A Study of Smartphone Assistive Devices for the Elderly Based on User Experience

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Abstract. As China's digital technology develops, the degree of aging deepens, and the silver-haired generation contacts the Internet one after the other, the original digital divide problem becomes more prominent. Smartphones, which are a necessity for people's daily life, are affected by many different factors such as physical condition, age, and education level. The popular traditional cell phones on the market no longer suit the demands of elderly users, who have significant difficulties using them. It provides a foundation for designing auxiliary devices for elderly smartphones to enhance user experience. Based on the user experience elements, a research analysis is conducted on the case of elderly people encountering spam pop-ups while using smartphones. The method of user experience map is then adopted to further explore the pain points of elderly people utilizing smartphones. According to the product function and the actual needs of customers, we study the smartphone assistive device for the elderly, use Rhino to build the design model, and later render it with Keyshot. In anticipation of serving as a reference for the subsequent product design, the final solution is appraised with a Likert scale.

Keywords: Elderly, smartphone, assistive device

1 Introduction

At present, China's aging society continues to intensify. By the end of 2021, the number of individuals over 65 years old (including those under 65 years old) in the country has risen to 190 million, accounting for 13.50% of the total population. In the post-epidemic era, the difficulty of applying smart technology to the elderly remains a major problem. With each generation of silver-haired using the Internet, China's smart technology is advancing extremely rapidly. People cannot live without intelligent products and services for clothes, food, housing, and transportation. However, the existing design of smart products does not satisfy the requirements of elderly users and cannot give them a good digital experience. With the goal of creating a digitally inclusive society, digital

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skills, and their continued growth are increasingly becoming core preconditions for involvement in both private and public life. It is also crucial to ensure that all citizens can engage and acquire the skills required for development [1]. The current design should guarantee equitable access to digital services for elderly users, successfully bridging the "digital divide" faced by them. In this paper, we investigate the user experience-based design of smartphone assistive devices for the elderly.

2 Popularity and use of smartphones among the elderly

In 2022, the China Internet Network Information Center published the 50th Statistical Report on the Development Status of China's Internet. As of June 2022, the country had 1.051 billion Internet users, with an Internet penetration rate of over 74.4%, of which 99.6% used their cell phones to access the Internet. The most notable progress was that the percentage of Internet users aged 60 and older increased from 6.9% in 2019 to 11.3% in 2022 [2]. The application of smart technology continues to permeate the middle-aged and older population, as evidenced by the structure data of Internet users recently published by CNNIC (Figure 1). Owing to the three-year epidemic, health code verification through cell phones is mandatory for all residents. One of the skills residents need is the ability to avoid using a smartphone almost every step of the way. Although China has abolished health code verification, the popularity of smartphones has not slowed. How to effectively integrate the elderly into digital life and bridge the "digital divide" requires more comprehensive and detailed consideration from all sectors of society.

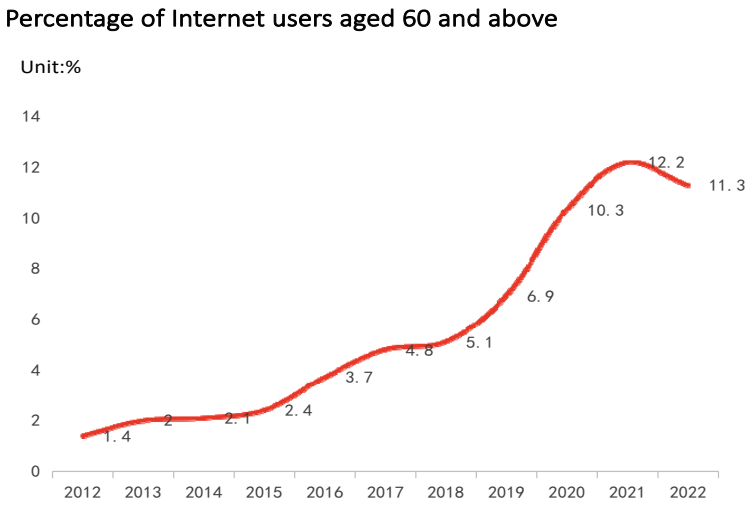

Fig. 1. Trends in the proportion of Internet users aged 60 and above among Internet users nationwide from 2012 to 2022

