Faculty of Computer Science and Information Technology

A Web-Based Foot Measurement System Using Smartphone Camera for Accurate Foot Dimension Calculation

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Bachelor of Computer Science with Honours

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Figure ***Error! No text of specified style in document.****.1: Gantt chart of the project schedule for Final Year Project 1*

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A Web-Based Foot Measurement System Using Smartphone Camera for Accurate Foot Dimension Calculation

KEVIN WONG KING YOU

This Final Year Project is submitted in partial fulfillment of the requirements for the degree of

Bachelor of Computer Science with Honours

(Computational Science)

Faculty of Computer Science and Information Technology

UNIVERSITI MALAYSIA SARAWAK

2025

Sistem Pengukuran Kaki Berasaskan Web Menggunakan Kamera Telefon Pintar untuk Pengiraan Dimensi Kaki yang Tepat

KEVIN WONG KING YOU

Projek ini merupakan salah satu keperluan untuk Ijazah

Sarjana Muda Sains Komputer dengan Kepujian

Fakulti Sains Komputer dan Teknologi Maklumat

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Abstract

The rapid growth of online shopping has created a demand for accurate and convenient foot measurement methods to ensure proper shoe sizing. Traditional approaches like manual measurements or in-store visits are often inaccurate and time-consuming, leading to high return rates and customer dissatisfaction. This project proposes a web-based foot measurement system that enables users to accurately measure their foot dimensions using a smartphone camera. Accessed via a QR code, the system directs users to a web application with instructions for scanning their foot alongside a standard reference object, such as an A4 paper, for calibration, leveraging image processing techniques to calculate foot dimensions from the captured image. By providing a user-friendly and accessible solution for remote foot measurement, the system aims to improve size determination accuracy for online shoppers. Evaluation of the system revealed strong performance, with a Mean Absolute Error (MAE) of just 0.18 EU sizes based on 10 tested samples—80% of which were exact matches, and 90% within ±0.5 size. Further testing showed that the best results were achieved when the phone was positioned at 40 cm height, angled at 90°, and the foot was properly aligned, emphasizing the importance of correct image capture setup to ensure consistent accuracy.

Abstrak

Pertumbuhan pesat dalam pembelian dalam talian telah mewujudkan permintaan terhadap kaedah pengukuran kaki yang tepat dan mudah bagi memastikan saiz kasut yang sesuai. Pendekatan tradisional seperti pengukuran manual atau lawatan ke kedai sering kali tidak tepat dan memakan masa, menyebabkan kadar pemulangan yang tinggi serta ketidakpuasan pelanggan. Projek ini mencadangkan satu sistem pengukuran kaki berasaskan web yang membolehkan pengguna mengukur dimensi kaki mereka dengan tepat menggunakan kamera telefon pintar. Sistem ini boleh diakses melalui kod QR dan membawa pengguna ke aplikasi web yang menyediakan arahan untuk mengimbas kaki bersama objek rujukan standard seperti kertas A4 bagi tujuan penentukuran, dengan menggunakan teknik pemprosesan imej untuk mengira dimensi kaki daripada imej yang dirakam. Dengan menyediakan penyelesaian yang mesra pengguna dan mudah diakses untuk pengukuran kaki dari jarak jauh, sistem ini bertujuan untuk meningkatkan ketepatan penentuan saiz bagi pembeli dalam talian. Penilaian sistem menunjukkan prestasi yang memberangsangkan, dengan Ralat Mutlak Purata (MAE) hanya 0.18 saiz EU berdasarkan 10 sampel yang diuji—80% daripadanya adalah padanan tepat, dan 90% berada dalam julat ±0.5 saiz. Ujian lanjut menunjukkan keputusan terbaik dicapai apabila telefon diletakkan pada ketinggian 40 cm, dengan sudut 90°, dan kaki diselaraskan dengan betul, menekankan kepentingan tetapan tangkapan imej yang betul untuk memastikan ketepatan yang konsisten.

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CHAPTER 1

INTRODUCTION

1.1Background of Study

Accurate foot measurement plays a crucial role in determining the correct shoe size, whether for online purchases or physical store visits. Footwear that fits poorly can cause discomfort, reduce mobility, and lead to foot and posture problems. Wearing shoes that fit properly helps reduce friction and pressure on the skin, preventing issues such as blisters, calluses, and corns. Additionally, well-fitted shoes improve balance, reducing the risk of falls and injuries (SelectFlex, 2023). Despite its importance, traditional foot sizing methods, such as using a tape measure or trying on shoes in stores, are often time-consuming and prone to human error. The discrepancies in shoe sizing standards between different brands and regions further complicate the process, leading to consumers frequently ending up with shoes that do not fit properly.

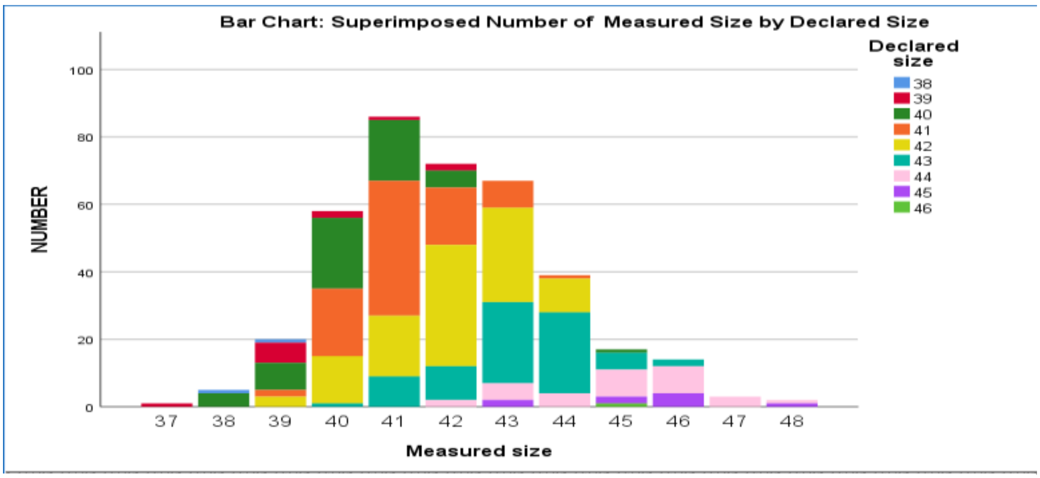

Figure 1.1: Comparison of declared and measured shoe sizes among participants, showing the most common shoe sizes for both groups1 (Miliani, Cherid, & Rachedi, 2022).

As depicted in Figure 1.1 (Miliani, Cherid, & Rachedi, 2022), foot measurements were compared between the shoe sizes declared by the participants and those obtained through pedometer measurement. The study involved 384 trainees aged between 17 and 21 years. It was found that the declared shoe sizes ranged from 38 to 46, with size 42 being the most common (26.76%). However, the foot size measurements showed a different trend, with size 41 being the most frequent (22.4%). The discrepancy between declared and measured sizes is statistically significant, with 65.1% of participants wearing shoes that did not fit properly.

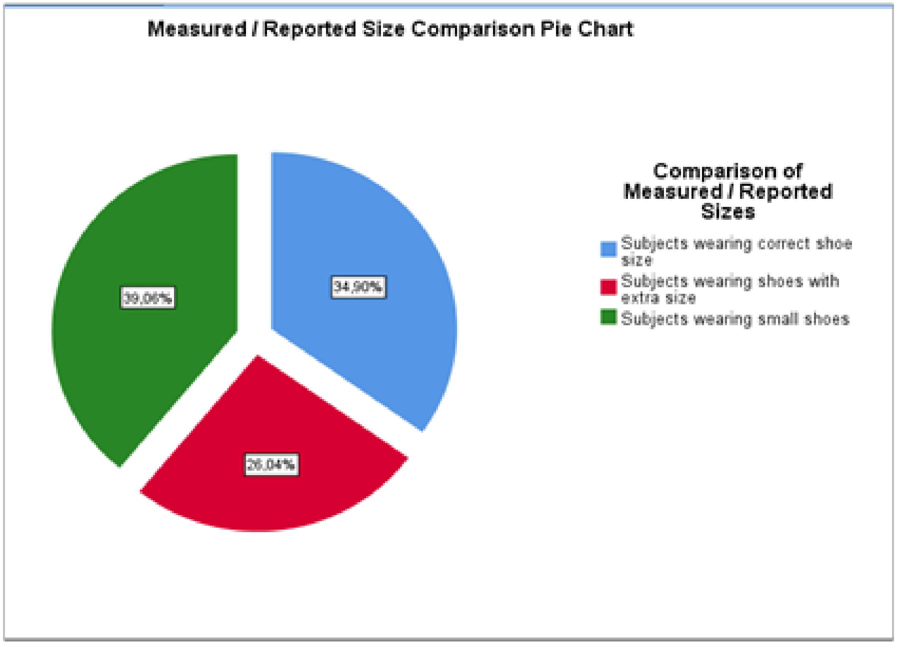

Figure 1.2: Proportions of participants wearing incorrect shoe sizes (Miliani, Cherid, & Rachedi, 2022).

The intra-individual comparison from Figure 1.2 (Miliani, Cherid, & Rachedi, 2022) revealed that 65.1% of participants wore the wrong shoe size. Among these, 39.1% wore shoes that were too small, and 26% wore shoes that were too large. Only 34.9% of participants wore the correct shoe size. These findings indicate that a significant proportion of individuals wear shoes that do not match their foot measurements, leading to potential discomfort and health issues.

In online shopping, the lack of precise sizing methods is particularly problematic. Customers often resort to ordering multiple sizes of the same shoe and returning the ones that do not fit, leading to higher return rates and increased logistical costs for retailers. Estimates suggest that footwear returns account for a significant percentage of total online returns, often due to sizing issues, with reports indicating that return rates for shoes purchased online can range from 20% to 35% (High Heels Daily, 2017). This not only impacts on the profitability of retailers but also contributes to waste and environmental concerns due to the increased shipping and packaging associated with returns.

Similarly, in physical stores, while customers have the advantage of trying on shoes, the accuracy of manual foot measurement tools, such as Brannock devices, can still vary. Additionally, manual measurements may not account for specific foot characteristics such as width, arch height, and other dimensions that can significantly affect fitness. As a result, even shoppers in physical stores may struggle to find footwear that offers the best possible comfort and support (SelectFlex, 2023).

Advanced technological solutions have emerged to address these issues, including digital foot scanners and mobile applications designed for foot measurement. However, these methods come with their own limitations. Foot scanners typically require specialized hardware that is costly and not accessible to the average shop owner, while some mobile apps demand complex calibration processes and often necessitate downloading dedicated software. These barriers reduce the practicality of such solutions for everyday consumers, limiting the widespread adoption of accurate foot measurement techniques.

To address these challenges, this project proposes a web-based foot measurement system that leverages the ubiquity of smartphones. Users will be able to access the system via a QR code, leading them to a web application that provides instructions for scanning their foot alongside a standard reference object, such as an A4 paper, for calibration. The system will utilize image processing techniques to measure foot dimensions accurately, including length, width, and other relevant metrics, which are crucial for a proper fit. This approach aims to simplify the foot measurement process, making it accessible to both online shoppers and those in physical stores seeking more precise sizing.

1.2 Problem Statement

Shoe size mismatches arise from several factors, including limited knowledge about proper sizing, cultural habits such as inheriting shoes within families, using second-hand footwear, and challenges faced by those with exceptionally large or small feet. Furthermore, imported footwear often fails to account for local foot shapes, leading to frequent sizing inconsistencies (Miliani, Cherid, & Rachedi, 2022). Ill-fitting shoes can cause more than discomfort—they may result in significant foot health issues like instability, painful blisters, claw toes, fractures, and calluses, which can affect daily life and overall well-being. To address these concerns, precise foot measurement is crucial for reducing these risks and achieving better shoe fit. This project highlights the need for accessible and accurate foot measurement tools, aiming to improve shoe comfort, promote foot health, and enhance the overall quality of life.

1.3 Project Scope

The project scope involves developing a web-based foot measurement system accessible via QR code, allowing users to scan their foot using a smartphone camera. The system will use an A4 paper as a calibration reference to measure key foot dimensions, such as length and width, through an accurate image-processing algorithm. It aims to provide an intuitive user interface that guides users through the scanning and uploading process. Testing will evaluate the system's accuracy and usability against traditional measurement tools, refining the design based on user feedback. Constraints include limitations due to environmental factors, such as lighting, and the system's inability to offer personalized shoe recommendations.

1.4 Objectives

The objectives of this project are to:

- Design a Web-Based Foot Measurement System
- Develop the proposed Web-Based System.
- Evaluate the Functionality and Accuracy of the Proposed System

1.5 Methodology

This section describes the structured approach used to guide the development of the project. A clear methodology ensures each phase is planned, executed, and evaluated effectively. It also helps maintain consistency and quality throughout the project lifecycle.

1.5.1 Development Methodology

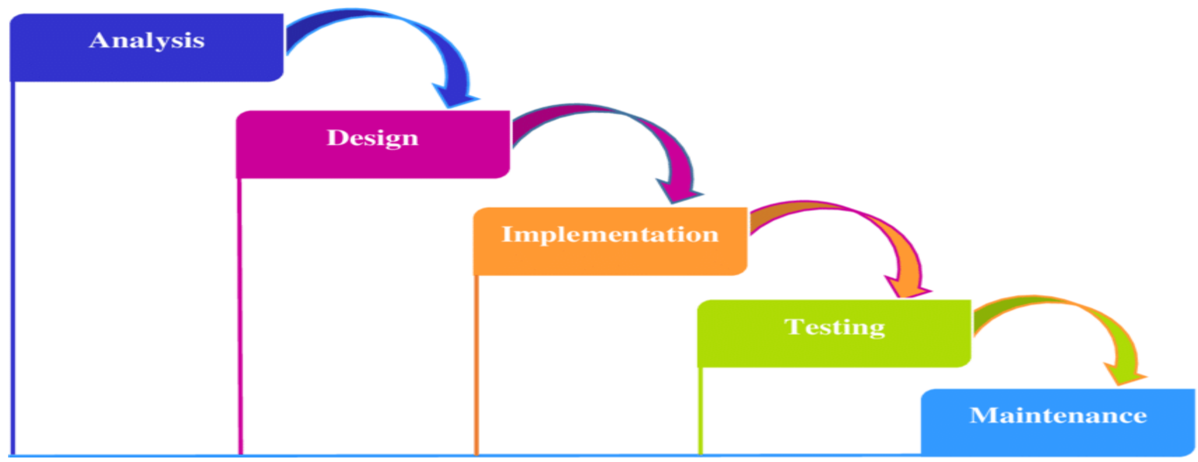

Figure 1.3: Waterfall Methodology (Senarath, 2021).

Figure 1.3 (Senarath, 2021) illustrates the structured methodology adopted for this project, following the principles of the Waterfall Methodology. This approach is highly sequential, where each phase must be fully completed before progressing to the next. It is designed for projects with clear, well-defined requirements, minimizing changes once development begins (Senarath, 2021). This structured methodology ensures a clear and organized process, making it particularly suited for developing a precise and reliable foot measurement system.

The project begins with the Requirement Analysis phase, which focuses on establishing a solid foundation by defining the project's objectives, understanding the problem statement, and gathering detailed system requirements. This phase involves consulting stakeholders to clarify expectations and conducting research on existing foot measurement technologies and relevant image processing techniques. These efforts are crucial to identify the technical challenges and inform the direction of the project (Senarath, 2021).

The next phase, System Design involves both logical and physical design aspects. The logical design includes developing flowcharts, Data Flow Diagrams (DFD), and Entity-Relationship Diagrams (ERD) to ensure the system's functionality is well-mapped. On the physical side, wireframes and user interface layouts are crafted to provide a clear and intuitive user experience (Senarath, 2021). By thoroughly planning these aspects, a strong blueprint is created to guide the subsequent development phase.

In the Development and Implementation phase, the design is translated into functional code. Using Python and image-processing libraries such as OpenCV, the foot measurement algorithm is developed. To ensure measurement accuracy, A4 paper is used as a reference for scaling. The development process adheres to the structured design established earlier, ensuring alignment with the project's initial objectives (Senarath, 2021). This disciplined approach facilitates consistency throughout the implementation.

The Testing and Evaluation phase ensures the system's accuracy before deployment. As noted by Senarath (2021), rigorous testing in the Waterfall methodology helps identify issues early. Real foot samples were used to compare estimated and actual measurements, while factors like mobile height, foot placement, and camera angle were tested to determine optimal conditions. These findings support system improvements and a better user experience.

1.5.2 Software and Skills

The proposed foot measurement system integrates several technologies to ensure efficient development and accurate performance. Visual Studio Code served as the primary IDE, supporting both frontend and backend development with its rich extension ecosystem. The interface was built using Streamlit, enabling rapid deployment of a responsive and interactive web app directly from Python scripts. SQLite was used as the local database solution, providing lightweight and efficient data storage for user foot measurements without requiring a server setup. OpenCV powered the core image processing pipeline, handling tasks such as image resizing, normalization, and edge detection to extract accurate foot measurements using A4 paper as a reference. Additionally, Scikit-image was employed to extract Histogram of Oriented Gradients (HOG) features, enhancing texture analysis and improving the overall reliability of the measurement process.

1.6 Significance of Project

The primary goal of this foot measurement system project is to enhance the shopping experience for customers by providing an accessible, accurate tool to measure foot dimensions without needing specialized devices. By enabling customers to scan QR code, access the web-based platform, and follow straightforward instructions to upload their foot scan, the system offers a user-friendly approach that can be accessed from anywhere. This project addresses the challenges of inconsistent shoe sizing and enhances convenience for online and in-store shoppers by providing precise measurements that help minimize the risk of incorrect shoe size selections. Additionally, this tool promotes inclusivity, offering a solution that benefits users who may face difficulties with in-store fittings. Overall, this project aims to contribute to the retail experience by improving size accuracy, reducing returns, and encouraging an efficient and user-centered approach to shopping.

1.7 Project Schedule

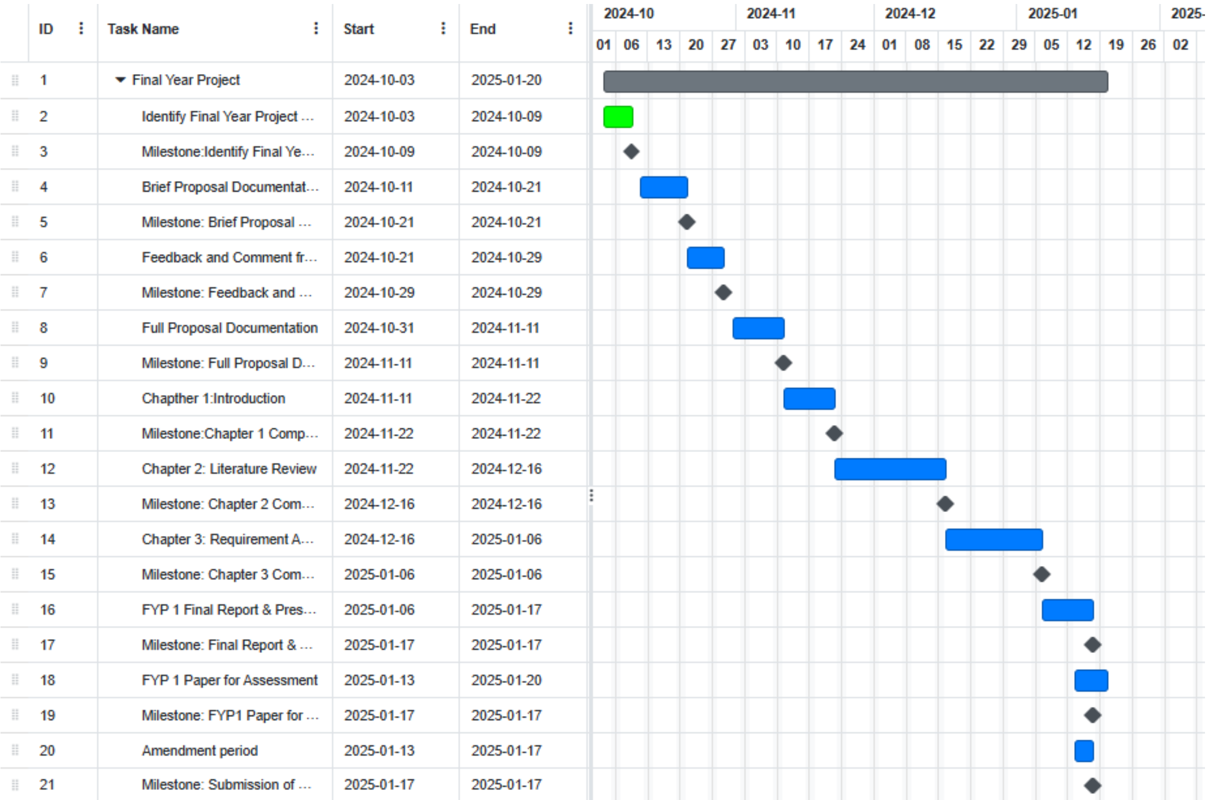

Figure 1.4: Gantt chart of the project schedule for Final Year Project 1

As shown in Figure 1.4, Final Year Project 1 started from 3rd October 2024 to 17th February 2025 with the submission of project paper assessment, Chapter 1: Introduction, Chapter 2: Literature Review, and Chapter 3: Requirement Analysis and Design thus the pre-record presentation.

