L · Garana

Smart Home Platform for Hair Loss Treatment Medical Devices Based on LG Pra.L MediHair

An Hyosung
Dept.of Information System
Hanyang Univ.
Seoul, Republic of Korea
anhyosung@hanyang.ac.kr

Zhang Yan
Dept.of Information System
Hanyang Univ.
Seoul, Republic of Korea
wkddus@hanyang.ac.kr

Jeon Hyuna
Dept.of Information System
Hanyang Univ.
Seoul, Republic of Korea
younghyuna12@hanyang.ac.kr

Park Jinwoo
Dept.of Information System
Hanyang Univ.
Seoul, Republic of Korea
jinwoo220@hanyang.ac.kr

***Abstract*—Hair has held a significant position in human society throughout history. However, with time, issues like environmental pollution, social concerns, and improper use of various chemicals have exacerbated the problem of hair loss among people. This issue is now affecting individuals at a younger age, demonstrating a trend towards earlier onset. As the demand for hair loss treatment has grown, various products such as hair loss shampoos and medications have emerged. Additionally, advancements in technology have made it possible for at-home medical devices to become readily available. In 2020, South Korean company LG Electronics introduced its hair care product, LG Pra.L Medihair, which garnered considerable attention. However, it's important to note that treating hair loss is not an overnight process and requires consistent, long-term usage. To prevent individuals from giving up due to a lack of immediate results, we have incorporated features like reminders and visual comparison charts of treatment progress in our device. These enhancements provide users with a more intuitive way to monitor their hair loss treatment. Furthermore, we offer personalized preventive and treatment solutions based on users' age and scalp condition. We also recommend medications and shampoos that can be used in conjunction with the Pra.L Medihair device. In essence, this application aims to assist users in a more effective utilization of the Pra.L Medihair machine for hair loss treatment.**

Keywords—visualization, personalized, effective

TABLE I: ROLE ASSIGNMENTS

Roles	***Name***	***Task descriptions and etc.***
User/ Customer	An Hyosung	The main users and customers of this application are people who have hair loss or are worried about that. This app can increase customer satisfaction because it works without charging. UI/UX will also be user-friendly and reduce complexity by adding only the necessary features. If the user reports an unexpected error, we will receive feedback and correct it through inquiries and suggestions.
Back-end Developer	Park Jinwoo	As backend developer responsi-bilities include building a login and registration system for user authentication. Additionally, implementation of an email-based authentication code sending feature and a password recovery function is undertaken. Further-more, design and establishment of a database to store and manage user hair loss data, information collected from Medi Hair, and recommended treatment methods and product details are carried out. Development of an API that provides personalized information and recommendations based on analysis results from the AI model is also a key task. Lastly, construction of a system that integrates remote control functionality via Bluetooth is executed.
Front-end Developer	Zhang Yan	Front-end developers are responsible for developing and maintaining the user interface of an application. Implement user interface interactions through HTML, CSS and JavaScript as well as various derived technologies, frameworks, and solutions. Test user interfaces to ensure functionality is working properly, debugging and fixing potential issues. Also works with back-end developers to ensure that the front and back ends of the application work together effectively.
Development Manager	Jeon Hyuna	The software development manager is responsible for managing and leading the entire software development team to ensure the successful delivery of the project. Promote cooperation between front-end and back-end developers and improve development efficiency. Maintain and upgrade the software by feeding back the needs of users and customers.

I. INTRODUCTION

A. Motivation

Hair is becoming a symbol of youth as the desire to maintain healthy youth naturally emerges as life spans increase and social activities increase in line with the rapid changes in modern society. Hair originally has the purpose of maintaining body temperature and protecting the head, but over time, it has changed into one of the means of expressing one's personality. Throughout history, and in most (although not all) civilizations, scalp hair has been associated with positive signals such as beauty and power but Baldness or hair loss on the other hand has a negative attribute [1].

Today, the demand for various hairstyles increases the frequency of physical and chemical beauty, resulting in damage not only to the hair but also to the scalp, causing hair loss. As a result, interest in scalp care for healthy scalp and beautiful hair is increasing, and various hair care products are being created for people who are severely stressed by hair loss. In terms of hair loss, not only genetic factors, which are fundamental reasons, but also acquired factors such as environmental pollution, stress due to social life, and hormonal secretion abnormalities caused by changes in negative eating habits are increasing. Hair loss, which used to be a symbol of aging, has become lower in age, with the average incidence of hair loss for men from 34.1 in 2005 to 31.6 in 2010, and young college students in their 20s are also seriously considering hair loss [2].

