Development of a Real Time Fine Dust Smart Fashion Tag Device using Open API

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Abstract: Background/Objectives: Recently, companies have developed an increasing number of smartphone applications related to rising fine dust health hazards, but these applications remain unable to provide information in real time and companies have yet to develop wearable devices. Methods/Statistical analysis: The purpose of this study is to develop a wearable device that intuitively and continuously informs fine dust concentrations based on the six requirements of technical and design aspects. These aspects are determined through user needs analysis based on interdisciplinary convergent research. In addition, we integrated an Open Application Programming Interface (API) to receive fine dust and atmospheric state information in real time. Finally, we developed a customized design-applied GUI and an easy-to-attach/detach smart fashion tags. Findings: To develop a wearable fine dust detector using Open API, we conducted a study of user needs to identify requisition of technological and design features. The technological features included real-time detection capabilities, reliability, and functionality, and the design features included form, detachability, and customizability. Using convergence research, we developed an attachable and customized keyring, charm/pendant type smart fashion tags.

Improvements/Applications: This convergence research highlights the potential for combining IT and high value-added fashion in an organic new keyring business. As fine dust poses an ever more serious threat, developing portable, functional, and aesthetically pleasing fine dust detectors is important and demanding. Thus, we have planned follow-up research to provide real-time fine dust data by reflecting the needs of users in various age groups.

Keywords: Find dust, Wearable, Open API, Customizing, Smart fashion tag

I. INTRODUCTION

Recently, increasingly widespread social awareness of the severity of fine dust has spurred the demand for air purifiers and real-time fine dust measurement device. As a result, the demand for smartphone applications development that can monitor the fine dust concentration is increasing. Usually, the data for fine dust application are provided by public institutions, which is advantageous because it can be used immediately and the data can be combined in a personalized manner based on development trends.

Fine dust data needs to be continuously updated. The current applications, however, provide data only when users ask for it. Developing a device that can provide users with continuous and customized services is therefore mandatory. Given that wearable devices need to be approached as user-focused and specialized fashion products that unite technology and design [1]. In this study, we aimed to develop keyring and charm/pendant type fine dust detectors using customized designs that reflect user preferences, and to design a smart fashion device that allows users to independently explore countermeasures by acquiring intuitive and continuous fine dust data.

We conducted this research in several phases. First, we identified service factors applicable to our research purposes by analyzing theory related to fine dust, Open API, and wearable devices and cases. Second, we developed the requisite of technological and design features by analyzing user insights derived from a user needs investigation that reflecting the service factors mentioned above. Third, we performed this convergence research by supplementing and revising system and hardware design, GUI (Graphic User Interface), and developing a smart fashion tag prototype. Finally, we used a step-by-step strategy to develop an attachable smart fashion tag device for fine dust detection. Figure 1 shows the fusion process model that reflects these steps.

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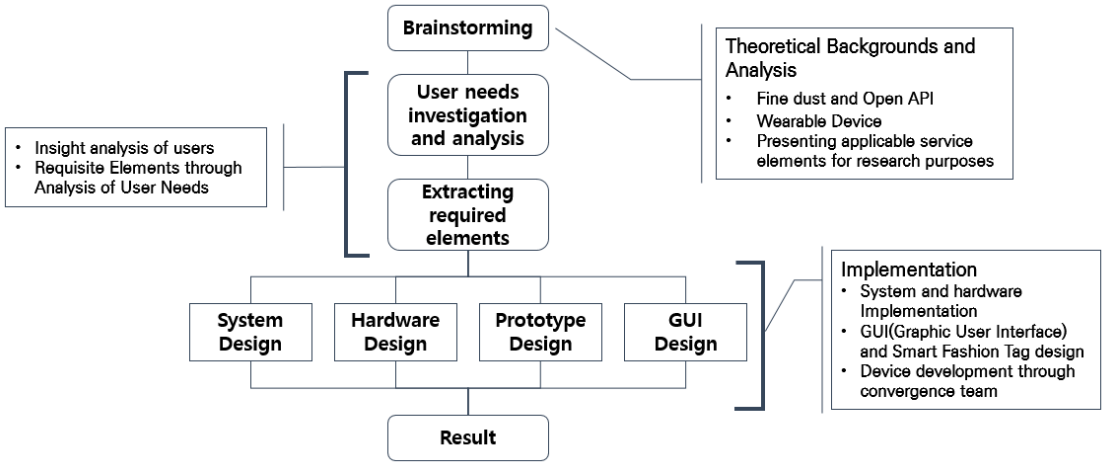


