Boundary Expansion of Animation: Esthetic and Functional Research on Interactive Animation for Mobile Systems

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Abstract. The development of digital technology and hardware terminals has opened up a new frontier for expanding animation applications, allowing animation to return to its native form as the interactive interface of various information products. Mobile system interactive animation is a product of the fusion of art and technology. Functionality is its essential attribute, and in the carrier, function, esthetics, and audience discourse present new characteristics. Moreover, interactive animation has a positive effect on improving the user's experience of the product in terms of sensory performance, interactive behavior, and emotional care.

Keywords: mobile terminal; system; interface; interactive animation.

1. Introduction

The rapid development and popularization of mobile intelligent devices have changed people's traditional way of life, helping them acquire information and create value more efficiently. The human−computer relationship has entered an unprecedented stage of close contact, with the typical smartphone almost becoming a new human organ. With the continuous improvement of the hardware performance of mobile terminals and the optimization of the system, the application field of animation can be expanded to the interface space of mobile terminals, and the mode and form of human−computer interaction have also undergone substantial changes. In digital products, where animation is mainly utilized to convey information, a variety of functions to switch the animation visual experience has become an important symbol to express the taste, highlight the personality, and then project the customer's unique value[1]. In the context of user experience, mobile system interaction animation is widely utilized in all interface levels, revealing new functional characteristics; combining technology and art in different forms and ways; building a new bridge between the product and the user; providing a diversified sensory experience; and helping the user to realize a real, vivid, and smooth interactive experience.

2. Application and development of interactive animation for mobile terminal

Interactive animation is a new media animation that utilizes the human−computer interaction system as the carrier and can support event response and interactive function when running. Moreover, users can control the animation to make it present different visual forms. Interactive animation is the product of human−computer interaction in the digital media era, and it is the combination of animation with new technology and media. It integrates digital processing technology, network transmission technology, modern communication technology, multimedia technology, and other technical fields, with significant interdisciplinary "fusion form." Interactive animation creates the art space for human−machine cohabitation with its unique interactive

language. Interactivity is the fundamental characteristic of interactive animation, which blurs the relationship between subject and object, transcends multimedia, facilitates multiexperience, and comprises a new art form paradigm[2]. In the interface of an intelligent mobile terminal, real three-dimensional space is compressed into a two-dimensional virtual display space, and a new mode of visual experience can be created so that the audience can clearly feel that they are in a real world based on their own sensory systems[3]. Interactive animation is based on the dynamic form of composition, combined with the comprehensiveness of the new media. The result is the user having a realistic feel and experience of the animation and the product platform that carries it.

As the mobile terminal with the widest influence on people's life, smartphone platforms are categorized as iOS and Android. iOS is a mobile operating system developed by Apple Inc. iOS is a completely closed system, and the integration of software and hardware in this system is very high. Apple's system engineers have written numerous animation algorithms and directly encapsulated them into APIs for APP development. Unified, coherent, flexible, Gaussian, and fuzzy are some of the characteristics of the iOS system interaction animation industry benchmark. Android was developed by Google based on the Linux free and open-source operating system, and many cell phone manufacturers, such as Huawei, Xiaomi, Samsung, OPPO, and VIVO use its wide scope for customization to create third-party UI systems with their own characteristics to achieve different performances and design standards.

3. New characteristics of mobile terminal interactive animation

The word animation originates from the Latin root anima, which means soul, and the meaning of animate in English is to give life to something. Therefore, the word animation can be interpreted as "to give life to something that has no life." Animation is a comprehensive art that integrates art, film, music, literature, and other art forms, as well as art and technology. With continuous changes in technology and media, the boundaries of animation art are expanding, and it presents new characteristics in carrier, esthetics, function, and audience.