In addition to the increase in hair loss among young men in their 20s and 30s, women's hair loss is also increasing due to malnutrition, perm, dyeing, and drying caused by excessive diet, and the hair loss market is expanding rapidly due to this increase in the hair loss population, and the hair loss-related industry has entered a growing period [3]. The domestic hair loss market consists of hair care products, hair care services, hair loss treatments, wigs and hair transplants, and related new products are being developed one after another in the pharmaceutical and household goods industries. South Korean firm LG Electronics has also launched its hair care product, LG Pra.L Medihair.

In this article, we define the direction of in-depth development of Pra.L Medihair and present methodologies and prototypes for developing related applications. The current Pra.L Medihair has raised complaints and problems from several users. We also present a solution to this in this article. Therefore, we want to provide a new product utilization method and vision.

B. Problem Statement (client's needs)

Due to the nature of Medihair's treatment method, it takes a long-term commitment of at least four months to see noticeable results, which can be challenging for first-time users. If significant results are not seen within a short period, it is easy to become discouraged and fail to achieve the expected treatment outcomes. Furthermore, since this product does not require daily use, it is easy to forget to use it.

Among the various causes of hair loss, severe mental stress can also significantly impact hair growth. Faced with a relatively long waiting period, psychological stress may also increase. Like hair loss shampoos, Medihair only has a therapeutic effect on specific causes of hair loss. Given the diversity of factors causing hair loss, individual analysis based on scalp type and the location of hair loss is necessary before treatment.

C. Research on Any Relative Software

- ATOMOM

This is artificial intelligence (AI) skin health measurement and customized management software for atopic dermatitis patients. It provides a 1:1 customized care program by analyzing the skin condition and lifestyle habits of skin photos taken of the user's face, body, etc., using non-face-to-face atopic dermatitis diagnostic technology obtained by using AI to learn from tens of thousands of dermatological clinical data. It also has an ai health report that analyzes more than 40 types of diagnosis and degree of improvement of atopic dermatitis and other skin diseases, health record management that helps prevent worsening of symptoms, and a peace-of-mind store that provides products that contain only those that have been selected through strict benchmarks.

- LG ThinQ

This is a smart home platform and software from LG Electronics. It is designed to enable LG's appliances and smart devices to connect to the Internet with smart control, automation and connectivity features to provide a more convenient home experience. With LG ThinQ, users can remotely control and monitor LG appliances that support the platform, such as a washing machine that allows you to remotely view its laundry status and formation completion via your phone.

- INOUT

This is a simple and neat recipe, exercise, and weight loss logging software. Users can identify their weight changes at a glance through charts and graphs, as well as get detailed information on calories and nutrients consumed on a daily, weekly, and monthly basis. And you can customize the notifications to receive them at the desired time for healthy habits.

- Google Calendar

This is an online calendar application developed and provided by Google Inc. designed to help users easily manage and organize their time, schedule and appointments. Users can easily create, edit and delete events, appointments and reminders. Google Calendar supports day view, week view, month view and task list view for users to better understand their schedule. And reminders and notifications can be sent to ensure users don't miss important appointments and events. These reminders can be sent via email, mobile notifications, pop-ups, and more.

- Google Analytics

This is a free web analytics tool provided by Google that focuses on measuring and improving online business results by collecting and analyzing data about website visitors. It provides more than 100 standard reports covering a wide range of data about visitors, and by selecting the data to be analyzed, reports can be customized to view data on specific metrics and dimensions. System segments and customized segment functionality for more in-depth data analysis are also available.

II. REQUIREMENT

A. Sign up

When the app starts, it displays the login and sign-up screen. During the sign-up process, the User enters their ID, password, and email. An authentication code is sent to the User's email address, and when the User enters the correct authentication code, the sign-up button becomes active. When storing the password in the database, use Flutter's crypto encryption library to perform SHA-256 hashing on the password and store the hashed password.

B. Log in

When the app starts, it displays the login and sign up screen. The User enters their ID and password. The entered password is hashed using SHA-256. If this hashed password matches the ID stored in the database, the app displays 'Login Successful' message and proceeds to the next screen. If the password is incorrect, messages like 'Incorrect password' or 'The entered ID does not exist' are displayed. Additionally, provide an option for password reset through email verification for users who have forgotten their passwords.