Fig 1. Convergence Process Model

II. MATERIALS AND METHODS

2.1. Fine Dust and Open API

Fine dust (PM10) is generally defined as dust with a diameter of 10μm or less. Dust with a smaller diameter of 2.5 μm or less is called ultra-fine dust (PM 2.5), which is about 1/20 to 1/30 times of the thickness of a human hair [2, 3]. Fine dusts were the first group of carcinogens designated by the world health organization (WHO). They cause allergic rhinitis, conjunctivitis, keratitis, bronchial diseases such as bronchitis, emphysema and asthma, and alveolar damage. Exposure to fine dusts can also cause premature death, myocardial infarction, stroke, and heart rate abnormalities [3]. Despite its many risks, people struggle to recognize fine dust because detecting it visually and feeling the body's immediate reaction to it is difficult. However, since fine dust warnings have increased recently, people have become increasingly anxious about it. Consequently, the number of applications and related products developed to monitor fine dust concentrations in real time are increasing.

Currently, most fine dust applications use the Open APIs of public institutions. An API is an interface that allows users to control the functions provided by an operating system or programming language in an application program [4]. In other words, Open API is public API that anyone can use, and if they are used, program developers can create applications without knowing the detailed functions of the operating systems. Therefore, importing data through Open API makes it possible to shorten the development time for various services and facilitates the personalization of the services, although detailed data regarding individual user locations remains unknown. At present, fine dust detector has limitations from the view of wearable design. Because miniaturization is not possible due to the sensor size. At the same time, miniaturization is an important constraint for the wearable design. In this study, we used an Open API to design and produce our device.

2.2. Wearable Device Development Trend

The development of computing technology and changes in life styles have fueled the creation of highly portable wearable devices. A wearable device is a computing device that periodically interacts with a user by running an application (App) in smartphone or in the wearable device itself. The wearable device can be installed by wearing or attaching to the body [5]. Recently, wearable devices have become an increasingly important part of various fitness and wellness, medical and healthcare, manufacturing, military, information and entertainment applications [6]. Among the various devices, smart bracelets, accessory-type wearable devices developed for infotainment, fitness, and personal well-being have the largest share in the wearable device market [6]. Table 1 shows an analysis of wearable device accessory-types [7].

According to Choi et al. [8], wearable devices are expected to satisfy users by diversifying and differentiating their designs so that they can be worn to match a given user's attire. Therefore, developing designs that have varied forms (watches, bands, glasses, and rings) and styles is crucial.

The advancement of ICT has spurred the rapid development of wearable devices in today's global market. Identifying and analyzing industries in which consumers are highly interested like wearable devices are essential. Therefore, by developing a wearable fine dust detector, we aimed to create a functional and aesthetically pleasing device that is relevant to everyday life.

Table 1. Types and Functions of Accessory Type Wearable Device

Type	Function	Representative Brand
Watch	- Smart phone replacement such as sending and receiving text, photograph, music playback, remote control - Various fitness functions such as heart rate measurement and pedometer	Samsung Galaxy Gear, Apple AppleWatch, Pebble Steel
Band	- Activity measurement, pedometer, heart rate, stopwatch, timer, etc. Health management function - SNS, phone, email, notification and media	Nike+ FuelBand, Samsung Gear Fit, RazerNabu, ThalmicLab arm band MYO

	controller	
Glasses	- Daily life image recording, augmented reality, etc. - Voice recognition, navigation, voice call, message transmission, interpretation, daily information, etc. - Use in conjunction with application(emotional analysis, etc.)	Google Glass, Epson BT-200, Liquid Image, OPS Goggle
Ring	- NFC(Near Field Communication), Near-field data communication of about 10cm - Near-field data communication of about 10cm - To acquire life information such as food, movie, discount, public transportation	GalaRing, GEAK Ring

2.3. Survey and Analysis of User Needs

Based on the development direction of the fine dust device derived from the theoretical review and the results of the case study, we conducted a survey by categorizing the technical and design aspects step by step. Since we knew the wearable device needed to recognize and meet users' various needs, prior to product development, our convergence research team conducted a quantitative questionnaire survey of 151 males and females between the ages of 20 and 30 years old, using a 5-point Likert scale.

