



Design And Implementation Of An Android-Based Human Anatomy Learning Tool Using Google Filament

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Abstract: Anatomy Insight is an Android-based application designed to facilitate interactive learning of human anatomy through real-time 3D model rendering. Developed using Kotlin, Jetpack Compose, and Google Filament, the app provides a visually immersive experience by enabling users to explore detailed anatomical structures with high-performance rendering techniques.

The application supports over 2,369 anatomical subparts, each with dynamic selection capabilities, allowing users to focus on specific structures. A search functionality enables retrieval of anatomical models by both scientific and common names, enhancing accessibility for students and professionals alike. Advanced rendering optimizations, including HDR lighting, ambient occlusion, bloom effects, and MSAA (multi-sample anti-aliasing), ensure a high-fidelity visualization of 3D anatomy models. Anatomy Insight leverages Google Filament's real-time rendering capabilities, utilizing ModelRenderer.kt for loading GLB-format anatomical models and hdrutils.kt for HDR environment lighting. Navigation within the application is handled using NavController, providing a seamless transition between the home and search pages. By integrating open-source 3D anatomical models and public domain educational descriptions, this app serves as a comprehensive learning tool for medical students, healthcare professionals, and enthusiasts. Future enhancements include interactive quizzes, AR support, and multi-language integration, further enriching the learning experience.

Key Words - Human Anatomy, 3D Model Visualization, Kotlin, Android App, Jetpack Compose, Google Filament, Real-Time Rendering, Educational Technology, Medical Learning.

I. INTRODUCTION

Understanding human anatomy is a fundamental aspect of medical education, yet traditional learning methods such as textbooks and 2D diagrams often fail to provide the depth and interactivity required for comprehensive understanding. With advancements in 3D visualization and real-time rendering technologies, digital tools have emerged as an effective alternative for anatomy learning. This paper presents the design and implementation of Anatomy Insight, an Android-based application that utilizes Google Filament for high-performance 3D anatomical visualization.

The primary objective of Anatomy Insight is to enhance anatomy education through an interactive and immersive learning experience. Built with Jetpack Compose and Kotlin, the application allows users to explore over 2,369 anatomical subparts in high detail. It supports dynamic subpart selection, enabling students, healthcare professionals, and educators to focus on specific anatomical structures. The search functionality allows users to retrieve models using scientific and common names, making the app accessible to a wide range of users. One of the core technical features of this application is real-time rendering using Google Filament,

leveraging HDR lighting, ambient occlusion, bloom effects, and multi-sample anti-aliasing (MSAA) to deliver high-fidelity visualizations. The app employs ModelRenderer.kt to load GLB-format 3D models and HDRUtils.kt to implement HDR environment lighting. A NavController-based navigation system ensures a smooth user experience between the home and search pages.

Anatomy Insight bridges the gap between traditional learning methods and modern technological advancements, providing a portable, user-friendly, and highly detailed anatomy exploration tool. By integrating open-source 3D models and public domain educational descriptions, the app ensures both accuracy and accessibility. Future enhancements, such as augmented reality (AR) support, interactive quizzes, and multi-language integration, aim to further enrich the learning experience. This paper details the design, architecture, and implementation of Anatomy Insight, demonstrating how real-time 3D rendering can revolutionize medical education by providing a more engaging and effective way to study human anatomy.

1.1 Project Scope

The Anatomy Insight project is designed to provide an interactive, high-performance 3D anatomy learning tool for Android devices. This application leverages Google Filament, Kotlin, and Jetpack Compose to create an immersive and visually enhanced educational experience for students, medical professionals, and anatomy enthusiasts. The key features and scope of the project include:

