

LG Follow

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Abstract—Imagine an office worker getting ready for work in the morning, listening to music or the news through an AI speaker. During the morning routine, they might wash up in the bathroom, make coffee in the kitchen, have breakfast, choose clothes from the closet, and get dressed. For someone who moves between rooms so frequently, it’s almost impossible to catch 100% of the audio output from a stationary AI speaker.

We are introducing technology that called LG Follow allows sound to follow the user, creating an environment where they can hear audio in any part of the house with LG appliances equipped with speakers.

We will use a Raspberry Pi and PIR sensors to detect the user’s location. The location information will be sent to a central control system, the AI speaker. For instance, if they leave the living room and enter the bedroom, the speaker in the living room will stop, and the speaker in the bedroom will automatically take over, seamlessly continuing the audio experience. Matter protocol manages the communication between Raspberry Pi and the AI speaker.

Additionally, we provide an app called Sound Sketch that turns children’s drawings into songs using generative AI. When a child draws a picture, the AI will create a song based on their own music. Through generative AI, the drawings will be transformed into prompts, and those prompts will be turned into music. With LG Follow, kids can enjoy listening to their own music as they move around the house, making each moment truly unique and magical.

TABLE I: : Role Assignments

Roles	Name	Task description and etc.
Backend Developer	Mingyu Jung	The backend developer would implement the logic to process location data from the Raspberry Pi and PIR sensors, ensuring the user’s movement through the house is accurately tracked and relayed to the AI speaker system. Ensure that when the user moves between rooms, the appropriate speaker is activated, and the previous one is turned off, all in real-time. Handle communication between the Raspberry Pi, PIR sensors, and AI speaker system using the Matter protocol, ensuring compatibility between the smart home appliances and devices.

Roles	Name	Task description and etc.
Frontend Developer	Taegeon Park	The role of a frontend developer includes designing the frontend architecture and creating user interfaces and experiences using Figma. It involves collaborating with the backend team to discuss and implement required features while ensuring seamless integration with the server. The responsibilities also extend to reviewing designs and functionalities, keeping the user and consumer in focus to deliver an optimal user experience.
Backend Developer	Gyudong Kim	AI developer utilizes openai models CLIP and BLIP to generate prompts from input images. To ensure the safety of children, AI developers fine-tune the BLIP model so that inappropriate prompts are not created. Once the prompts are generated, AI developers use the Suno API to create songs from these prompts. Also AI developers are responsible for designing and building databases to store and manage various types of data, such as user information, home appliances, and the generated drawings and songs, ensuring efficient integration and management within the application. Implement a database to store user preferences, drawings, and song files generated by Sound Sketch.
Frontend Developer	Mingeun Kim	The frontend developer would design the interface for the ThinQ app, ensuring that both LG Follow and Sound Sketch are intuitive and user friendly. This includes creating buttons and layouts for turning speakers on/off and uploading drawings to generate songs. The developer will focus on helping LG Follow and Sound Sketch features, enabling users to control speakers in different rooms and upload or manage children’s drawings in the app.

I. INTRODUCTION

A. Motivation

- 1) *We wanted to create an experience where the sound follows the user, ensuring uninterrupted audio no matter where they are in the house. With LG appliances equipped with speakers, the user can now enjoy continuous sound as they move from room to room, eliminating the frustration of missing important parts of the music or news. Our motivation goes beyond just convenience, it's about creating an immersive and seamless audio experience that adapts to the user's movement. By integrating AI and smart home appliances, we aim to make daily life smoother and more enjoyable.*
- 2) *Our motivation for making Sound Sketch from a desire to bring children's creativity to life in a magical way and to strengthen the bond between parents and their children. Children often express their imagination through drawing, and we wanted to elevate that experience by transforming their artwork into personalized music. With the power of generative AI, a simple drawing becomes a unique, original song, giving children a new way to connect with their creations. What makes this experience even more special is the opportunity for parents and children to collaborate. By drawing together and hearing their joint artwork turned into a song, they can build memories and strengthen their connection through a shared creative process. With LG Follow, these songs can accompany them throughout the house, creating a sense of togetherness and joy, wherever they go. Our goal is to seamlessly blend creativity and technology, offering families a fun and interactive way to bond while engaging with music that feels personal and meaningful. Every moment becomes truly unique and magical as they hear their imagination come to life.*
- 3) *We've made LG Follow and Sound Sketch easy to use by integrating them into the ThinQ app, ensuring both features are conveniently controlled in one place. With LG Follow, users can easily turn off the speaker in any appliance if they don't want sound in a specific room. Meanwhile, Sound Sketch lets you transform children's drawings into songs, bringing creativity to life in a fun way. Everything is accessible and simple to control from the app, making the entire experience smooth, personalized, and user-friendly.*

B. Problem statement (client's needs)

In today's homes, AI speakers are commonly used to play music or news, but they are limited by their stationary nature. For someone who moves frequently between rooms during their morning routine—such as washing up in the bathroom, making coffee in the kitchen, or getting dressed in the bedroom—it becomes nearly impossible to catch all the

audio from a single fixed speaker. This leads to a frustrating, interrupted experience where important parts of the audio are missed.

LG Follow solves this problem by allowing sound to follow the user throughout the house. As users move from room to room, LG appliances equipped with speakers provide continuous audio, eliminating gaps and ensuring they never miss a moment of music or news. This technology is designed to deliver a seamless and immersive audio experience, adapting to the user's movements to enhance their daily routine.

Additionally, we identified a need for families to engage creatively, leading to the development of Sound Sketch, an app that transforms children's drawings into personalized songs using generative AI. Children often express their imagination through drawings, and this feature elevates that creativity by turning their artwork into unique songs. It also offers parents and children the opportunity to bond through collaboration, creating memories as they hear their joint artwork come to life as music. By integrating LG Follow, these songs can follow the family throughout the house, adding a layer of joy and togetherness.

Both features, LG Follow and Sound Sketch, are integrated into the ThinQ app for ease of use, allowing users to control audio and manage drawings in one convenient place.