C. Developing a Hair Loss Analysis AI Model

Using 100,000 scalp image data categorized by types available on AI-HUB, machine learning is conducted to build an AI model. The AI model analyzes the User's hair loss progression based on scalp types (dry, oily, hair loss-prone) and different hair loss patterns. The AI model provides information to the User regarding potential improvements and treatment duration based on the User's hair loss progression.

D. Collecting Hair Loss Information from the User

After the login, users enter the information about the ir hair loss progression. For example:

- Duration of experiencing hair loss.
- Medications currently being taken.
- Areas affected by hair loss.
- Family history of hair loss.

By using the information provided by the User, the AI model assesses their hair loss progression, and provides solutions.

E. Receive and Analyze Hair and Scalp Information from Medihair

Medihair products are equipped with five microscopes designed specifically for hair (front, center, rear, and two sides) to capture images of the user's hair thickness, hair density, and scalp condition from various areas. Using an AI model, this information is analyzed to determine the progression of the user's hair loss. Each time data is retrieved from Medihair, it is saved along with the date. Additionally, a feature will be developed to compare the user's hair and scalp information at 1-month, 3-month, 6-month, and 1-year intervals.

F. Recommend Customized Treatment Methods, Medicines, and Shampoos

Based on the user's hair loss status, we recommend suitable treatment methods. (e.g., Monday: TopCare mode, Wednesday: FrontCare mode, Friday: TotalCare mode, recommended three times a week). We assess the type of hair loss and recommend appropriate medications (e.g., for thinning hair or hair density issues, medications with relevant nutrients or medicines will be suggested). Lastly, we recommend a shampoo suitable for the user's scalp condition (e.g., protein shampoo or hair loss prevention shampoo depending on the scalp's condition). When recommending shampoos, we'll also provide a link where the shampoo can be purchased (For medications, only the information will be displayed as they are not available for online purchase).

G. Provide Scalp Solutions and Information on Scalp Age

We assess the user's progression of hair loss and offer solutions for preventing and treating hair loss. The expected improvements from the solution will also be communicated (e.g., By implementing the solution, the progression rate of hair loss could increase from 5 years to 7 years). Using the AI model, we determine the 'age' of the user's scalp and provide this information. We'll also inform the user about the potential improvement in their scalp's age if they follow the provided solution.

H. Personalized Notification

The AI model allows the User to choose whether to receive notifications based on the recommended treatment plan. If the User opts to use the notification, personalized notifications are provided tailored to the User's ongoing routine. (e.g.: Today is Wednesday, and it's the day for FrontMode. Please operate Medihair in FrontMode before 9 PM.)

I. Remote Control Functionality

Currently, a remote control is required to operate Medihair. The application connects to Medihair via Bluetooth and sends instructions present on the remote to Medihair. Functions such as checking the battery level of Medihair, viewing real-time scalp images, and selecting modes are available.

III. DEVELOPMENT ENVIRONMENT

A. Choice of Software Development Platform

Our team plans to develop applications compatible with both Mac and Windows operating systems. For cross-platform functionality on iOS and Android, we'll utilize Flutter framework with Dart. Additionally, Node.js framework will be employed for its compatibility with JSON format and built-in web server, while MySQL will enhance data analysis speed, avoiding the need for manual data extraction.

TABLE II: Tools and Language Choice

Tools and Language	***Reason***
Flutter	Flutter is an outstanding mobile app development framework developed by Google, allowing developers to create and maintain apps for both iOS and Android platforms with a single codebase. This cross-platform capability significantly enhances productivity. Flutter utilizes a widget-based approach to building user interfaces, enabling rapid design and modification of screens. It delivers near-native performance and includes excellent tools for optimizing screen performance, enhancing user experience. Additionally, Flutter benefits from a robust community, enabling developers to easily find and implement new features and packages, streamlining the development process.
MySQL	MySQL stands out as a top-tier open-source relational database management system (RDBMS) known for its stability and performance. It excels in processing large volumes of data quickly, making it ideal for large-scale applications. MySQL provides support for various operating systems, allowing developers to use it in diverse environments. With powerful query capabilities, developers can execute complex database operations effortlessly. MySQL ensures data integrity and transaction handling, guaranteeing the safety of the database. Its scalable performance and high reliability make it an ideal choice for reliable data storage and processing in large-scale applications and web services.
Node.js	Node.js is a server-side JavaScript runtime built on Chrome's V8 JavaScript engine, offering asynchronous I/O processing and exceptional scalability. Its event-driven, single-threaded model efficiently handles numerous connections simultaneously, ensuring high performance. Node.js processes data swiftly, significantly reducing response times for web applications. By utilizing Java Script for both frontend and backend, developers maintain consistent code, enhancing efficiency. Node.js benefits from a vibrant community, providing a wealth of modules and packages, enhancing developer productivity. It is particularly well-suited for developing large-scale web applications and real-time applications, making it an ideal tool for building responsive, high-performance network applications.

