Clothes Tower : Signature Closet

*N-ism

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Abstract—**People have a lot of clothes. Did you forget anything? Are there clothes that you can't find when you need them? Clothes Tower is a smart closet that allows users to use clothes more conveniently by receiving the type and unique number of clothes through the application. Users will be able to wear the clothes they want in the best condition at any time through the Clothes Tower.**

Index Terms—**Clothes, Closet, management, Application, Furniture**

I. Introduction

A. Motivation / Problem Statement (client's needs)

Recently, people's interest in fashion is getting hotter. Previously, there were many people who valued only expensive brand clothing. However, these days, each person buys and wears clothes according to their own personality. Wear many kinds of clothes such as outerwear, top, bottom, shoes, and accessories. In addition, as styles diversify, people share their own methods through SNS (Instagram or YouTube). Therefore, consumers sometimes forget the clothes they have organized in their closets because they repeatedly wear, buy, and throw away various clothes. Even once the season changes, there may be cases where you don't know which clothes were there. In addition, there will not be many people who manage many clothes with only one closet. We thought about how to manage many clothes in one space. And we found the answer at the parking tower where the vehicle was stored. The parking tower is a mixture of elevators and parking lots. The purpose of the parking tower is to maximize space utilization with the aim of parking many vehicles in a narrow space. For example, it is commonly used in high-rise buildings with many people due to the high floor of hotels and buildings where the circulation of cars is not fast. In addition, the advantage of the parking tower is that it is easy to monitor parking conditions, easy to operate equipment, and easy to operate and maintain as messages are printed in the event of a failure. From now on, we will compare and analyze the 'Clothes Tower' and the parking tower to find client's needs.

1) Space Utilization
   - Parking Tower

TABLE I
ROLE ASSIGNMENTS

Roles	Name	Task descriptions and etc
User	PyeongSoo Park	It analyzes and investigates which services customers want. It analyzes the purpose of the closet in detail and investigates how customers feel satisfied with the closet. It is in charge of various fields such as design and function.
Customer	JeMin Seo	It is in charge of the overall planning of ideas. From the customer's point of view, it contemplates and presents which parts are inconvenient and should be added. As the project progresses, problems are first discovered.
Software Developer	JunSung Kim	Create data that drives the closet and construct a draft on how to induce it to work. Design and implement applications. Overall, it is responsible for solving the driving method and software problems of the item.
Development Manager	SeungHwan Cheon	Identify and lead the overall flow of planning. Check the direction of the plan from time to time to see if it meets the original intention. In addition, it manages whether the tasks of the previous roles are being performed properly.

As the number of vehicles to be accommodated increases, it is difficult to solve with the existing parking method (using the entire floor as a parking space). This is because it is far from design and utilization to divide one floor into parking and office spaces. Therefore, if you use it as a parking space,

you have no choice but to use all floors as a parking space. Therefore, it was used vertically and long to increase the utilization of the building.

- Clothes Tower

    As clothes became more diverse and more diverse, there was a problem of lack of storage space. In addition, since clothes worn in different seasons vary depending on the season, clothes worn in different seasons often forget where they were placed when they were taken out and worn. Therefore, Cloth Tower, like the parking tower, adopted a horizontal extension method for use in the house. In the case of closets, it was judged that the entire space could be used, such as built-in cabinets and dress rooms.

2) Easy to Manipulate

- Parking Tower

    The car is stocked and shipped through the screen. When the vehicle is put in at the time of warehousing and the number of the vehicle is entered, the machine remembers the information and places the vehicle in an empty space in the parking tower. When shipped, the vehicle is moved like an elevator to the position of the borrower with only a simple license plate input operation. Therefore, it is possible to relieve the hassle of driving separately or finding a vehicle.

- Clothes Tower

    Clothes can be taken out and put in through the display shown outside the closet. When putting clothes in, simply enter and store information about clothes. And store clothes in an empty space. When taking out clothes, the closet aligns corresponding clothes according to the style and needs desired by the user through previous data. This, like the parking tower, can solve the hassle of users wandering around looking for clothes.

3) Operation and Maintenance

- Parking Tower

    If there is a machine failure or error through the screen, it is delivered through message output. Therefore, the machine operator only needs to check the facility without having to check everywhere, so time and cost are saved.

- Clothes Tower

    In case the closet fails to properly show the clothes the user wants, the application linkage method was chosen. Since clothes can be managed and maintained through applications as well as displays in the closet, users

can prepare clothes in advance regardless of location. Therefore, it guarantees time saving for the user.

B. *Research on any related software*

- *Acloset*

    'Acloset' is an application that manages clothes that users have. There are four categories in total. It consists of a home screen, a shopping screen, a registered clothes management screen, and a style management screen. The home screen shows an analysis of the weather, recommended styles, clothes worn this week, and styles. On the shopping screen, products that customers need are sold by classifying them by type of clothes. The screen for managing registered clothes shows the current status of clothes that users have by adding and deleting clothes themselves. The style management screen shows how the user will dress in advance by adding style.

- *OTTOK*

    'OTTOK' is an application that analyzes the style when the user registers the clothes and matches the coordination. When registering clothes, you can register them separately by type. In addition, you can register by item or by coordination when registering. When a user coordinates clothes registered, the AI of the application analyzes them. Based on this information, it is possible to compare or watch coordination styles with other users.

- *AmazonEchoLook*

    'Amazon Echo Look' is an AI and camera that advises users on what clothes look good on them through machine learning after performing a 360-degree 3D scan. It is equipped with AI, so you can ask about the weather or schedule. Photos or videos taken through a camera can be checked through a smartphone, saved, or shared on SNS. Also, sending photos to AI recommends clothes that suit users better through machine learning.

II. REQUIREMENT

A. *Software(Application)*

1) Hanger type page

- Adding/Deleting clothes

    Basically, clothes are added one by one. Enter the basic information of the clothes and transmit the data of the clothes to the server when adding them. The added clothes are searched as a list within the corresponding page. When deleting, you can delete the clothes in the list by clicking.

- Searching for clothes

  User can inquire about clothes in the list and search for specific clothes. User enters a search word based on the basic information of the clothes, user will see the clothes that meet the conditions.