3 Smartphone usage pain points for the elderly

Although the number of seniors using smartphones has risen dramatically, most of them only use their phones for video chatting with friends and family and have not fully benefited from the convenience brought by digital life. In this digital period, the mechanism of using and operating intelligent technology is somewhat complicated for the elderly, which unintentionally increases the "threshold" for them to use smartphones. Therefore, smartphone users need to have certain knowledge and skills to use them comfortably, and they need to constantly update their operating skills n accordance with new iterations of cell phones [3]. Furthermore, smartphones are intended to fulfill the requirements of young people and to pursue greater commercial interests, typically neglecting the needs of older groups and even underprivileged groups that cannot keep up with social development and are undereducated. The elderly's ability to use smartphones comfortably is also influenced by variances in age, physical condition, and education level is also influenced by variances. Nowadays, the majority of smartphones and apps have "senior mode" or "elder mode" for the elderly, but this merely enlarges fonts and icons without simplifying the operation process or being optimized for the elderly. Additionally, the auxiliary functions are only superficial, which is a serious violation of the Usability issues.

As getting older, the elderly's physical abilities including eyesight, hearing, reading, and learning continue to decline. They also become less competent in front of new technology competent, rejected by intelligent technology. As per the survey, some elderly people think that smartphones are exclusive to young people because they are unfamiliar with the functions of smartphones. These elderly people need to be shown the convenience of smartphones so that they are fully aware of the convenience and value of smartphones in their lives. Since some seniors' eyesight and literacy levels prevent them from seeing the screen or typing, their usage of smartphones is restricted to memorizing the icons and performing the clicking and touching. Many elderly people are aware of the convenience brought by smartphones. However, they do not know how to operate their smartphones or how to solve the technical problems they encounter while using them because of their age and poor learning ability. Their children are unable to accompany them around the clock to guide them. When faced with deceptive advertisements and traps, it is easy for young people to avoid them, but not for the elderly with poor cognitive abilities. Some elderly people are reluctant to use smartphones because they are concerned about being cheated, information leakage, not knowing how to close advertising pop-ups, and having difficulties distinguishing false information [4]. It is evident that the existing smartphones and the matching assistive devices cannot suit the use demands of the elderly, and future smartphones and assistive devices for the elderly must be upgraded and created.

4 Design analysis of user experience elements of smartphone assistive devices for the elderly

4.1 Overview of user experience elements

In the mid-1990s, an American industrial designer named Donald Arthur Norman proposed user experience design was a series of behaviors, thoughts, and feelings generated by users when utilizing products or services. It was a purely self-subjective consciousness of users in the process of using products and services, including the rational values and emotional experiences provided to users [5].

Jesse James Garrett advocates the use of user experience elements to study user experience in the U.S. This approach comprises the strategic layer, scope layer, structure layer, framework layer, and performance layer. It is also a bottom-up design process that uses design to translate abstract contents and concepts into tangible objects [6]. It can effectively address the issues caused by the narrow scope and shallow structure of products. Moreover, user needs and product goals are difficult to express comprehensively and deeply, which means that the complicated design process may be divided into understandable, clearly defined steps or design processes to improve the efficiency of product design. After deconstruction, this design method may transform abstract content into comprehensible concepts and achieve a brief, clear, and organized expression of complex concepts [7]. The first layer is a strategic layer related to product goals and user requirements. The second layer is the scope layer, which contains product functional specifications and content requirements. The third layer is the structure layer, which concerns the design of the concrete implementation and the interaction between products and users. The fourth layer is the framework layer, which involves the interface, information, and navigation design. The fifth layer is the presentation layer, which encompasses visual design and perceptual design, or the transformation of a conception into reality as well as the fusion of product functionality and aesthetics, as shown in Figure 2 [8].