- **High-Fidelity 3D Anatomy Models:** Supports over 2,369 anatomical subparts, allowing users to explore human anatomy with detailed visualizations.
- **Real-Time 3D Rendering:** Utilizes Google Filament to implement advanced rendering techniques, including HDR lighting, ambient occlusion, bloom effects, and MSAA (multi-sample anti-aliasing) for high-quality visual output.
- **Dynamic Model Interaction:** Users can zoom, and rotate anatomical structures, enhancing engagement and understanding.
- **Efficient Search Functionality:** Enables users to find anatomical structures using scientific and common names, improving accessibility for both medical professionals and beginners.
- **Optimized Performance & Navigation:** Implements ModelRenderer for efficient 3D model handling and HDR for realistic environmental lighting. NavController-based navigation ensures seamless user experience between different sections of the app.
- **Educational Content Integration:** Incorporates descriptive medical texts sourced from OpenStax, Gray's Anatomy (1918 Edition), and MedlinePlus, providing scientifically accurate information.
- **User-Friendly Interface:** Designed using Jetpack Compose, ensuring an intuitive and modern UI/UX for enhanced usability.
- **Scalability & Future Enhancements:** The project is structured for future updates, with potential expansions including augmented reality (AR) integration, multi-language support, and interactive quizzes.

By integrating cutting-edge 3D rendering technology with educational resources, this project aims to redefine anatomy learning, making it more accessible, engaging, and effective for a wide range of users.

II. RESEARCH METHODOLOGY

2.1 Technology Stack

The Anatomy Insight application is developed using a modern Android technology stack to ensure high performance, real-time rendering, and an intuitive user experience. The key technologies used in the project are:

- **Programming Language:** Kotlin – The application is developed in Kotlin, the official language for Android development, ensuring concise and efficient code while improving maintainability.
- **User Interface:** Jetpack Compose – The UI is built using Jetpack Compose, a modern declarative UI toolkit, allowing flexible and responsive design while optimizing performance.
- **3D Rendering Engine:** Google Filament – For real-time 3D visualization, the app utilizes Google Filament, a high-performance rendering engine that supports physically-based rendering (PBR), HDR lighting, ambient occlusion, and multi-sample anti-aliasing (MSAA) to enhance anatomical model visualization.

- **Model Loading & Interaction:** ModelRenderer.kt – This custom Kotlin-based module enables efficient loading and rendering of GLB (GL Transmission Format Binary) anatomy models, supporting high-polygon 3D structures with smooth interaction.
- **Lighting & Effects:** hdrutils.kt – Implements HDR (High Dynamic Range) lighting for realistic shading and improved depth perception in the 3D models.
- **Navigation:** NavController – Manages smooth and intuitive navigation between different app sections, such as the home screen, search interface, and model viewer.
- **Data Management:** Open-Source Anatomical Databases – The application integrates Z-Anatomy models (licensed under CC BY-SA 4.0) and educational content from OpenStax, Gray's Anatomy (1918), and MedlinePlus, ensuring accurate and scientifically validated anatomical descriptions.

By utilizing this advanced technology stack, the Anatomy Insight app provides an optimized, visually immersive, and interactive learning experience, making anatomy education more accessible and engaging.