C. Research on any related software

- 1) *Sonos (Multi-Room Audio Systems): Sonos is a leading brand in multi-room audio systems. Sonos allows users to control audio in various rooms through a smartphone app, letting users sync music in different areas of the house. However, unlike LG Follow, Sonos requires manual control for changing rooms or selecting where to play audio. It does not automatically follow the user based on their movement.*
- 2) *Google Nest and Amazon Echo: Google Nest and Amazon Echo provide smart home automation, including voice-activated music playback. They can control music in various rooms and offer smart integrations with other appliances. However, users need to manually control playback across different speakers, and the sound doesn't seamlessly follow the user.*
- 3) *Suno: Suno is a generative AI company that specializes in music creation. The platform allows users to generate original songs, complete with melodies and harmonies, by providing simple text prompts or lyrics.*
- 4) *Melobytes: Melobytes is one tool where users can upload an image, and the system generates music from it using algorithms tailored to the visual data. It transforms the picture into unique sound compositions that reflect the visual input.*

- 5) *Img2Prompt (Anakin.ai): This tool uses AI to analyze an image and generate a text prompt that encapsulates its key visual features. The generated prompt can then be used for various creative projects, like digital art or content creation.*
- 6) *GoEnhance AI: This platform allows users to upload an image, and its AI algorithms automatically generate a text prompt based on the visual content. These prompts can be used with tools like DALL-E or Midjourney to generate new AI-created images based on the original photo's characteristics.*

II. REQUIREMENTS

A. Log in

- 1) *Initial Screen: When the app is launched, the log in screen is displayed to users as the initial interface, providing access to existing users.*
- 2) *User Input: The user is required to enter their credentials, including:*
 - ID: A unique identifier associated with the user.
 - Password: The secret passphrase known only to the user.
- 3) *Password Hashing: The entered password is securely hashed using the SHA-256 hashing algorithm before it is compared to the stored hash in the database. Hashing the password enhances security by ensuring that plain-text passwords are not transmitted or stored.*
- 4) *Validation and Authentication: The app checks if the entered ID exists in the database.*
 - If the ID does not exist, the app displays a message such as 'The entered ID does not exist.'
 - If the ID exists, the app compares the hashed password entered by the user with the stored hash associated with the ID.
 - If the hashes match, the app displays a 'Log in Successful' message, indicating a successful log in.
 - If the hashes do not match, the app displays an 'Incorrect password' message.
- 5) *Password Reset Option:*
 - For users who have forgotten their passwords, the app provides a password reset option.
 - Users can initiate a password reset process by requesting an email verification.

- An email containing a verification link or code is sent to the user's registered email address.
- Upon successful verification, the user is guided through the process of resetting their password.

B. Prompt Generation from Drawing

- 1) *It generates prompts using CLIP and BLIP models from pictures entered by the user.*
- 2) *The BLIP model learns about 120,000 pieces of image captioning data in the ai-hub to generate prompts in Korean.*
- 3) *Use its own filtering function to prevent the generation of prompts that threaten children, such as cruel, dangerous, so that appropriate prompts are generated.*
- 4) *Generated prompts are limited under 300 words.*
 - Get image information created by users using Amazon S3.
 - Use the CLIP model to generate text that is most relevant to the image.
 - Using the learned BLIP model and self-filtering functions, appropriate prompts are generated.
 - Save the contents of the prompt and the date of creation to the database.
 - Write the saved prompt in the description box of the song to be created.

C. Music Generation from Prompt

- 1) *It generates music using generated prompts and SUNO API.*
- 2) *Generated music contains title, description, created time, and duration with time type.*
- 3) *If user push play button, music plays and duration will be counted second by second.*
- 4) *User can download the music with download button, using Amazon S3 url.*
 - Use the prompt that saved at database.
 - Translate the Korean prompts to English with Google Translation API.
 - Generate music with translated prompts and SUNO API.

- Play music with play button.
- Download the generated music, using Amazon S3.

D. Speaker-to-Speaker Connection

1) *Register Raspberry Pi as Matter Bridge To enable communication between Matter-compatible and non-Matter-compatible speakers, Raspberry Pi must be registered as a Matter Bridge. This allows for seamless music transitions between AI speakers and regular speakers within the Matter network. Registration procedure is as follows:*

- In the Matter-supported device management app, select the option to add a new Matter Bridge.
- Scan the QR code or manually enter the setup code provided by the Raspberry Pi.
- Once connected, Raspberry Pi will act as a Matter Bridge between devices.
- Raspberry Pi is now registered as the Matter Bridge.

2) *Control Speakers Through Raspberry Pi Once the Raspberry Pi is set as a Matter Bridge, it facilitates communication between regular speakers and AI speakers in the home network. Matter protocol handles real-time status updates and control commands.*

Procedure:

- When switching music playback from AI speakers to regular speakers, Raspberry Pi controls this transition using Matter protocol.
- Music playback transitions in real-time, and Raspberry Pi ensures that both AI speakers and non-Matter speakers can communicate smoothly.

E. User Location Tracking

1) *Register PIR Sensor to Raspberry Pi PIR sensors detect user movement and must be connected to Raspberry Pi for real-time location tracking and music control. Registration procedure is as follows:*

- Connect the PIR sensor to Raspberry Pi.
- Add the PIR sensor to the Raspberry Pi through directly register the sensor.
- PIR sensor is now registered to Raspberry Pi for location tracking.

2) *Control Based on Location Tracking The PIR sensor tracks the user's location, and the Raspberry Pi uses this data to send streaming transition commands to the AI speakers or room speakers based on movement.*

- When the user moves to another room, the Raspberry Pi sends the command to switch music playback to the speakers in the new room.
- Matter protocol ensures the transition occurs in real-time based on location tracking data provided by the PIR sensor.

F. Location-Based Sound Transition

1) *Register Room Speakers for RTP Streaming Room speakers need to be set up for RTP (Real-time Transport Protocol) audio streaming to ensure real-time music transitions.*

Procedure:

- Set up room speakers for RTP streaming.
 - Ensure that the speakers are registered to receive RTP streams from the Raspberry Pi.
- 2) *Handle Music Transitions via RTP and Matter Music transitions are handled using RTP for audio data transfer, while Matter protocol manages communication between speakers.*
- When music moves from the living room to another room, RTP streams the audio to the room speaker.
 - Matter ensures that the correct speaker is selected based on the user's movement.

G. Speaker On/Off Functionality

1) *Register Central Server for User Preferences To manage user preferences for music playback in certain rooms, the central server must communicate with the Raspberry Pi via MQTT and Matter.*

- Configure the central server to store user preferences for music playback in each room.

- Use MQTT to send this configuration to the Raspberry Pi.

2) *Transmit User Preferences via MQTT serves as the lightweight message protocol to send the user's settings from the central server to the Raspberry Pi.*

- The central server sends an MQTT message containing the user's preferences (e.g., turn off music in a specific room).
- Raspberry Pi receives the MQTT message and applies the preferences.

