Start Date	Expected End Date	Accurate End Date	Deliverable
Phase 1: Conceptualization and Planning	**Define core features (AR makeup, skin tone detection)**	**03/02/2025**		**07/02/2025**		**Feature specification document**
	Collaborate with stakeholder	**10/02/2025**		**21/02/2025**		**Gather requirements**

Phase	Activity	Expected Start Date	Accurate Start Date	Expected End Date	Accurate End Date	Deliverable
	Proposal Drafting	25/02/2025		31/03/2025		Document Chapter 1 and 2
Phase 2: Sprint Planning	Sprint backlog setup & task distribution	04/03/2025		09/03/2025		Breakdown taks
Phase 3: Design and Prototyping	Create wireframes & UI mockups	10/03/2025		12/03/2025		UI mockups
	Design system architecture	13/03/2025		19/03/2025		Architecture document
	Develop AR prototype for testing	20/03/2025		28/03/2025		AR test prototype
Phase 4: Development	Develop facial detection module	01/04/2025		10/04/2025		Facial tracking module
	Integrate AR makeup overlays	11/04/2025		20/04/2025		Real-time AR makeup module
	Implement AI for shade matching	21/04/2025		28/04/2025		Shade matcher AI
	Backend development & product DB	29/04/2025		07/05/2025		Backend and product API
	Complete full app prototype	08/05/2025		15/05/2025		Functional Web-based AR Try-On app
Phase 5: Testing and Feedback	Perform unit testing	16/05/2025		22/05/2025		Unit test report
	Integration testing	23/05/2025		30/05/2025		Integration report

Phase	Activity	Expected Start Date	Accurate Start Date	Expected End Date	Accurate End Date	Deliverable
	User experience testing	31/05/2025		06/06/2025		Feedback report
	Gather user feedback	07/06/2025		10/06/2025		Feedback & improvement log
Phase 6: Iteration and Refinement	Fix bugs and improve features	11/06/2025		17/06/2025		Bug report & revised build
	Optimize AR and performance	18/06/2025		24/06/2025		Performance-improved build
Phase 7: Deployment and Monitoring	Finalize deployment plan	25/06/2025		27/06/2025		Deployment document
	Deploy demo app	28/06/2025		05/07/2025		Deployed Web-based AR makeup app
	Monitor user activity & analytics	06/07/2025		12/07/2025		User analytics report
Phase 8: Continuous Improvement	Release updates	13/07/2025		20/07/2025		Updated app release
	Add advanced AR features	21/07/2025		10/08/2025		Enhanced AR capabilities

Gantt Chart

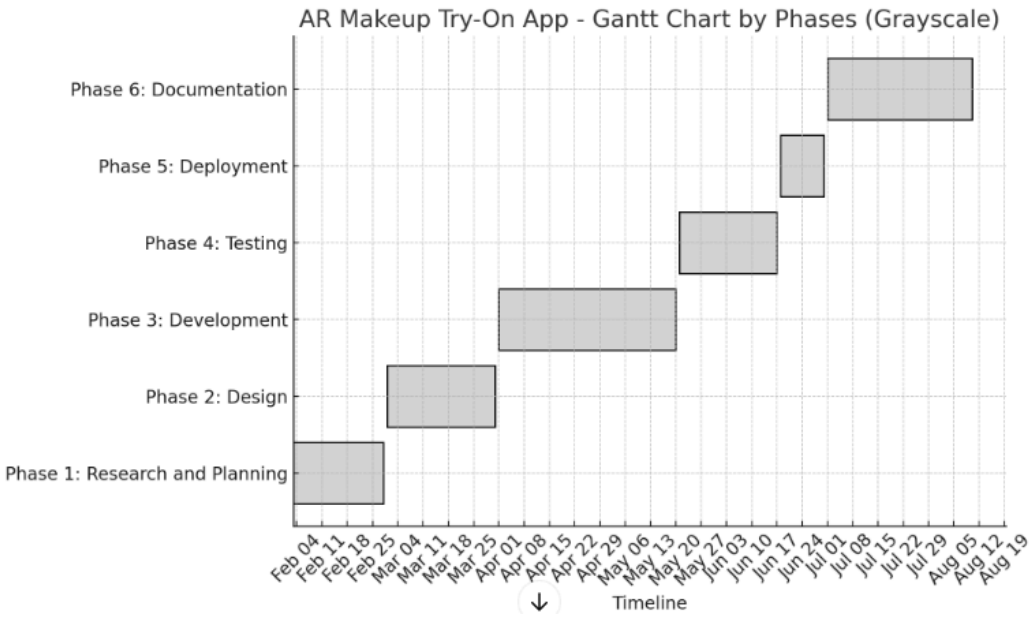

Figure 0-1 Gantt chart

Budget

ITEM	**COST(Kshs)**
Internet and Airtime	**4000**
Printing	**1000**
Transport	**2000**
Laptop	**54000**
Extra Expenses	**3000**
TOTAL	**64000**