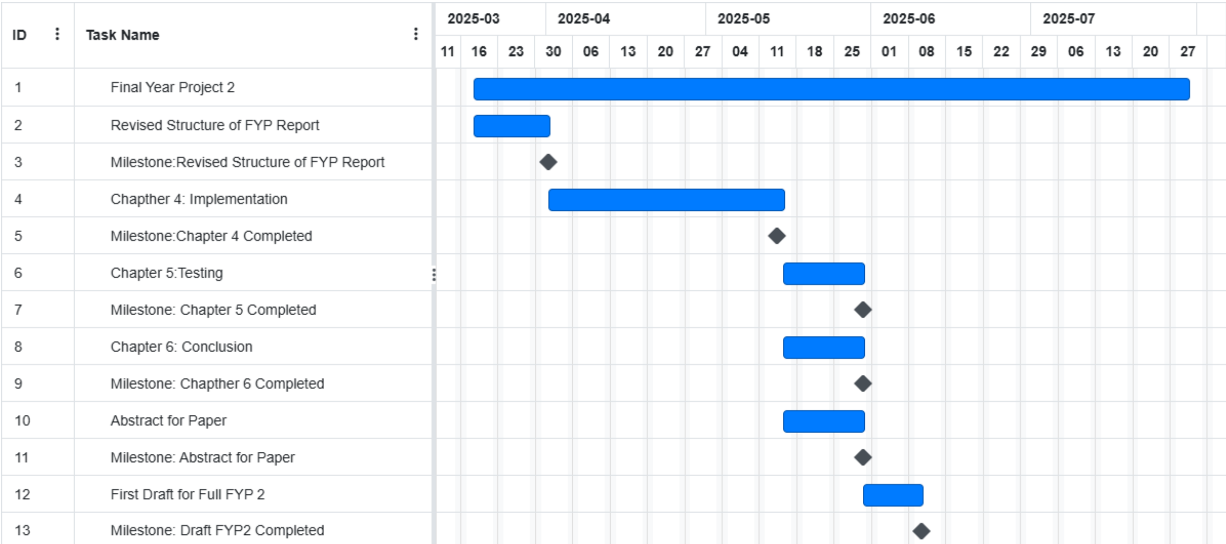

Figure 1.5: Gantt chart of the project schedule for Final Year Project 1

As shown in Figure 1.5, Final Year Project 2 started from 18th March 2025 to 10th Jun 2025 with the submission of project paper assessment, Chapter 4: Implementation, Chapter 5: Testing and Analysis, and Chapter 6: Conclusion

1.8 Expected Outcome

The expected outcome of this project is a web-based foot measurement tool accessible via QR code scanning. It will allow users to measure their foot dimensions accurately by following on-screen instructions and uploading a foot image taken alongside an A4 paper for scale. This system will provide users with precise measurements across key dimensions of the foot, eliminating the need for specialized equipment. By offering clear, consistent sizing data, the platform aims to improve both online and in-store shopping experiences, helping users choose more accurate sizes and reducing returns related to sizing issues.

1.9 Project Report Outline

This project report is structured into three key chapters, each focused on a distinct aspect of the project development process.

Chapter 1 provides an overview of the project, introducing the concept of a web-based foot measurement system aimed at improving the shopping experience for users. It outlines the background, problem statement, and objectives, detailing the scope and significance of the system. This chapter also presents the expected outcomes, the project methodology, and a brief description of the project schedule. Additionally, it highlights the structure of the entire report, offering a roadmap for the following chapters.

Chapter 2 reviews the existing technologies, tools, and systems related to foot measurement and online shopping. It includes a comparative analysis of similar systems, evaluating their strengths, weaknesses, and how they address challenges in size accuracy for shoes. This chapter sets the foundation for the proposed system by analyzing current solutions and identifying gaps that the new system aims to address.

Chapter 3 focuses on defining the technical and functional requirements of the system. The chapter details the design methodologies, such as the Waterfall methodology, used to guide the development process. It includes a breakdown of the logical and physical design, describing the system architecture, the data flow, and the user interface design. Visual representations, such as activity diagrams and wireframes, will be provided to demonstrate the system's design.

Chapter 4 details the development of the foot measurement system, built in Python using Visual Studio Code with Streamlit for the interactive web interface. OpenCV handles image processing tasks like background filtering and foot segmentation, while SQLite manages user data and measurement history. The system supports both image upload and instant capture, followed by smart filtering, A4 paper classification, and conversion of results into multiple international shoe sizes. Key interfaces include the foot measurement screen, user authentication pages, a personalized user dashboard, and an admin panel with tools for system management and feedback response, ensuring both usability and system control.

Chapter 5 presents the testing procedures and results that validate the system's performance. Environmental testing assessed the impact of camera height, foot placement, and phone angle, identifying optimal conditions for accurate measurement—40 cm height, centered foot, and 90° camera angle. Accuracy testing, using 10 real foot samples, showed a Mean Absolute Error of 0.18 EU sizes, with 90% of predictions falling within ±0.5 size, confirming the system's precision. These tests demonstrate that the system provides consistent and reliable results, while also offering guidelines to users for best practices in image capture.

Chapter 6 summarizes the project by highlighting its success in delivering an accurate, user-friendly foot measurement system with features like secure login, size recommendations, and user feedback integration. The system meets its goal of simplifying foot measurement and improving online footwear selection. However, current limitations include the lack of 3D scanning, no direct integration with online retailers, and reliance on good camera quality. Future enhancements will focus on 3D scanning capabilities, e-commerce integration, and improved processing for varied camera inputs, aiming to extend the system's use in health, sports, and online shopping applications.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter explores existing systems for foot measurement, with a particular focus on online tools and technologies. By reviewing and comparing these systems, as well as examining some of the key technologies involved, the analysis highlights their strengths, weaknesses, and the insights they provide, which are essential for the development of the proposed system.

2.2 Review of Similar Existing System and Articles

This section reviews three existing systems or platforms: "Volumental," "SizeWise," and "FindMeAShoe." In the following section, the key features of each system are examined in detail.

2.2.1 Volumental

Volumental, founded to revolutionize the shoe shopping experience, offers innovative services that combine 3D foot scanning, retail purchase data, and artificial intelligence (AI) to deliver personalized footwear recommendations. By providing a seamless integration between in-store and online experiences, Volumental helps consumers find the perfect fit with ease. The platform focuses on enhancing the consumer journey by enabling 3D foot scans and offering tailored shoe recommendations from retail partners (Volumental, 2023).

The core objective of Volumental is to make footwear shopping more personalized and accessible by using advanced technology to match consumers with shoes that fit their unique foot profiles. This is achieved through Volumental's 3D foot scanning service, which allows users to create a digital model of their feet either in-store or via a web-based scan. The service integrates seamlessly with e-commerce features, such as the Volumental e-commerce Widget, to provide online shoe recommendations and help consumers make informed purchasing decisions.

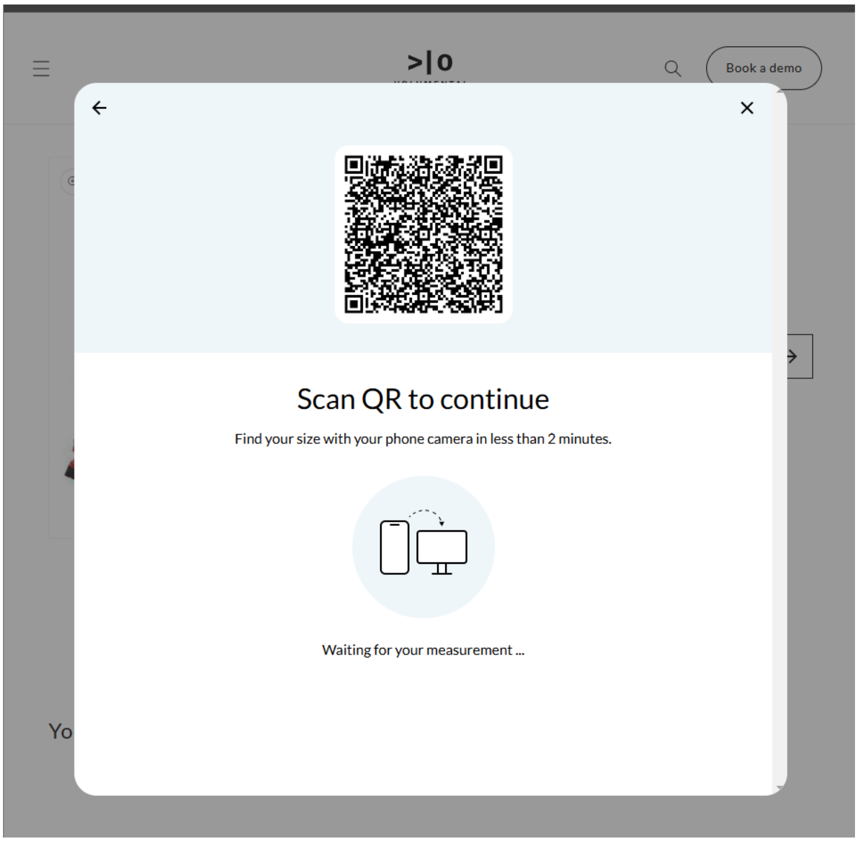

Figure 2.1: Volumental QR code for foot scanning (Volumental, 2023).

Figure 2.1 showcases the online foot scanner, which facilitates 3D foot measurements for creating a detailed foot profile.

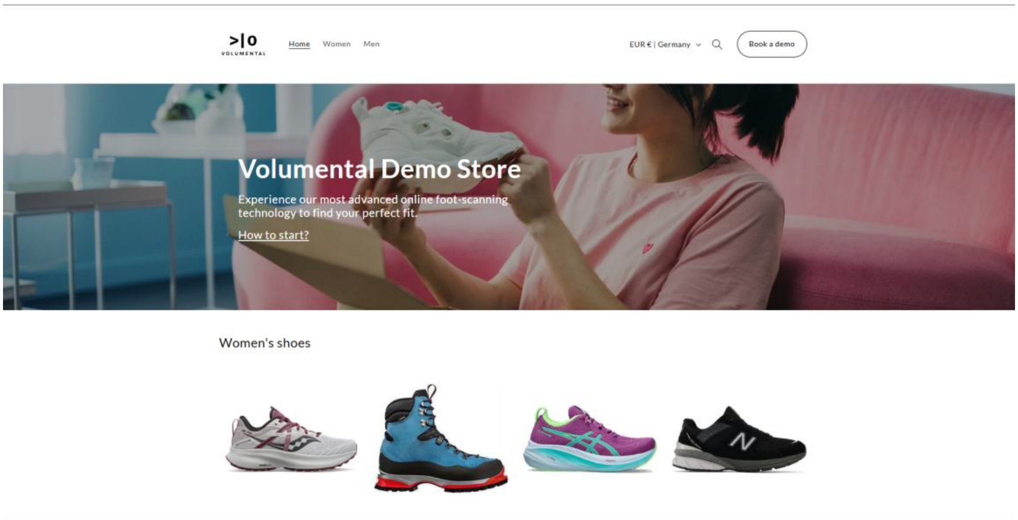

Figure 2.2: The main page of Volumental (Volumental, 2023).

Figure 2.2 highlights the main page, likely to present an overview of the platform's features and services. Together, these visuals emphasize the platform's user-friendly design and advanced scanning technology, which enhance the overall shoe shopping experience.

Table 2.1: Pages and functions of Volumental

Pages/ Functions	Description
Multi-brand Compatibility	Supports various shoe brands, allowing retailers to cater to a broader range of customers.
Foot Scan	Users can perform a 3D foot scan online to generate a digital model of their feet.
Shoe Recommendations	Based on the foot scan and personal data, Volumental provides tailored shoe recommendations from retail partners.
Retail Partner Integration	Users can share their foot scan with retail partners for an optimized shoe shopping experience both in-store and online.

Volumental Widget	This e-commerce widget allows users to receive shoe recommendations directly on partner retail websites.

Table 2.1 summarizes the key pages and functionalities of Volumental, highlighting features such as multi-brand compatibility, 3D foots scanning, personalized shoe recommendations, and integration with retail partners through tools like the Volumental Widget. These functionalities make Volumental a versatile tool for both in-store and online shoe shopping experiences.

Strengths

- Convenience

Requires only a smartphone camera, making it accessible without the need for specialized hardware or in-store visits.

- AI-Driven Accuracy

Uses advanced AI to analyze foot shape and volume, providing more precise size recommendations than traditional length-based methods.

Weaknesses

- Limited to Retail Partners

The effectiveness of Volumental's service is dependent on the number and engagement of retail partners. If a consumer's preferred store is not a partner, they may not benefit from the full range of services offered.

- Potential User Error

Scan accuracy may be affected by poor lighting, incorrect angles, or improper foot positioning during the scanning process.

The Volumental web application is designed to offer a personalized and seamless shoe-shopping experience by using AI-driven foot scanning. It creates a detailed foot profile with just a smartphone, helping customers find the best-fitting shoes and reducing return rates. A key strength is its data-driven approach, which enhances decision-making and improves overall shopping satisfaction. However, a limitation is that its availability is restricted to partnered retailers, making it inaccessible for some customers. Additionally, while the process is convenient, user errors such as poor lighting or incorrect angles may affect scan accuracy.

2.2.2 FindMeAShoe

FindMeAShoe is an online platform designed to help users find perfect-fitting shoes based on their unique foot measurements. The platform utilizes advanced technology such as 3D foot scanning to provide personalized shoe recommendations, aiming to improve the online shoe shopping experience by ensuring a better fit and reducing returns. By allowing customers to create a detailed foot profile, FindMeAShoe offers a tailored solution to the common problem of buying shoes that don't fit well, enhancing customer satisfaction (FindMeAShoe, n.d.).

Figure 2.3:The main page of FindMeAShoe (FindMeAShoe, n.d.).

Figures 2.3 illustrate the main interface of FindMeAShoe. The main page provides an overview of the platform's features. These visuals help users understand the platform's ease of use.

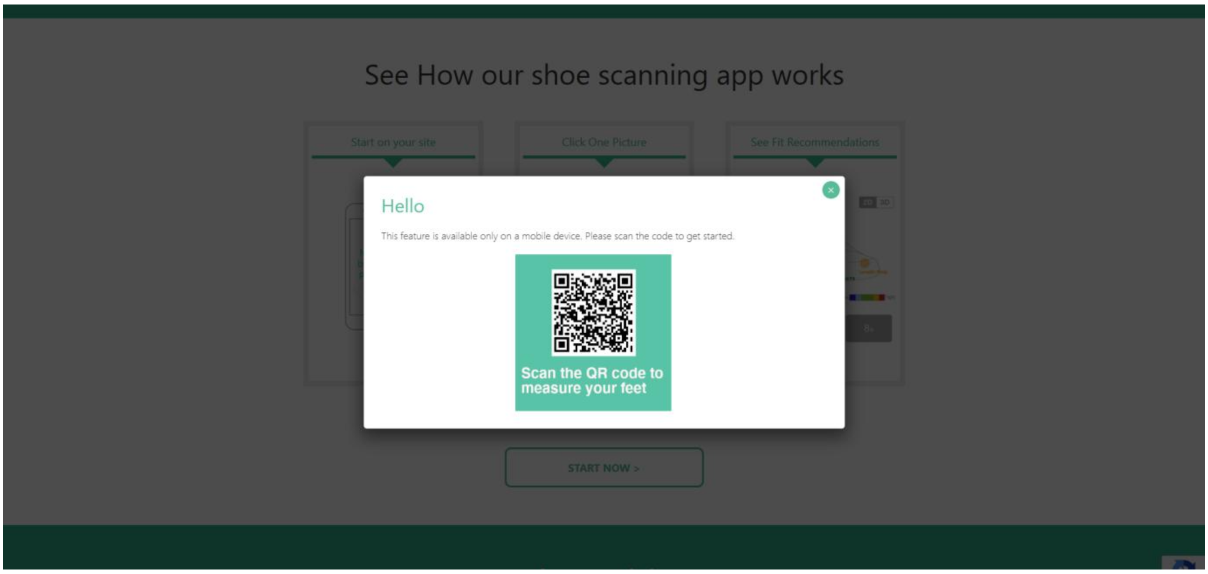

Figure 2.4: Scanning page for FindMeAShoe (FindMeAShoe, n.d.).

Figure 2.4 illustrates the scanning process of FindMeAShoe. The page provides a QR code for users to scan so they will enter the foot scanning process.

Table 2.2: Pages and Functions of FindMeAShoe

Function	Description
Foot Measurement	Captures foot dimensions (length, width, arch height) using 2D or 3D scanning technology or smartphone cameras.
Size Matching	Matches foot measurements to appropriate shoe sizes across different brands and regions.
Fit Prediction	Uses AI to predict how well a shoe will fit based on user-provided feedback and foot measurements.
Feedback and Learning	Gathers user feedback on fit and comfort to refine AI recommendations over time.
Multi-Device Support	Ensures functionality across smartphones, tablets, and desktops for convenience.

Global Size Conversion	Converts shoe sizes between different sizing systems (e.g., US, UK, EU, CM).

Table 2.2 provides an overview of FindMeAShoe's functionalities, including foot measurement, size matching, AI-driven fit prediction, and global size conversion. These features aim to enhance the online shoe shopping experience by providing accurate, personalized shoe recommendations.

Strengths:

- Easy and Accessible

FindMeAShoe works with any smartphone camera through a web browser, requiring no additional hardware.

- User-friendly interface

The platform is simple to navigate, offering an intuitive interface that allows users to easily input foot measurements or use 3D scanning technology to generate personalized shoe fits.

Weaknesses:

- Retailer Limitations

The service is currently only available in certain locations and with specific retailers, limiting its accessibility to a wider audience.

- Device Compatibility

The system might not work equally well across all devices, especially older or lower-end smartphones with less powerful cameras.

In summary, FindMeAShoe offers an accessible and user-friendly solution for online shoe shopping, using AI-powered foot scanning to provide brand-specific size recommendations. Its web-based platform eliminates the need for app downloads, making it convenient for users. However, its 2D-based scanning lacks the precision of 3D depth sensing, which may affect accuracy. Additionally, the service is limited to partnered retailers, and scan quality depends on proper lighting and foot positioning. As the platform improves accuracy and expands its partnerships, it has the potential to enhance online shopping experience by reducing sizing issues and returns (FindMeAShoe, 2023).

2.2.3 Sizewise

SizeWise is an AI-driven online platform designed to improve the accuracy and convenience of shoe shopping by providing personalized size recommendations. Using foot scanning and proprietary algorithms, it matches users with the best-fitting shoes based on their unique foot shape and measurements, rather than relying on standard sizing charts. This approach enhances the online shopping experience and reduces return rates caused by poor fit (SizeWise AI, n.d.).

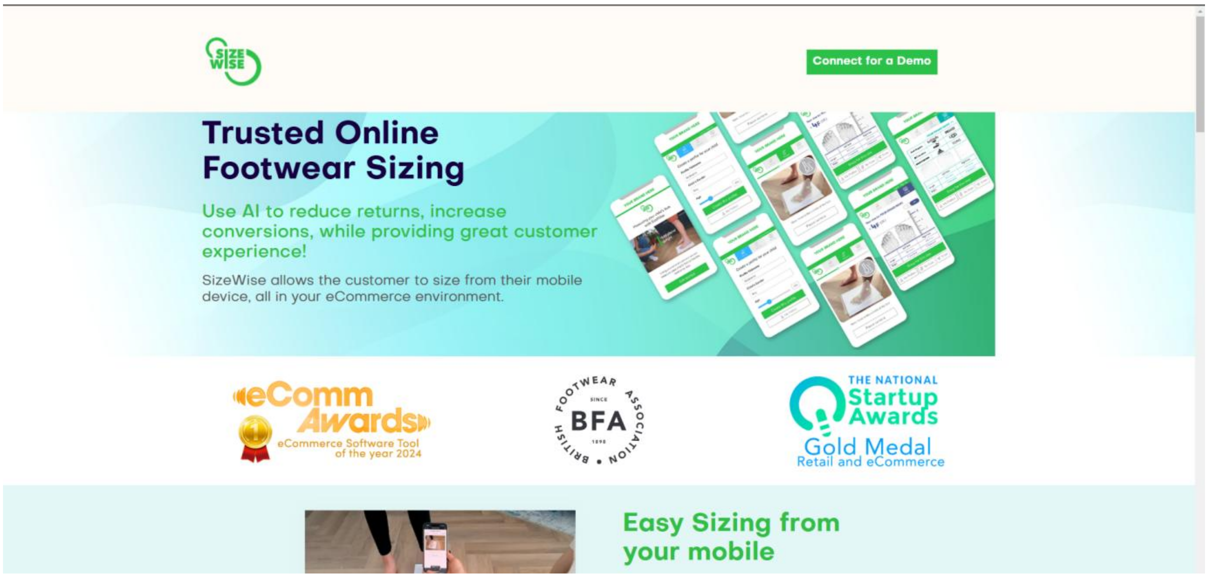

Figure 2.5: The main page of Sizewise (SizeWise AI, n.d.).

Figure 2.5 shows the Sizewise platform's main interface. The main page provides a general introduction to the platform's services,

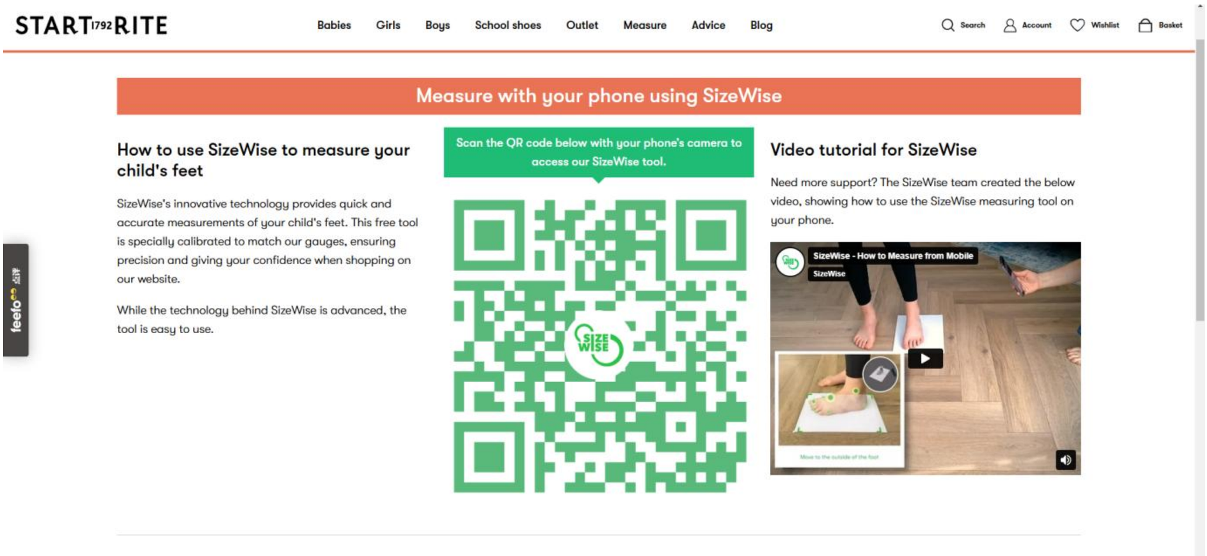

Figure 2.6: Scanning page of Sizewise (SizeWise AI, n.d.).