2.2 System Architecture

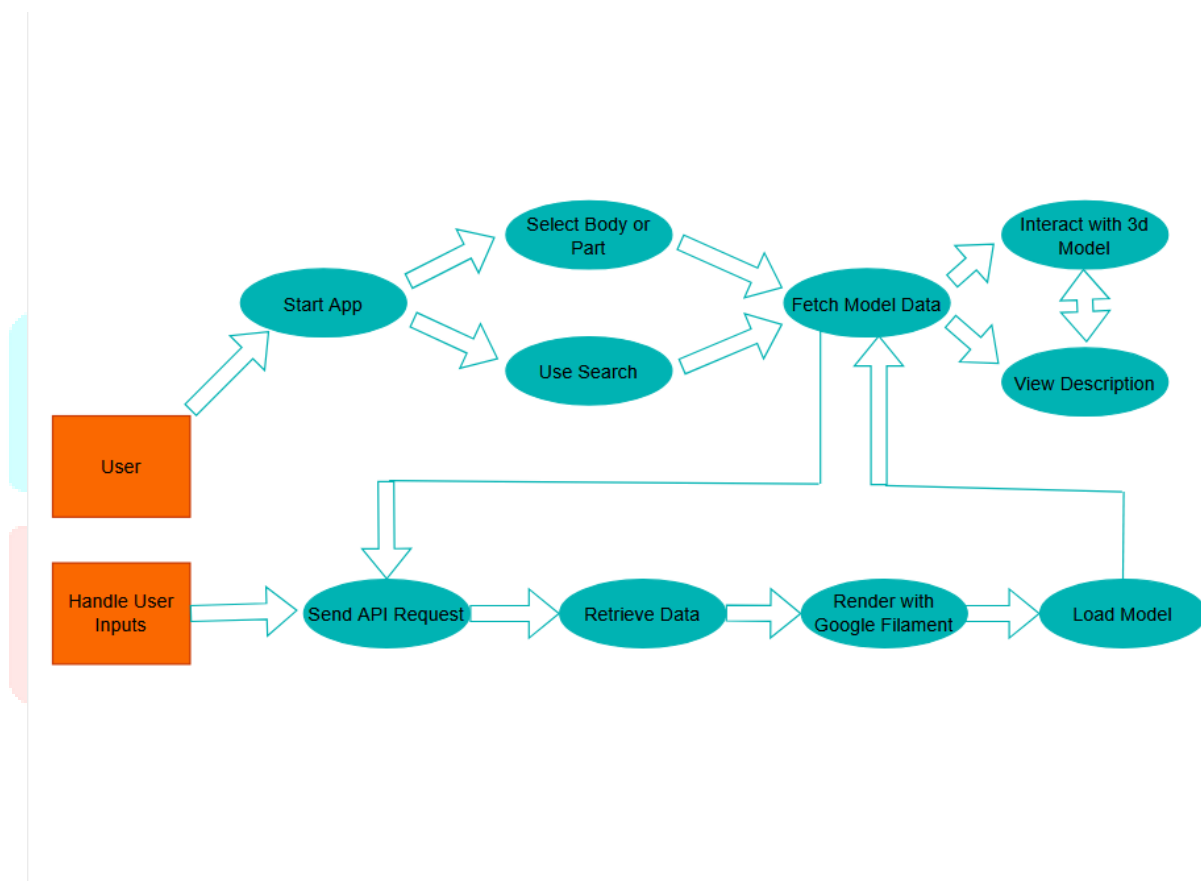


Fig 2.1 System Architecture

The Anatomy Insight application is designed to provide an interactive 3D learning experience by efficiently managing anatomical models, rendering, and data storage. The system follows a client-server architecture, where the Android application handles user interactions and 3D model rendering, while a local Room database stores anatomical subparts for quick retrieval.

The 3D models used in the app are derived from a high-quality anatomical model. Using Blender, only the most relevant 2,369 parts (out of approximately 4,000) were extracted and optimized for smooth performance. These segmented subparts are stored in the Room database, allowing for fast local access and offline functionality. Google Filament is responsible for rendering these models with physically-based rendering (PBR), HDR lighting, and smooth interaction controls.

The app also integrates search functionality, interactive labels, and guided learning modules, ensuring a seamless and immersive anatomy learning experience for students and professionals alike.

2.3 Key Features

- **Advanced Search System**
Users can search for anatomical structures using both scientific and common names. Upon selecting a result, the corresponding 3D model is highlighted, displaying its name and detailed description, enhancing the learning experience.
- **Interactive 3D Visualization**
The app employs Google Filament for high-quality rendering of anatomical models, allowing users to rotate, zoom, and interact with each part in real-time, providing an immersive learning environment.
- **Optimized Anatomy Database**
Instead of storing the full anatomical model, only 2,369 essential subparts are included in the Room database, ensuring faster loading times and efficient storage management while maintaining anatomical accuracy.
- **Offline Accessibility**
With locally stored anatomical data and models, users can access and explore content without an internet connection, making the app convenient for students and professionals in any setting.
- **Guided Learning & Information Display**
Users can view detailed descriptions of anatomical parts alongside the models, including their functions, locations, and related structures, providing a comprehensive study tool.

III. SYSTEM FEATURES AND IMPLEMENTATION

The Android-Based Human Anatomy Learning Tool is designed to provide an interactive and immersive educational experience for students and medical professionals. The system integrates efficient search functionality, high-quality 3D rendering, and a structured anatomical database to ensure accessibility and ease of learning.

The app allows users to search for anatomical structures using scientific or common names, displaying the relevant 3D model and descriptions upon selection. The integration of Google Filament ensures real-time rendering and smooth interaction with the models, allowing users to rotate, zoom, and explore anatomical structures in detail.