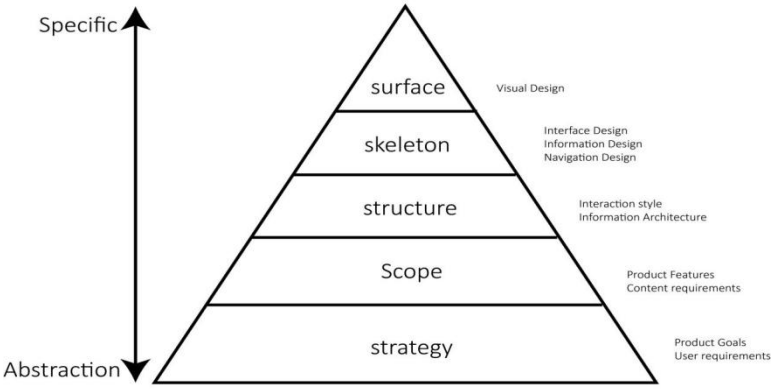

Fig. 2. User Experience Element Structure

4.2 Analysis of the strategy design

Among the user experience elements of smartphone usage by the aged, the elderly who do not know how to use smartphones are the core users at the strategic level. They desire to learn how to use smartphones to access the Internet, keep in touch with their family and friends, live more colorful lifestyles, and fully realize the convenience of "medical", "food", "housing" and "transportation" delivered by smartphones and the Internet. It is obvious that the current smartphones and apps are too cumbersome and intricate for them. In addition to the elderly group, other users who require quick access to smartphones include those with cataracts, glaucoma, and other eye diseases that impair vision, as well as disadvantaged individuals with low levels of education and illiteracy. These two groups are prospective users because the assistive usage of smartphones significantly benefits them as well. The design goal for smartphone assistive devices should be focused on the problem of the elderly who are unable to use smartphones while assisting potential users. Finally, it can enhance the overall usage of smartphones in society and create a digitally inclusive society.

4.3 Analysis of the scope design

As seen in Figure 3, this paper applies the user experience map to thoroughly analyze the pain points of the elderly when they use smartphones, taking the example of advertising pop-ups encountered by the elderly during using smartphones. It can define the product functions in detail and accurately along with further exploring the pain points of the elderly in utilizing smartphones.

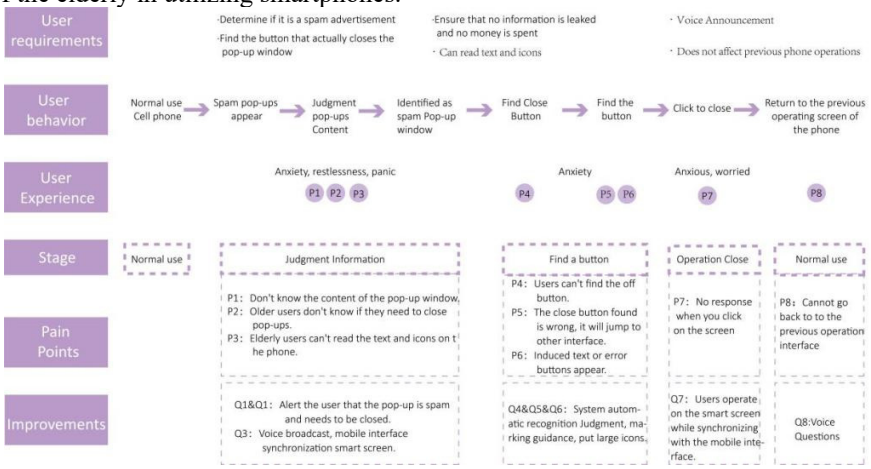

Fig. 3. User experience map of spam pop-ups encountered by the elderly during using smartphones

According to the user experience map, there are three steps that seniors need to take when they encounter spam pop-ups on their smartphones: judging the content of the pop-ups, locating the button to close them, and eventually closing them. The elderly may have difficulties judging the content of pop-ups, such as not knowing whether the