- Ventilation system

  A ventilator in a hanger-type closet can be operated.

- Styler

  If user enters the desired date and time among the registered clothes, the styler function is activated.

2) Drawer type page

It is a page that can adjust the environment of each drawer. It is a drawer that can hold similar types of clothes, and it is possible to maintain an optimal condition for each drawer by adjusting temperature and humidity. It controls access to the desired drawer.

3) Calendar and Weather page

The user's schedule may be registered. It helps users easily check schedules and actively utilize styler functions. In addition, the weather API helps you choose what to wear.

B. Software(AI Speaker)

1) Additional function using the camera in the closet

Recognize and classify information on clothes.

2) Access to clothes

Based on the information on the previously stored clothes, the user exports the clothes he or she wants.

3) Recommendation function depending on the weather

Based on the weather, clothes are recommended to users.

4) Organizing clothes according to the season

Differentiate out-of-season clothes from clothes in the closet according to the season.

C. Hardware

1) Hanger type space

- Closet

  It is largely divided into an entrance part of clothes used as a styler and a storage space for clothes. The storage space is separated for each clothing. The access of clothes is managed through the rail.

- Styler

  It is located at the entrance to the clothes. It has the same function as the styler on the market and manages the smell and contamination of clothes.

- Partition

  It prevents stains due to the color of the clothes through the partition. In addition, when partitions are installed, static electricity is prevented, and lint and dust pollution that occur when clothes overlap each other is prevented in advance.

- Ventilation fan

  It is responsible for the overall ventilation of the closet-type space. Air circulation in the closet-type space prevents the unique quaint smell of the closet.

- A camera for recognition

  It is responsible for automatically recognizing information about clothes placed in the closet by the user.

2) Drawer type space

All drawers move through rails. It controls access to drawers using applications.

3) Display

The application and function are the same, and user can manage closet yourself without a cell phone.

III. DEVELOPMENT ENVIRONMENT

A. Choice of software development platform

- Which platform and Why?

  1) Android

  Fig. 1. Android

  Our service chose to develop an app instead of a website because users have to manage their clothes remotely without being affected by the location. The next options were IOS, android, and cross-platform applications. There are team members who have experienced Android development, and we chose the Android app to make the most of the native features of the Android operating system.

  2) Ubuntu Linux environment of AWS EC2

  The server operates in the Ubuntu Linux environment of AWS EC2. Since AWS' Free tier service is used, the service can be distributed quickly without any cost burden. In

Fig. 2. AWS EC2

this project, we plan to actively use AWS services. DB used AWS RDS. Since the free tier includes the use of MYSQL DB, it was possible to build a stable DB without cost. DB can be easily managed remotely in conjunction with MYSQL Workbench 8.0 CE of the local PC.

3) Node.js

Fig. 3. Node.js

Node.js was selected as the server-side development language. Node.js is a JavaScript runtime of a single thread asynchronous model that can be learned relatively easily by people unfamiliar with server programming. In addition, data in JSON format can be easily processed. Due to the nature of the project, we chose node.js because we do not use data analysis or machine learning, and there are not many CPU-intensive tasks. (Express, a representative backend framework of node.js, is light and convenient, but it is difficult to experience structured programming because developers have to devise the structure of the program from scratch. There is also a disadvantage in that it is difficult to use Swagger, an API documentation tool to be used for this project. So, in this project, we decided to use a node.js framework called Nest.js, which is similar to JAVA's Spring Framework. Nest.js judged that the framework would help improve backend capabilities because it has the architecture of MVC patterns and contains important concepts such as DI (dependency injection) and IoC (Inversion of control). It is

also convenient because the framework itself provides swagger documentation.)

• Which programming language and Why?
  1) TypeScript

Fig. 4. TypeScript

TypeScript is a programming language developed and maintained by Microsoft. It is superset of JavaScript and adds optional static typing to the language. TypeScript is designed for the development of large applications and transcompiles to JavaScript. Since grammatical errors are checked at the time of compilation, it has the advantage of being able to develop more stably than script languages in which errors occur in runtime environments. Another advantage of TypeScript is that it can maximize the functionality of development tools when writing code. Visual Studio Code, which is widely used in development, is optimized for type script development because the inside of the tool is written in type script. Typically, the automatic code completion function is superior to JavaScript.

  2) Java

Fig. 5. Java

Java is a high-level, class-based, object-oriented programming language that is designed to have as few implementation dependencies as possible. It is a general-purpose programming language intended to let programmers write once, run anywhere meaning that compiled Java code can run on all platforms that support Java without the need for

recompilation. Java applications are typically compiled to bytecode that can run on any Java virtual machine (JVM) regardless of the underlying computer architecture. The syntax of Java is similar to C and C++, but has fewer low-level facilities than either of them. The Java runtime provides dynamic capabilities (such as reflection and runtime code modification) that are typically not available in traditional compiled languages. As of 2019, Java was one of the most popular programming languages in use according to GitHub, particularly for client–server web applications, with a reported 9 million developers. Java was originally developed by James Gosling at Sun Microsystems (which has since been acquired by Oracle) and released in 1995 as a core component of Sun Microsystems' Java platform. The original and reference implementation Java compilers, virtual machines, and class libraries were originally released by Sun under proprietary licenses. As of May 2007, in compliance with the specifications of the Java Community Process, Sun had relicensed most of its Java technologies under the GPL-2.0-only license. Oracle offers its own HotSpot Java Virtual Machine, however the official reference implementation is the OpenJDK JVM which is free open-source software and used by most developers and is the default JVM for almost all Linux distributions. As of October 2021, Java 17 is the latest version. Java 8, 11 and 17 are the current long-term support (LTS) versions. Oracle released the last zero-cost public update for the legacy version Java 8 LTS in January 2019 for commercial use, although it will otherwise still support Java 8 with public updates for personal use indefinitely. Other vendors have begun to offer zero-cost builds of OpenJDK 8 and 11 that are still receiving security and other upgrades.