3) *Control Music Playback via Matter Raspberry Pi uses Matter to control music playback based on the user's settings.*

- If the user prefers no music in a specific room, Raspberry Pi prevents playback in that room.
- Matter ensures the speakers are controlled accordingly.

H. Image Temporary Storage and Music CRUD

1) Image Temporary Storage

- When a user saves a drawing temporarily, Redis, a fast-access cache database, is used to store the image data.
- Redis acts as a memory-based storage solution that saves the temporary image data and allows for rapid retrieval when needed. This is particularly useful if the user pauses or edits the drawing, enabling them to resume their work later without data loss.
- By utilizing Redis, the app ensures quick access to the saved image while reducing latency and enhancing user experience during the drawing process.

2) Music CRUD

- Once the drawing is transmitted to the Flask server, the image is stored temporarily in Redis, a memory-based cache, which allows fast retrieval of the drawing. This enables the user to pause or resume work on the drawing.
- The Flask server processes the request and ensures real-time streaming of the music, allowing users to listen to the song as soon as it's generated.
- For storage and long-term management of the generated music, the metadata and music links are handled by Spring Boot, which communicates with a MySQL database to store information such as the song title, date of creation, and the associated drawing theme.
- Users can perform CRUD operations on the generated music.
 - Create: Saving the generated music to the database and S3 for long-term access.
 - Read: Streaming the saved music from S3 and retrieving metadata from the database for display in the app.
 - Update: Modifying the song's metadata or regenerating the music by submitting a new drawing.
 - Delete: Removing the music file from S3 and its metadata from the MySQL database, while ensuring Redis invalidates any cached data related to the

deleted music.

III. DEVELOPMENT ENVIRONMENT

A. Hardware Development Environment

1) Raspberry Pi

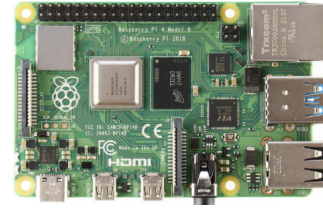


Fig. 1: Raspberry Pi

The Raspberry Pi is a small computer commonly used in various programming and IoT projects. Its efficient and cost-effective design makes it popular for home automation and IoT environments.

Role:

- **IoT Device Control:** The Raspberry Pi serves as the main device for controlling IoT devices in this project. It connects with multiple sensors and actuators (e.g., PIR sensor, temperature sensor), collects data, processes it, and sends it to the system.
- **Using MQTT Protocol:** The Raspberry Pi communicates with other devices or servers through the MQTT protocol, allowing real-time monitoring and control of IoT device states.
- **Serving as a Matter Bridge:** The Raspberry Pi is configured as a Matter bridge to facilitate communication with devices compatible with the Matter Protocol. This setup enables it to communicate with various Matter-compliant IoT devices, allowing centralized control and monitoring of each device via the Spring Boot server. The Matter bridge acts as a communication hub for IoT devices, ensuring interoperability among devices within the same network.
- **Network Management and Processing:** Through network connectivity, the Raspberry Pi connects to the Spring Boot server or the Matter Protocol to transmit and receive data and to process various commands.

Technical Features:

- **Compact Size and Low Power Consumption:** Ideal for environments with space and power constraints.
- **Expandability:** The GPIO pins allow easy connection to various sensors and actuators, providing flexibility for

various IoT projects.

- **Matter Bridge Integration:** Acting as a Matter bridge, the Raspberry Pi operates as an integration point for interacting with Matter-supported devices. This enables other Matter-compatible devices to connect through the Raspberry Pi, ensuring smooth communication.
- **Supports Various Languages:** Raspberry Pi can be controlled using multiple programming languages such as Python, C++, and Java, offering developers a high degree of flexibility.

2) Matter Protocol

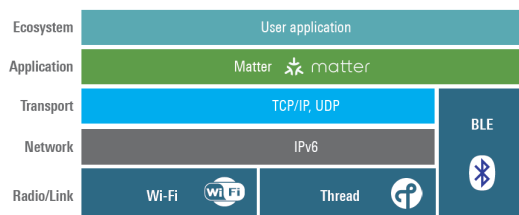


Fig. 2: Matter

The Matter Protocol is a communication protocol developed to enhance interoperability among smart home and IoT devices. Supported by major IoT device manufacturers, Matter ensures compatibility between devices from different manufacturers within a smart home ecosystem.

Role:

- **Provides Interoperability among IoT Devices:** With the Matter Protocol, various IoT devices within the same network can communicate seamlessly. This enables the devices used in the project to interact smoothly with one another.
- **Standardized Data Transmission:** The Matter Protocol offers a standardized method for data transmission, simplifying data management and transfer for developers.
- **Enhanced Security Features:** Matter strengthens security by employing encryption for data transmission between devices and an authentication system that only allows approved devices to connect.

Technical Features:

- **Multi-Platform Support:** Matter supports various network technologies such as Wi-Fi, Ethernet, Thread, and BLE, allowing flexible configurations suited to the environment.
- **Simplified Development Process:** Matter streamlines communication protocols, making integration easier for

developers and ensuring compatibility across a wide range of IoT devices.

- **High-Performance Security:** It provides security based on authentication, ensuring that data transmission between IoT devices is securely protected.

3) PIR Sensor



Fig. 3: PIR Sensor

A PIR (Passive Infrared) sensor is used to detect motion and is commonly employed in security and home automation systems. It senses infrared signals emitted by the human body to determine motion and can monitor user presence within a specific area.

Role:

- **User Detection and Music Control:** The PIR sensor detects users within a room and triggers actions like playing or stopping music when certain conditions are met. When a user is detected, it sends a signal to the Spring Boot server to turn on the music. If the user leaves the detection range or after a certain period, it can be configured to stop the music automatically.
- **Energy Efficiency Maintenance:** The PIR sensor helps in reducing unnecessary power consumption by detecting activity in a particular area. When no user is detected, it automatically turns off devices like music or lighting to save energy.
- **Real-time Status Transmission:** It sends real-time movement data to the Spring Boot server, which can then use this information to control other IoT devices based on user location.

Technical Features:

- **Low Power Consumption:** The PIR sensor consumes minimal power as it only sends a signal when the detection state changes.
- **Easy Installation and Connection:** It can be easily connected to the GPIO pins of control devices like Raspberry Pi and can be handled with simple signal

processing.