pop-ups are useful, whether they are spam, whether they need to be dismissed, and whether the phone is too small to view the text. While looking for the close button, it may appear that it cannot be found or that the discovered one is wrong. Due to the small size of the button during the close stage, it is challenging to recognize when the pop-ups are closed. The elderly have much worse perceptual and cognitive abilities than young people. As a result, it can be tough for them to recognize when to click the button, which usually leads to long presses and erroneous button presses [9]. In order to avoid the above issues and to realize that the elderly can easily deal with various problems when using smartphones, additional designs for smartphone assistive devices required at the level of user experience elements are followed. (1) The system automatically detects the contents of pop-up windows and determines if they need to be closed manually, reminds the user that they are spam pop-up windows, and gives guidance for the next operation. (2) Smartphone auxiliary device for voice broadcast and the smart screen for phone content synchronization can solve the problem of text being difficult to read on a small phone screen. (3) Users are guided to close the spam pop-ups by enlarging the close button with corresponding gesture instructions. (4) When users come across other difficulties, they can voice describe them. The device identifies the cell phone interface and resolves the issues by offering voice explanation and logo guidance.

4.4 Structure and skeleton design

The functional framework of the smartphone assistive device is proposed based on the function and content requirements of the product (see Figure 4). Too many features will inevitably cause greater unfamiliarity and interaction difficulties for the elderly, making them anxious and resistant. Meanwhile, a single function is unable to satisfy all of the users' basic requirements, thus it is crucial to thoroughly comprehend the needs of the elderly and summarize the elements of the product. The auxiliary device combines education, question-answering, and a smart screen to offer more intuitive and compassionate assistance to the elderly. Especially, we should completely consider the cognitive limitations of the elderly group, establish operation habits that match their specific needs, simplify the operation procedures of the cell phone, and set up the operation through various visual languages in the interaction mode. As a consequence, the user has a "brainless experience", which indicates that the user does not have to think and issue instructions through the brain throughout the operating process, but rather have a conditioned reflex reaction or a kind of "brainless experience". After the behavior becomes habitual, it behaves more like a conditioned response or a regular process [10]. The learning cost of the elderly is greatly reduced by constantly reading from left to right and from top to bottom, which is like we do. Yet, the elderly have relatively weak sensory reactions because of their age. Therefore, it may bring effective help by interacting with information in a multi-channel manner. When an older person uses an assistive device, text, guidance signs, and voice output appear in conjunction to give timely feedback to the user to indicate that the function has been completed successfully. Furthermore, studies have proven that clear and relevant feedback is necessary

when a user tries to accomplish the task operation [11]. It may employ upbeat and relaxing music to signal correct operation and a verbal warning to indicate incorrect operation. The visual and auditory senses balance each other to guarantee that the user receives comprehensive and accurate information.