B. Which software in use?

1) AWS EC2

Fig. 6. AWS EC2

We chose AWS EC2 as the deploy environment. EC2 is a cloud computing service provided by Amazon Web Services. Developers can quickly implement and distribute services without having to purchase actual servers. Linux Ubuntu 20.04 was used as the EC2 operating system.

2) AWS RDS

Fig. 7. AWS RDS

RDS is a distributed relational database serviced by Amazon Web Services (AWS). It is a web service that operates in the cloud designed to simplify the setting, operation, and scaling of relational databases within an application. If DB is installed directly inside EC2, it is difficult to set up and manage. If you use RDS, you can easily access the DB only with a DB client.

3) AWS S3

Fig. 8. AWS S3

AWS S3 is an object storage service that provides industry-leading scalability, data availability, security and performance. AWS S3 allows users to store and protect the desired amount of data in a variety of use cases, including data rakes, websites, mobile applications, backup and restore, archives, enterprise applications, IoT devices, and big data analysis. AWS S3 provides management to optimize, structure, and organize access to data to meet specific business, organization, and compliance requirements. In our project, instead of storing the image data transmitted from the Android application on the server, we will save it in AWS S3.

4) Figma

Fig. 9. Figma

Figma is a vector graphics editor and proto-typing tool which is primarily web-based, with additional offline features enabled by desktop applications for macOS and Windows. The Figma Mirror companion apps for Android and iOS allow viewing Figma prototypes in real-time on mobile devices. The feature set of Figma focuses on use in user interface and user experience design, with an emphasis on real-time collaboration.

5) Github

Fig. 10. Github

GitHub is Microsoft's web service that hosts source code based on distributed version control software git and supports collaboration support functions. It is currently the most popular source code hosting service and software development platform.

6) CATIA

Fig. 11. CATIA

It is a 3D CAD and PLM software developed and sold by Dassault Systems in France. CA-TIA (Computer Aided Three Dimension Inter-active Application) stands for interactive applied three-dimensional computer design, and is an integrated CAD/CAM/CAE SYSTEM that can handle product planning to production in batches. Although precise mathematical definitions are strong in curved modeling, which is important, on the contrary, if the user does

Software	Task Description	Cost
AWS EC2	Virtual Server	$0
AWS RDS	Remote Database	$0
AWS S3	Image Repository	$0 or $1
Figma	UI design tool	$0
Github	Remote repository	$0
CATIA	3D Modeling	About 23 ,000 euro / About €1,470 per year / for Education : €99 per year
NGINX	Web Server	$0

not know the meaning of these precise mathematical definitions of these shapes, there is a problem that is quite difficult to learn. In particular, it is essential software for design in the aircraft and automobile industries due to its many curved and precise designs through Surface Modeling, and is widely used in areas that require precise design such as mold design. Considering that Dassault Systems is a company that makes mirage fighters, it is the software that originally built airplanes. It has begun to be developed for use in the design of the aviation and space industries, and now the area of use is wide.

7) NGINX

Fig. 12. NGINX

Nginx is a lightweight web server specialized for simultaneous access processing. It is sometimes used as an HTTP Web Server that responds to static files that meet your request when you receive a request from a client, or as a load balancer that can reduce the load on the WAS server by using it as a Reverse Proxy Server.

- Cost

C. Development Environment

1) Provide clear information of development environment
  - Window 10
    - 2.80GHz, Core Intel i7
    - 16GB Memory
  - Visual Studio Code 1.62.0
  - TypeScript 4.3.5
  - Node 14.17.6

2) Provide clear information of development environment
- Window 10
  - 1.50GHz, Core Intel i5-1035G4
  - 8GB Memory
- Android Studio 4.2.1
- Android Emulator 30.6.5
- Android SDK Platform-Tools 31.0.2
- Compile SDK Version 30(API 30: Android 11.0(R))
- Intel x86 Emulator Accelerator 7.6.5
- Android SDK Build-Tools 32-rc1 30.0.3 (Build Tools Version)
- Android Gradle Plugin Version 4.2.1
- Gradle Version 6.7.1
- Junit:4.+
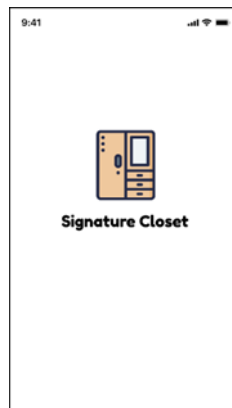- JDK Version JAVA 16.0.2

IV. SPECIFICATION

A. Software(Application)

1) Loading page

Fig. 13. Loading page

The intro screen was made into a closet image, and the duration of the intro screen was implemented as 3 seconds.

2) Hanger type page

It is the first part of the category below. It is a page where you can manage hanger-type closets. The clothes registered in the hanger-type closet are shown in the form of images. Three icons are displayed on the upper right so that stylers, ventilation systems, and search functions can be used, respectively.

- Adding/Deleting clothes

Users can directly add and delete clothes registered in the closet. The registration of clothes is done in the following way.

a) Top/Bottom/Others

The major classification for classifying clothes was decided as the first branch point. It distinguishes whether the clothes
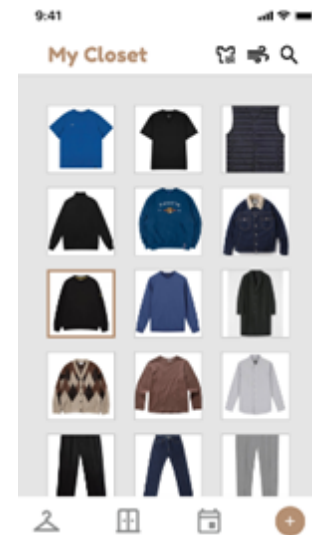
Fig. 14. Hanger type page

Fig. 15. Adding page 1

the user wants to register are top or bottom, or classifies them so that other clothes (hats, mufflers, etc.) can be selected.

b) Top(long-sleeved/short-sleeved), Bottom (long pants/shorts)

If the user chooses top, bottom, or other, it will move on to the next screen. The second branching point shows a different screen for each option. First, if you choose 'top', distinguish whether it is long-sleeved or short-sleeved. Next, if you choose 'bottom', distinguish whether it is long pants or shorts. If the length of clothes is classified as long and short as