Figure 2.6 shows the Sizewise platform's scanning process. Like the others, it provides a scannable QR code for users to access the foot measurements process.

Table 2.3: Pages and Functions of Sizewise

Function	Description
Foot Dimensions Measurement	Measures key foot dimensions like length, width to determine foot size.
Measurement Standardization	Convert raw foot measurements into standardized sizes (e.g., US, EU, UK) for easy comparison and use.
Fit Analysis (Non-shoe-related)	Analyzes foot measurements and gives general insights about fit for comfort, without recommending shoes.
Scan Accuracy Feedback	Provides feedback to users about the scan's quality, highlighting areas that may need rescue due to errors.
Foot Size Output	Outputs the foot's detailed measurements (e.g., length, width, arch) in a user-friendly format.

Table 2.3 outlines Sizewise's features, such as foot dimensions measurement, measurement standardization, and scan quality feedback. These functionalities are designed to provide users with highly accurate shoe size recommendations and improve the overall shopping experience.

Strengths:

- Highly accurate size recommendations

Sizewise uses a combination of foot scanning and machine learning algorithms to provide users with highly accurate shoe size recommendations. By considering not just foot length, but also width, arch type, and foot shape, Sizewise helps customers find shoes that fit well from the start, reducing the likelihood of returns due to size discrepancies.

- Reduced returns and exchanges

Since users are provided with personalized shoe size recommendations, the likelihood of purchasing shoes that don't fit is greatly reduced. This not only enhances customer satisfaction but also benefits retailers by reducing the financial and logistical costs associated with returns and exchanges.

Weaknesses:

- Limited availability

Sizewise, like other personalized shoe fitting platforms, is only available through a select number of retail partners and in certain regions. This restricts its accessibility to users who are outside of these areas or who don’t have access to participating retailers.

- User Skill Requirement:

The user must follow instructions carefully (e.g., proper foot positioning during the scan), which may be a barrier for less tech-savvy individuals or those unfamiliar with the process.

In summary, SizeWise provides an effective solution to the challenge of ill-fitting shoes by offering personalized size recommendations through advanced AI technology. Its accuracy and user-friendly interface make it a strong contender in the online shoe shopping market. However, its effectiveness depends on capturing precise foot images, which can be challenging due to factors like poor lighting, incorrect angles, or improper positioning. As the platform improves its scanning technology and user guidance, it has the potential to enhance accessibility and create a more reliable and convenient shoe shopping experience for users worldwide. (Sizewise, 2023).

2.3 Comparison of features in the reviewed existing system

Table 2.4 presents a detailed comparison of various shoe-fitting systems, focusing on essential features that enhance user experience and accessibility. The analysis covers key aspects such as login and registration capabilities, foot scanning technology, profile management, social interaction features, and platform accessibility. It also examines how these systems utilize QR code technology for seamless foot measurement and the presence of a structured main page for easy navigation. Additionally, the table highlights whether these platforms offer their services for free. This comparison provides insight into the strengths and limitations of existing systems, helping to identify areas where the proposed system introduces improvements and added functionality.

Table 2.4: Comparison of Features in Three Systems

Systems	FindMeAShoe	Sizewise	Volumental	Proposed System
Login	✗	✗	✗	✓
Register	✗	✗	✗	✓
Main Page	✓	✓	✗	✓
Foot Scanning Technology	✓	✓	✓	✓
Manage Profile	✗	✗	✗	✓
Social Interaction (Comments/Reviews)	✓	✓	✓	✓
Using QR code to access camera	✓	✓	✓	✓
Free or paid	FREE	FREE	FREE	FREE

Based on the data presented in Table 2.4, a detailed examination of FindMeAShoe, Sizewise, Volumental, and the proposed system highlights both common features and unique advantages across the platforms. While all four systems integrate foot scanning technology to enhance the accuracy of shoe size recommendations, there are notable differences in their overall functionalities and user experience.

Unlike FindMeAShoe, Sizewise, and Volumental, which do not include login and registration features, the proposed system incorporates both. This addition allows users to create and manage their accounts, ensuring a more personalized and seamless experience. Profile management is another unique feature of the proposed system, enabling users to store their foot measurement data and access it whenever needed, something that the other systems do not offer.

While FindMeAShoe and Sizewise provide a main page for easy navigation, Volumental lacks this feature. The proposed system addresses this gap by incorporating a structured main page, ensuring users can efficiently access scanning, recommendations, and other features without confusion. The presence of a main page enhances usability, making the system more intuitive and user-friendly.

All four systems incorporate foot scanning technology as a core feature, allowing precise foot measurement for better shoe recommendations. Similarly, they all support the use of QR codes to access the camera, streamlining the scanning process and ensuring a smooth experience for users. This feature eliminates the need for manual uploads, making foot measurement quick and efficient.

A significant improvement across all platforms is the inclusion of social interaction features. Unlike previous systems that lacked this aspect, FindMeAShoe, Sizewise, Volumental, and the proposed system now support comments and reviews. This function allows users to share their experiences and provide feedback, fostering a more interactive and engaging community for shoe recommendations.

Lastly, all four systems remain free of charge, ensuring accessibility for a wide range of users without financial barriers. This affordability promotes the widespread adoption of these platforms, making personalized shoe fitting available to everyone.

In summary, while FindMeAShoe, Sizewise, and Volumental offer strong foot scanning and recommendation capabilities, the proposed system sets itself apart by incorporating login, registration, and profile management features. These enhancements provide a more personalized and user-friendly experience, positioning the proposed system as a more comprehensive solution in the personalized shoe-fitting market. By integrating these additional features, the proposed system ensures greater usability while maintaining the core strengths of existing platforms.

2.4 Technology and Tools Used to Develop the Proposed System

Figure 2.7: Streamlit logo (Streamlit, n.d.).

Streamlit (see Figure 2.7) is described on its official website as an open-source app framework designed specifically for machine learning and data science projects. It allows developers to rapidly build and share custom web applications using Python scripts. By integrating user interfaces directly into Python code, Streamlit simplifies the development process and ensures fast, interactive visualizations. For this web-based system, Streamlit can be used to create an interactive front-end that integrates seamlessly with machine learning models and data processing workflows, facilitating efficient development and user-friendly deployment (Streamlit Inc., n.d.).

Figure 2.8: Microsoft Visual Studio Code (Microsoft, n.d.).

According to the Visual Studio Code website shown in Figure 2.8, it is a lightweight, yet robust code editor optimized for building modern web applications. Its features include support for numerous programming languages, integrated debugging, and a large library of extensions. These capabilities make Visual Studio Code a practical choice for developing and managing the front-end and back-end codebases of this web-based system (Microsoft, n.d.).

Figure 2.9: Logo of SQLite (SQLite, n.d.).

As shown in Figure 2.9, SQLite provides a lightweight, serverless, and self-contained database engine suitable for local data storage and embedded applications. It simplifies tasks such as data storage, query execution, and local data management without the need for complex setup or external servers. For this system, SQLite enables efficient management of user data and transactional records through its simplicity, portability, and ease of integration with Python-based applications (SQLite, n.d.).

Figure 2.10: Logo of OpenCV (OpenCV, n.d.).

The OpenCV library from Figure 2.10 offers a comprehensive suite of computer vision tools and algorithms designed for real-time image processing. These tools allow developers to perform tasks such as object detection, image filtering, and feature extraction with high efficiency and flexibility. By leveraging OpenCV, the system's image processing capabilities can be enhanced to accurately analyze visual inputs while maintaining performance and development efficiency (OpenCV, n.d.).

Figure 2.11: Logo of scikit-image (van der Walt et al., 2014).

The scikit-image library as shown in Figure 2.11 provides developers with a rich collection of image processing algorithms for tasks such as segmentation, filtering, and morphological operations. Built on top of the SciPy ecosystem, scikit-image emphasizes simplicity, efficiency, and integration with other scientific Python tools, making it an excellent choice for analyzing and transforming image data. For the proposed foot scanning system, scikit-image can serve as a core image processing library, ensuring accurate feature extraction and efficient visual data handling (van der Walt et al., 2014).

2.5 Summary

Chapter 2 provided a comprehensive analysis of the existing systems related to the proposed web-based platform. It reviewed the current landscape of online platforms such as FindMeAShoe, Sizewise, and Volumental, each focusing on personalized shoe fitting and recommendations. The features of these systems were compared, highlighting strengths, weaknesses, and opportunities for improvement in the proposed system. One of the key gaps identified was the need for more interactive features and seamless integration of personalized services. To build the proposed system, various tools and technologies will be utilized to ensure smooth development, deployment, and user experience. Docker will help manage the environment, Visual Studio Code will be the primary development tool, MySQL Workbench will support database management, Vuetify will enhance the front-end experience, Laravel will handle back-end operations, and MySQL will be used for database storage. These tools, together, will create a scalable, reliable, and efficient platform for users to interact, purchase, and receive personalized recommendations.

CHAPTER 3

REQUIREMENT ANALYSIS AND DESIGN

3.1 Introduction

This chapter outlines the requirements and specifications for the proposed web-based foot size measurement system. The methodology adopted for this project is Waterfall Methodology, which ensures a structured and sequential approach to development. The chapter includes the methods used for requirements analysis, logical design elements such as Data Flow Diagrams (DFDs), 3NF normalization, and Entity Relationship Diagrams (ERDs), as well as physical design elements like the Graphical User Interface (GUI).

3.2 Methodology

The proposed system follows the Waterfall software development lifecycle to ensure a systematic approach. Unlike agile methods, which allow overlapping phases, the Waterfall methodology emphasizes a linear sequence of activities. The following table summarizes the five phases of the Waterfall model and the corresponding activities:

Table 3.1: Five phrases and their activity

Phrases	Activities
Requirement Gathering	-Define functional requirements based on user needs for a foot measurement system. -Conduct a survey using Google Forms to gather input and feedback from users regarding expectations for the system.
Design	a) Logical Design: - Create Data Flow Diagrams (DFDs). - Apply 3NF normalization for database optimization. - Develop an Entity Relationship Diagram (ERD). - Define system architecture.

	b) Physical Design: - Develop the system based on the design using appropriate coding frameworks.
Implementation	a) Develop the system based on the design using appropriate coding frameworks. b) Ensure adherence to design documents to minimize changes during development
Testing	a) Conduct rigorous testing to identify and resolve bugs, security issues, or usability problems. b) Validate the system to ensure alignment with requirements and reliability for end-users.
Deployment & Maintenance	a) Deploy the system in a living environment. b) Conduct extensive post-deployment testing, document technical details, and track issues. c) Gather user feedback for ongoing improvement, releasing updates and patches as needed

3.3 Requirement Analysis

This chapter will focus on the requirement planning and user design of the web-based foot scanner system using the waterfall methodology. In the requirement planning phase, several parts will be discussed, such as conducting a Q&A session using Google Forms to understand the needs and expectations of users regarding the foot scanning and measurement system. Additionally, the functional requirements of the proposed system will be defined based on the feedback from the Google form.

The user design part is separated into two sections: logical design and physical design. The logical design will include a data flow diagram, 3NF normalization, and an entity-relationship diagram. The physical design will cover the graphical user interface (GUI) design of the proposed web-based foot scanning system.

3.3.1 Questionnaire Sessions

A Google form, with the questions attached in Appendix A, is distributed to anyone through an online platform, receiving 30 responses. The Q&A session is conducted to assess the feasibility of the proposed web-based foot scanning system, as well as to gather ideas and suggestions for the development of the system. This feedback helps refine the system's functional requirements and ensures it meets the needs and expectations of the target users.

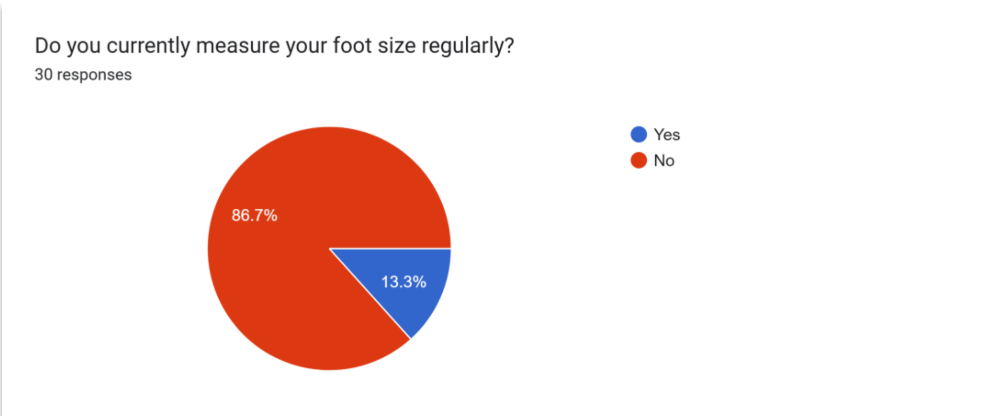

Figure 3.1: Question on frequency of measuring foot size

In Figure 3.1, 86.7% of 30 responses show that nowadays people rarely measure their own foot size. This shows how important the system needed to be created.

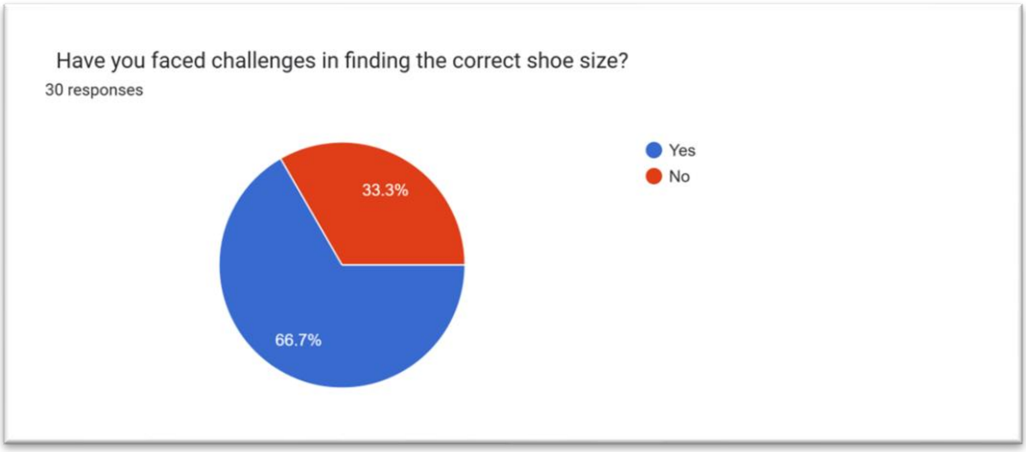

Figure 3.2: Question on does challenges occur in finding the correct shoe size

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In Figure 3.2, 66.7% of 30 responses said that they are facing problems in finding the correct shoe size. The proposed system would be able to solve the above problem.

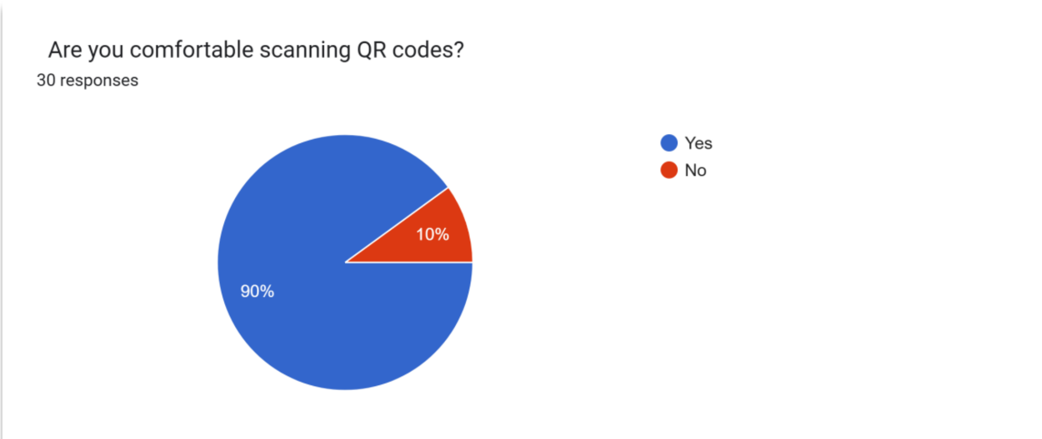

Figure 3.3: Question on comfortable level on scanning QR code

In Figure 3.3, 90% of 30 responses said that they are comfortable in scanning QR codes, this is matching the main method for users to approach to the web-based system.

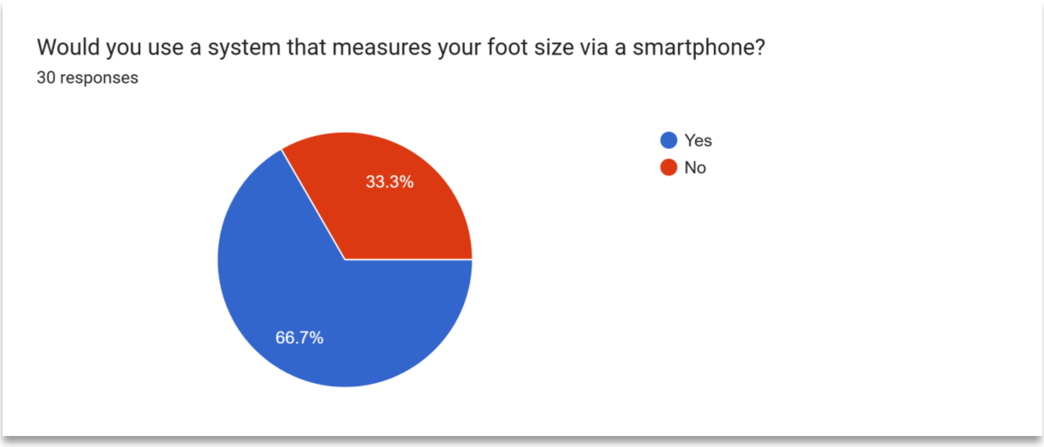

Figure 3.4: Question on willingness to measure foot size using a smart phone.

Figure 3.4 shows that 66.7% of the participants are willing to make sure the foot size using a smart phone, the percentage is not that high, but it is still a positive side for the system proposed.

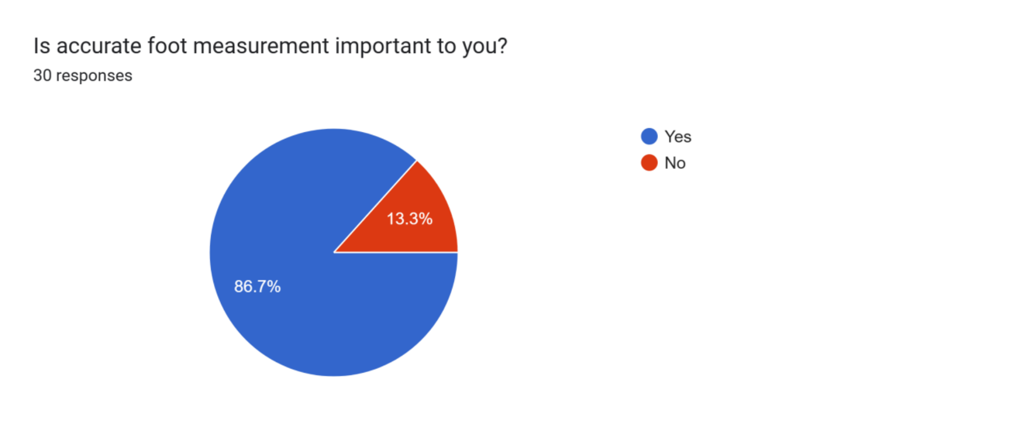

Figure 3.5: Question on importance of the accurate foot measurement to the participant.

Figure 3.5 shows that the participant is having a high awareness of the importance of having the accurate foot size measurement.

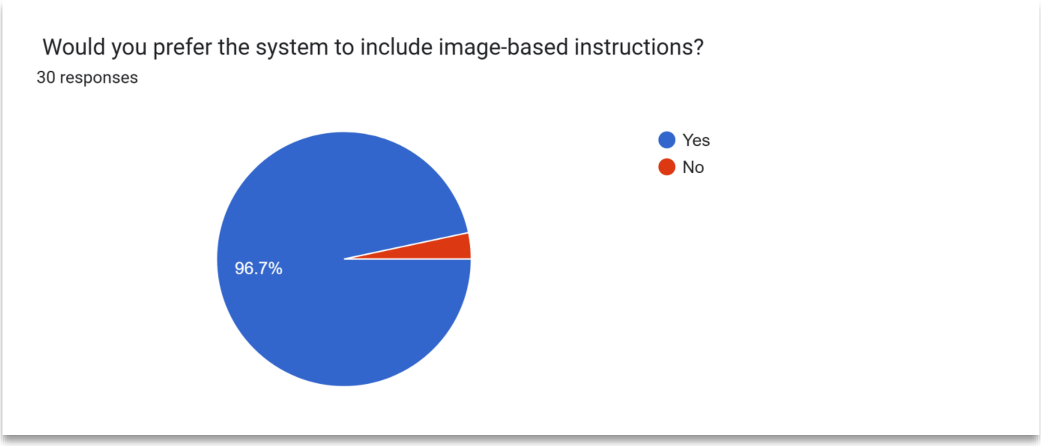

Figure 3.6: Question on preference on the system to include image-based instruction

In Figure 3.6, almost all (96.7%) of the participants prefer image-based instruction, so the proposed system should have the images when giving tutorial.