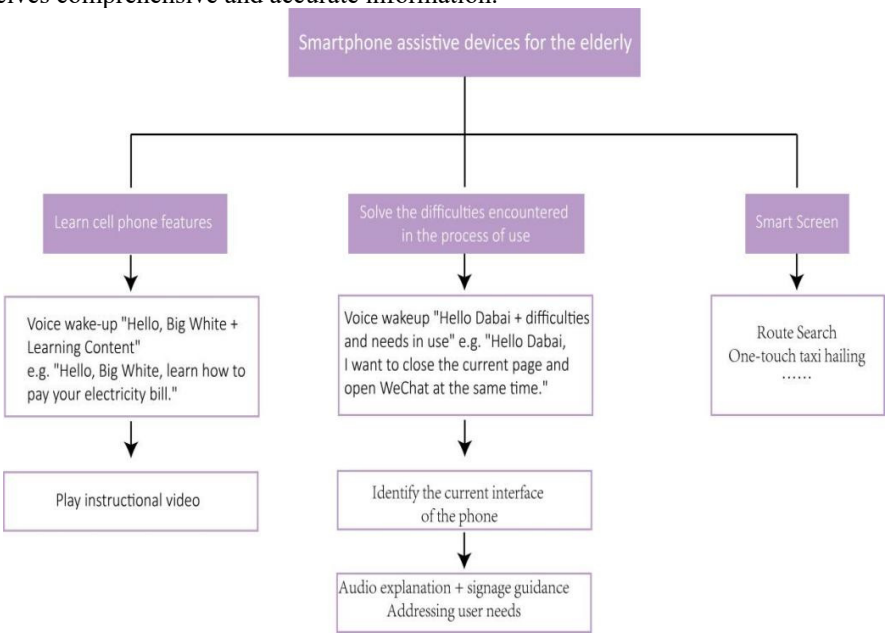

Fig. 4. Smartphone assistive device functional framework

4.4.1. Structure and skeleton design.

Although there is a cognitive and responsiveness difference between the elderly and young people, this does not imply that the elderly groups lack the ability and enthusiasm to learn new things. As the level of living for the elderly groups improves, they develop a preference for living independently along with a greater psychology of self-gratification and start to pursue a higher quality of life. They will particularly seek their emotional needs as well as their sense of social participation and realization of self-worth [12]. The ability to teach is one of the features of smartphone assistive devices. Senior people may view videos to learn the operation process of smartphones based on their learning preferences. The device will immediately start playing the appropriate learning video when the voice “Hello Dabai + content you want to learn” wakes up. Besides, the user can watch the video again and again, which may help the elderly to learn how to operate a smartphone via watching, learning, practicing, receiving feedback, and watching again. The device automatically starts playing educational videos, which may be watched several times by users. The elderly can become proficient at utilizing smartphones by watching, learning, practicing, getting feedback, relearning, and receiving additional training. The auxiliary device assists the elderly in using smartphones by teaching them how to do more than just make phone calls, take pictures, and use flashlights. it also instructs them how to surf the Internet safely, identify

online scams, use cell phone payments, and make smartphones convenient for their clothing, food, housing, and transportation. This successfully solves the issue of the elderly having difficulty using smart technology.

4.4.2. Question and answer function design.

During the investigation process, we observe that the majority of elderly people are not ignorant of smartphones. Besides, they perceive the basic operation and the benefits of smartphones in satisfying daily life and leisure requirements. Nevertheless, the use of digital technology is a bit complicated, and they do not know how to deal with new problems that arise throughout the operation. The Q&A function is urgently needed by elderly users because their children cannot constantly be with them to answer their questions. The device automatically identifies the current interface of the cell phone and provides voice instructions according to the user's needs, while the logo on the smart screen guides the user to complete the operation and settle the problem. This gives the elderly an opportunity to learn how to tackle the current problem, as well as how to learn from the past. The question-and-answer function of the auxiliary device is taken as an example to draw a storyboard in Figure 5.

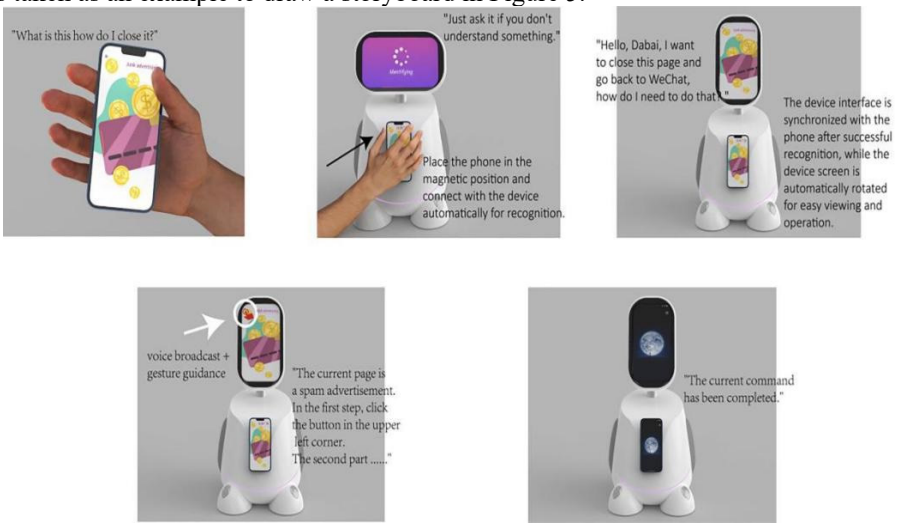

Fig. 5. Story Version

4.4.3. Question and answer function design.

The elderly will experience an apparent deterioration in vision as their ability to adjust their eyesight declines with age [13]. Auxiliary devices can also function as smart screens for independent use, including map queries, one-touch taxi hailing, etc., to meet the needs of the elderly in life as well as daily leisure and emotional communication. This will make it more convenient for the elderly to use smartphones and enjoy smart technology.