B. Cost Estimation

To successfully develop our application, it's imperative to retrieve data from the database and maintain real-time communication with the server. This necessitates hosting real-time servers and integrating multiple APIs into our system to obtain both database information and live server updates. This approach ensures seamless data retrieval and up-to-date information, enhancing the overall functionality and user experience of our application.

TABLE III: Cost Estimation

Tools and Language	Reason
AWS EC2	AWS EC2 stands as a Virtual Private Server (VPS) provider, empowering developers with the resources necessary for computing, storage, and networking. It offers the flexibility to deploy and manage websites and web applications in the cloud environment. With AWS EC2, developers have access to a comprehensive suite of tools, including virtual machines, containers, databases, content delivery networks (CDNs), load balancers, and DNS management services. These tools facilitate the swift setup and seamless operation of projects. Moreover, AWS EC2 ensures reliability through its low and predictable monthly rates, providing an affordable yet robust solution for hosting and managing diverse online projects.

C. Software in Use

1. Git & Github
   Git, a distributed version control system, records tasks within project folders, enabling systematic development through version management. Multiple developers can collaboratively work on the same project files without exchanging source code separately. Github, a web hosting platform supporting Git projects, provides a user-friendly graphical interface, enhancing collaborative coding and project management.

2. Notion
   Notion, an all-in-one productivity and collaboration tool, efficiently manages notes, schedules, tasks, and projects. Serving as a versatile enterprise collaboration tool, it replaces team wikis, project management, and document sharing tools. Notion finds diverse applications, including personal wikis, websites, blogs, databases, and company websites. It's widely used in businesses in Korea, including platforms like Carrot Markets and Zigzag, offering extensive flexibility in document creation and collaboration.

3. AWS EC2 (Elastic Compute Cloud)
   AWS EC2, a cloud computing service, allows remote usage of server resources across data center locations. It offers flexible capacity scaling, enabling users to pay for the resources used, ensuring cost-effectiveness. Users have complete control over instances, enhancing security, network configuration, and storage management. EC2 is a powerful and economical choice for hosting various applications and services in the cloud environment.

4. Visual Studio Code
   Visual Studio Code, an open-source code editor developed by Microsoft, supports Windows, macOS, and Linux platforms. Beyond syntax enhancement and Git control, it features debugging support and SSH access. Users can customize themes, shortcuts, and settings, enhancing their coding experience. It's a highly adaptable editor that fosters collaboration and allows developers to tailor their workspace to specific needs, promoting efficient coding practices.

5. AWS RDS (Relational Database Service)
   AWS RDS simplifies relational database management in the cloud, automating tasks such as setup, scaling, and backups. It offers cost-effective capacity provisioning, eliminating the complexity of hardware management. RDS supports various database engines, providing users with a reliable and scalable solution for handling large datasets. With automated maintenance and backups, RDS ensures data integrity and availability, making it an ideal choice for database management in cloud-based applications.

6. Google Colab
   Google Colab, short for Colaboratory, is a cloud-based platform provided by Google that enables users to write and execute Python code in a web-based interactive environment. It integrates with Google Drive and allows users to create, share, and comment on Colab notebooks, similar to Jupyter notebooks. Colab provides free access to GPU resources, allowing users to accelerate machine learning tasks and data analysis. It also supports collaborative work, enabling multiple users to collaborate in real-time on the same document, enhancing teamwork and productivity. With pre-installed libraries and seamless integration with Google services, Colab simplifies the process of coding, experimenting, and sharing data science projects.

7. Figma
   Figma is a cloud-based design and prototyping tool that facilitates collaborative interface design and user experience (UI/UX) planning. It offers a web-based platform, allowing multiple designers to work on the same project simultaneously in real-time. Figma supports vector graphics editing, interactive prototyping, and design version control. Its collaborative features make it an ideal choice for remote teams and designers working on projects together. Figma enables seamless communication, feedback, and iteration during the design process. It also provides a platform for developers and stakeholders to visualize the design, fostering better understanding and efficient collaboration between design and development teams.