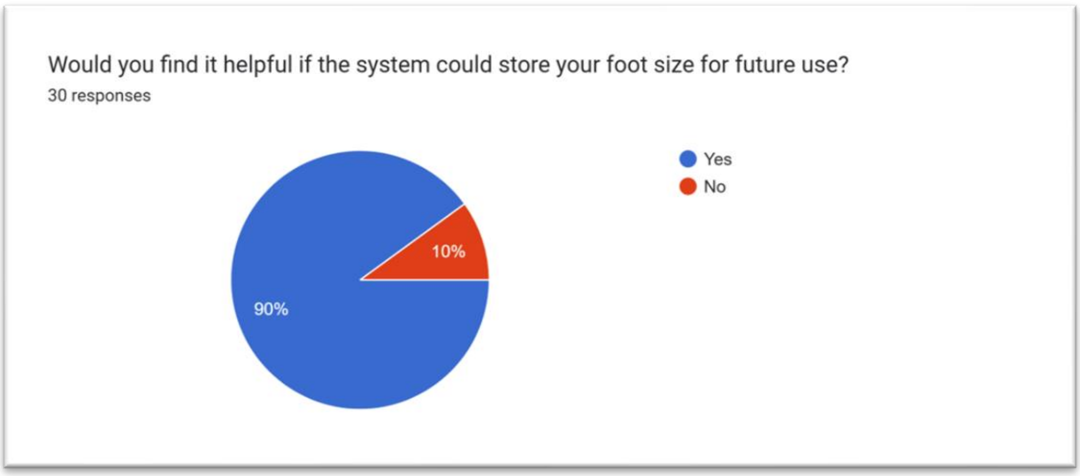

Figure 3.7: Question on the how helpful the system will be if it can store the foot size for future use

Figure 3.7 shows that most (90%) of the participants would like the system to save their data, so the system should have the ability to store and record the user's foot size for future references.

In summary, the feedback gathered from the online Q&A session conducted through Google Forms underscores the necessity of the proposed web-based foot scanning system. It is seen as a valuable tool for students, offering an easy and efficient way to accurately measure foot dimensions. The system is recognized for its potential to help students find properly fitting footwear, as well as its added value in facilitating foot-related health and lifestyle decisions. The feedback highlights the system's ability to address a key need among users, ensuring the proposed solution is relevant and beneficial for the community

3.3.2 Requirement Planning:

There are two types of users identified for this proposed system. They are admin and the user. The requirement for the system is also listed.

Table 3.2: Functional requirements for two types of users and system

Requirement	Description	Priority
User: Admin		
Register new users	Add new users to the system database.	High
Login to the system	Authenticate access to the admin panel.	High
Edit user details	Update user profiles, such as name, email, and role.	High
Manage foot measurement data	View, filter, and delete uploaded foot measurement data.	Medium
Monitor user activity	Access a dashboard that displays system usage and	Medium

	user activity metrics.	
User: End User		
Register an account	Create a new account to access the foot measurement system.	High
Login to the system	Authenticate user access to the system.	High
Upload foot image	Provide an image of their foot standing on A4 paper for measurement processing.	High
View measurement results	Access calculated foot size data (e.g., length, width, arch height).	High
Edit profile information	Update personal details like name, email, or password.	Medium
Request support	Send inquiries or issues to the admin via an integrated messaging feature.	Medium
System		
Process foot image	Analyze the uploaded foot image and extract measurements.	High
Provide measurement feedback	Display results in a user-friendly format, including visual cues or tips for accuracy.	High

Maintain data security	Ensure secure handling and storage of user data, complying with privacy regulations.	High
Generate analytics	Aggregate and analyze user data to optimize measurement accuracy and user experience (admin access).	Medium

3.4 System Design

The system design consists of logical design and physical design.

3.4.1 Logical Design

The logical design included a dataflow diagram (Context diagram, Level 0 diagram, and Level 1 diagram), entity-relational diagram (ERD), Third normalization form (3NF) conversion and Data Dictionary.

Context Diagram:

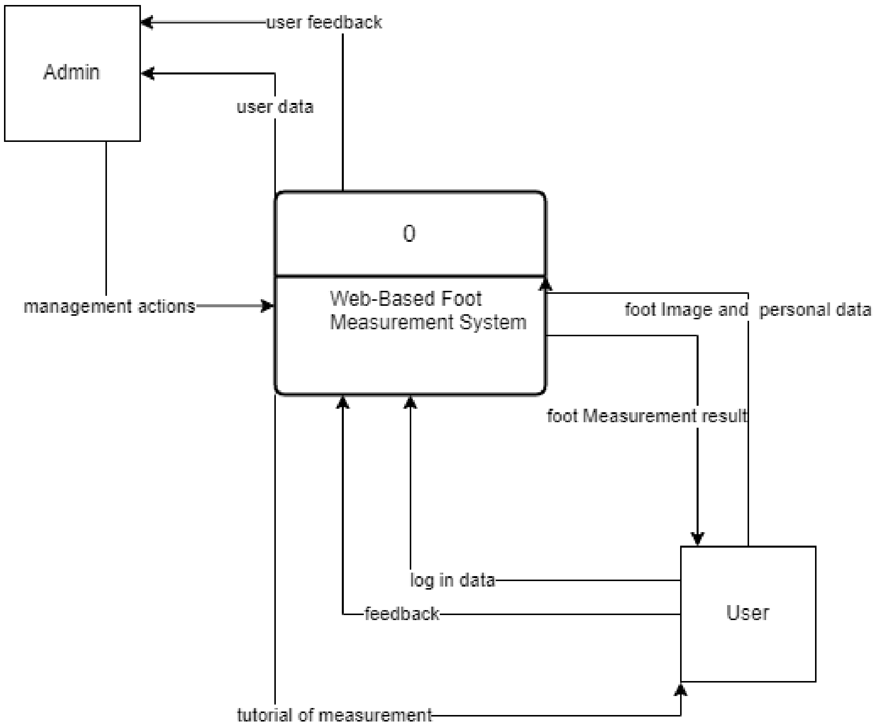

Figure 3.8: Context Diagram

The context diagram in Figure 3.8 outlines the Web-Based Foot Measurement System's interactions with two entities: User and Admin. Users provide Log in Data, upload Foot Images, receive Measurement Results and Tutorials, and share Feedback. Admins manage the system by accessing User Data and reviewing Feedback for improvements. It highlights key data exchanges without detailing internal processes.

Dataflow Diagram (Level 0)

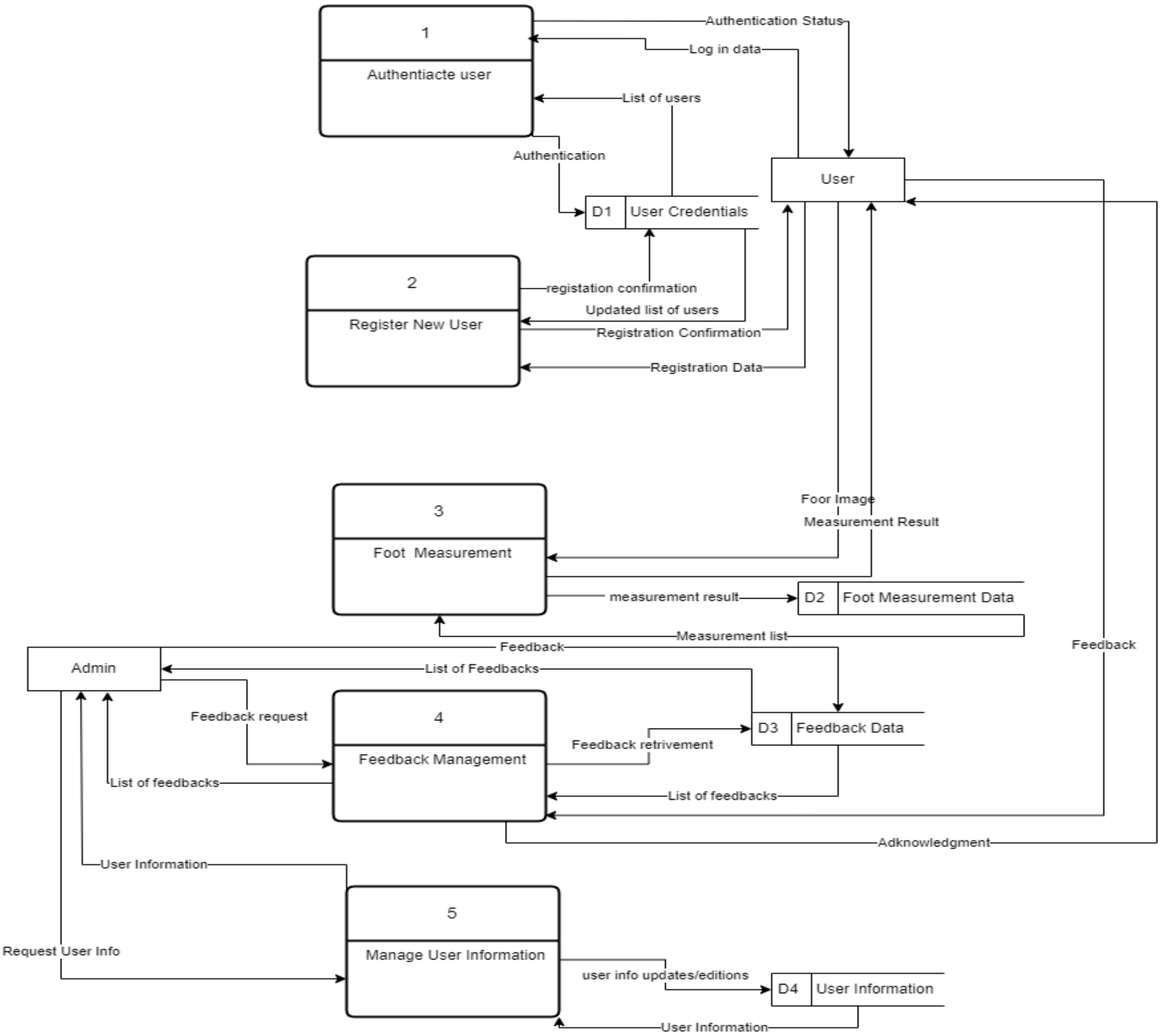

Figure 3.9: Level 0 Data Flow Diagram

The Level 0 Data Flow Diagram in Figure 3.9 provides a top-level view of the system, illustrating the primary processes and their interactions with external entities. It begins with User and Admin as external entities. Users interact with the system through processes like Register New User, Authenticate User, Manage Foot Measurements, and Submit Feedback. Admins access the system to Manage User Information and Review Feedback. Data flows represent exchanges such as registration data, authentication credentials, foot measurement uploads, feedback details, and role assignments. Key data stores like User Data, Foot Measurement Data, and Feedback Data facilitate smooth data management between processes.

Dataflow Diagram (Level 1)

The Dataflow Diagram level 1 presents a detailed breakdown of the Level 0 DFD, focusing on decomposing and analyzing each process from level 0.

Process 1: Authenticate User

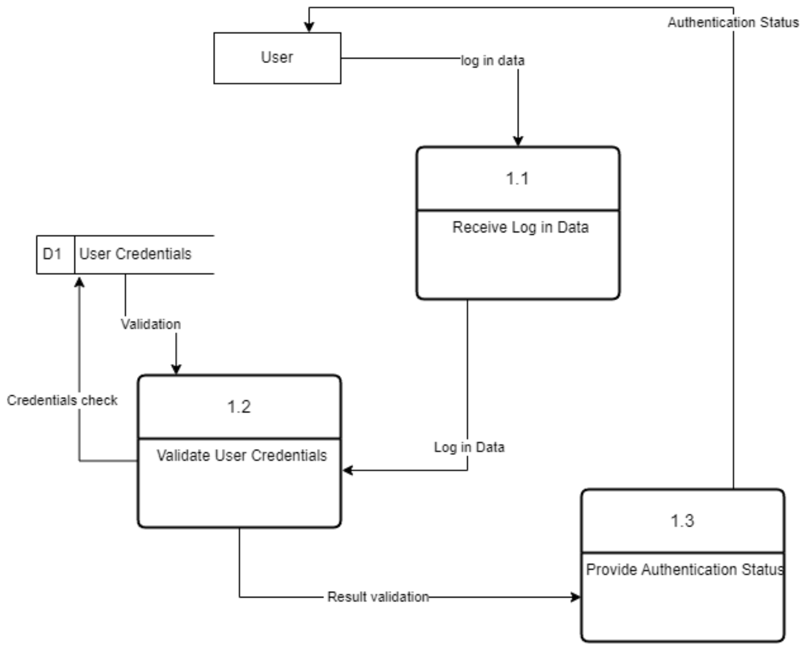

Figure 3.10: Level 1 Data Flow Diagram (Authenticate User)

Figure 3.10 illustrates the Authenticate User process, which includes Receive Login Credentials, Validate Credentials, and Provide Authentication Status. Users input their email and password, which are received and validated against stored data in the User Data store. Valid credentials allow access to the system, while invalid ones return an error message to the user.

ii. Process 2: Register New User

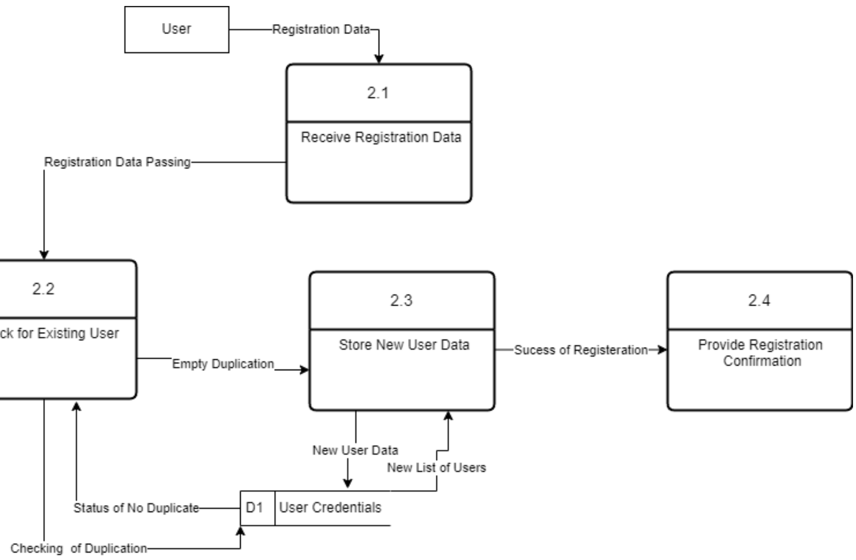

Figure 3.11: Level 1 Data Flow Diagram (Register New User)

The Register New User process shown in Figure 3.11 breaks into three sub-processes: Collect Registration Data, Validate Data, and Store User Details. Users provide their name, email, and password, which flow into the Collect Registration Data sub-process. Data is validated for correctness and uniqueness before being stored in the User Data store. Successful registrations return a confirmation message, while errors prompt the user to re-enter data.

iii. Process 3: Foot Measurement

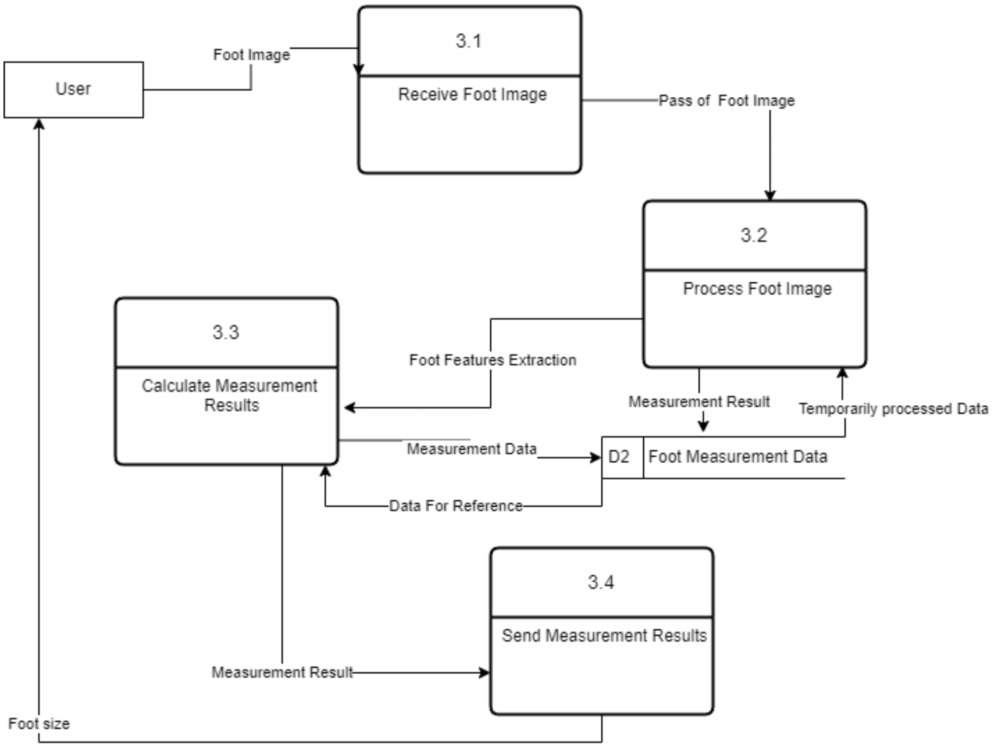

Figure 3.12: Level 1 Data Flow Diagram (Foot Measurement)

The Foot Measurements (Figure 3.12) process includes Upload Foot Image, Process Foot Measurement, and Store Results. Users upload foot images, which the system processes to generate measurement results. These results, along with the image, are stored in the Foot Measurement Data store. Users can view their results and access measurement history as needed.

iv. Process 4: Feedback Management

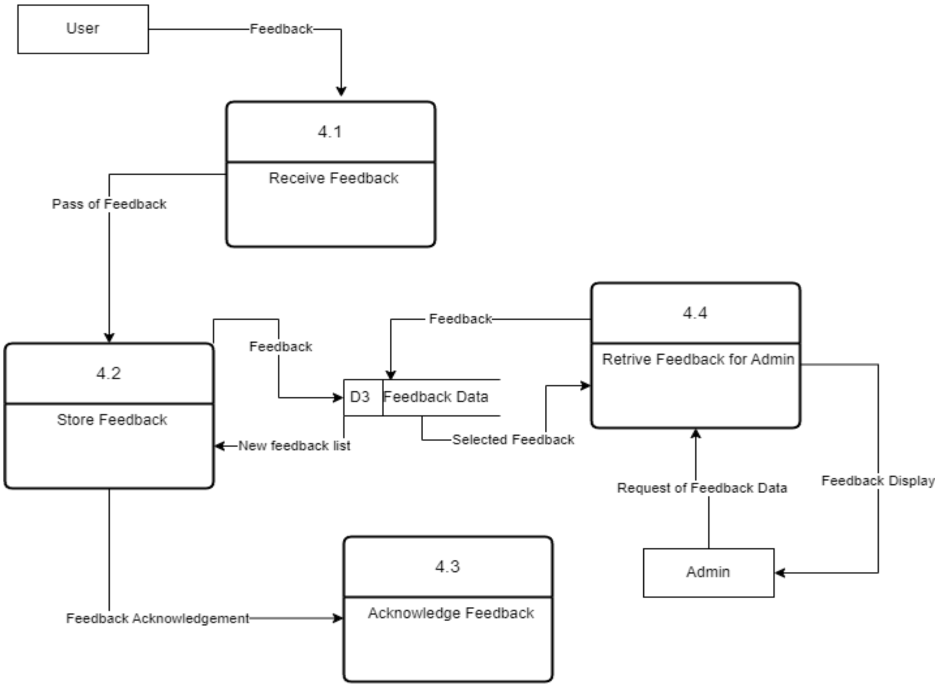

Figure 3.13: Level 1 Data Flow Diagram (Feedback Management)

Figure 3.13 shows the Feedback Management, which is divided into Collect Feedback, Store Feedback, and Acknowledge Submission. Users submit feedback through a form, which is collected and stored in the Feedback Data store. Once the feedback is successfully saved, the system provides an acknowledgment to the user. The Review Feedback process comprises Access Feedback Data, Mark Feedback as Resolved, and Log Admin Action. Admins view feedback from the Feedback Data store, take appropriate actions, and mark entries as reviewed or resolved. These interactions are logged for accountability in the Feedback Data store.

v. Process 5: Manage Users Information

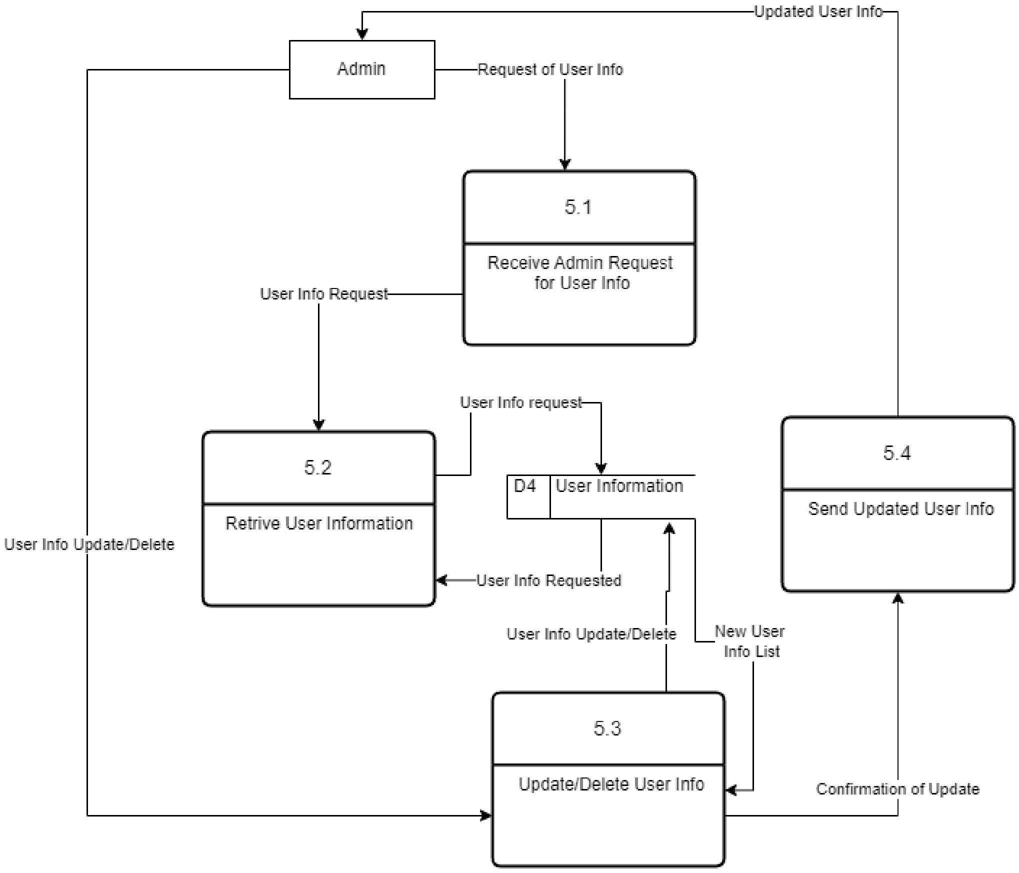

Figure 3.14: Level 1 Dataflow Diagram (Manage Users Information)

The Manage User Information process from Figure 3.14 includes Access User Data, Modify User Details, and Save Changes. Admins retrieve user information from the User Data store, update relevant fields, and save changes back to the database. This ensures accurate and up-to-date user management.