A solid majority of participants (86.8%) answered that they were aware of the risks of fine dust: 47.7% described it as very dangerous and 39.1% described it as dangerous. Participants' methods for collecting fine dust data, however, were limited to smartphone applications (58.9%), news on TV (17.2%), and websites (23.2%). The extensive limitations in acquiring fine dust data highlights the importance of developing portable, functional, and aesthetically appealing wearable devices. As such, we identified the necessary technological and design features by investigating user needs. By this analysis, we obtained the necessary elements as real-time data access, reliability, and functionality in terms of technology, and form, detachability, and design customizability in terms of design.

2.3.1. Technological Requirements

We analyzed user insights to draw up a list of technological requirements and developed the necessary features based on this list. We identified 3 main factors related to fine dust data in our analysis.

First, we identified real-time access to data as a crucial technological element and determined that the reporting of data should be easy for users to understand and to access immediately. In our survey, 41.7% of the respondents were very positive, and 43% of the respondents were positive about the necessity of being able to check fine dust concentrations in real time. A total of 84.7% responded positively. Meanwhile, 39.1% of the respondents were very satisfied with the demand of real-time fine dust information notification, and 42.4% of the respondents were satisfied with the demand. A total of 81.5% responded positively.

Second, regarding their degree of trust in the reliability of the fine dust information provided by public institutions, 7.3% of survey respondents indicated that they were very satisfied and 51.7% indicated that they were satisfied. Thus, a total of 59% of respondents answered positively.

Third, functionality refers to the ability of the fine dust detector device. As a result of the survey, the response about the functionality was very good (30.5%), and good (47.7%). A total of 78.2% answered positively. In addition, the users who used fine dust-related applications, 48.8% and 30.2% were very satisfied and satisfied, respectively, that the applications provide fine dust and weather information together. Thus, a total of 79% of respondents answered positively.

From the results of this analysis, in the side of technology, we determined that users require real-time fine dust information, the reliability of public institution information is high, and users need fine dust and current weather information about their locations.

2.3.2. Aesthetic Design Requirements

After analyzing the list of user requirements, we identified 3 necessary aesthetic design factors for user satisfaction. First, we determined that we must design the wearable devices as life-friendly products by analyzing the characteristics of each molding element suitable for wearable devices. In response to the question about wearable device design, 77.5% of the respondents answered "good" regarding general accessories and life-style products. In the measure of 5 point scale for the fine dust wearable device, size was measured as 4.56, reliability was 4.37, usability was 4.17, price was 4.03, design was 3.79, and brand was 2.75.

Second, we determined that the wearable device must be designed to be mountable and detachable at positions desired by wearers. Regarding the preference for attachability/detachability, 19.9% and 45% of the survey respondents answered very good and good, respectively. A total of 64.9% answered positively. About the practicality of detachability, 20.5% and 53% of the respondents answered very good and good, respectively. A total of 73.5% answered positively.

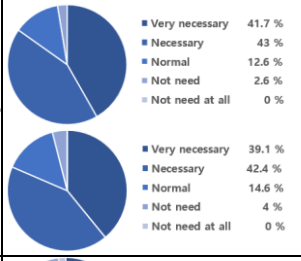
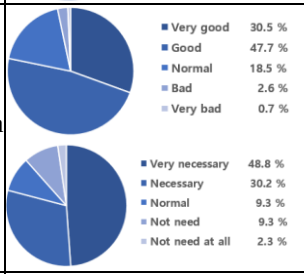
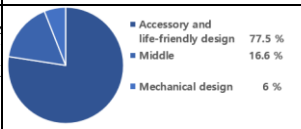
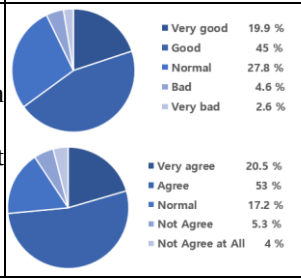
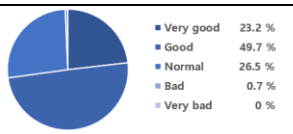
Third, customization enables users to change the shape of the device and the GUI of the application according to their own design preferences. Regarding the preference for customizability, 23.2% and 49.7%, answered very good and good, respectively, and a total of 72.9% answered positively.