8. Scikit-learn
   Scikit-learn is a popular open-source machine learning library in Python. It provides simple and efficient tools for data mining and data analysis, built on NumPy, SciPy, and matplotlib. Scikit-learn offers a wide range of machine learning algorithms for classification, regression, clustering, dimensionality reduction, and more. It also includes various tools for model selection, evaluation, and data preprocessing. Scikit-learn is designed for ease of use and efficiency, making it accessible for both beginners and experienced machine learning practitioners. Its extensive documentation and community support make it a go-to choice for building machine learning models and conducting data analysis tasks in Python.

9. NumPy
   NumPy is a powerful numerical computing library in Python. It provides support for large, multi-dimensional arrays and matrices, along with a collection of high-level mathematical functions to operate on these arrays. NumPy is the foundation for many other scientific computing libraries in Python. It offers efficient array operations, enabling tasks such as linear algebra, statistical analysis, Fourier analysis, and more. NumPy arrays are faster and

more memory-efficient than Python lists, making them ideal for handling large datasets and numerical computations. NumPy's multidimensional arrays and versatile functions simplify complex mathematical computations and data manipulations, making it an essential library for scientific computing and data analysis tasks in Python.

IV. SPECIFICATION

A. Login Page

Users enter their email and password, and the syste m verifies their credentials against the database. For me mbers without login information or those who have forg otten their password, there are links to the registration p age and a password recovery feature.

B. Register Page

Users enter their email, and an authentication code is sent to that email. After correctly entering the authentication code, they're prompted to enter their password twice. Passwords must contain both letters and numbers, be at least 10 characters long, and may include special characters. The double entry ensures the accuracy of the password.

C. User Information Page

Users provide their name, age, and gender. This information is stored in the database. The inputted age and gender are used to compare the average hair thickness and density of that age and gender group to the user's hair loss status to determine progress.

D. Main Page

Once logged in, users are directed to the Main Page. In the center of the main screen, there are four main buttons leading to Hair Analysis, Analysis Record, Product Recommendations, and Remote Control. At the bottom, there are navigation buttons for Settings, Home (Main Page), Notifications, and My Page (where users can add or modify their information).

E. Hair Analysis Page

This page offers hair loss status verification and tailored treatment solution design through hair analysis. The analysis begins when users are wearing Medihair. A hair analysis machine learning model determines the user's hair thickness, density, and the extent of hair loss. After the analysis, tailored treatment solutions are recommended to the user through Medihair (e.g., "Three times a week, Total Care Mode"). The analyzed hair information is stored in the database for progress tracking and can be reviewed in the "Hair Record Page".

F. Hair Record Page

This page provides a function to view hair analysis records conducted on the Hair Analysis Page. Users can view records from the current day and from previous dates. Additionally, a feature allows users to compare current records with past ones to identify improvements.

G. Remote Control

This page offers a function to remotely control Medihair using the app's built-in remote. Using Medihair requires a remote, and the L-Garana app provides this remote control feature. This ensures easy use of Medihair without a physical remote and enhances the app's accessibility.

H. Product Recommendation page

Based on users' hair & scalp analysis, LGarana recommends hair care products and food, tailored to users' specific needs. This page will provide a curated selection of shampoos, conditioners, and other hair care products like scalp massagers and other complementary treatments to relieve hair loss concerns, and help you achieve healthier and more resilient hair.

I. Settings

1. Connection:

   This section verifies the connectivity of Medihair. Navigate to the 'Connectivity Status' within the app, where it will display 'connected' once established.

2. Medihair & App Manual:

   For further guidance, refer to the user manual available within the app. Additionally, the app presents a convenient dark mode feature.

3. Dark Mode:

   The app offers a dark mode option, ensuring a more comfortable and visually appealing experience, especially in low-light environments."

J. Alarm

On the alarm page, users can easily manage their alarms. They have the option to toggle alarms on and off using a simple switch, delete unwanted alarms, and set specific dates and times for each alarm. This user-friendly interface ensures that users receive timely reminders for their Medi-hair usage and helps them monitor their hair status periodically.

K. Profile

On the profile management page, users can log in and log out. They also have the option to add a new profile, allowing them to set a unique nickname for each profile. This feature provides flexibility in user switching, allowing users to easily change between profiles and personalize their experience on the platform.

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