3.4.1.2 Third normalization form (3NF) conversion

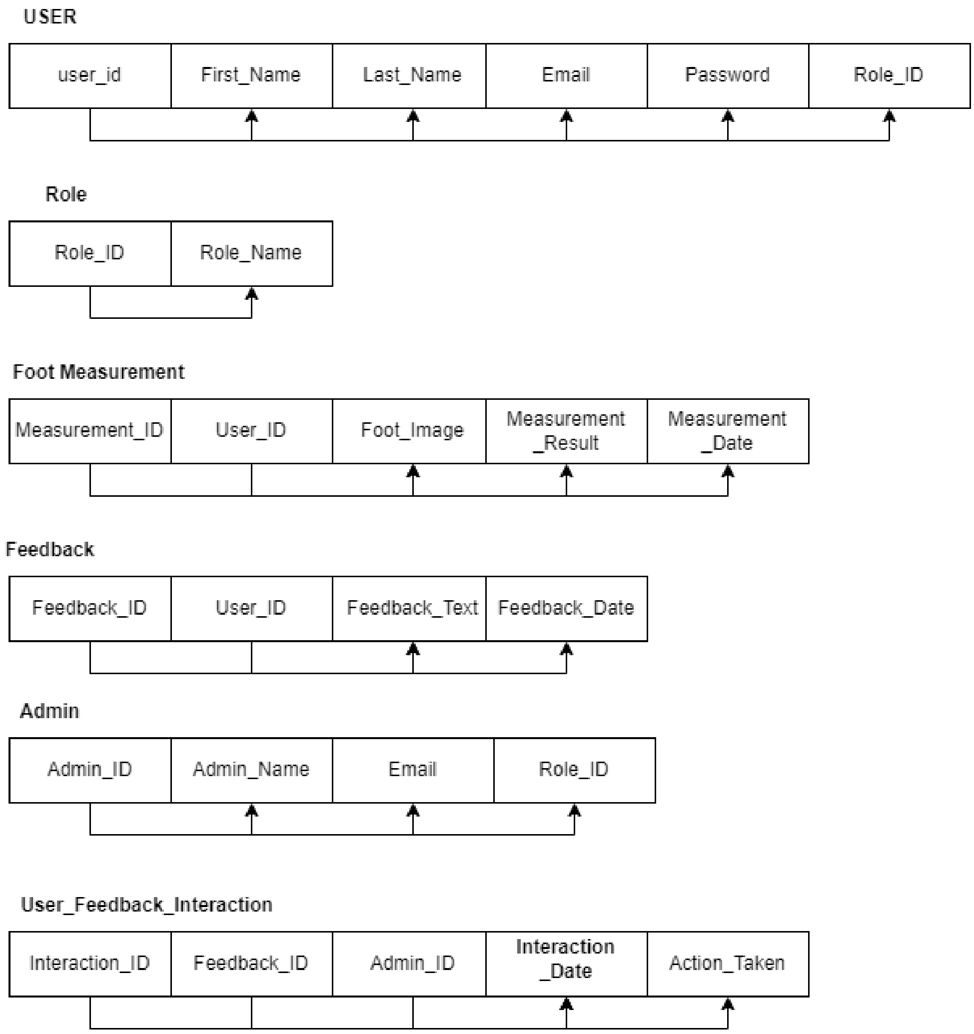

Figure 3.15: Third Normalization Form Table(3NF)

From Figure 3.15, The database in 3NF ensures each table has attributes dependent solely on the primary key, avoiding redundancy and transitive dependencies. The User table links directly to the Role table via Role_ID to assign roles without duplicating data. The Foot Measurement table stores each user's results and images, linked to User_ID, while Feedback connects feedback entries to users via User_ID. The Role table defines roles independently, referenced in the User table. These relationships ensure efficient data organization, eliminate anomalies, and maintain data integrity across the system.

3.4.1.3 Entity Relationship Diagram

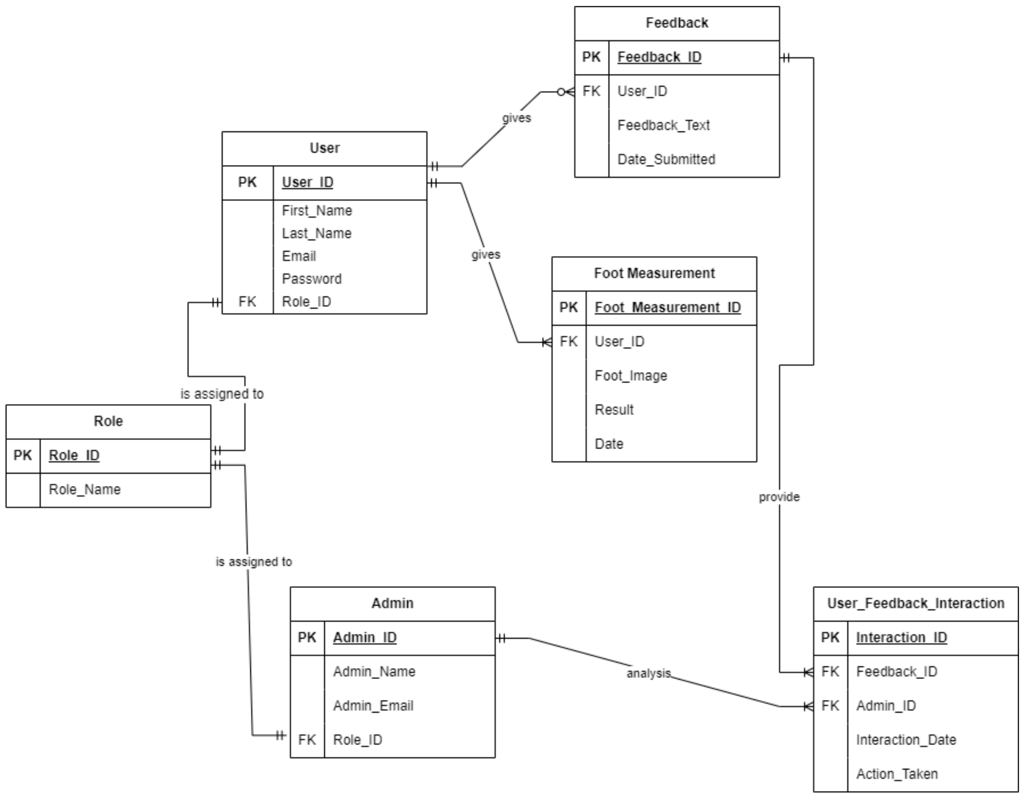

Figure 3.16: Entity Relationship Diagram

The Entity Relationship Diagram (ERD) in Figure 3.16 illustrates how the entities within the system are related. The User table connects to the Role table via Role_ID, establishing the user's role (Admin or User). The User table also links to the Foot Measurement table through User_ID, storing foot measurement results and images for each user. Additionally, the User table is connected to the Feedback table via User_ID, where users can submit feedback. The Role table defines various roles, and the relationships between tables ensure data consistency and integrity, with foreign keys maintaining the connections across entities.

3.4.1.4 Data Dictionary

The data dictionary serves as a centralized repository that defines the structure, attributes, and relationships of data elements within a database. It offers detailed information for each table, including field names, data types, constraints such as primary and foreign keys, and descriptive notes. Tables 3.3 to Table 3.8 present the data dictionaries used in this system.

Table 3.3: Data Dictionary for 'User' table

Attribute	Data Type	Constraint	Description
User_ID	INT	PRIMARY KEY, AUTO_INCREMENT	Unique identifier for each user.
Name	VARCHAR(255)	NOT NULL	Full name of the user.
Email	VARCHAR(255)	NOT NULL, UNIQUE	Email address of the user.
Password	VARCHAR(255)	NOT NULL	Password for user authentication.
Role_ID	INT	FOREIGN KEY (references Role.Role_ID)	Role of the user (Admin, Regular User).

Table 3.4: Data Dictionary for 'Role'Table

Attribute	Data Type	Constraint	Description
Role_ID	INT	PRIMARY KEY, AUTO_INCREMENT	Unique identifier for each role.
Role_Name	VARCHAR(100)	NOT NULL	Name of the role (e.g., Admin, User).

Table 3.5: Data Dictionary for ‘Foot Measurement’ Table

Attribute	Data Type	Constraint	Description
Foot_ID	INT	PRIMARY KEY, AUTO_INCREMENT	Unique identifier for each foot measurement record.
User_ID	INT	FOREIGN KEY (references User.User_ID)	User who has the foot measurement.
Result	VARCHAR(255)	NOT NULL	Measurement results (e.g., foot size, dimensions).
Date	DATE	NOT NULL	Date when the foot measurement was taken.
Foot_Image	BLOB	NULL	Image of the user's foot.

Table 3.6: Data Dictionary for ‘Feedback’ Table

Attribute	Data Type	Constraint	Description
Feedback_ID	INT	PRIMARY KEY, AUTO_INCREMENT	Unique identifier for each feedback.
User_ID	INT	FOREIGN KEY (references User.User_ID)	User who provided the feedback.
Feedback_Text	TEXT	NOT NULL	Content of the feedback.

Date	DATE	NOT NULL	Date when the feedback was provided.

Table 3.7: Data Dictionary for 'Admin' Table

Attribute	Data Type	Constraint	Description
Admin_ID	INT	PRIMARY KEY, AUTO_INCREMENT	Unique identifier for each admin.
Name	VARCHAR(255)	NOT NULL	Full name of the admin.
Email	VARCHAR(255)	NOT NULL, UNIQUE	Email address of the admin.
Role_ID	INT	FOREIGN KEY (references Role.Role_ID)	Role of the admin (e.g., Admin, Super Admin).

Table 3.8: Data Dictionary for ' User Feedback Interaction' Table

Attribute	Data Type	Constraint	Description
Interaction_ID	INT	PRIMARY KEY, AUTO_INCREMENT	Unique identifier for each interaction.
Admin_ID	INT	FOREIGN KEY (references Admin.Admin_ID)	Admin handling the interaction.
Feedback_ID	INT	FOREIGN KEY (references Feedback.Feedback_ID)	Feedback involved in the interaction.

Action	VARCHAR(255)	NOT NULL	Action taken by the admin on the feedback (e.g., reviewed, resolved).
Date	DATE	NOT NULL	Date when the interaction occurred.

3.4.2 Physical Design

The graphical user interface (GUI) design is included in the physical design. There are two types of design involved in this section, one is for the admin, and one is for the user.

3.4.2.1 Graphical User Interface Design

Login Page (Admin)

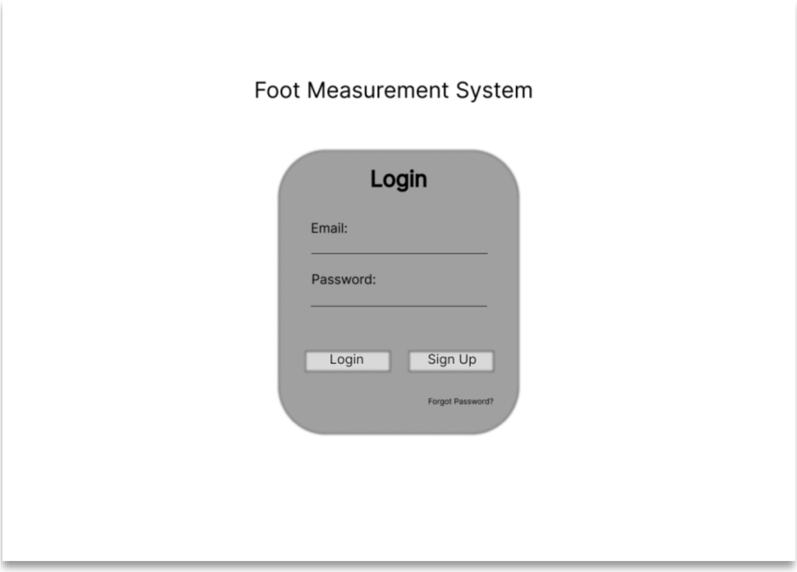

Figure 3.17: Wireframe for Login Page(admin)

Figure 3.17 displays the login page wireframe, which asks the admin to enter their email and password to log in or sign up.

Feedback page(admin)

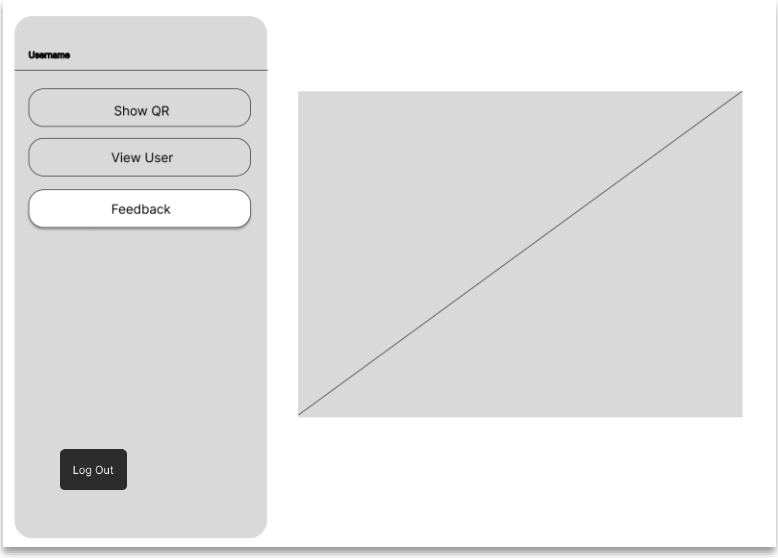

Figure 3.18: Wireframe for Feedback page(admin)

Figure 3.18 shows the wireframe for feedback page on admin site, Admin can see the feedback from the user here, so he is acknowledged on what is needed to be improved on.

Showing QR code

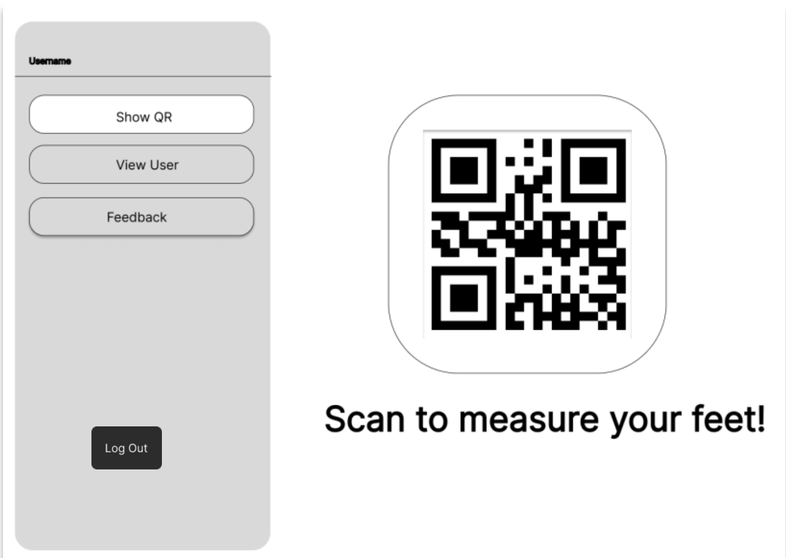

Figure 3.19: Wireframe for QR code page(admin)

Figure 3.19 shows the wireframe for QR code page for admin, this is where the admin can generate the QR code that will be scanned by the users.

View user(admin)

Figure 3.20: Wireframe for view user page(admin)

In Figure 3.20, the admin can see the information of the users, he can also make some updates and delete them in the user list by pressing the ‘edit’ button.

Log out page(admin)

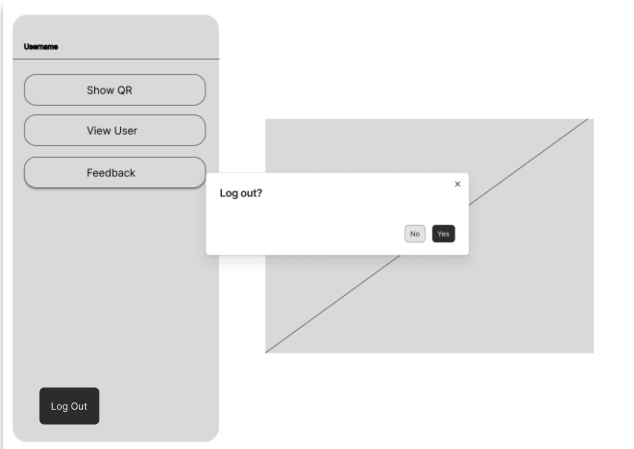

Figure 3.21: Wireframe for log out page(admin)

Figure 3.21 shows how an admin can log out of the system if he has nothing needed to be done in the system.

Scan QR page(user)

Figure 3.22: Wireframe for scanning QR (user)

Figure 3.22 shows that the user will use the camera in their smartphone to scan the QR code prepared by the admin so they can enter the web page.

Login page(user)

Figure 3.23: Wireframe for login page(user)

Figure 3.23 shows the first page the user will be observing right after they scan the QR code provided, this is where user can log into the web page.

Sign up page(user)

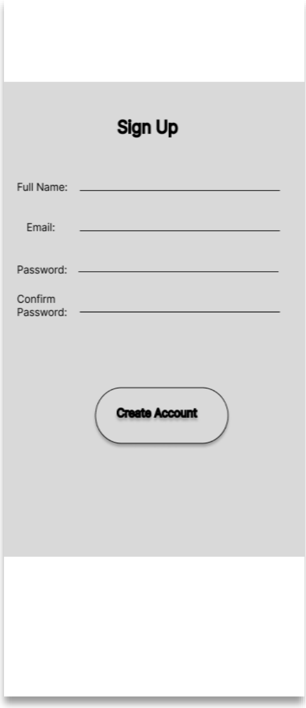

Figure 3.24: Wireframe for sign up page(user)

Figure 3.24 shows the page will appear after the user preset the sign-up button in case they don’t have an account. Users can register themselves here so they can straight away log into the web page next time.

Drop down menu function(user)

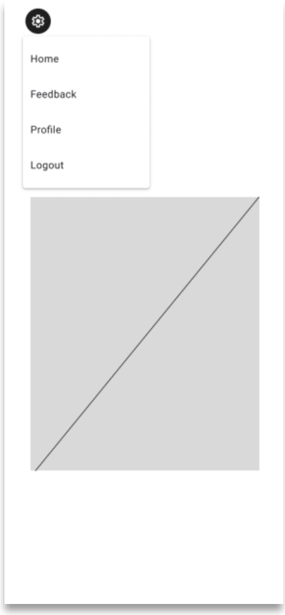

Figure 3.25: Dropdown menu function(user)

Figure 3.25 shows the drop-down menu function is used in the system. This is to help users access the function they want quicker.

Feedback page(user)

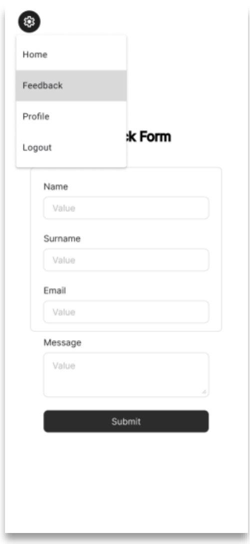

Figure 3.26: Wireframe for feedback page(user)

Users can go to the feedback form page by clicking the button in the drop-down menu as shown in Figure 3.26, users can always send their feedback through this page to acknowledge the admin on what problem the web page is having.