Fig. 16. Adding page 2

Fig. 17. Choosing a hanger type number

the second branch, we expect the effect of allowing users to search for clothes according to the season. Finally, if 'other' is selected, the branch point is skipped because there is no need to distinguish the length.

c) Color

The third branch designates the color of the clothes. On the day of going out, it was subdivided so that users can easily and quickly search for clothes in preferred colors. When the user selects the color of the clothes, it is handed over to the next screen.

d) Material

The fourth branch selects the material of the clothes. Some people determine the material of clothes according to the season and weather. Some people decide the material of clothes according to their style. Based on users' preferences, materials can be divided to quickly find clothes that users want. Materials are divided into cotton, poly, acrylic, napping, cashmere, linen, and all.

e) Choose a hanger-type number

Finally, choose which hanger to hang in the closet. It is information that can help users choose one piece of clothing they want. As the most clearly distinguishable information of clothes, it is the smallest branch point and the standard that can be practically distinguished within the closet. Hanger-type numbers are given from number 1.

f) "Save clothes information" button

Fig. 18. Save clothes information 1

Press the Save Clothes Information button to output a confirmation message once again. In the confirmation message, it is divided into 'Yes' and 'No', and when selecting 'Yes', the information is sent to the DB and a pop-up message that it has been saved is output. When selecting 'No', return to the 'Photo Registration' page.

• Searching for clothes

It is an event generated when clicking the 'magnifier' icon at the top right of the hanger-type closet page. The list is sorted

Fig. 19. Save clothes information 2

Fig. 20. Searching page

according to preferred criteria based on information on clothes registered by the user. Within one page, the criteria registered by the user are displayed on the screen once again. After selecting the information on the desired clothes, pressing the 'Search' button at the bottom to perform a search.

- Ventilation system

  It is an event generated when clicking the 'wind' icon in the upper right corner of the hanger-type closet page. When the icon is clicked, a confirmation message about the use of the ventilation system is output. The answer to the message is divided into a "Yes" button and a "No" button. Press the "Yes"

button to display a pop-up message saying that the ventilation system is running and return the screen to the hanger-type closet page. Pressing the "No" button returns to the hanger-type closet page without a separate screen.

- Styler

Fig. 21. Styler page

It is an event generated when clicking the 'iron' icon in the upper right corner of the hanger-type closet page. When you click the icon, the screen is turned over to a page where the Styler function can be used. On this page, the user must select the date and time, and clothes. Likewise, when the 'Start Styler Function' button is pressed, a confirmation message is output. Pressing the "Yes" button between the "Yes" button and the "No" button will display a pop-up message saying that the styler is running and return the screen to the hanger-type closet page. Pressing the "No" button returns to the hanger-type closet page without a separate screen.

3) Drawer type page

It is the second part of the category below. It is a page where you can manage a drawer-type closet. It shows a list of six drawers in a drawer-type closet. Also, each drawer makes a button that can adjust the temperature and humidity.

- Temperature control

  Press the "temperature" button to launch a pop-up on temperature selection and create a "Yes" button and a "No" button at the bottom. If you press the "Yes" button, you

Fig. 22. Drawer type page

Fig. 23. Calendar and Weather page

will return to the drawer-type closet page with a pop-up message saying that the set temperature is applied to the drawer. Pressing the "No" button returns to the drawer-type closet page without a separate screen.

- Humidity control

    Press the "humidity" button to launch a pop-up on humidity selection and create a "Yes" button and a "No" button at the bottom. When the "Yes" button is pressed, a pop-up message appears saying that the set humidity is applied to the drawer and returns to the drawer-type closet page. Pressing the "No" button returns to the drawer-type closet page without a separate screen.

4) Calendar and Weather page

    It is the third part of the category below. Set the calendar to the initial plane.

- Additional schedule

    After selecting the desired date, press the 'Register Schedule' button under the calendar. Display a text box that allows you to register the contents of the schedule as a pop-up message. In this pop-up, the "Yes" button and the "No" button are added to the bottom to add the contents of the schedule within the calendar and display a message that the schedule has been registered when selecting the "Yes" button. When selecting the 'No' button, return to the calendar/weather page without a separate screen.

- Weather check

    Click the weather icon to go to the site where you can check the weather. It helps users choose clothes according to the weather.

B. Software(AI Speaker)

1) Additional function using the camera in the closet

    Close the closet when the user triggers the use of the closet. After closing the closet, take a picture of the clothes with a recognition camera. Outputs an end message along with a message that you have remembered information about clothes.

2) Access to clothes

    When the user triggers information on the desired clothes, it outputs a message that classification proceeds. Classify clothes based on the information and send them out. When a user says that he or she is terminating the closet, he or she outputs an end message along with a message that the closet door is closed.

3) Recommendation function depending on the weather

    When the user triggers a question about the weather, information about the weather is delivered to the user based on the weather API. In addition, they print out messages recommended for clothes based on the weather and ask for their intention to execute the closet function.

4) Organizing clothes according to the season

    When a user asks about the weather, the information is stored separately. When the user triggers a question about whether to organize clothes, it checks whether the criteria for seasonal changes are satisfied in the list. If the criteria are met, the appropriate clothes are sent according to the information. If the criteria are not met, they output a message at the same time saying that they do not have to organize them yet and whether they will still organize

them. When the speaker accepts the response, the conversation is output when the criterion is satisfied, and when the response is rejected, the conversation is terminated.
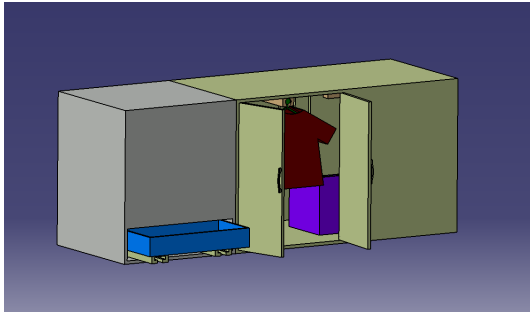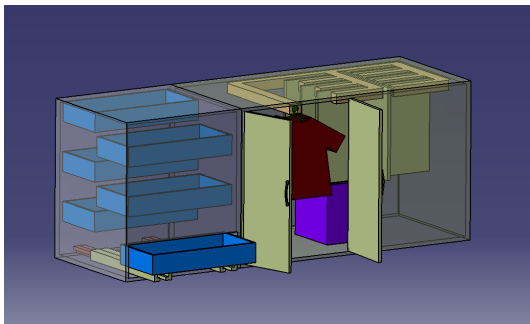
C. Hardware