- **Instant Response Time:** The PIR sensor is suitable for applications that require immediate feedback as it quickly detects human movement.
- **Wide Detection Range:** It generally provides a broad detection angle, allowing it to sense movement throughout an entire room.

B. Software Development Platform

1) Linux



Fig. 4: Linux

Linux, an operating system based on UNIX, is known for supporting multiple users, multi-tasking, and multi-threading, making it highly suitable for development environments. As an open-source OS, it has been widely distributed and modified for various needs, with popular distributions like Ubuntu. Linux excels in server environments, desktop applications, and embedded systems development due to its flexibility, performance, and robust security features. Its extensive command-line utilities make it particularly adept for working with development boards and IoT devices, allowing seamless integration with hardware. Additionally, Linux's strong community support ensures quick troubleshooting and continuous enhancements, making it an excellent choice for IoT development and large-scale software projects.

2) Windows



Fig. 5: Windows

Windows, developed by Microsoft, is one of the most widely used operating systems globally, known for its compatibility with a vast range of software applications

and hardware devices. Its graphical user interface and accessibility make it versatile for personal, business, and development use. Windows supports multi-tasking and multi-threading, which enhances its capability for running complex applications and handling high-demand development tasks. With tools like Visual Studio, Windows provides comprehensive support for app development across multiple platforms, including desktop, web, and mobile applications. Windows Subsystem for Linux (WSL) allows developers to use Linux command-line tools and utilities directly on Windows, making it an adaptable choice for cross-platform development. Furthermore, Windows offers strong support for gaming and multimedia applications due to DirectX and hardware acceleration capabilities. Its enterprise-level security options, combined with Microsoft's extensive documentation and community support, make Windows a reliable operating system for both general-purpose computing and advanced development environments.

3) macOS



Fig. 6: macOS

macOS, developed by Apple and based on UNIX, is widely recognized for its user-friendly interface and stability, making it a preferred operating system for developers, particularly in design, media, and software development environments. Its robust integration with Apple hardware ensures optimized performance and energy efficiency, which is essential for seamless application testing and development. macOS includes powerful command-line utilities and developer tools such as Xcode, which supports app development for the Apple ecosystem, including iOS, macOS, watchOS, and tvOS. Additionally, the macOS environment provides strong support for multi-tasking and multi-threading, and its UNIX-based architecture offers compatibility with various development frameworks and programming languages, making it highly adaptable to web, mobile, and cloud applications. macOS's extensive developer community, combined with Apple's regular updates, ensures high security standards, efficient troubleshooting, and consistent performance, making it an ideal choice for both individual developers and large-scale development teams.

1) Spring Boot



Fig. 7: Spring Boot

Spring Boot is a lightweight Java-based backend framework that simplifies the process of quickly developing standalone web applications. It reduces the complexity of configuring the Spring Framework by including embedded web servers, such as Tomcat or Jetty, enabling the application to run with minimal additional setup in both development and production environments.

Role:

- Web Application Development: Facilitates the rapid development of standalone web applications.
- Auto-configuration: Provides automatic configuration for various Spring features without needing XML or Java Config classes.
- Dependency Management: Simplifies dependency configuration with Spring Boot Starter, boosting development efficiency.
- Security and Authentication: Easily integrates with Spring Security, allowing for streamlined implementation of authentication and authorization.
- Asynchronous Processing and Scheduling: Ideal for IoT, mobile, and cloud applications, enabling easy development of REST APIs, asynchronous processing, and scheduling functionalities.

Technical Features:

- Embedded Server: Bundles web servers such as Tomcat, Jetty, and Undertow, eliminating the need for separate configurations.
- Automatic Configuration: Automatically sets up necessary features, streamlining application setup.
- Support for Various Environments: Easily adaptable from local development to cloud deployment.
- MQTT Support: Enables MQTT messaging with libraries like Eclipse Paho MQTT Client, allowing Spring Boot applications to publish and subscribe to MQTT messages.



Fig. 8: Java

2) Java

Java is an object-oriented programming language known for its platform independence, allowing applications to run consistently across different operating systems. With the motto Write Once, Run Anywhere, Java achieves cross-platform compatibility through the JVM (Java Virtual Machine), enabling stable and efficient application development.

Role:

- Server-side Logic Development: Java's reliability makes it widely used for server applications.
- Multithreading and Asynchronous Processing: Java's multithreading and asynchronous processing capabilities are ideal for IoT systems that require real-time data handling.
- Large-scale System Operation: Thread management, garbage collection, and robust libraries enable Java to handle high-traffic server applications effectively.

Technical Features:

- Object-Oriented Programming: High reusability and scalability, making maintenance straightforward.
- Platform Independence with JVM: Allows consistent code execution across various platforms via the JVM.
- Extensive Standard Libraries: Provides libraries for networking, databases, file handling, and more, supporting efficient application development.
- Reliability and Performance: Ensures stability in large-scale systems and guarantees performance in multithreaded environments.

3) Python



Fig. 9: Python

Python is a widely used interpreted language known for its simplicity, readability, and versatility across various applications and platforms. Its ease of use and concise syntax significantly reduce development time and minimize errors, making it a popular choice for developers.

Role:

- **Cross-Platform Compatibility:** Python is a cross-platform language that can run on various operating systems (Linux, Windows, Mac) with minimal modifications, providing flexibility and efficient deployment.
- **Data Processing and Manipulation:** Its strengths in string processing and data manipulation make Python ideal for applications involving text and image processing, data analysis, and scientific computing.
- **Automation and Scripting:** Python's readability and flexibility make it suitable for automation tasks, enabling the development of scripts and tools for repetitive tasks and efficient workflows.

Technical Features:

- **Concise and Readable Syntax:** Python's straightforward syntax enhances code readability and reduces development time, contributing to rapid prototyping and easier debugging.
- **Extensive Libraries:** Python offers a rich ecosystem of libraries, including Pandas, NumPy, and OpenCV, which simplify complex operations such as data analysis, machine learning, and image processing.
- **Community and Documentation:** Python boasts a large and active community, providing a wealth of resources, support, and libraries that streamline development.

4) Flask

Flask is a lightweight web framework for Python, known for its simplicity, flexibility, and suitability for small to medium-sized web applications and APIs. Flask provides a straightforward foundation for building web applications with minimal setup.