Home page(user)

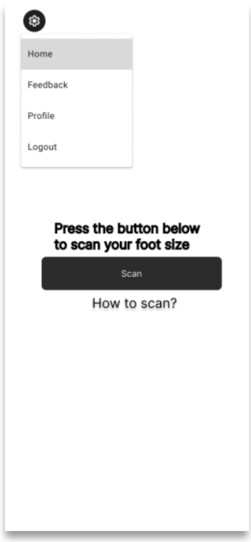

Figure 3.27: Wireframe for Home page (user)

Figure 3.27 shows the most import part in this system, this is where the user can scan their foot size by tapping the 'Scan' button as shown, if the user is new, they can even tap 'how to scan' to have step by step tutorial on what they should prepare and what should they do to get the most accurate measurement.

Tutorial page(user)

Figure 3.28: Wireframe for tutorial page(user)

This is the page (Figure 3.28) which will only appear when the user presses the ‘how to scan?’ button, it will pop out a small window with some pictures and writing teaching the user on the correct steps to measure they foot size. After the user knows how to measure, press the scan button and the camera will be activated, and the measurement will begin.

Result page(user)

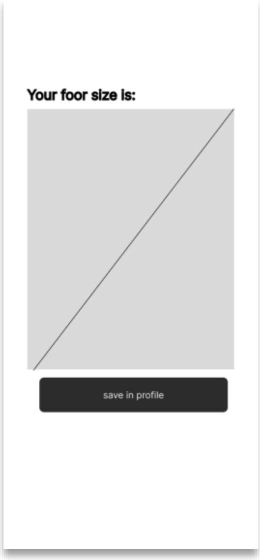

Figure 3.29: The wireframe for result page(user)

Figure 3.29 shows the result page after the user finished their measurement, it will suggest users about their size in a clear and detailed way so user can refer when they are about to get a new pair of shoes.

There is a 'save in profile' button, so users can always go to the profile page to refer to their size instead of repeating the measurement.

Profile page(user)

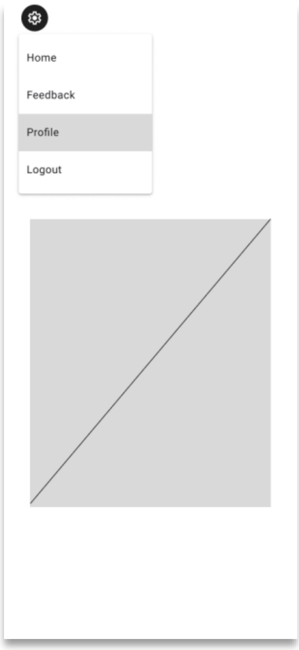

Figure 3.30: The wireframe for profile page(user)

As mentioned earlier, this page (Figure 3.30) is where the user can refer if they want to know call back their foot size.

Log out page(user)

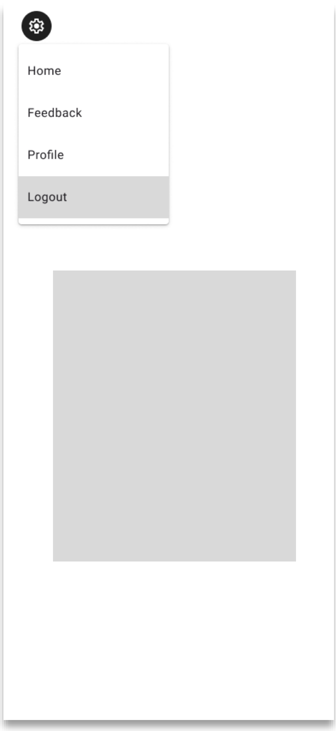

Figure 3.31: The wireframe for log out page(user)

This page (Figure 3.31) is the page that will show if the user is about to exit the web page.

3.4.3 System Architecture Design

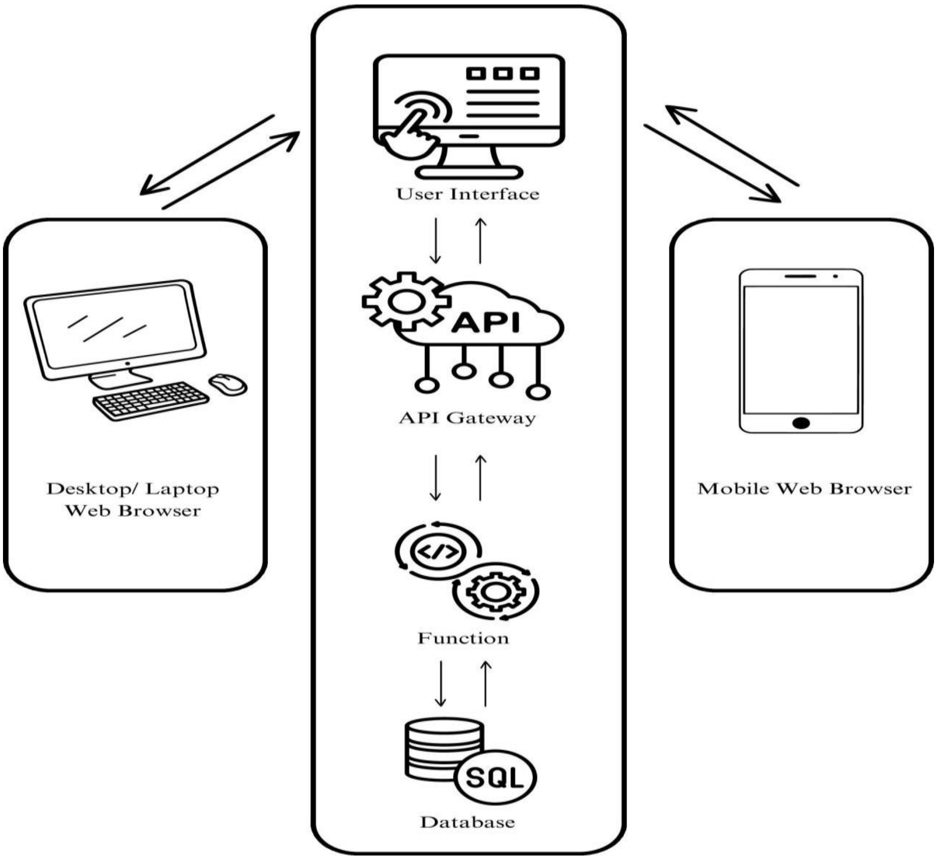

Figure 3.32: The system architecture design of the Web-based Foot Measurement System

Figure 3.32 illustrates the design of the system architecture for the web-based foot scanning system. The system features three distinct user roles (admin, user, and guest), each interacting with the user interface. The user interface communicates with the API gateway, which facilitates the execution of functions. These functions involve processing foot scans, retrieving measurements, and updating user data in the database. Additionally, the system ensures seamless data exchange between the user interface, API gateway, and database to provide accurate foot measurements and related features.

3.5 Summary

This chapter briefly discussed the requirement analysis and system design for the web-based foot scanning system using Waterfall Methodology. It included gathering user feedback through Q&A sessions to define functional requirements and covered both logical (DFD, 3NF, ERD) and physical (GUI) design aspects. Overall, it ensured the system aligns with user needs and is technically feasible for real-world use.

CHAPTER 4

IMPLEMENTATION

4.1 Introduction

This chapter describes the implementation of the Web-Based Foot Measurement System, developed to estimate foot dimensions from an uploaded image using A4 paper as a reference scale. The system was designed with accessibility and simplicity in mind, enabling users to interact through a browser-based interface without requiring any installations. Development was conducted using Visual Studio Code as the primary code editor, Streamlit for the web interface, and SQLite for lightweight database management. The entire application is built using Python, integrating image processing capabilities with a dynamic and user-friendly frontend. Key libraries such as OpenCV, NumPy, and scikit-image were utilized for image processing and measurement calculations. This chapter explains the environment setup and the main implementation details in a step-by-step manner.

4.2 Environment Setup

The environment setup for the project begins with the installation of essential development tools, including Visual Studio Code and Python. SQLite is used as the database system due to its simplicity and lightweight design. Once these tools are installed, the next step is to set up the virtual environment and install the required Python libraries that support both the frontend interface and backend processing of foot measurement data. Here are the steps to set up:

1.Install Visual Studio Code and Python

- Download and install Visual Studio Code from its official website to manage and edit the source code.

- Download and install Python from the official Python website. Make sure to add Python to the system path during installation.

- Confirm successful installation by running python --version in the command prompt.

2. Set Up the Python Environment and Libraries

    - Open Visual Studio Code and navigate to the project directory.

    - Install the required libraries using pip:

      pip install streamlit opencv-python-headless numpy pandas scikit-image scikit-learn pillow tqdm sqlite

    - These libraries support the main functionalities:

    a) Streamlit for the web interface.

    b) OpenCV, NumPy, and scikit-image for image processing and foot dimension calculations.

    c) SQLite (built-in) for database storage.

    d) Pillow for image handling and manipulation.

    e) scikit-learn for machine learning, specifically SVM-based prediction or classification.

    f) tqdm for adding progress bars during lengthy processing tasks.

    g) shutil for handling file operations, such as moving or deleting temporary files.

h) random for generating random values where applicable in simulations or randomization of steps.

3. Set Up SQLite Database

- Use the built-in sqlite module in Python to create a local database file (e.g., foot_data.db).
- Write a Python script to define the schema and initialize the database table for storing:
- Foot length and width.
- Converted shoe sizes (US, UK, EU).
- Date and time of measurement.
- Ensure the database is initialized at the start of the Streamlit app by calling a setup function.

4. Run and Validate the Application

- Launch the app by running the command: streamlit run app.py.
- This command will open the app in a web browser at http://localhost:8501.
- Confirm the following to validate the setup:
- The interface loads properly.
- Image upload and measurement features work as intended.
- Measurement results (length, width, shoe size) are calculated and displayed.

- Data is successfully stored in the local SQLite database for future retrieval.

4.3 Implementation of Features

This project presents main features, including login, user page, admin page, feedback system, foot measurement system. Each of these features will be introduced in detail in this section.

4.3.1 Login Page

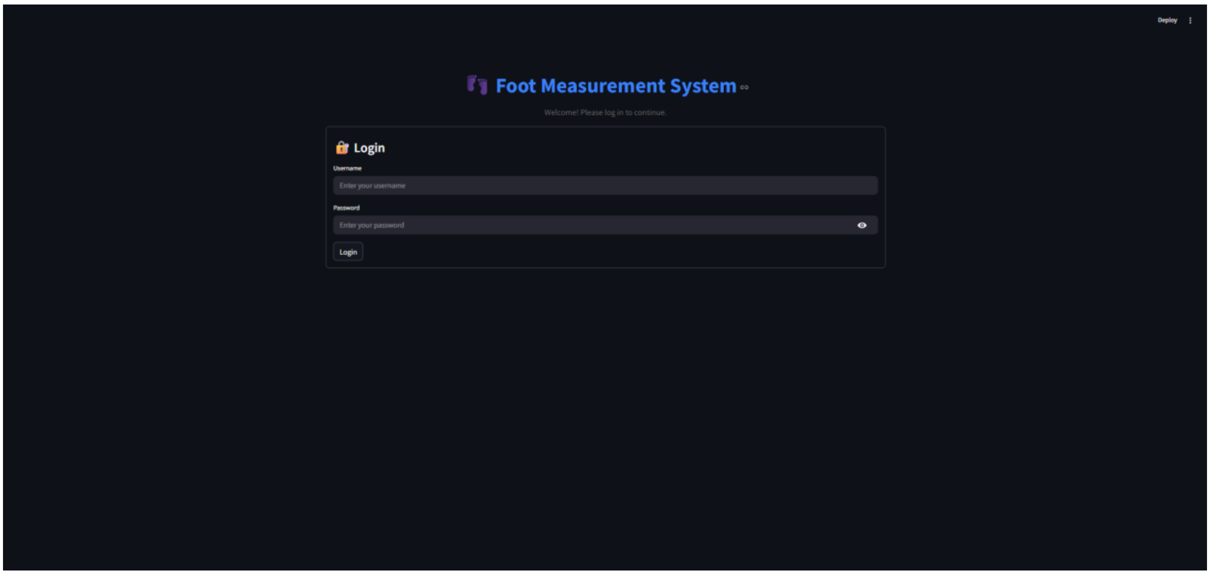

Figure 4.1Login Page

Figure 4.2 Login Page with Invalid password or username

Figure 4.1 illustrates the login page of the project. Users are required to log in using their username and the correct password. Upon successful authentication—when the entered credentials match those stored in the database—users are granted access and redirected to a role-specific dashboard. If either the email or password is incorrect, an alert message is displayed in red, indicating the error. Figure 4.2 specifically shows the login page when incorrect login credentials have been entered.

4.3.2 Dashboard(user)

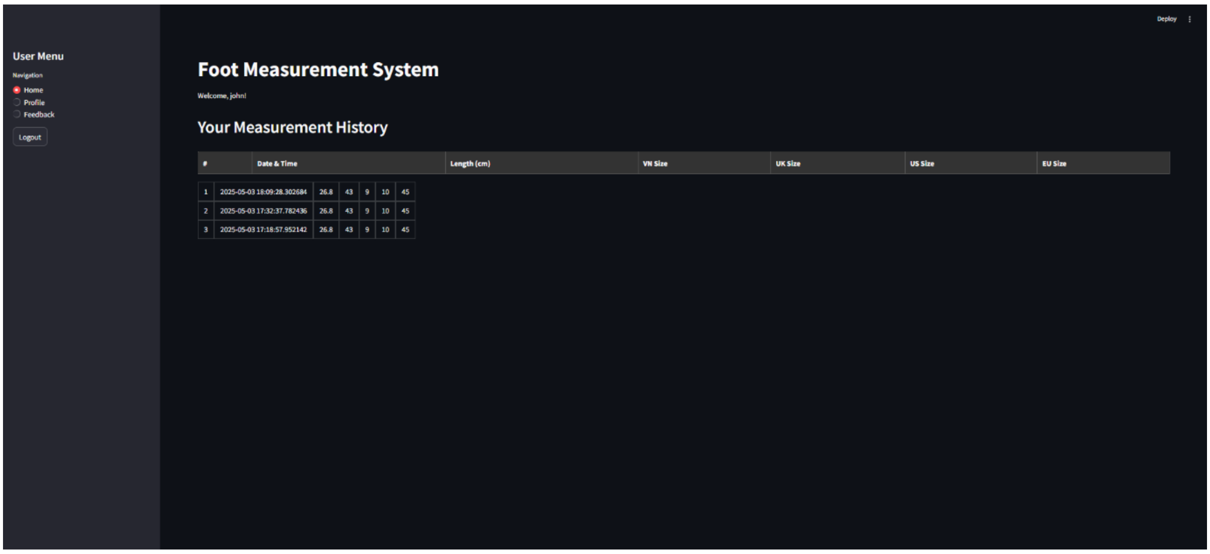

Figure 4.3: User profile with side showing option menu

Figure 4.3 displays the sidebar menu, which enables users to navigate through various sections of the system. From this menu, users can access the homepage to view their measurement history, visit their profile page, and access the feedback system.

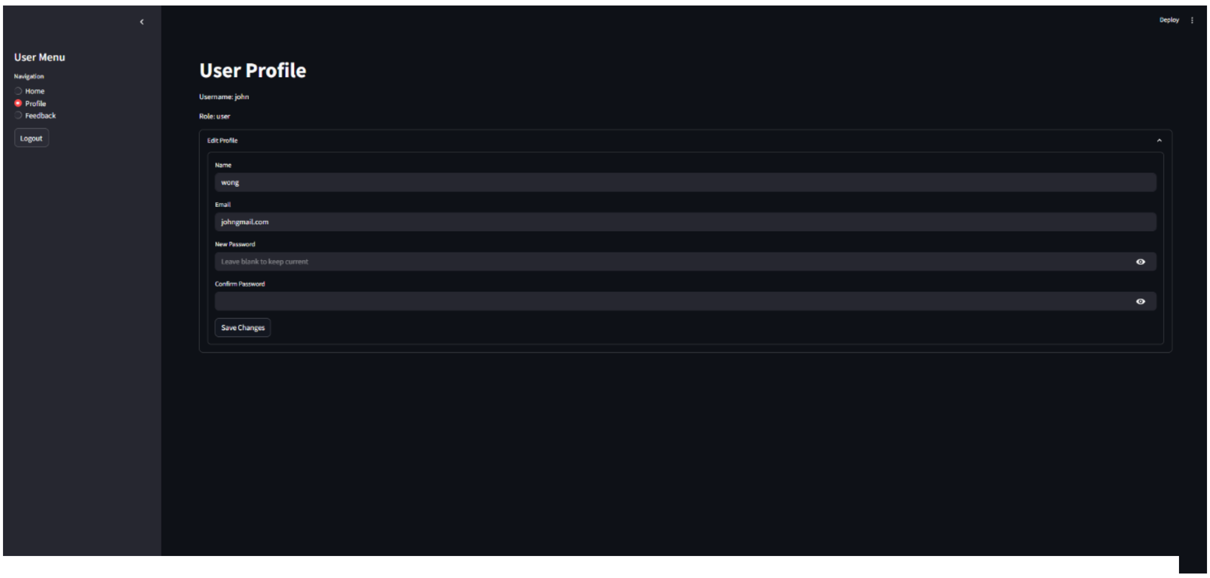

Figure 4.4: User profile page

Figure 4.4 shows the user profile page, where users can update their personal information, including their password if desired. Once the changes are saved, the database is updated accordingly. Users will then need to use their updated username and password for future logins.

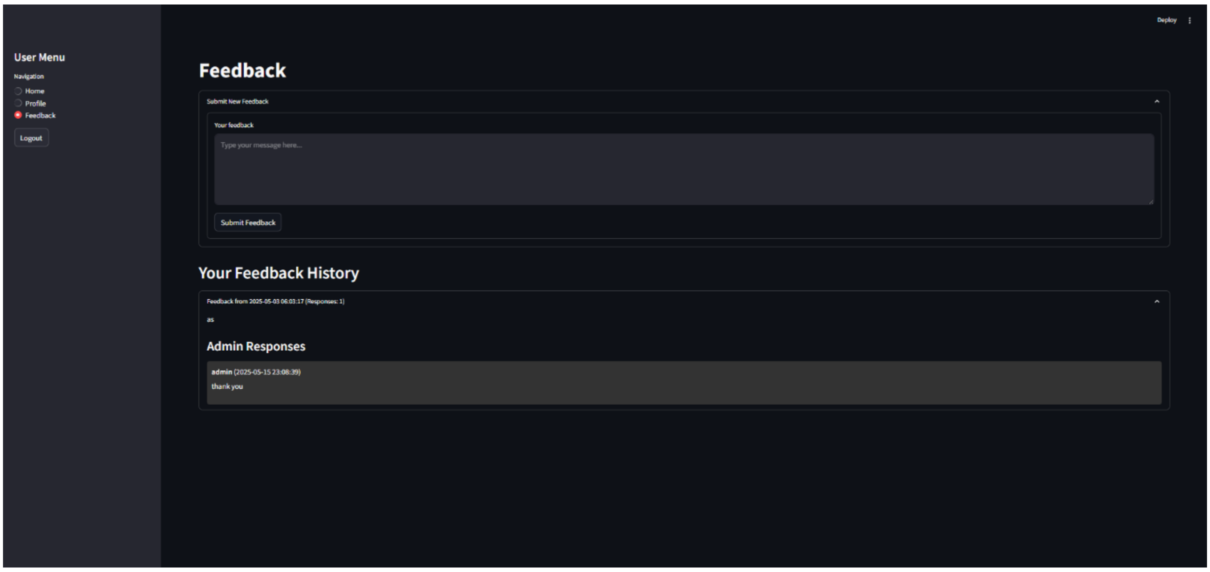

Figure 4.5: Feedback with admin respond

Figure 4.5 displays the feedback page designed for user interaction with the system administrator. On this page, users can write and submit their feedback, comments, or concerns directly to the admin. In addition to submitting new feedback, users can also view a comprehensive history of all their previously submitted feedback. This feature allows users to track their communication and ensure their messages have been recorded and addressed appropriately.

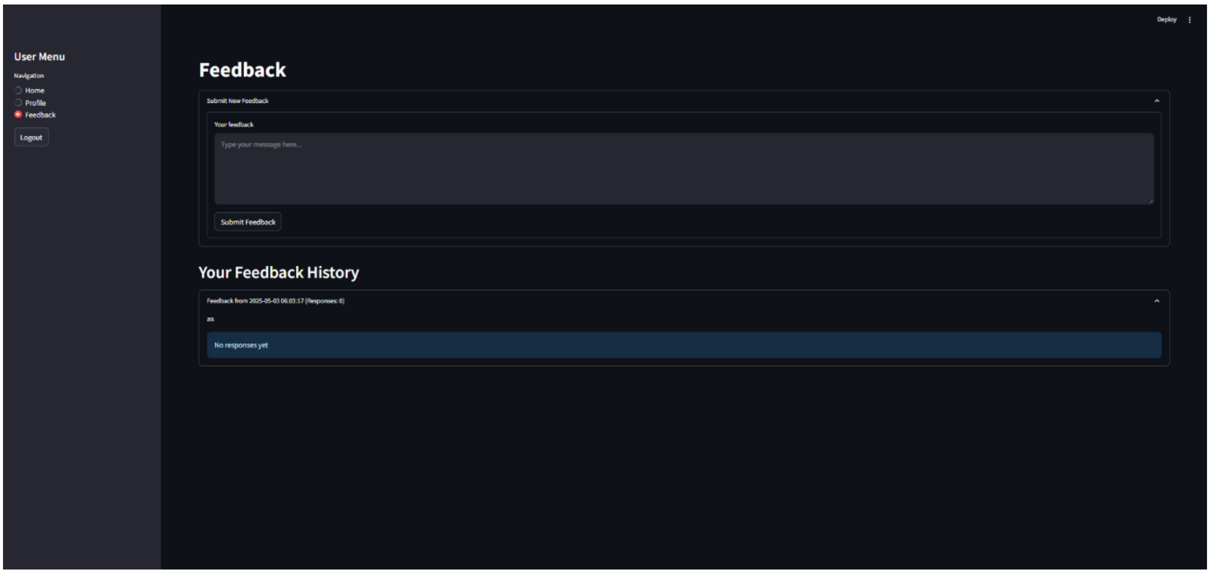

Figure 4.6: Feedback system at user page

Figure 4.6 illustrates the feature that allows users to view responses from the administrator regarding their submitted feedback. This response serves as confirmation that the feedback has been received and reviewed by the admin. It also demonstrates the system's commitment to addressing user concerns and fulfilling their needs in a timely and responsive manner.