4.5 Surface design

Appearance design will have a direct impact on the user's acceptance of the product. Combined with the product function and use of the scene, the smartphone assistive device is designed from three aspects, including shape, color, and material.

The creation of a 3D model for the design solution enables a better visual representation of the product structure, scale, and details. As exhibited in Figure 6, a 3D model of the product is constructed by Rhino based on the sketch of the solution. The product shape is based on a simple and pure minimalist style, which is rounded and curved. This soft shape can decrease the elderly's unfamiliarity and resistance to intelligent products, increase the affinity of the assistive device to people, and improve the safety of the product to avoid unnecessary safety hazards to the elderly. Abstract, three-dimensional arm decorations are included on both sides of the product, which increases its flexibility and sense of hierarchy. Figure 7 clarifies that the screen can be adjusted to the preferences of users, the camera is positioned at the top of the screen, and the speaker is set at the bottom of the "Dabai". With a height of 403mm, the product can be placed on the desktop. When a man-machine interface is used, it is easy to complete voice dialogue, video learning, facial recognition, screen touch, and other operations without excessive bending or raising the head. The precise dimensions are displayed in Figure 8.

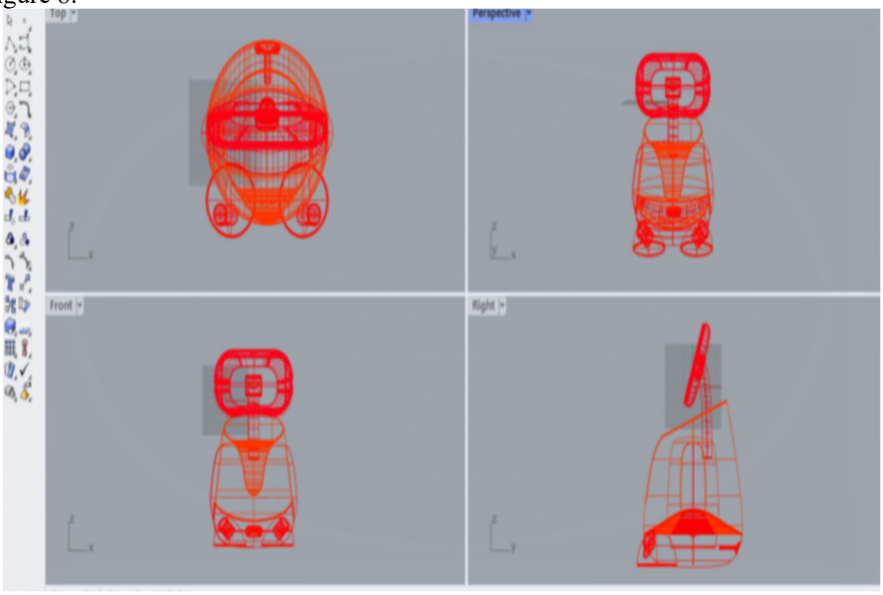

Fig. 6. 3D model

Fig. 7. Renderings

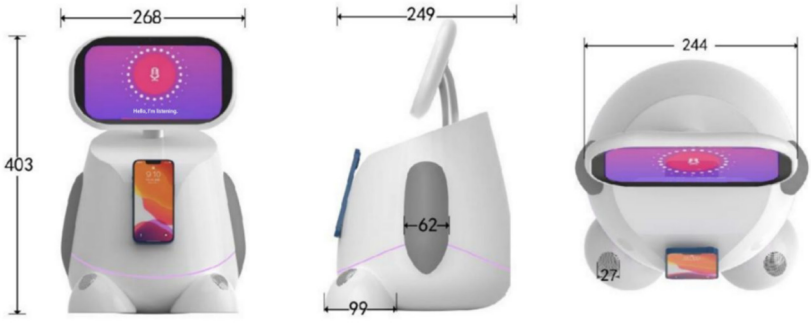

Fig. 8. Size Chart

The elderly may see color more clearly than the shape or material since color is the most dynamic and intuitive element of product design content change. However, research has revealed that excessively bright and vivid colors not only affect the visual experience of the elderly but also cause them more visual stress [14]. Consequently, the product is primarily white and gray with colored cue lights, allowing users to obtain

feedback information more naturally. Meanwhile, the lower color purity and comparatively high brightness can provide a gentle and light aesthetic experience.