Fig. 10: Flask

Role:

- **RESTful API Development:** Flask is optimized for creating RESTful APIs, providing tools for handling HTTP requests and responses, which is ideal for applications requiring data exchange in formats like JSON.
- **Integration with Python Models:** Flask can easily integrate with Python-based machine learning models, making it simple to serve model predictions and data processing results to client applications.
- **Customizable and Modular:** Flask allows developers to include only the components needed for a project, creating a lean and efficient development environment.

Technical Features:

- **Lightweight and Flexible:** Designed to be minimalistic, Flask allows developers to build web applications without unnecessary features, ensuring a flexible and tailored environment.
- **Powerful Routing and Request Handling:** Flask's built-in support for routing and handling HTTP methods makes it suitable for building APIs and web services.
- **Rich Ecosystem of Extensions:** Flask supports numerous extensions, allowing for easy integration of features like authentication, database connections, and caching.

5) React Native

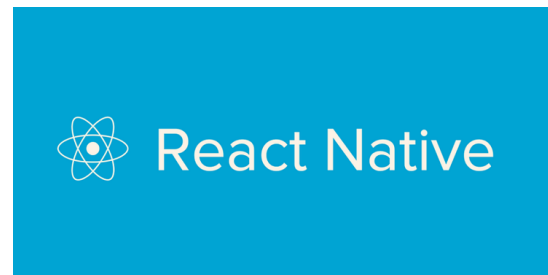


Fig. 11: React Native

React Native is a popular cross-platform framework that allows developers to create apps that work on both iOS and Android from a single codebase, significantly reducing development time and costs. By using JavaScript, a widely-

known language, React Native offers accessibility for developers, along with extensive community support and a rich ecosystem of libraries and tools.

Role:

- **Cross-platform Development:** React Native enables the development of applications that operate seamlessly across iOS and Android, simplifying access for users on both platforms.
- **Optimized Performance for Unique Services:** Chosen for its ability to deliver optimized performance and a smooth user experience, React Native supports the app's functionalities, including user tracking, sound playback, and song creation from user-drawn images.
- **Component-based Structure:** With its component-based structure, React Native enhances code reusability and organization, making the code easier to manage and maintain.
- **UI and Logic Separation:** React Native allows for the separation of UI components and business logic, increasing code readability and maintainability.

Technical Features:

- **Cross-platform Capability:** Allows development for both iOS and Android from a single codebase.
- **JavaScript Usage:** Built with JavaScript, React Native is approachable and integrates well with various development tools.
- **Hot Reloading:** Supports hot reloading, enabling rapid testing and iterative development.
- **Reusable and Maintainable Code:** The component-based architecture improves reusability, organization, and maintainability, supporting long-term development.

D. Software & AI model In Use

1) BRIP

BLIP (Bootstrapping Language-Image Pre-training) is a cutting-edge AI model that enables unified vision-language understanding and generation. By training on a large dataset of image-text pairs, BLIP can perform diverse tasks such as image captioning, visual question answering, and text-guided image generation.

Role:

- **Image Captioning:** BLIP generates descriptive captions for images, providing a textual representation of visual content, which is useful for accessibility and content categorization.

- **Visual Question Answering:** BLIP interprets visual data to answer questions about images, offering real-time assistance and context comprehension for visual-based tasks.
- **Text-Guided Image Generation:** BLIP creates or modifies images based on textual prompts, bridging the gap between visual creativity and text-based control.

Technical Features:

- **Zero-shot Learning:** BLIP's zero-shot capabilities allow it to adapt to new tasks without additional training data, making it versatile across various applications.
- **Specialized Language Training:** By training on datasets with images and Korean captions, BLIP can generate Korean prompts, making it suitable for localized applications and non-English language tasks.
- **Enhanced Vision-Language Bridging:** BLIP effectively integrates textual and visual data, enabling it to process and produce outputs that combine both modalities seamlessly.

2) Amazon S3



Fig. 12: Amazon S3

Amazon Simple Storage Service (Amazon S3) is a highly scalable object storage service known for its industry-leading data availability, security, and performance. Amazon S3 provides a robust infrastructure for storing and managing large volumes of data, particularly useful for media files such as images and music.

Role:

- **File Storage:** Stores generated music files and uploaded image files in S3, with Flask generating music files that the Spring Boot server saves to S3, providing clients with URLs for file download or streaming.
- **Cloud Storage:** Manages large data volumes efficiently, including user-related images and audio files.
- **Data Management:** Used for organizing temporary or outdated data, as well as for backups. Access permissions can be configured to restrict file access to specific users.

Technical Features:

- Scalability: S3 automatically scales to accommodate large volumes of data as file counts increase.
- Reliability: Offers high durability, ensuring data is securely stored.
- Flexible Access Management: Access Control Lists (ACLs) and bucket policies allow for detailed permission settings.

3) MySQL



Fig. 13: MySQL

MySQL is a widely used open-source relational database management system (RDBMS) known for its stability, performance, and ability to handle large datasets efficiently. Its robust functionality makes it ideal for managing data-intensive applications, including those that track user locations, manage media files, and facilitate device interactions.

Role:

- Data Storage: Stores and manages user information, generated music metadata (title, creation date, etc.), and music request data. This enables the system to store a wide variety of data permanently for retrieval as needed.
- Data Integrity Assurance: Ensures data consistency and integrity through transactions and foreign keys, maintaining stability even when multiple users access data simultaneously.
- CRUD Operations: Supports Create, Read, Update, and Delete operations through integration with the Spring Boot application.

Technical Features:

- SQL-Based: Uses standard SQL queries, making data management straightforward.
- Scalability: Efficiently manages large transactions and data with scalable architecture.
- Reliability: Provides strong backup and recovery capabilities to ensure data security.

4) Amazon RDS (Relational Database Service)

Amazon RDS is AWS's managed relational database service, handling database server management and maintenance,



Fig. 14: Amazon RDS

allowing developers to focus on data-related tasks rather than setup and maintenance.

Role:

- MySQL Server Hosting: Supports MySQL and other database engines, making it easy to set up and manage MySQL servers. In this project, RDS manages user information, music metadata, and music requests.
- Automated Management: Handles database backups, security patches, and software updates automatically, reducing database management burdens.
- Scalability: Supports scale-up/down as traffic or storage needs change. For high read performance, Read Replicas can be added.

Specific Functions:

- Persistent Data Storage: The RDS MySQL server stores user-related data, music metadata, and music requests, ensuring reliable data management even with high request volumes.
- Data Backup and Recovery: Performs regular backups automatically, with automatic recovery capabilities to ensure data integrity and reliability.
- High Availability: Multi-AZ deployment replicates databases across availability zones, providing high availability and fast recovery in case of failures.