Fig. 24. Overall 1

Fig. 25. Overall 2
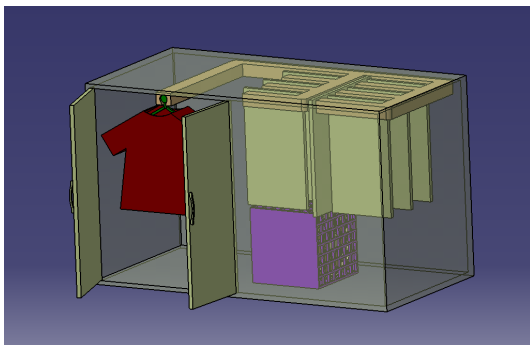
1) Hanger type space

Fig. 26. Hanger type space 1

The hanger-type closet can be divided into five parts. It is divided into a closet, a styler, a partition, a ventilator, and a camera.

- Closet

  The hanger-type closet imitated the elevator-type parking tower. I thought it was a suitable method for a hanger-type closet because the
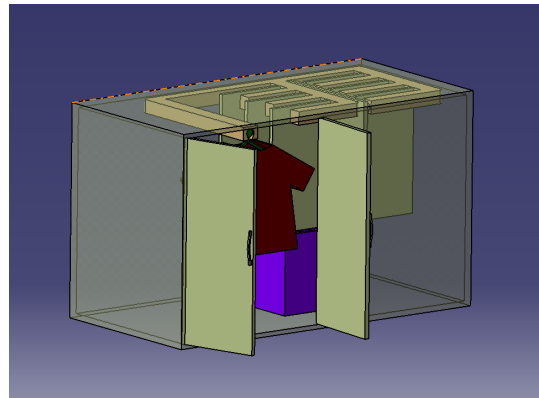
Fig. 27. Hanger type space 2
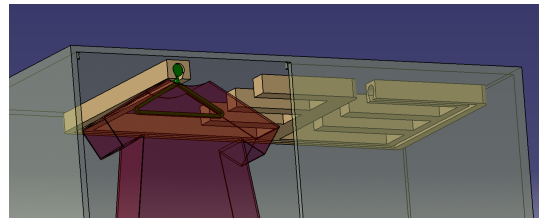
Fig. 28. Closet

storage space was fixed and easy to manage for each item. Move the clothes along the rail to the designated place. In the closet, rails were designed and spaces were separated like branches coming from trees so that various clothes could be stored.

- Styler

Fig. 29. Styler (LG)

While performing the styler function, it also serves as the entrance to the closet. Space efficiency was improved by unifying rails moving from the entrance to the closet. The shape of the rail is a "U" shaped rail that enters the back of the entrance and leads to the closet.
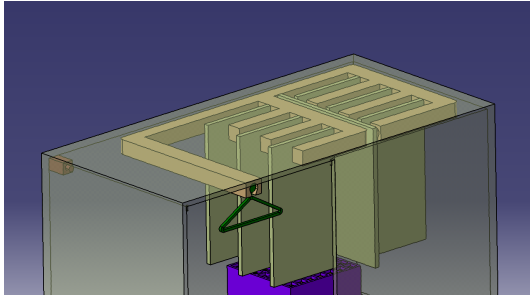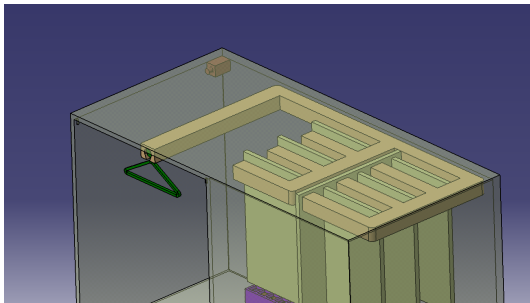
- Partition

Fig. 30. Partition 1

Fig. 31. Partition 2

The partition is located in the closet. It is a role that separates the space of each clothing. Like rails, it is divided into branches from large to small partitions. It serves to prevent static electricity, clothing stains, lint, and dust generation.
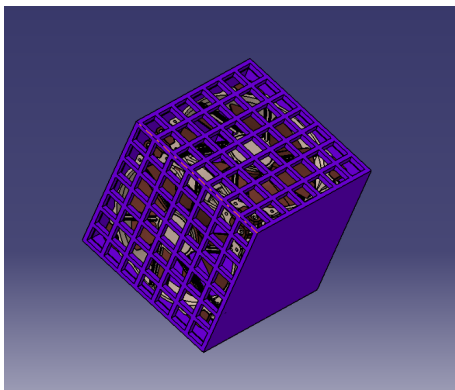
- Ventilation fan

Fig. 32. Ventilation fan

The ventilator is located below the closet space. Each side is pierced in the form of a net to prevent damage to the clothes by applying wind directly to the clothes. Since the closet is somewhat away from the entrance, it serves to circulate the air in the

closet. Block dust and odor generation in the closet in advance.