To optimize performance, only 2,369 essential subparts are included in the Room database, reducing load time while maintaining anatomical accuracy. Additionally, the system supports offline access, enabling users to explore anatomy without needing an internet connection. With a well-organized user interface, structured data storage, and efficient rendering techniques, this system offers a comprehensive and user-friendly learning tool for human anatomy education.

3.1 Key Features

1. Home Page

- Simple and user-friendly interface that allows easy navigation.
- Displays anatomical models in organized rows for quick selection.

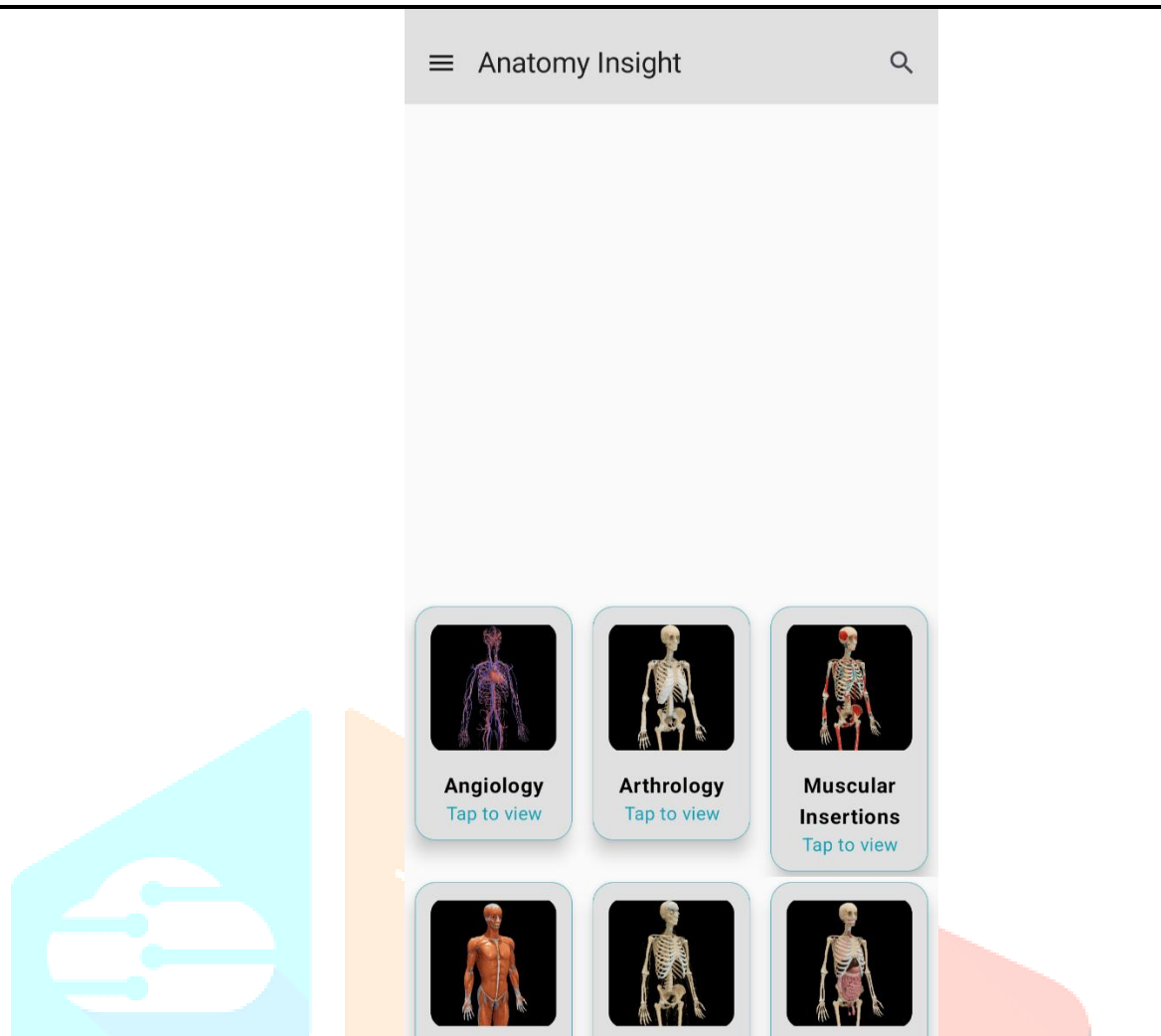


Fig 3.1 Home Page

- Search functionality for finding models using scientific and common names.
- Allows users to click on a model to view details.
- Provides a description of the model along with relevant anatomical details.