Based on the results of our design-related analysis, we determined that it is necessary to minimize the size of the tag type product in accordance with user preferences and to ensure its practicality by making it detachable. Taking into account user needs, we developed customization

measures by designing a versatile, attachable, and changeable item in the form of keyring or pendant and providing users with various images.

Using the survey results to develop the fine dust device, we identified and categorized technical and design factors, and determined the necessary elements in both categories. Table 2 summarizes the application methods, reflecting user requirements.

Table 2. Requisite Elements through Analysis of User Needs (Technology & Design)

Division	Keyword	User Requirements	Application plan	Graph (Unit, %)
Technology	Real-time	* Intuitive communication * Real-time fine dust information notification	*Update data at regular intervals	
	Reliability	* Reliability verification for fine dust information	*Using Open API from public institutions	
	Function	* Fine dust concentration information of current space * Obtaining living information such as weather information	*Provision of verified data information	
Design	Form	*Accessory and life-style design	*Highly practical design of keyring, charm/pendant type	
	Detachable	*Possibility to attach or detach to bags or clothes depending on user's preference	*Removable interface with keyring or pendant band *Change the item to suit your situation and purpose	
	Customizing	*Application screen can be changed according to user's preference	*Provides various images to suit user's needs	

III. IMPLEMENTATION OF TECHNOLOGY AND DESIGN

Based on the above-mentioned technical and design requirements, we designed keyring and charm type smart fine dust tag devices. In the initial system design, we proposed a system that receives fine dust information from Open APIs, processes the data, and provides information to users. Secondly, our design implemented Android smartphone application GUI and utilized keyring and charm type detachable customizable design.

3.1. System Implementation

Figure 2 shows the structure of the device proposed in this study. The system consists of a micro-controller unit (MCU) that controls fine dust devices, an RGB OLED (SSD1351) that provides data to users, and Bluetooth to communicate with Android smartphone.

We divided the system mainly into two parts: Android applications and a smart fashion tag device. First, Open API is used in Android applications created with Android Studio. This API is provided by an Air Korea site, operated by the Korea Environment Corporation. Users can receive data based on their locations from GPS built into the smartphones. The smart fashion tag device is connected to the smartphone via Bluetooth to receive the analyzed data. In addition, smart fashion tags continuously display information to users, utilizing received data via RGB OLED.

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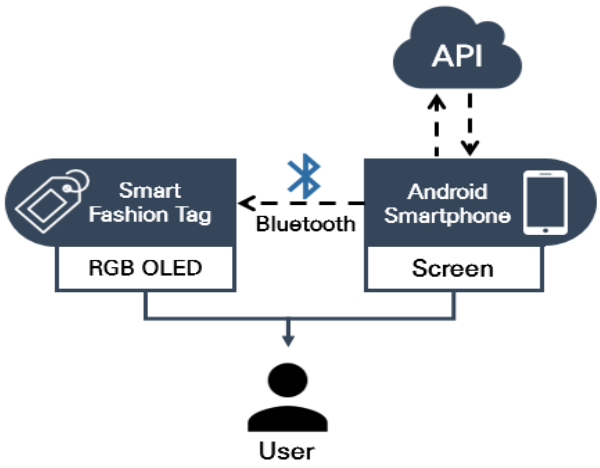

Fig 2. System Structure

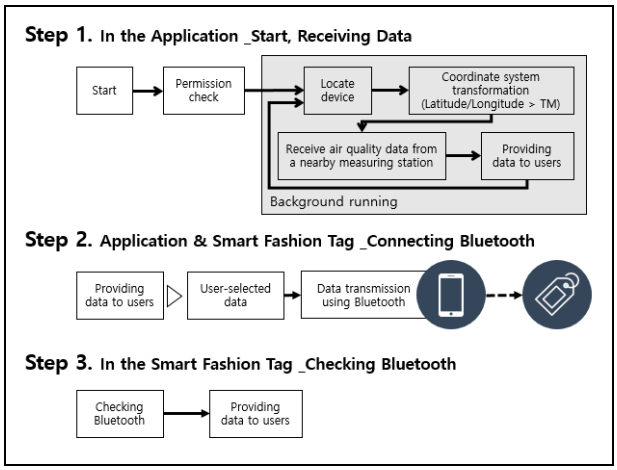

Fig 3. System Flow

Before developing the smart fashion tag suggested in this research, we first formulated the hardware. To increase portability, we used a relatively small MCU. Data were received via Bluetooth, and we used an RGB OLED that can provide intuitive data by showing colors, images, and numbers. Because smart fashion tags receive and provide data to smartphones connected via Bluetooth, previously received data and user connection is required when connection is not available for a certain time.