Technical Features:

- Automatic Backups: Regular backups enable point-in-time recovery.
- Security: Supports VPC isolation, AWS IAM integration, and data encryption via AWS Key Management Service (KMS).
- Monitoring and Alerts: Integrates with Amazon CloudWatch for real-time database performance

monitoring and notifications for any issues.

Integration with RDS:

- **Spring Boot:** The Spring Boot project connects directly with AWS RDS MySQL, leveraging Spring Data JPA for efficient database interactions. Database URL, username, and password are configured using the RDS endpoint.
- **RDS MySQL Setup:** After creating a MySQL instance in the RDS console, its endpoint and credentials are used to connect the Spring Boot application.

5) Visual Studio Code



Fig. 15: VS Code

Visual Studio Code (VS Code) is a lightweight and highly customizable code editor developed by Microsoft. Known for its versatility and extensive extension ecosystem, VS Code supports a wide range of programming languages and development environments, making it a popular choice for developers across various fields.

Role:

- **Code Editing and Development:** VS Code provides a streamlined, efficient environment for writing, editing, and managing code in multiple languages. It offers a powerful, customizable interface that supports development workflows from simple scripts to large projects.
- **Extension Support:** With thousands of extensions available, VS Code allows developers to add language support, frameworks, linters, debuggers, and tools specific to their project needs, enhancing productivity and flexibility.
- **Remote Development:** VS Code's remote development feature allows users to work on projects hosted on remote servers or in containers, enabling efficient collaboration and resource utilization.

Technical Features:

- **Lightweight and Fast:** Designed for speed and efficiency, VS Code is a lightweight editor that quickly adapts to various development environments without significant resource usage.
- **Integrated Debugging and Git:** VS Code includes built-in debugging and Git support, streamlining the development

and version control process within a single interface.

- **Highly Customizable:** Through JSON configuration files, settings, and an extensive extension library, VS Code allows for deep customization to meet individual development needs.

6) Android Studio



Fig. 16: Android Studio

Android Studio is Google's official integrated development environment for Android app development, offering a comprehensive suite of tools and resources tailored specifically for Android platforms.

Role:

- **Emulator for Testing:** It provides a fast and feature-rich emulator, simulating a wide range of Android devices and configurations for thorough testing without needing physical devices.
- **Extensive Testing Tools:** Android Studio includes a variety of testing tools and frameworks that support automated and manual testing, enhancing app quality and stability.
- **Easy SDK Access:** The IDE includes Android SDK and essential tools out-of-the-box, allowing developers to start building Android applications immediately.

Technical Features:

- **Integrated Emulator:** Fast, powerful emulator to test app functionality across device configurations.
- **Comprehensive Testing Support:** Tools for unit, UI, and integration testing.
- **Code Inspection and Lint:** Automates code quality checks and flags potential issues.

7) Xcode



Fig. 17: Xcode

Xcode is Apple's official IDE for developing applications on iOS, macOS, watchOS, and tvOS, offering a complete suite of tools and resources to streamline development for Apple's platforms.

Role:

- **Apple Platform Development:** Xcode is essential for creating applications for Apple's ecosystem, providing all necessary tools to develop iOS and macOS applications quickly and efficiently.
- **Built-In Simulator:** The simulator allows for testing applications without needing a physical device, supporting various iOS versions and device types.
- **Storyboard and App Structure Visualization:** The storyboard feature enables developers to see the structure of the app at a glance, aiding in the systematic design of complex applications.

Technical Features:

- **Drag-and-Drop Interface Builder:** Simplifies UI design with visual placement and Auto Layout.
- **Comprehensive Preview Options:** Preview and adjust for multiple devices and screen sizes.

8) Figma



Fig. 18: Figma

Figma is a cloud-based design and prototyping tool used for creating interactive and collaborative design experiences. Known for its flexibility and real-time collaboration features, Figma allows designers and teams to work together seamlessly from anywhere.

Role:

- **UI/UX Design:** Figma provides a robust platform for designing user interfaces and experiences, with tools to create detailed wireframes, mockups, and high-fidelity designs.
- **Prototyping:** Enables the creation of interactive prototypes that allow designers to simulate user flows and test interactions, providing a clear vision of the final product.
- **Collaboration:** Real-time collaboration allows multiple team members to work simultaneously on the same file, streamlining the feedback process and reducing delays.

Technical Features:

- **Developer-Friendly Inspect Tool:** Developers can access design specifications, CSS code, and assets directly, ensuring a smooth design-to-code transition.
- **Interactive Prototyping and Animation:** Offers tools to create interactive animations and transitions, making it easy to visualize and test user interactions.
- **Cloud-Based and Cross-Platform:** Figma operates in the cloud, accessible from any browser and supporting both Windows and macOS, making it highly versatile and collaborative.

IV. SPECIFICATION

A. Log In

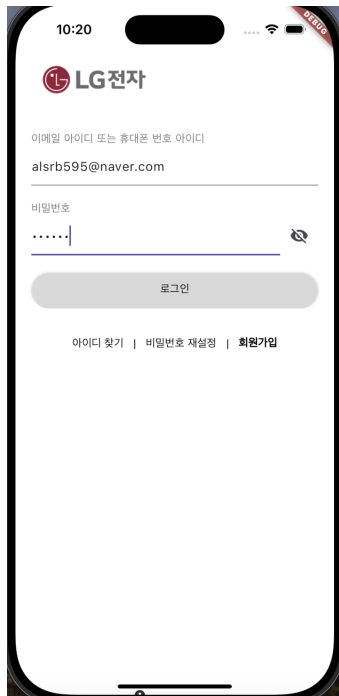


Fig. 19: Log In

1) ID Input

- Placeholder: 'Email ID' to guide the user on the input type.
- Input Format: Accepts either an email address.
- Validation: Checks if the input follows the correct format
 - Email: Format like user@example.com

2) Password Input

- Placeholder: Displays 'Password' as guidance for the user.
- Input Format: Accepts text for password entry, displayed as '•' symbols to conceal the input.

3) Log in

- Enabled/Disabled State:
 - Enabled: The button becomes active once both ID and password are entered.
 - Disabled: The button remains inactive if the ID and password fields are empty.
- Action: When clicked, the button attempts to log in with the provided ID and password.
 - On Success: Redirects to the main screen.

- On Failure: Shows an error message ('The entered ID or password is incorrect').