4.3.3Dashboard(admin)

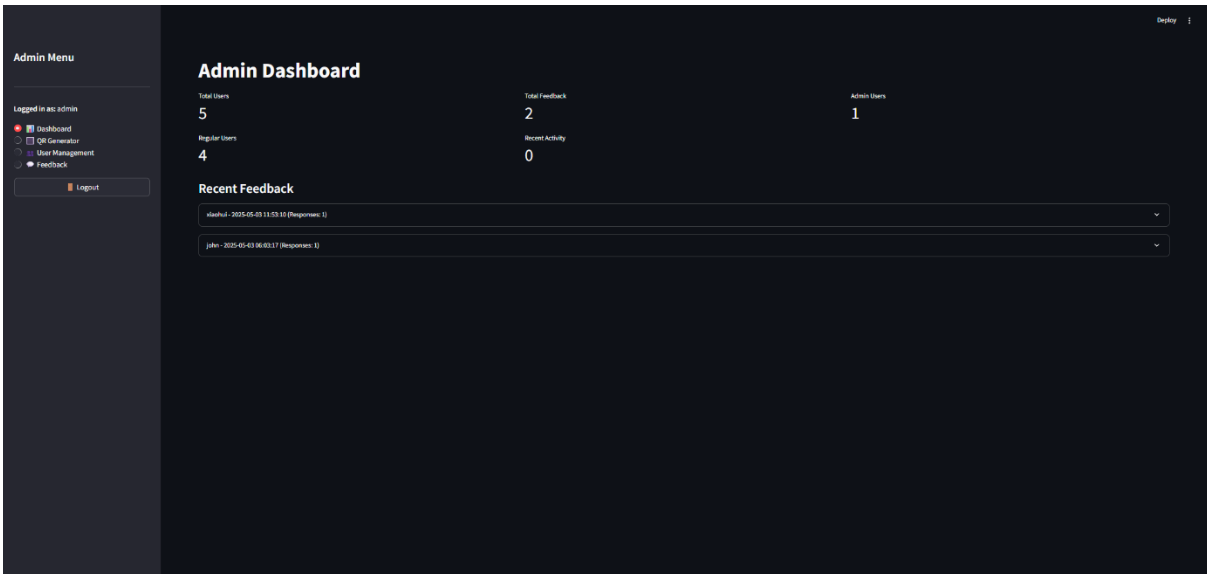

Figure 4.7 Home page(admin)

Figure 4.7 shows the admin homepage of the foot measurement system. From this dashboard, administrators can view key system statistics, including the total number of users, submitted feedback, and recent user activity. Additionally, admins have access to several important features: they can display the QR code generator for customers to scan, manage user accounts through the user management module, and access the feedback system to review and respond to user submissions.

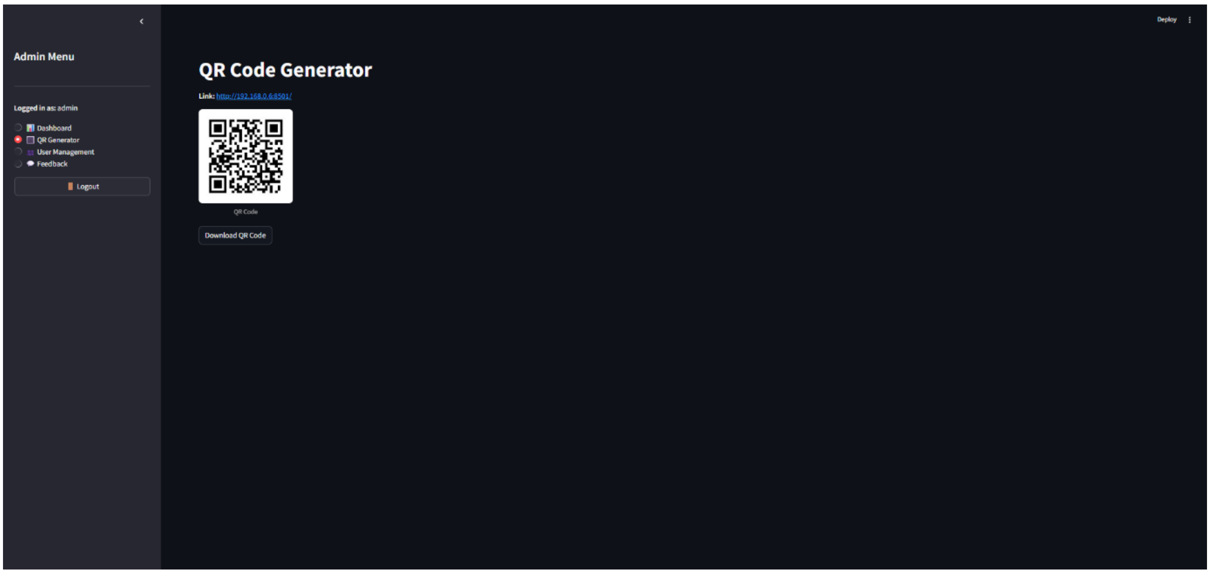

Figure 4.8 QR code page(admin)

Figure 4.8 shows the QR code generation page accessible to the admin. On this page, the admin can generate a QR code for users to scan, which provides direct access to the foot measurement page via an embedded link. Additionally, the generated QR code can be downloaded for external use, allowing it to be shared or printed as needed.

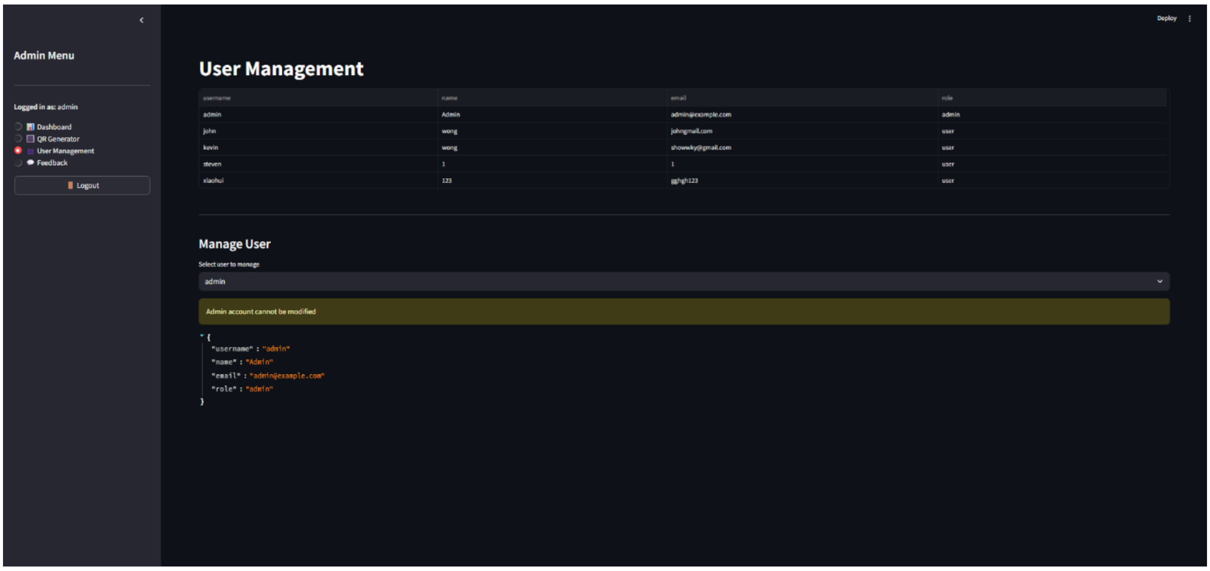

Figure 4.9 User management page(admin)

Figure 4.9 shows the user management page on the admin side. Here, the admin can view user information and their assigned roles. Additionally, the admin has the authority to access detailed user profiles, edit user roles, and delete users from the system as needed.

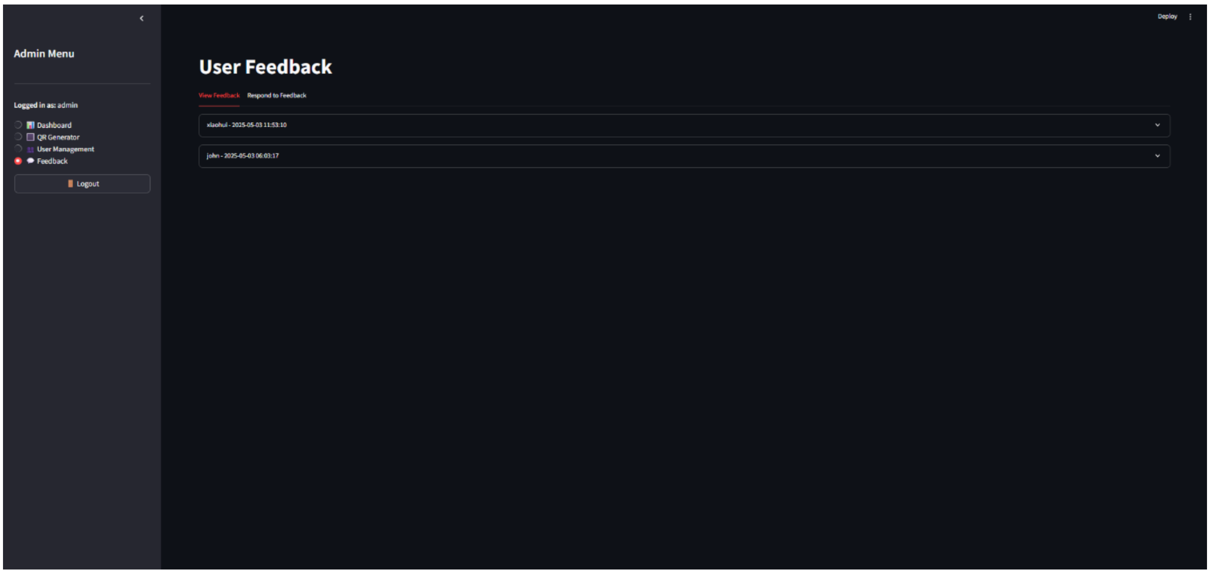

Figure 4.10: Feedback system(admin)

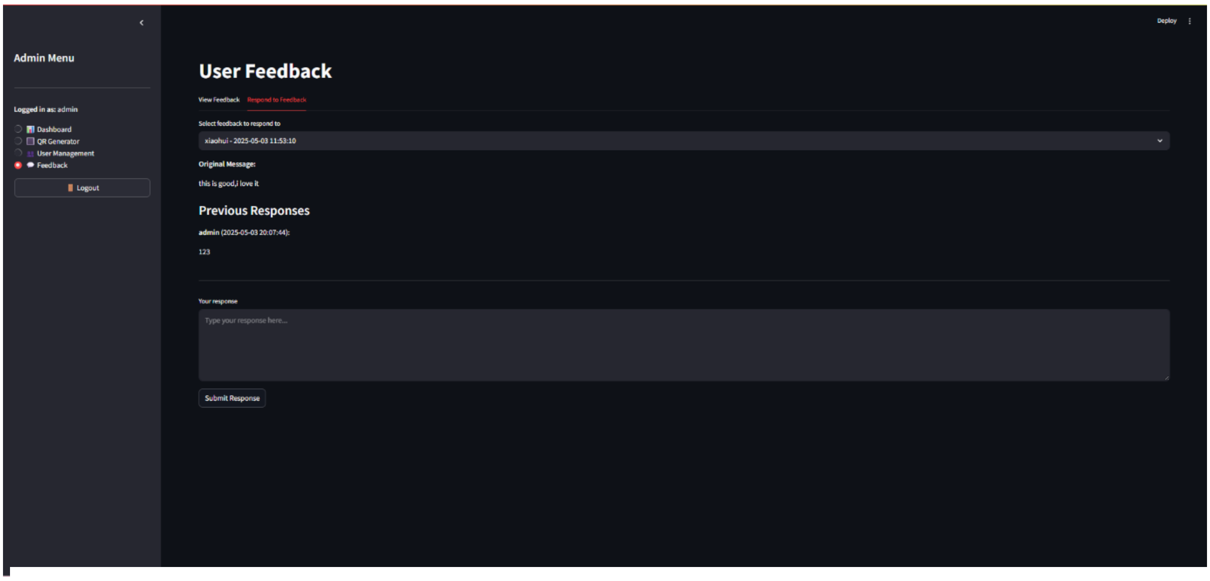

Figure 4.11 Response to user feedback

Figure 4.10 illustrates the feedback system from the admin's perspective. Through this interface, administrators can continuously monitor all feedback submitted by users, ensuring that no message goes unnoticed. This centralized system allows admins to efficiently review user comments, concerns, and suggestions. As demonstrated in Figure 4.11, admins have the ability to respond directly to user feedback, which not only confirms that their input has been received but also shows the system's dedication to addressing user needs and maintaining a positive user experience. This two-way communication helps build trust and encourages users to engage more actively with the platform.

4.3.4 Foot Measurement Page

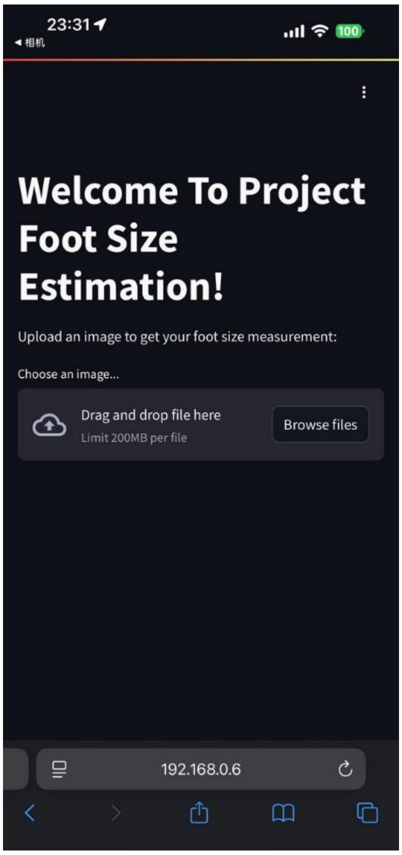

Figure 4.12 Foot Measurement page(user)

Figure 4.12 shows the foot measurement page that appears after a user scans the QR code. On this page, users have the option to either upload an existing photo of their feet from their device or take a new photo on the spot. This functionality is accessible through the dropdown menu that appears when clicking the "Browse Files" button, providing flexibility and convenience in submitting foot measurements.

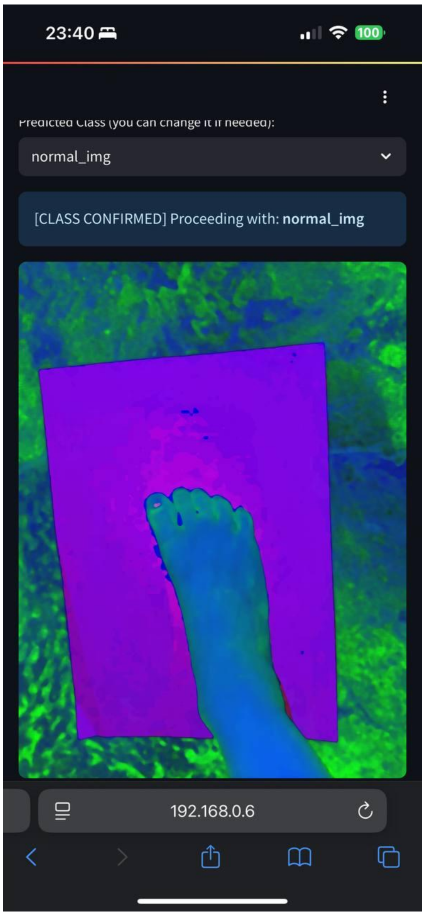

Figure 4.13 Filter selection for different backgrounds

Figure 4.13 shows the dropdown menu under the Class (Filter) section, where users can select a more appropriate classification for their foot measurement. This feature allows users to manually adjust or correct the automatically assigned class if they feel it does not accurately represent their measurement. It ensures better accuracy and user control in the classification process.

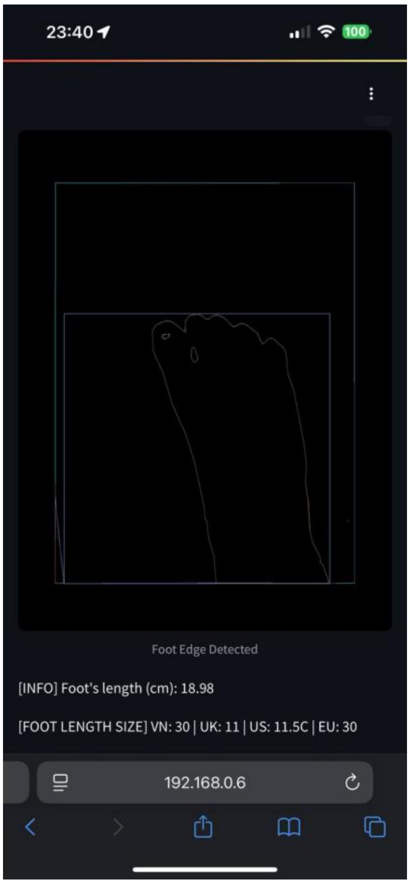

Figure 4.14: Result after measurement(user)

Figure 4.14 shows the results page displayed after the foot measurement process is completed. On this page, users can view their foot size presented in various international sizing standards, including UK, US, VN, and others. This allows users to easily understand and compare their measurements across different regional sizing systems for better convenience and usability.

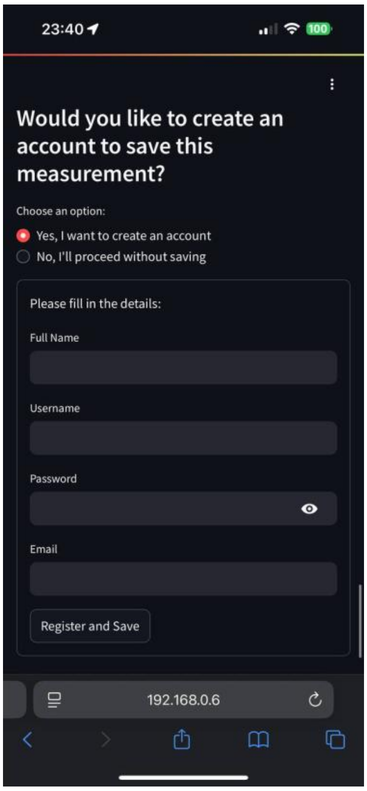

Figure 4.15 Creating account(user)

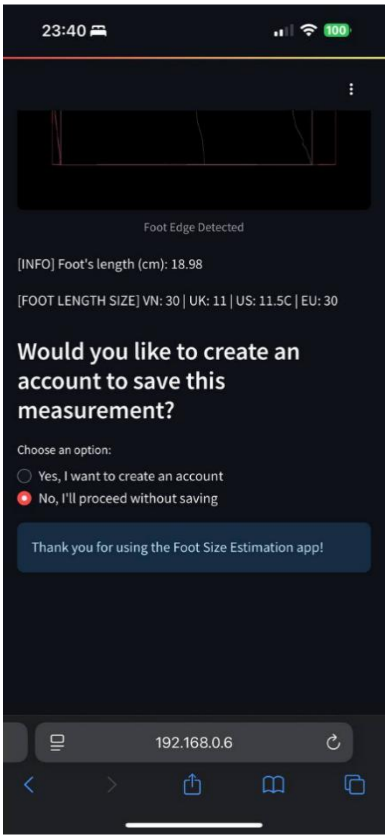

Figure 4.16 No creating account(user)

Figure 4.15 illustrates the page that appears when a user is prompted to create an account after completing the foot measurement process. Creating an account allows users to save their measurement data, track their foot size history, and access additional features available on the user dashboard. However, if the user chooses not to create an account, the process ends, and the system returns to the initial state, as shown in Figure 4.16.

Figure 4.17 Manual adjust A4 margin box

Figure 4.18 Manual adjust Foot Edge margin box

Figure 4.17 shows the sliders for manual adjusting the A4 bounding box, while Figure 4.18 displays the sliders for manually adjusting the foot edge bounding box to achieve higher accuracy

4.4 Summary

This chapter described the implementation of the Web-Based Foot Measurement System, developed to accurately estimate foot dimensions from an uploaded image using A4 paper as a reference scale. Prioritizing accessibility and ease of use, the system enables users to measure their feet directly through a browser interface without the need for additional software installations. The development environment was built using Visual Studio Code for coding, Streamlit for creating the web interface, and SQLite for lightweight database management. The application leverages Python, incorporating powerful image processing libraries such as OpenCV, NumPy, and scikit-image to analyze images and perform precise measurement calculations. The chapter detailed the setup process and elaborated on key features, highlighting the integration of image processing with a simple, user-friendly frontend designed to provide an efficient and accurate foot measurement experience.

CHAPTER 5

TESTING AND ANALYSIS

5.1 Introduction

This chapter outlines the different types of testing carried out to validate and verify the functionality of the proposed application. Testing is a critical step for developers as it helps uncover bugs or software failures. Furthermore, it plays a vital role in improving the overall quality of the application. This chapter focuses on both functional and accuracy testing, with the respective results discussed in the following sections.

5.2 Functional Testing

Functional testing is carried out to verify that each feature within the application performs in accordance with the defined software requirements. Each function is tested against its respective requirement to ensure that the outputs meet user expectations. The testing process involves providing sample inputs, recording the resulting outputs, and validating that the actual outcomes align with the expected results. The results of these tests are presented in Tables 5.1 to 5.5.