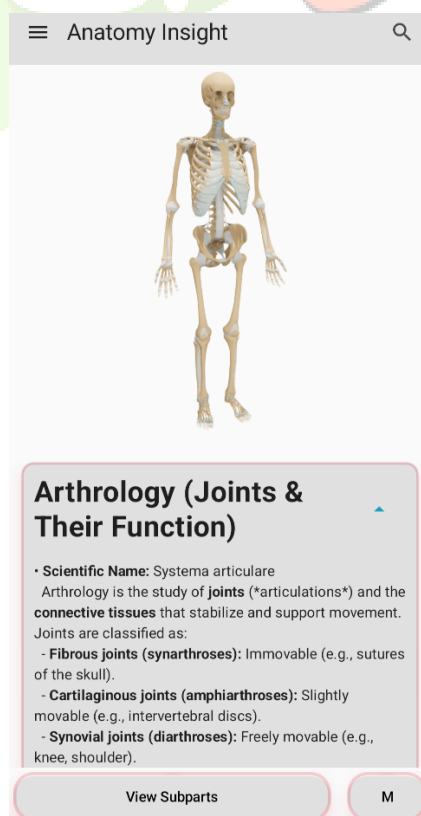


Fig 3.2 3D-Model with Description

2. Model Details Page

- Displays the selected anatomical model in a 3D interactive view.

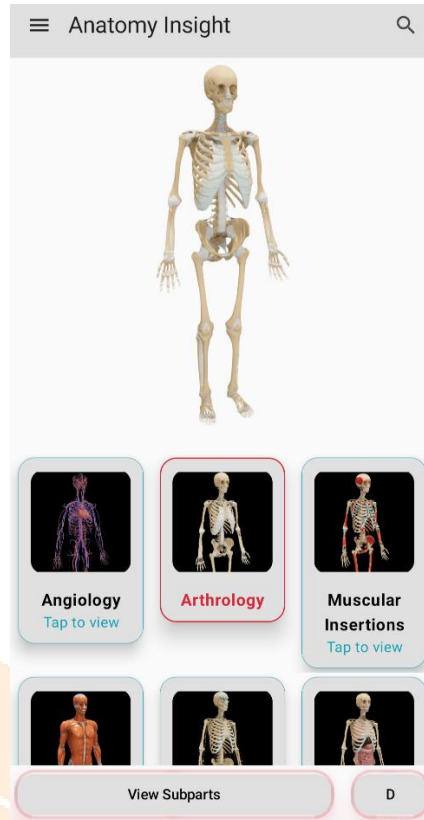


Fig 3.3 3D-Model on Home Page

- Offers buttons to explore subparts of the selected model.
- Shows a list of subparts derived from the main model.



Fig 3.4 3D-Models Subparts

3. Subpart List and Descriptions

- Allows users to click on subparts to view their descriptions.