4) Log in Process

- Input Check: When the log in button is clicked, the ID and password are validated against database records.
- Password Hashing: The entered password is hashed using the SHA-256 algorithm before being compared to the stored hash in the database.
- Authentication and Response:
 - Success: On successful log in, the user is redirected to the main screen.
 - Failure: If log in fails, an error message ('The entered ID or password is incorrect') is displayed.

B. Main Page

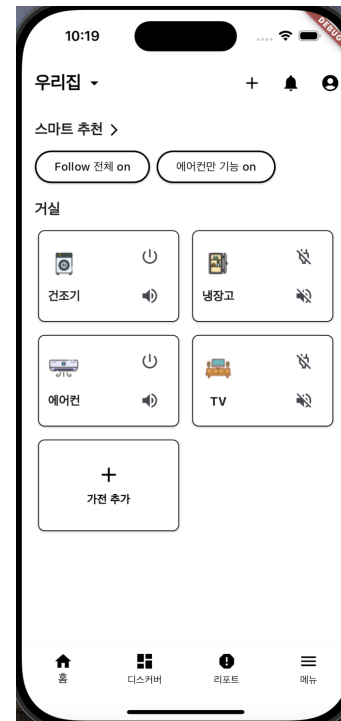


Fig. 20: Main Page

1) Home Application Power On/Off

- Power Button: Turns individual appliances On/Off. (In the On state, the power button is displayed in color, and in the Off state, it appears in grayscale with a strikethrough.)
- When the user clicks the power button for a specific appliance, the application records the device's status (On/Off) in the database or local storage.

- Upon status change, the application sends a command to the appliance to toggle its power state.
- If the device is currently on, clicking the button will turn it off, and if it is off, clicking the button will turn it on.

2) LG Follow Function On/Off

- **Speaker Button:** Controls the LG Follow function for audio playback in the room where the appliance is located. (In the On state, the power button is displayed in color, and in the Off state, it appears in grayscale with a strikethrough.)
- **User Location Detection**
 - **PIR Sensors:** PIR (Passive Infrared) sensors installed in each room detect the user's movement. When the user enters a room, the PIR sensor in that room activates and sends the location data to the Raspberry Pi.
- **Data Collection and Transmission by Raspberry Pi**
 - **Raspberry Pi:** Acts as a central hub that collects location data from all room PIR sensors. As the user moves from room to room, the Raspberry Pi updates the user's location in real time.
 - **Matter Protocol:** Raspberry Pi communicates with AI speakers and other room speakers via the Matter protocol to control audio output based on the user's current location.
- **Audio Transition**
 - When the user enters a new room, the Raspberry Pi sends a command to stop audio playback in the previous room's speaker and switch the audio to the speaker in the current room.
 - This setup allows the user to hear audio naturally in each new room as they move throughout the house.
- **User Control Options for LG Follow**
 - **LG Follow On/Off for Specific Devices:** Users can enable or disable the Follow feature for specific appliances in particular rooms, allowing more customized control over where audio follows them.

3) Add Product Button ('+' Button)

- Opens a QR code scanning screen to add a new appliance.
- When the user clicks the '+' button, the application navigates to the QR code scanning screen.
- The user can scan a QR code to register a new appliance, which will then be added to the home screen for control.

C. Device Registration

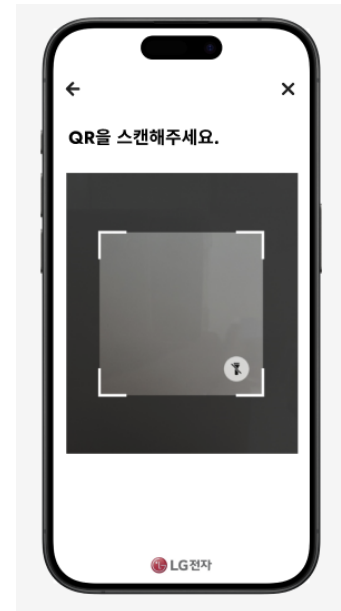


Fig. 21: Device Registration

- **QR Scanning Frame:** A square frame located in the center of the screen where users align the QR code.
- **QR Code Recognition and Registration**
 - **Automatic Scanning:** When a QR code is aligned within the scanning frame, the app automatically recognizes it without requiring a separate confirmation button.
 - **Validation:** Once the QR code is scanned, the app verifies if it corresponds to a valid LG appliance model and matches the format stored in the database.
 - **Registration:** If validated, the appliance is registered to the user's account and linked to the LG Follow feature.
- **Navigation Upon Successful Scan**
 - **Automatic Transition:** Once the QR code is successfully recognized and the appliance is registered, the app automatically navigates the user back to the main screen.
 - **Confirmation Message:** Upon returning to the main screen, a brief confirmation message ('Appliance registered successfully') may appear to inform the user of successful registration.
- **Error Handling :** If the QR code is invalid or unrecognized, an error message appears ('Invalid

QR code. Please try again’).

- Through these features, users can easily control appliance power, manage room-specific LG Follow audio settings, and add new appliances.

D. Menu Page

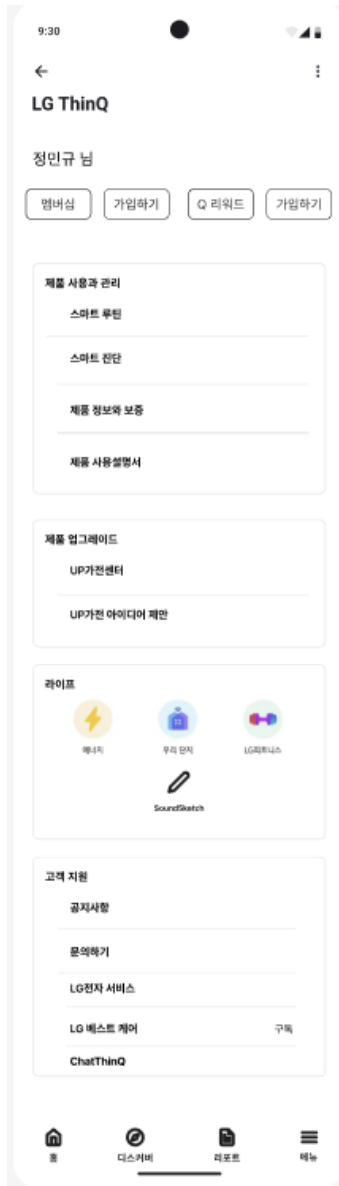


Fig. 22: Menu Page

User starts on the home screen and presses the menu button located on the bottom navigation bar, they open the menu page. From there, if the user navigates to the Life section and selects the Sound Sketch button, the app transitions to the Sound Sketch screen, providing them access to that feature.