Table 5.1 Login Page test (User)

TestID	Test Case	Pre-condition	Test Steps	Input Data	Expected Result	Actual Result	Status (Pass/ Fail)
LPU-001	Test on valid login	User already has a valid account	User attempts to log in with valid credential	Username: Kevin0801 Password: Kewvin0801	User able to log in	User log in successfully	Pass

LPU-002	Test on invalid login	User already has a valid account	User attempts to log in with valid username but invalid password	Username: Kevin0801 Password: Kevin0000	User unable to log in	User failed to log in	Pass
LPU-003	Test on invalid login	User already has a valid account	User attempts to log in with invalid username and valid password	Username: Kevin1234 Password: Kewvin0801	User unable to log in	User failed to log in	Pass
LPU-004	Test on invalid login	User already has a valid account	User attempts to log in with invalid username and invalid password	Username: Kevin0000 Password: Kewvin0000	User unable to log in	User failed to log in	Pass

Table 5.2 Login Page test (User)

TestID	Test Case	Pre-condition	Test Steps	Input Data	Expected Result	Actual Result	Status (Pass/ Fail)
LPA-001	Test on valid login	Admin already has a valid account	Admin attempts to log in with valid credential	Username: admin Password: admin123	Admin able to log in	Admin log in success fully	Pass
LPA-002	Test on invalid login	Admin already has a valid account	Admin attempts to log in with valid username but invalid password	Username: admin Password: admin000	Admin unable to log in	Admin failed to log in	Pass
LPA-	Test on invalid	Admin already	Admin attempts to	Username:	Admin unable to	Admin failed	Pass

003	login	has a valid account	log in with invalid username and valid password	admin000 Password: admin123	log in	to log in	
LPA-004	Test on invalid login	Admin already has a valid account	Admin attempts to log in with invalid username and invalid password	Username: admin0000 Password: admin0000	Admin unable to log in	Admin failed to log in	Pass

Table 5.3 User Page test

TestID	Test Case	Pre-condition	Test Steps	Input Data	Expected Result	Actual Result	Status (Pass/ Fail)
UP-001	Test on display user info	User logged in to user page	Look at home page for user foot size measurement.		User able to see their foot size clearly with standard size output	User can clearly see the measurement, even the time taken.	Pass
UP-002	Test on edit user profile	User logged in to user page	User edit the profile by changing the name, email.	New name:Kevin Wong King Ing New Email:Kevin123@gmail.com	User will be logged out , log in again with the latest info displayed.	User back to login page, after log in again, new info is displayed.	Pass
UP-003	Test on changin	User logged	User change new	New Password:K	User will be logged	Message	Pass

	g password	in to user page.	password	evin0801	out after a message shows password changed pop out.	showing password has been changed pop out, and user is logged out.	
UP-004	Test on precious password	User already change a new password	User log in with the previous password.	Password:Kevin0801	User unable to log in	User failed to log in	Pass
UP-005	Test on current valid password	User already change a new password	User log in with the current valid password.	Password:Kevinwky0801	User able to log in	User log in successfully	Pass
UP-006	Test on the feedback function.	User logged in to user page.	User Try to submit something as a feedback	Feedback: This is an interesting project	User will able to see his feedback history under the feedback form. (Admin should also see it.)	New feedback history has been created with zero responses from Admin	Pass
UP-007	Test on log out function.	User logged in to user page.	User wants to log out through log out button		User redirected to login page	Login page appears after pressing	Pass

						logout button.	
UP-007	Test on receiving the response from admin	User has give feedback	User wants to see the response from admin		User able to see reponses ‘ Thank you so much’	User see reponses ‘ Thank you so much’	Pass

Table 5.4 Admin Page test

TestID	Test Case	Pre-condition	Test Steps	Input Data	Expected Result	Actual Result	Status (Pass/ Fail)
AP-001	Test on display admin dashboard	Admin logged in to admin page	Look at dashboard to see activities of users.		Admin able to see total number of users, feedback and recent activities.	Admin can see and keep track all number of users and recent feedback.	Pass
AP-002	Test on viewing the users feedback	Admin logged in to admin page	Admin press on the feedback and should able to see what users wrote		Admin able to see whats the content of each feedback box.	Admin sees all the content written by the users with no of responses from admin.	Pass
AP-003	Test on QR	Admin logged	Admin go the QR generator		Admin should see	Admin page	Pass

	Generator	in to admin page	page.		a QR code and a link to the foot measurement system.A button to download QR code is also shown.	appears a link to foot measurement system, QR code and download QR code button.	
AP-004	Test on link to foot measurement page.	Link is provided.	Admin press on the link.		Admin directed to foot measurement page	Foot measurement page appears.	Pass
AP-005	Test on scanning QR code.	QR code is displayed	User scan on the QR code.		User directed to foot measurement page.	User go to foot measurement page.	Pass
AP-006	Test on the download QR code function.	QR code is displayed.	Admin download the qr code		Admin should get a QR code.png at downloads page.	Admin successfully download the QR code.	Pass
AP-007	Test on User management page.	Admin logged in to admin page	Admin press the user management button.		Admin should see users information and able to manage the user by viewing, editing and	Admin see users information and able to manage the user by	Pass

					also delete the user.	viewing, editing and also delete the user.	
AP-008	Test on switching the users to edit	Admin logged in to admin page	Admin press the drop-down menu and change the users to edit		Admin can switch any user exists to edit.	Admin switch any user exists to edit.	Pass
AP-009	Test on edit the users role	Admin logged in to admin page	Admin press the drop-down menu and change the users to become admin	Username: Kevin0801 Role:admin	User Kevin0801 become admin	Username:Kevin0801 became admin, and logged in as admin.	Pass
AP-010	Test on delete the users	Admin logged in to admin page	Admin delete the user.	Username: Kevin0801(delete)	User Kevin0801 deleted and cannot be found	User Kevin0801 deleted	Pass
AP-011	Test on delete the admin	Admin logged in to admin page	Admin delete the admin.	Username:admin	Admin cannot be deleted	Admin is rejected for delete	Pass
AP-012	Test on viewing feedback	Admin logged in to admin page	Admin views the feedback from users		Admin should see the feedback from each user	Admin can pick which users feedback to look at	Pass

AP-013	Test on respond to feedback	Admin logged in to admin page	Admin responses to the feedback from users	Username: Kevin Feedback responses: Thank you so much	Admin should see the previous response so do the user can see the response from admin	Admin see the previous response so do the user can see the response from admin	Pass

Table 5.5 Foot Measurement Page (User)

TestID	Test Case	Pre-condition	Test Steps	Input Data	Expected Result	Actual Result	Status (Pass/Fail)
FMP-001	Test on Putting in the image	User has reach foot measurement page	User put in the image but taking photo or upload		Foot measuremnt is out with clear output and a registeration form is appear	User see the foot measurement result and a regiteration form.	Pass
FMP-002	Test on different filter	User has reach foot measurement page	User press the drop down menu and choose other background filter.		User can see different preprocessing with different background filter	User see different preprocessing with different background filter	Pass
FMP-	Test on	User	User choose		Message	User see	Pass

003	proceed without saving	has reach foot measurement page	not to saving their profile		showing appreciation should pop out	a message' Thank you for using the Foot Size Estimation app!'	
FMP-004	Test on creating account	User has no account yet	User choose to save his profile and provide his info in the registration form.	Full Name: Kevin Wong King You Username: Kevin0801 Password: Kewvin0801 Email: showwky@gmail.com	User info is saved and an account is created.	User see message 'Registration successful and measurement saved!'	Pass
FMP-005	Test on saving image-classified pictures for AI training.	User has put in the picture and found a better class	User press the saving picture button.		The image is saved in the corresponding class in the image-classified folder	The image saved successfully and can be found in the class folder.	Pass
FMP-006	Test on adjusting the A4 bounding box.	The auto-detected A4 bounding box appears but is not in the correct position.	The user drags the bounding box to align it properly.		Once the manual bounding box is aligned, foot detection should be accurate.	Foot detection appears correct and measurement accuracy improves.	Pass

FMP-007	Test on Adjusting the Foot-Edge Bounding Box	The auto-detected foot-edge bounding box appears but is misaligned.	The user drags the bounding box to better align with the foot shape.		When the manual bounding box is correctly aligned, the foot size measurement should be most accurate.	With the manual bounding box correctly positioned, measurements are very accurate.	Pass

5.3 Environmental Factors Setting

To ensure optimal performance of the foot measurement algorithm, tests were conducted to evaluate how different environmental factors affect measurement reliability. The three key environmental factors are camera height, foot placement on the A4 paper, and phone angle during image capture. Each test aimed to determine the most favorable configuration for minimizing measurement errors and enhancing the system's accuracy.

5.3.1 Camera Height Evaluation

This test assessed how varying the height of the camera affects the accuracy of foot measurement. The phone was positioned perpendicularly (90° angle) to the A4 paper at different heights: 30 cm, 40 cm, and 50 cm. A photograph was captured at each height with the foot placed in the center of the A4 paper. The resulting measurement from the app was then compared with the ground truth foot length to determine the error.

5.3.2 Foot Placement Evaluation

To test the sensitivity of the algorithm to foot position, the foot was placed at different regions on the A4 paper: center, left, right, top and bottom. Camera height and angle were fixed to eliminate their influence. Each foot placement image was processed through the app and compared with the actual foot length to evaluate positional effects on measurement accuracy.

5.3.3 Phone Angle Evaluation

This test examined the influence of camera tilt on measurement output. The phone was positioned at various angles relative to the ground: 70°, 80°, 90° (perpendicular), 100°, and 110°, while keeping the camera height fixed. The foot remained centered on the A4 paper throughout. Measurements were recorded and compared to the ground truth to assess how angle deviations impact accuracy.

5.3.4 Environmental Factors setting test results

Table 5.6 Environmental factors setting test results

Test Category	**Test Condition**	**Actual Foot Length (cm)**	**App Measurement (cm)**	**Error (cm)**	**Notes**
Camera Height	30 cm	26.76	26.70	-0.06	Too close, slight distortion
	40 cm	26.76	26.75	-0.01	Very accurate
	50 cm	26.76	26.79	+0.03	Minor overestimation
Foot Placement	Center	26.76	26.75	-0.01	Slight shift, acceptable
	Left	26.76	26.62	-0.14	Slight shift
	Right	26.76	26.63	-0.13	Slight underestimation
	Top	26.76	26.90	+0.14	Significant overestimation
	Bottom	26.76	26.77	+0.01	Stable reading
Phone Angle	70°	26.76	26.61	-0.15	Significant underestimation
	80°	26.76	26.74	-0.02	Slight underestimation
	90° (Perpendicular)	26.76	26.75	-0.01	Most accurate
	100°	26.76	26.79	+0.03	Slight overestimation,

					acceptable
	110°	26.76	27.00	+0.24	Significant overestimation

As illustrated in Table 5.6, camera height has a significant influence on the accuracy of the foot size estimation. When the camera was positioned at a height of 30 cm above the A4 paper, the application slightly underestimated the foot size, with a deviation of 0.06 cm. This inaccuracy is likely caused by perspective distortion due to the camera being too close to the foot, which affects the detection of actual foot proportions. Raising the camera to 40 cm resulted in the lowest error, with only a 0.01 cm difference from the actual measurement. This suggests that 40 cm is the optimal height, offering a balanced perspective that captures the foot clearly without distortion. At 50 cm, a slight overestimation of 0.03 cm was recorded, indicating that increased distance begins to affect scale interpretation. Therefore, 40 cm emerged as the best camera height for reliable and accurate EU foot size predictions.

Foot placement on the A4 paper also played a vital role in ensuring consistent measurements. When the foot was positioned at the center of the paper, the error was minimal, with a deviation of just 0.01 cm. This indicates that the algorithm performs best when the foot is centrally aligned with the camera's focal point. In contrast, shifting the foot to the left or right caused greater inaccuracies, with underestimations of 0.14 cm and 0.13 cm respectively. The most significant deviation occurred when the foot was placed at the top of the A4 paper, resulting in an overestimation of 0.14 cm. On the other hand, placing the foot near the bottom of the paper-maintained measurement stability with only a 0.01 cm overestimation. These results suggest that the center and bottom regions of the A4 paper are the optimal zones for foot placement, likely due to more consistent alignment with the camera and less edge distortion.

The angle at which the phone was held during image capture also impacted size accuracy. When the phone was held at a 90° angle, perfectly perpendicular to the ground, the system produced the most accurate result, with just a 0.01 cm difference from the actual foot size. A slight tilt to 80° still yielded acceptable results with a minor underestimation of 0.02 cm. However, greater deviations, such as tilting the phone to 70° or 110°, resulted in significant measurement errors of -0.15 cm and +0.24 cm respectively. These findings demonstrate the system's sensitivity to angular misalignment and highlight the importance of maintaining a perpendicular phone angle during capture.

In summary, the evaluation confirmed that the most accurate and consistent EU foot size measurements are achieved when the image is taken with the camera held at a height of 40 cm, the foot is placed at the center or bottom of the A4 paper, and the phone is held at a 90° angle. These optimal conditions will be adopted as the recommended user guidelines within the application to enhance measurement reliability and improve the overall accuracy of the foot size estimation system.

5.4 Accuracy Testing of Foot Measurement System

To validate the accuracy of the developed foot measurement system, an accuracy test was conducted using 10 foot samples. The objective was to assess how closely the system's predicted measurements matched the ground truth measurements obtained by manual measurement.

5.4.1. Methodology

The methodology involved collecting ten foot samples and measuring them both manually and using the developed foot scanning system. Manual measurements served as ground truth, while system measurements were derived from image processing. Accuracy was then evaluated by comparing both sets of measurements using standard metrics

5.4.1.1 Data Collection

Ten foot samples were measured both manually and using the developed system. Manual measurements were taken using a standard tape measure to obtain the ground truth values, including key parameters such as foot length and foot width. The system's measurements were extracted from the foot images processed through the foot measurement algorithm.

5.4.1.2 Accuracy Metrics

The predicted measurements from the system were compared against the ground truth. The following metrics were computed to quantify accuracy:

- Mean Absolute Error (MAE): Average absolute difference between predicted and true measurements.
- Root Mean Squared Error (RMSE): Square root of the average squared errors, emphasizing larger deviations.
- Mean Absolute Percentage Error (MAPE): Average absolute percentage error relative to ground truth.

These metrics were computed for each measurement type across all samples.

5.4.2 Results

Table 5.7 summarizes the predicted and ground truth EU sizes for the 10-foot samples, along with the absolute error, exact match status, and whether the prediction was within ±0.5 size of the ground truth.

Table 5.7 Comparison of predicted and ground truth EU size

Sample ID	Ground Truth EU Size	EU Size Calculated by System	Absolute Error (sizes)	Exact Match	Within ±0.5 Size
FS-001	29	30.1	1.1	No	No
FS-002	38	38.0	0.0	Yes	Yes
FS-003	41	40.5	0.5	No	Yes
FS-004	43	43.0	0.0	Yes	Yes
FS-005	39	39.0	0.0	Yes	Yes
FS-006	33	33.0	0.0	Yes	Yes
FS-007	44	43.8	0.2	No	Yes
FS-008	42	42.0	0.0	Yes	Yes

FS-009	35	35.0	0.0	Yes	Yes
FS-010	36	36.0	0.0	Yes	Yes

From the results shown in Table 5.7 above:

Mean Absolute Error (MAE) is calculated using the formula:

$$\text{Mean Absolute Error } (MAE) = \frac{1}{n}\sum_{i=1}^{n}|\hat{y_i} - y_i|$$

Where:

- $\hat{y_i}$ is the predicted value
- y_i is the actual (ground truth) value
- n is the total number of samples

Substituting the values:

$$\text{MAE} = \frac{1.1+0+0.5+0+0+0+0.2+0+0+0}{10} = 0.18 \text{ EU sizes}$$

Exact Match Rate = 8 out of 10 → 80%

Within ±0.5 Size Rate = 9 out of 10 → 90%

5.4.3 Discussion

The system achieved a high level of accuracy in predicting EU foot sizes. The mean absolute error of 0.18 sizes indicates that, on average, the system's predictions were very close to the ground truth.

80% of the predictions exactly matched the expected EU size, and 90% were within ±0.5 size, which is generally acceptable for practical applications like shoe fitting. Only one sample (FS-001) fell outside this margin, with a prediction that was 1.1 sizes off. This could be due to a combination of image quality, foot alignment, or conversion inaccuracies for smaller foot sizes.

These results suggest that the system is well-calibrated for most foot sizes, particularly in adult ranges, and only needs refinement in specific edge cases (e.g., very small foot sizes).

5.4 Summary

This chapter summarizes the comprehensive testing conducted to validate the functionality and accuracy of the proposed foot measurement application. Functional testing confirmed that all system features—including user login, profile management, feedback handling, admin controls, and the foot measurement process—worked as intended, with all test cases passing. Accuracy testing examined key environmental factors such as camera height, foot placement on A4 paper, and phone angle, identifying optimal conditions (40 cm camera height, centered or bottom foot placement, and a 90° phone angle) that minimized measurement errors. Using 10-foot samples, the system achieved a mean absolute error of 0.18 EU sizes, with 80% exact matches and 90% of predictions within ±0.5 size of the ground truth. These results confirm the system's practical reliability for real-world shoe fitting, with minor improvements needed to enhance consistency for smaller foot sizes.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Achievement

The development of the Foot Measurement System has successfully implemented several important features aimed at simplifying and improving the accuracy of foot measurement for users. The system supports secure user authentication through a reliable login process, ensuring data privacy and personalized profile management. The foot measurement function utilizes image processing techniques to capture foot dimensions accurately, allowing users to view, edit, and track their measurements over time. Additionally, the system provides features for managing user data securely and facilitates recommendations for shoe sizes based on collected measurements. These functionalities collectively demonstrate that the system fulfills its goal of providing an accessible, accurate, and user-friendly platform for foot measurement, contributing meaningfully to fitting and personal health monitoring. This achievement aligns with the project's objectives of designing, developing, and evaluating an integrated solution that enhances the foot measurement experience.

6.2 Contribution

This project contributes significantly to the field of biometric measurement and footwear technology by providing an accurate and user-friendly foot measurement system. It enables users to measure their foot dimensions using a camera or scanning device, reducing the need for manual measurements and minimizing human error. The system supports real-time data processing, secure user login, and profile management, allowing users to track their foot growth or changes over time. Additionally, it can assist in recommending appropriate shoe sizes based on the collected data, enhancing comfort and reducing online shopping returns. These features collectively improve accuracy, convenience, and user experience in foot measurement and footwear selection.

6.3 Limitation

Despite its advantages, the current version of the system has several limitations. This section outlines the challenges still present, such as the absence of online shoe store integration, lack of multi-angle foot scanning for more detailed 3D measurements, and dependence on camera quality for accurate results.

6.3.1 No Integration with Online Shoe Stores

The system is currently not integrated with online shoe retailers. This limits its ability to provide direct size recommendations or facilitate purchases based on the measured foot dimensions.

6.3.2 Lack of 3D Scanning Capabilities

The current implementation supports only 2D foot measurements. Without multi-angle scanning, it cannot accurately capture foot volume or arch structure, which are important for advanced applications like orthotic recommendations or custom shoe fitting.

6.3.3 Dependence on Camera Quality

The accuracy of foot measurements heavily depends on the quality of the camera used. Low-resolution or poor-quality cameras can result in inaccurate measurements due to blurred or distorted images, limiting the system's reliability across different user devices.

6.3.4 Limited Background Robustness

The current system struggles to maintain high accuracy when used in environments with complex or inconsistent backgrounds. This limitation reduces its usability in real-world scenarios where ideal conditions are not always present. To improve classification and measurement accuracy, future work will involve training more robust AI models capable of handling a wider variety of backgrounds and lighting conditions.

6.4 Future Work

To overcome the identified limitations, future development will focus on integrating the foot measurement system with popular online shoe stores, enabling direct product recommendations based on user foot profiles. Additionally, the implementation of 3D scanning technology will allow the system to capture more comprehensive foot data, including volume, shape, and arch type. Efforts will also be made to optimize the system's image processing algorithms to compensate for varying camera qualities, improving measurement accuracy across a wider range of devices. Furthermore, future improvements will include training in more robust AI models to ensure reliable detection and measurement across diverse backgrounds and lighting conditions. These enhancements aim to boost the system's accuracy, usability, and application in various fields such as e-commerce, health, and sports.

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Appendices:

Appendix A

UNIVERSITI MALAYSIA SARAWAK

FACULTY OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

Questionnaire for Final Year Project

A Web-Based Foot Measurement System Using Smartphone Camera for Accurate Foot Dimension Calculation

Hello! My name is Kevin Wong King You, and I am a 4th-year Computational Science student from the Faculty of Computer Science and Information Technology (FCSIT) at UNIMAS.

I am currently developing a Web-Based Foot Measurement System as part of my Final Year Project (FYP). The primary objective of this system is to enable users to determine their foot size simply by taking a picture of their foot standing on an A4 paper.

This survey contains just a few questions and should take only 2–3 minutes to complete. Your feedback is invaluable in helping me design a system that is both userfriendly and convenient.

If you have any inquiries or suggestions, please feel free to contact me, Kevin Wong King You, at 79766@siswa.unimas.my.

Thank you for taking the time to participate in this survey!

Do you currently measure your foot size regularly? *

- ◯ Yes
- ◯ No

Have you faced challenges in finding the correct shoe size? *

- ◯ Yes
- ◯ No

Are you comfortable scanning QR codes? *

- ◯ Yes
- ◯ No

Would you use a system that measures your foot size via a smartphone? *

- ◯ Yes
- ◯ No

Is accurate foot measurement important to you? *

- ◯ Yes
- ◯ No

Would you prefer the system to include image-based instructions? *

- Yes
- No

Would you find it helpful if the system could store your foot size for future use? *

- Yes
- No