- A camera for recognition
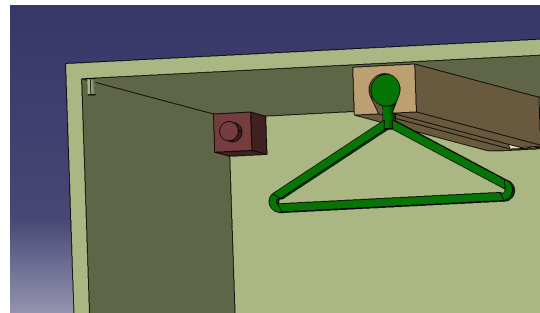

Fig. 33. A camera for recognition (Pixycam)
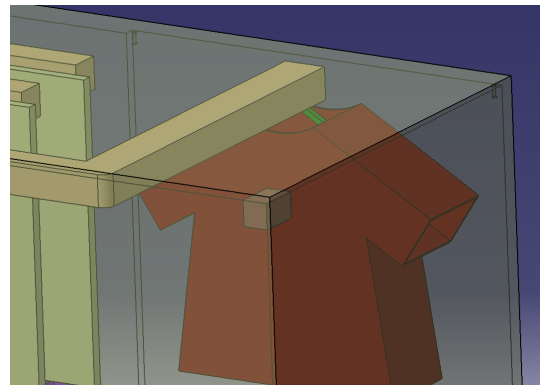

Fig. 34. Position of the camera

Fig. 35. Angle of the camera

It is located at the top of the hanger-type closet entrance and takes pictures and remembers information when the user closes the closet door. Since clothes can be directly photographed one by one, errors in recognition of clothes can be reduced.

2) Drawer type space
- Exterior of closet

In order to take the overall design neatly, all parts except the lower entrance were blocked. The entrance is fixed at the bottom of the
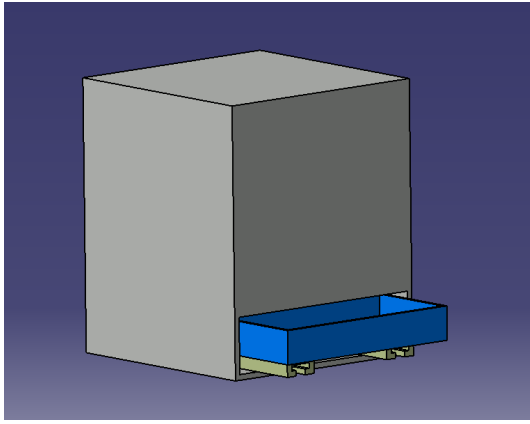
Fig. 36. Exterior of Drawer type space

closet. The entrance at the bottom is also made so that there is no protrusion when viewed from the outside.
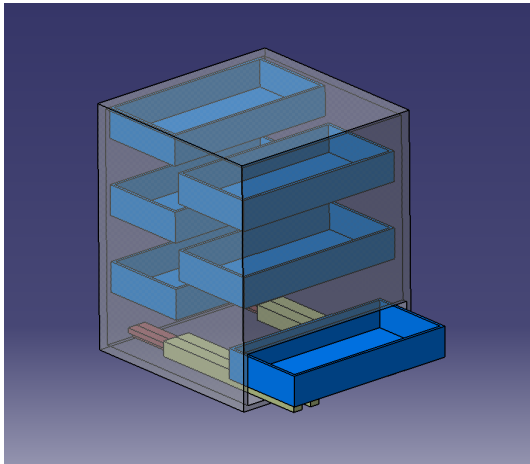
- Interior of closet

Fig. 37. Ixterior of Drawer type space

The drawer-type closet imitated the vertical circulation parking tower. I thought it was a suitable method for a drawer-type closet because I had to move and maintain a drawer that was larger than clothes. There are a total of six drawers, and each drawer is numbered. The structure of the drawer was designed in the form of a rectangular parallelepiped with width*length*height(1*2*3). Basically, six drawers are connected, and rails are placed at the entrance so that only the drawers can move in the right position.

3) Display

The display is located in the center of the entrance of the hanger-type closet. It operates in the form of a touch screen and is configured the same as functions in the application. It allows

Fig. 38. Display (LG)

Fig. 39. Position of the display

users to manage with only a closet without a cell phone. When the closet is managed through the application and the settings are changed, the display in the closet is also updated. Conversely, even if it is changed through a display in the closet, the application is also updated in the same manner.

D. Software and Hardware Interaction

1) If you select an item you want to take out of the hanger-type page/drawer-type page within the application, a confirmation message is output as to whether you want to enter or not. The answer to the message is divided into a "Yes" button and a "No" button. Press the "Yes"
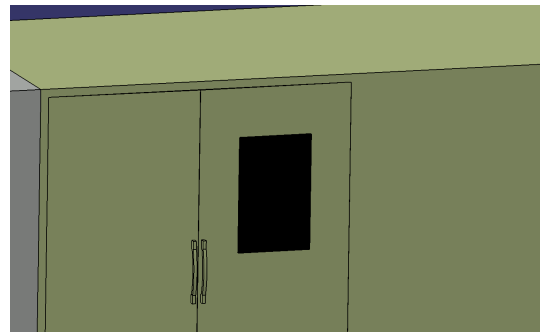

Fig. 40. Expansion of the display

button to display a pop-up message saying that you will enter and exit clothes/drawers. In the case of a hanger-type closet, the clothes are moved along the rail from the closet to the entrance. In the case of a drawer-type closet, the drawer is circulated to the entrance. Once the item has arrived at the entrance, it shows the clothes to the user through the entrance. If you press the 'No' button, no event will occur.

2) If you use the Styler function at the top right of the hanger-type closet page, you can move your clothes from the closet to the entrance in advance considering the date and time before the styler operates. The styler function is terminated at the time the user wants and clothes are shown to the user through the entrance.

3) When the ventilation system at the top right of the hanger-type closet page is implemented, the ventilation machine at the bottom of the hanger-type closet begins to rotate. When the air quality is checked and it is determined that sufficient ventilation has been made in the closet, the ventilator automatically stops running.

4) If you set the status of the drawer through the Temperature button and Humidity button in each drawer on the drawer-type closet page, the drawer in the actual closet changes the environment inside the drawer according to the user's preference.

5) When the closet is managed through the application and the settings are changed, the display in the closet is also updated. Conversely, even if it is changed through a display in the closet, the application is also updated in the same manner.