Fig. 23: Enter Sound Sketch

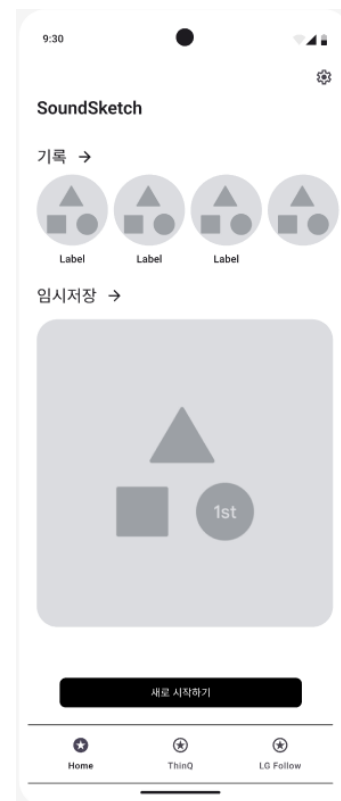


Fig. 24: Sound Sketch Main Page

E. Sound Sketch Main Page

1) Record Section

- The record section, located at the top, displays a list of previously created drawings along with their associated

music.

- Thumbnail: Each record is shown as a thumbnail that displays the user's actual drawing.
- Label: A label is displayed below each thumbnail, allowing users to easily identify each record.
- Functionality: Users can select a previous drawing to view the related music information or to play the associated audio.
- Saving Records: When a user completes and saves a drawing, it is added to the record section. The actual drawing is displayed as a thumbnail in the record section, and the metadata for the generated music is stored in the MySQL database via Spring Boot.
- Music Streaming: When a user selects a specific record thumbnail, the Flask server streams the associated music in real time, allowing the user to listen to it immediately.

2) Temporary Storage Section

- The temporary storage section shows the currently active drawing that the user is working on.
 - Thumbnail: The thumbnail displays the user's current drawing in a large square, making it easy to recognize.
- Functionality: Even if the app is closed or the user switches tasks, the ongoing drawing is saved. When the user taps this thumbnail, they can resume working on the saved drawing.
- Image Temporary Storage: When a user temporarily saves a drawing, the image data is stored in Redis, a fast-access cache database. This ensures that the user can pause or edit the drawing without losing data, thanks to Redis's memory-based storage, which minimizes latency and enhances the user experience during the drawing process.
- Temporary Data Recovery: When the user selects the saved drawing from the temporary storage section, Redis retrieves the data, allowing the user to resume their work seamlessly.

3) New Start Button

- The 'New Start' button at the bottom of the screen allows the user to begin a new drawing.
- Functionality
 - Transition to Drawing Page: When clicked, the app navigates to a new page where the user can start a new drawing.

- Temporary Data Reset: When a new project is started, the existing temporary data is reset or updated to save the new drawing.

- Reset and Transition to New Page: When the user clicks the New Start button, the current temporary data is reset, and the app navigates to the drawing page to start a fresh project.
- Data Management: For every new drawing, Redis either deletes or updates the previous temporary data to store the new drawing as the latest temporary data.

F. Sketch Page

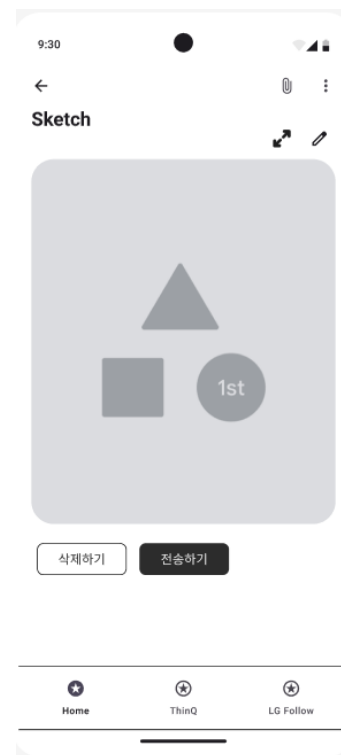


Fig. 25: Sketch Page

1) Canvas Section

- The gray background area in the center of the screen serves as a canvas where users can draw freely. This section is dedicated to allowing users to create and edit their drawings.
- Drawing Canvas: An interactive canvas where users can draw using various shapes, lines, and colors.

2) Submit Button

- Allows users to submit the completed drawing to the server for music generation.

- When clicked, the drawing is temporarily saved in Redis, then sent to the AI system via the Flask server, where music based on the drawing will be generated.

3) Delete Button

- Provides an option to delete the current drawing on the canvas.

- When clicked, the current drawing is removed from temporary storage, and the canvas is cleared for a fresh start. A confirmation message may be shown to confirm deletion.

4) Expand Icon

- Allows users to view the drawing in full-screen mode for more detailed work.
- When clicked, the canvas expands to full screen, providing a larger workspace for more precise drawing.

5) Back Icon

- Allows users to return to the Sound Sketch main page.
- When clicked, the current drawing is temporarily saved in Redis, ensuring it is stored before navigating back to the Sound Sketch main page.

6) Bottom Navigation Bar

- Home, ThinQ, LG Follow Tabs: The bottom navigation bar allows users to switch between the main sections of the app without losing their current work on the Sketch screen.

When the Submit button is pressed on the Sketch page, the app navigates to the Sound control screen, where users can configure LG Follow settings for different appliances.

1) Appliance Icons

- Each room in the displayed floor plan contains icons representing appliances equipped with the LG Follow feature.

- Toggle LG Follow: Users can tap on any appliance icon to toggle the LG Follow function for that specific device.

• On/Off Visuals

- If the LG Follow function is On, the appliance icon is displayed in color, indicating active audio tracking for that room.
- If the LG Follow function is Off, the icon appears in grayscale, indicating that audio tracking is disabled for that room.

- Switching States: Tapping a colored (On) icon switches it to grayscale (Off), turning off the LG Follow function. Conversely, tapping a grayscale (Off) icon switches it to colored (On), enabling the LG Follow function.

2) Set Up and SkipButtons

- Set Up: Allows users to save their current LG Follow settings.
- Skip: Bypasses LG Follow settings.
- Pressing either Set Up or Skip will return the user to the Sound Sketch main page.

G. Sound Controll



Fig. 26: Sound Controll