For the product material process, the shell of the product is made of PC + ABS plastic, commonly referred to as engineering plastic alloy. The selection of this material can overcome the deficiencies of the two raw materials, allowing them to play their respective benefits. It may increase the heat resistance, impact, and tensile strength of ABS while also enhancing processing performance and reducing the PC notch sensitivity. Thereby, production costs are reduced and environmental requirements are met [15]. The side arms of the product are composed of non-slip silicone, which is convenient to handle and move and gives a warm and cozy tactile experience. The 3D model of the product is rendered with Keyshot to restore the material and process to a maximum extent, whose details are depicted in Figure 9.

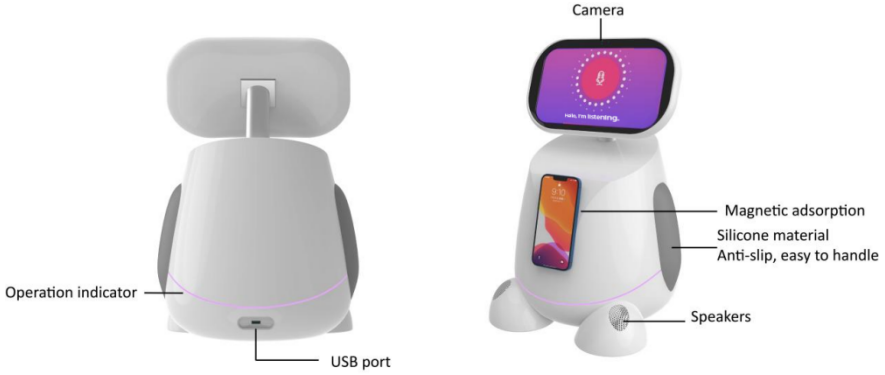

Fig. 9. Detail picture

5 Evaluation of the final design solution

15 users were asked to evaluate the final design with a Likert scale. The 15 users were shown the 3D model and rendering of the product as well as the materials, features, and functions. Users were asked to review the final product solution on six aspects: teaching function, answering function, smart screen design, usability, shape, and color. Scores ranged from 1 to 5, corresponding to the lowest to the highest level of satisfaction. The confidence interval might indicate the overall true value of the sample statistics. If the confidence level is set to 95%, the value interval will almost certainly cover the overall true value of the mean. The formula for calculating the 95% confidence interval is present in Equation (1).

$$CI = \bar{\chi} \pm 1.96\sigma/\sqrt{n} \tag{1}$$

In the formula, $\bar{\chi}$ represents the average of the ratings for each evaluation index and σ is the standard deviation. In addition, n is the sample size, which is 15 in this research.

Fifteen questionnaires were received for this survey. The user ratings were summarized in Table 1.

Table 1. User rating table for smartphone assistive devices for the elderly

Serial number	Evaluation Indicators	1 point	2 point	3 point	4 point	5 point	Average score	Confidence interval
1	Styling	0	0	2	6	7	4.33	4.69-3.97
2	Color	0	0	2	6	7	4.33	4.69-3.97
3	Availability	0	0	1	7	7	4.4	4.72-4.08
4	Teaching function	0	0	2	10	3	4.07	4.36-3.77
5	Answer function	0	0	2	7	6	4.27	4.62-3.91
6	mart Screen	0	0	5	6	4	3.93	4.33-3.53
	Total						25.33	

6 Conclusion

Some elderly people are now having difficulties in utilizing smartphones independently and freely because of their physical condition, age, education level, economic status, and development level of the region where they live. From the perspective of creating a digitally inclusive society, it is important to assist older people in rebuilding their self-confidence and overcoming the unfamiliarity as well as fear caused by new technologies. Moreover, it can help them better adapt to digital life, while protecting their right to participate equally in social life and reap the benefits of current technological and social development. Although the health code is no longer required for travel, this does not mean that the elderly may be completely isolated from digital life. Smartphone assistive devices designed for the elderly and special groups should be tailored to the needs of users and effectively address the aging digital gap.

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