Figure 3 shows a simplified version of the software flow of the system developed in this study. The software flow mainly occurs in three stages. In the first stage, the application starts, checks for permission to use several privileges, and receives Open API data. Then users receive location data and analyze the response data using the query statement provided by the API to request the data they desire on the screen. At this time, the user's location information is received from the Android smartphone and converted into the TM (Transverse Mercator) coordinate system required by the Open API. Based on this, the Android smartphone can receive air quality information from a nearby measuring station and provide it to the user. In addition, even when the application is in the background, the data is updated at predetermined times, and the data is displayed to the user through the smart fashion tag in real time.

In the second stage, we link the Android smartphone with the smart fashion tag through Bluetooth, which transmits the data selected by the user to the smart fashion tag when the user connects to Bluetooth.

In the third stage, we check the smart fashion tag to verify that it is continuously receiving data, and, after the data is received, we check the number and value of the data desired by the user. Finally, display the appropriate value through the OLED of the smart fashion tag.

3.2. Design Description

3.2.1. Customizing System

The survey we conducted regarding system customization preferences before developing the device revealed that users strongly desire the ability to individually change the GUI design and device form. Preference can also be called customizing. Customizing refers to a manufacturer or a handicraft maker service that involves creating products according to customer requests. Its meaning derives from the term “custom-made” [9]. Customizing also refers to the degree to which a product, service, or information is customized to match consumer’s choices and needs [10]. User customization occurs in environments that enable direct user action. Such systems require that users actively make changes by selecting and combining elements according to their individual desires [11].

The customization system for the smart fashion tag device for fine dust detection developed in this research supports the structural design so that users can choose the service they want and select various forms and designs as needed for given TPOs (Time, Place, Occasion).

3.2.2. GUI Design

We developed a GUI design to present various images on the device and application displays. Our design was guided by three concepts (Simple, Casual, Chic) that make communication easy and intuitive. The application consists of three screens. The first screen displays fine dust concentrations, i.e., intuitive air quality data with images and colors. The second screen allows users to customize how they view fine dust concentration images. On this screen, users can choose GUI with the preset three concepts. The last screen is synced with the smart fashion tag. This screen uses Bluetooth to connect with the smart fashion tag device. In addition, the design allows data to be updated and re-sent at pre-set time intervals. Figure 4 shows a screen of the completed application and the developed concept.

Fig 4. GUI of Application and Device

3.2.3. Device Design

We used insights derived from our user needs analysis to design the wearable device in the form of a modular keyring and a charm type accessory that can be mounted and detached. The device is made from a highly scalable leather material [12] that can be harmonized with other accessories, clothes, and bags depending on the user's individual style. In addition, the core body display part is square type, and it can be changed into a strap necklace or a keyring. We applied a structural design to enable users to select various tassels or tag of accessories based on their customization preferences. Figure 5 shows a trial product of the wearable smart tag for fine dust detection using Open API and the GUI screen of a smartphone app that controls the product.

Fig 5. Image of Device

IV. CONCLUSION

In this study, we employed interdisciplinary convergence to develop a location-based real-time fine dust application using open API and a fine dust smart fashion tag device. Based on our analysis of user needs, we identified six necessary technological and design elements. Using the results of this analysis, we developed the device GUI to enable customized design according to user preferences and designed the necklace, keyring, and charm type accessory to be worn wherever users want. The development of human-friendly wearable devices that provide customized services can lead to the creation of new industries that organically combine IT and high value-added fashion. In future research, we will suggest the development of a

wearable device for a modular customization system that reflects a wider age range of user requirements and utilizes independent precision sensors to provide more reliable information about fine dust particles.

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