V. ARCHITECTURE DESIGN AND IMPLEMENTATION

A. Overall architecture

B. Application

- Front end
  1) Directory organization
  2) Module
     a) Purpose

        We used Android Studio as an IDE(Integrated Development Environment) assuming that users use Android mobile devices for application development. Android Studio is an integrated development environment for Android app development. AndroidStudio supports basic layouts and various designs and supports languages called Java and Kotlin. We chose Java.

     b) Fuctionality

        AndroidStudios provides a lot of support for front-end developers to design efficient UI. In addition, connecting with the backend is also possible through an appropriate library. Various functions can be implemented through AndroidStudio,

TABLE III
FRONT END DIRECTORY ORGANIZATION

Directory	Files names	Module name
/Cloth_Tower_ Frontend/app/src/ main	AndroidManifest.xml	Major java source code The overall app structure [Android Studio]
/Cloth_Tower_ Frontend/app/src/ main/res	/drawable/circle.xml /drawable/drawer.png /drawable/ellipse_color.xml /drawable/ic_image.xml /drawable/ic_launcher_ background.xml /drawable/material_search_ background.xml /drawable/radius.xml /drawable-v24/calendar.png /drawable-v24/closet.png /drawable-v24/hanger.png /drawable-v24/ic_launcher_ foreground.xml /drawable-v24/ic_select.png /drawable-v24/plus.png /drawable-v24/search.png /drawable-v24/styler.png /drawable-v24/wind.png	Png - Image file Xml – design attribute setting [Android Studio]
/Cloth_Tower_ Frontend/app/src/ main/res/font	/font.ttf	design ttf file Xml – font design atrribute setting [Android Studio]
/Cloth_Tower_ Frontend/app/src/ main/res/layout	/cloth_info_complete.xml /cloth_list.xml /cloth_search.xml /color.xml /fragment_calendar.xml /fragment_drawer.xml /fragment_hanger.xml /fragment_wind.xml /intro_activity.xml /mainmenu.xml /mainscreen.xml /material.xml /photo.xml /styler.xml /subscreen_bottom.xml /subscreen_top.xml	Front screen [Android Studio]
/Cloth_Tower_ Frontend/app/src/ main/res/menu	/under_menu.xml	Underbar_menu screen [Android Studio]
/Cloth_Tower Frontend/app/src/ main/res/navigation	/nav_graph.xml	Fragment_layout [Android Studio]
/Cloth_Tower_ Frontend/app/src/ main/res/values	/colors.xml /dimens.xml /strings.xml /themes.xml	Figma design attribute setting [Android Studio]
/Cloth_Tower_ Frontend/app/src/ main/java/com/ example/se_demo	/Cloth_search.java /Color.java /FragmentCalendar.java /FragmentDrawer.java /FragmentHanger.java /FragmentWindSystem.java /InitialScreen.java /Intro_activity.java /MainActivity.java /Material.java /Photo.java /Styler.java /Subactivity_bottom.java /Subactivity_top.java /Top_Bottom.java /WindSystem.java /sendHelper.java	[Android Studio] Java source code Application function

and running emulator through SDK tools is very helpful in developing because it even shows the appearance of the actual terminal devices.

  c) Location of source code

  Cloth_Tower/Cloth_Tower_Frontend/app/src/main/java/com/example/se_demo

  d) Class component

  – InitialScreen.java

  It corresponds to the initial screen in the application. The under bar is composed of fragments, and there are a total of 4 categories(hanger, drawer, calendar, windsystem) in the lower bar. When the user presses the desired category, it goes to the corresponding screen through the intent.

  – Top_bottom.java, Subactivity.java, Color.java, material.java

  This is Java source code files in the process of adding clothes when pressing the hanger type category(in under bar). The corresponding data is accumulated for each screen, and the screen is turned over to the intent, and the data is stored in a variable called json Data according to the json format.

  – sendHelper.java

  It is a Java code that contains variables that contain accumulated data in a queue. We created two queues because the application we created has data when adding clothes and data when searching for clothes.

  e) Where it is taken from

  We got the information from Google and also referred to the official Android official document.
  https://developer.android.com/guide?hl=ko

  f) How and Why we use it

  Android studios have several functions related to UI as well as the ability to operate demo through emulators. As a result, developers can develop efficiently and quickly. In addition, it is possible to connection git with github so that git can be commited and pushed. This is a very important function when collaborating with team members through git and actually helped our team a lot.

- Back end

C. AI speaker

VI. USE CASES

A. Application

1) Use case1 : When selecting the clothes/drawers listed on the hanger/drawer type closet page of the application, come out to the exit through the rail.

  a) Select the item you want to take out from the hanger-type page/drawer-type page within the application.
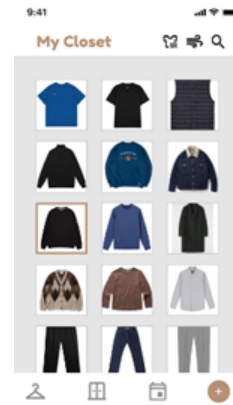

Fig. 41. Use case 1-a

Fig. 42. Use case 1-a

  b) A confirmation message is displayed as to whether you want to enter or not. The answer to the message is divided into a "Yes" button and a "No" button.

  c) Press the "Yes" button to display a pop-up message saying that you will enter and exit clothes/drawers. If you press the 'No' button, no event will occur.

  • Hanger-type closet: Move the clothes along the U-shaped rail from the closet to the entrance.

  • Drawer-type closet: Circulate the drawer to the entrance. Once the item has arrived at the entrance, it shows the clothes to the user through the entrance.
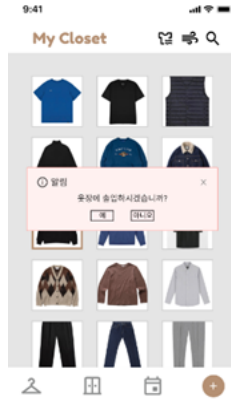
Fig. 43. Use case 1-b

Fig. 44. Use case 1-b

Fig. 45. Use case 1-c

Fig. 46. Use case 1-c

2) Use case2 : When executing the styler function on the hanger-type closet page of the application, execute the function on the styler on the entrance side of the hanger-type closet according to the date and time desired by the user.

   a) On the hanger-type closet page, click the Styler function in the upper right corner.

Fig. 47. Use case 2-a

Fig. 48. Use case 2-a

b) When the application opens a window for entering a date and time, the user enters a desired date and time. The closet moves clothes from the closet to the entrance in advance, considering the time the styler operates. After executing the Styler function at the time the user wants, the clothes are exported.