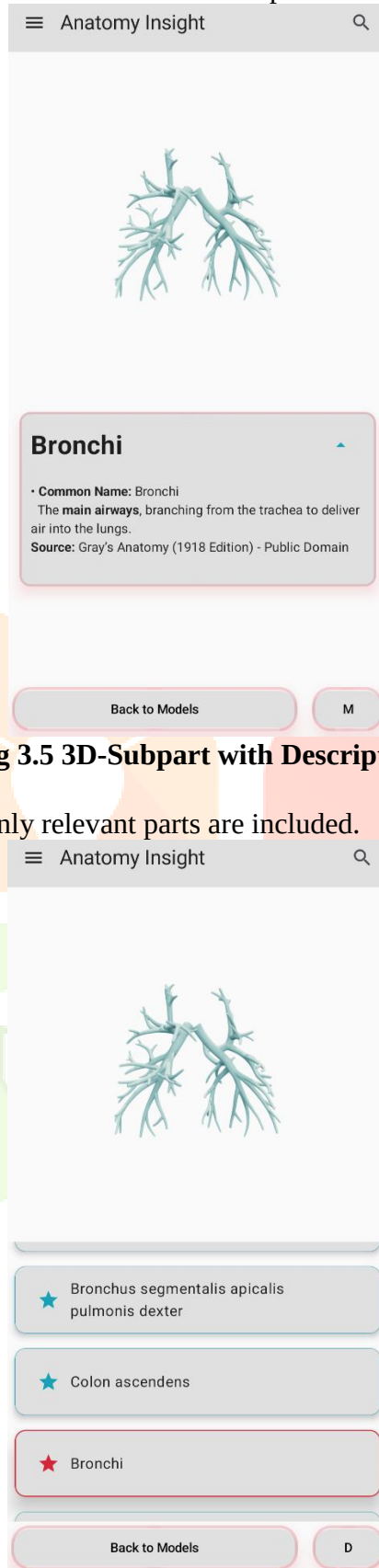


Fig 3.5 3D-Subpart with Description

- Optimized database ensures only relevant parts are included.

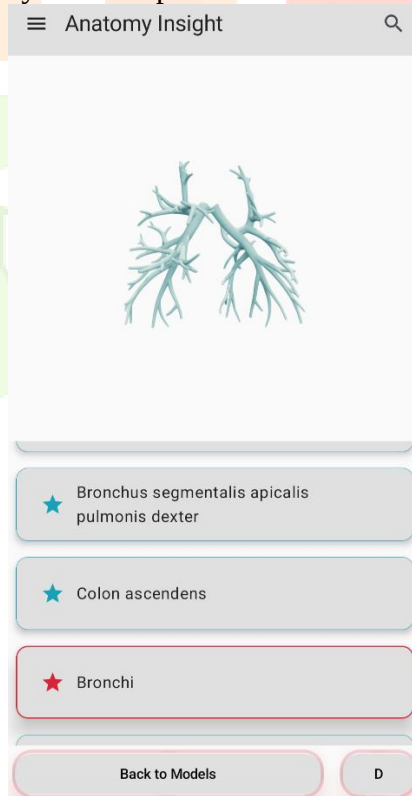


Fig 3.6 3D-Subpart with Parent Model's Subpart List

4. Search Functionality

- Users can search for models using scientific or common names.

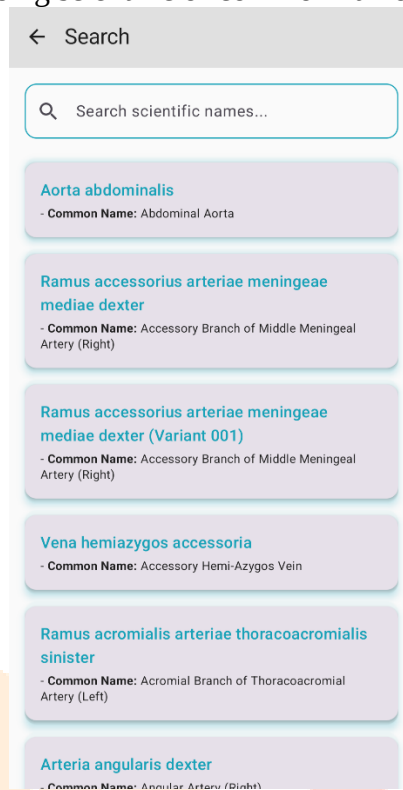


Fig 3.7 Search Page for Searching Subparts of All 3D-Models

- Instant search results with clickable options to navigate to models.

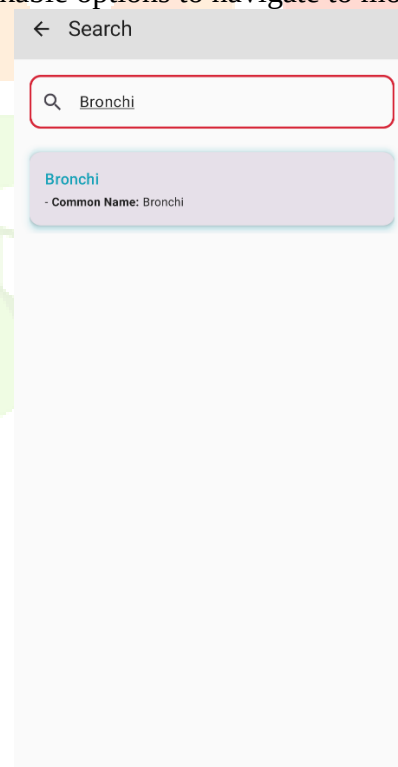


Fig 3.8 Searching a Subpart

This structured feature set ensures an efficient and interactive learning experience for users while keeping the app lightweight and optimized for performance.

IV. RESULT AND DISCUSSION

The Android-Based Human Anatomy Learning Tool demonstrates significant improvements over traditional anatomy learning methods by enhancing accessibility, interactivity, and user engagement. By integrating Google Filament for real-time 3D rendering, the system provides a seamless and immersive experience for exploring anatomical structures. The ability to search using scientific and common names ensures ease of use for both beginners and advanced users.

The effectiveness of the system is measured through parameters such as rendering speed, search accuracy, and user satisfaction. Compared to conventional 2D diagrams and static models, this application reduces cognitive load, improves visualization, and accelerates learning. The optimized Room database, containing only 2,369 essential subparts, enhances performance by reducing memory consumption without sacrificing anatomical detail. Additionally, offline accessibility allows users to study anatomy anytime, anywhere, making the tool a practical and efficient educational resource for students and medical professionals.

4.1 Performance Analysis

The performance of the Android-Based Human Anatomy Learning Tool is evaluated based on rendering speed, database efficiency, and user interaction responsiveness. The use of Google Filament ensures fast and smooth 3D model rendering, minimizing lag while interacting with anatomical structures.

Optimized Room database queries and efficient data indexing significantly reduce search times, allowing users to quickly retrieve anatomical models and descriptions. The system effectively handles large datasets (2,369 essential subparts) without overloading device memory, ensuring smooth performance even on mid-range smartphones.

Furthermore, the application's offline functionality enhances accessibility while maintaining low latency for model loading and searching. Future enhancements may include further optimizations in model compression and rendering techniques to improve efficiency without compromising detail.

4.2 Benefits Over Traditional Anatomy Learning Applications

This Android-Based Human Anatomy Learning Tool improves upon traditional anatomy learning applications by offering an interactive, 3D-based learning experience rather than relying solely on static images or videos. Unlike conventional apps, which may use predefined anatomy models, this system allows users to search for scientific and common names, instantly retrieving relevant 3D subparts and descriptions for better comprehension.

A major advantage is its optimized database structure, which stores only the most relevant 2,369 anatomical components, reducing unnecessary complexity while maintaining detailed and precise models. The use of Google Filament ensures smooth rendering and real-time interaction, providing a more engaging learning experience compared to traditional apps that struggle with performance issues on mobile devices.

Additionally, the inclusion of offline functionality allows users to access anatomical models anytime, making learning more flexible and accessible, even without an internet connection.

4.3 Adaptability & Future Enhancements

The Android-Based Human Anatomy Learning Tool is designed to be highly adaptable, ensuring smooth performance across different mobile devices and screen sizes. The optimized Room database structure allows for scalability, enabling the addition of more anatomical models without affecting system performance.

Future enhancements may include AI-powered search recommendations, which suggest relevant anatomical terms based on user behavior and learning patterns. The integration of augmented reality (AR) support can further enhance engagement by allowing users to visualize 3D models in real-world environments. Additionally, multilingual support can be introduced to broaden accessibility for non-English speakers.

To improve interactivity, future versions may feature quiz modules, progress tracking, and collaborative learning tools, making the application not only a reference tool but also a comprehensive anatomy learning platform for students and professionals alike.

V. CONCLUSION

The Android-Based Human Anatomy Learning Tool provides a modernized solution for anatomy education by integrating interactive 3D models, scientific and common name searches, and detailed descriptions into a single, user-friendly application. By eliminating the need for bulky textbooks and static images, the app enhances learning efficiency and accessibility for students and professionals. The inclusion of a structured

database with only relevant anatomical parts ensures optimized performance without unnecessary system load.

Advanced features such as intelligent search functionality and real-time model visualization improve usability and engagement, making complex anatomical structures easier to understand. Additionally, the app's scalability allows for future expansions, including augmented reality (AR), AI-driven recommendations, and multilingual support.

This innovative platform simplifies anatomy learning by offering an interactive, portable, and efficient alternative to traditional resources. With continuous enhancements, it has the potential to become an essential educational tool for medical students, educators, and healthcare professionals worldwide.

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