Fig. 49. Use case 2-b

Fig. 50. Use case 2-b

Fig. 51. Use case 2-b

3) Use case3 : When executing the ventilation system on the hanger-type closet page of the application, run the ventilator in the hanger-type closet.

a) On the hanger-type closet page, click the ventilation system at the top right.

Fig. 52. Use case 3-a

b) A confirmation message is displayed as to whether you want a ventilation system. The answer to the message is divided into a "Yes" button and a "No" button.

Fig. 53. Use case 3-b

c) Press the "Yes" button to launch a pop-up message that runs the ventilation system. The ventilator at the bottom of the hanger-type closet begins to rotate. When the air quality is checked and it is determined that sufficient ventilation has been made in the closet, the ventilator automatically stops running. If you press the 'No' button, no event will occur.

4) Use case4 : Adjust the temperature and humidity of the drawer when setting the temperature and humidity on the drawer-type closet page of the application.

a) On the drawer-type closet page, click the Temperature button or Humidity button in each drawer.

Fig. 54. Use case 3-c

Fig. 55. Use case 4-a

Fig. 56. Use case 4-a

b) Adjust the temperature/humidity of the drawer according to the type and condition of the clothes in the drawer and press the OK button.

Fig. 57. Use case 4-b

Fig. 58. Use case 4-b

c) The drawer in the closet changes the environment inside the drawer according to the user's preference.

Fig. 59. Use case 4-c

Fig. 60. Use case 4-c

5) Use case5 : Add a schedule and check the weather within the application.
- Additional schedule
  a) The user selects the desired date within the calendar.

Fig. 61. Use case schedule 5-a

  b) Press the 'Register Schedule' button below the calendar.
  c) Enter the contents of the schedule in the pop-up message and press the Add Schedule button.
- Weather check
  a) Click the weather icon below the calendar.
  b) The icon connects to the Meteorological Administration page.

B. AI Speaker

1) Use case1 : Scenario of adding clothes using a camera in the closet.
  a) The user says, "Open the closet door."
  b) The speaker says, "Run Closes Tower," and "The closet door is open."
  c) The user hangs the clothes he or she wants to add on the hanger in the closet.

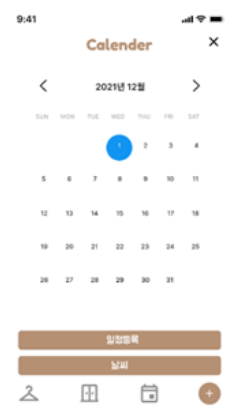Fig. 62. Use case schedule 5-c

Fig. 63. Use case schedule 5-c

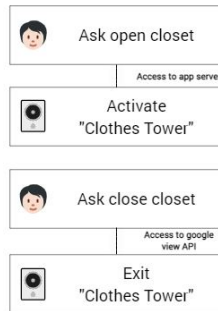Fig. 64. Use case weather 5-a

Fig. 65. Use case weather 5-b

Fig. 66. Use case 1

d) After hanging the clothes, the user says, "Close the closet door."
e) The speaker says, "The clothes are recognized," "Closing the closet door," and "Closing the Closet Tower."
f) After that, the clothes are moved to the storage space along the U-shaped rail of the hanger-type closet.

2) Use case2 : Clothing access scenario
   a) The user says, "Show me your clothes."
   b) The speaker says, "Run Closes Tower," and "The closet door is open."
   c) The user can request according to the desired classification. For example, you can say, "Show me by color."
   d) The speaker says, "What color should I show you?"
   e) The user says, "Show me in red."
   f) The speaker says, "We are classifying red clothes."
   g) At the end of the classification, the corresponding clothes are moved from the storage space to the entrance along the U-shaped rail, and the speaker says, "It's done."
   h) The user takes out the clothes he or she wants and says, "Close the closet door."
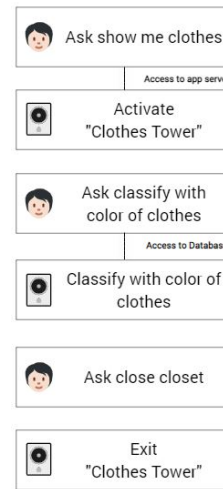   i) The speaker says, "Closing the closet door." Say, "End the Cloth Tower."

Fig. 67. Use case 2

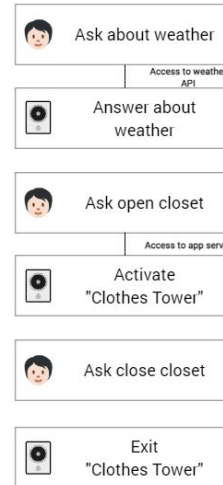3) Use case3 : Scenario for recommending clothes according to the weather.

Fig. 68. Use case 3

   a) The user says, "Tell me the weather."
   b) After speaking about the weather, the speaker briefly recommends what clothes are good and asks for action. For example, "It's 8 degrees Celsius," "I recommend long clothes," and "Shall we run Cloth Tower?"

4) Use case4 : Seasonal clothing arrangement function scenario
   a) The user says, "Tell me what clothes to organize."
   b) The speaker delivers information about what season is approaching based on information about the weather. For example, "Spring is near" and "Will you organize your winter clothes?"
   c) The user says, "Please organize winter clothes."
   d) The speaker says, "Take out winter clothes." After that, the closet opens the closet door and sends

Fig. 69. Use case 4

clothes corresponding to the information to the entrance through a U-shaped rail.

e) The user takes out the clothes, organizes them, and says, "Close the closet door."

f) The speaker says, "Closing the closet door," and "Closing the Cloth Tower."

However, if the criteria for seasonal changes are not met in the second order, the following scenario is proceeded.

a) The speaker says, "It's in-between seasons," "I think you'd better have various kinds of clothes," and "Do you still want to organize your closet?"

b) If the user accepts in response to yes, the speaker says "Run Closes Tower" or "The closet door is open." The user can run from scenario 3 above. If you refuse in response to "No," the speaker says "Yes, I understand" and ends the execution.