3.1 Migration of vectors—screen shots to interfaces space

Changes in the medium can expand the functions of various forms of art, allowing it to break free of its original function and develop into broader and wider dimensions. From 1906, when the first film close to the modern definition of animation—"The Humorous Phase of Funny Face"—was released in the United States, to 1949, when the first animation produced specifically for television, "Crusader Bunny," was broadcast on NBC's affiliated television stations in the US, the carrier of animation expression and dissemination has transformed from the movie screen to the television screen and extends to the present day. This form of animation opened up a new world for people to explore the forms of art expression and greatly removed the boundaries technology imposed on artists' wild ideas. In an era when movies and television dominate people's visual esthetic experience, traditional animation takes the lens as the basic unit, and through the grouping of many lenses, it converges into a completed animation image. The narrative and expression of each animation depend on a single lens, and the composition, light and shadow, color, scene, sound, and other elements of the lens jointly make up the cornerstone of the existence and development of animation while giving animation a lasting and powerful artistic vitality.

The development of digital technology has transformed all types of information, such as picture, text, sound, and image into a digital form, laying the foundation for the emergence of a graphic interactive interface. In an era of rapidly developing hardware and software technology and the Internet, the graphic interactive interface has exhibited explosive expansion. Moreover, the emergence of the system, webpage, and application interface of the computer, intelligent terminal, as well as other equipment offers wide scope for the application of animation. Among them, with the continuous expansion of the influence of the mobile terminal, animation has been increasingly applied to the interfaces of all kinds of applications of mobile terminals at all levels, which provides

a channel of communication between human and machine. Unlike traditional animation, the animation in the interface space weakens the performance of the lens and often requires a return to the original state of animation, that is, moving images. Therefore, animation in different levels of the interface space also presents new visual forms.

3.2 transformation of function—narrative representation to information conveyance

Narrative and emotional expression are the main functions of traditional animation. As a comprehensive form of artistic expression, animation has a greater degree of freedom and creative space than movies and can create a more striking and rich illusory world, which provides the audience with a rich audiovisual experience. This characteristic means animation has a strong narrative and expressive ability for a variety of stories, including fictional stories, historical events, and real-life experiences, as well as the ability to express the author's thoughts, feelings, and attitudes in the narrative process. In addition, animation, with its strong expressive power, is widely used in science popularization and product promotion.

When animation is applied to the interfaces of mobile terminals at all levels, the narrative and performance functions are no longer its main values. During user interaction, animation plays the role of conveying information, and the information of each level interface is presented during user operation with animation as a carrier, guiding the user to operate efficiently, reminding them to obtain useful information in time, and providing timely feedback on the user's operation behavior to improve the user's experience of the product.

3.3 Esthetic turn—audiovisual enjoyment to fluid experience

The esthetic experience of animation works refers to the sense of beauty and artistic experience that the audience obtains when viewing animation works through the perception, understanding, and enjoyment of its form, content, structure, and style, among other aspects. The audiovisual expression of traditional animation works crucial to its esthetic experience. The character image, picture color, light and shadow, composition, scenery, camera movement, sound effects, and other audiovisual elements in animation have a direct sensory impact on the audience, creating a unique sense of atmosphere and immersion. Additionally, the storyline and character emotion of animation works have a large effect on its esthetic experience. A fascinating storyline with rich and full character emotion can cause resonance and emotional reaction in the audience and enhance their identification and participation in the works. Traditional animation is the process of providing the audience with audiovisual enjoyment in expressing the creator's concept, granting the audience perceptions of narrative, meaning, and technical beauty as well as other levels of esthetic experience.

When the margin of animation application expands to the interface of each level of a mobile terminal, its functional attributes change drastically, and the interactive animation in the interface is dominated by functionality. Moreover, it exhibits a restrained trend in visual performance, and the overall style tends to be simple and unified. The transition of the interface and the presentation of the information are realized through the use of a unified design style and visual language as well as graphic elements and dynamic effects to achieve a balance between visual performance and functionality. This esthetic shift also reflects the conceptual change from art creator-centered to user-centered to provide users with a smooth and natural operating experience, reduce the difficulty of user operation, enhance user immersion and satisfaction when using the product, and ultimately realize the value of the product.

3.4 Alternation of Audience Discourse - Viewer Appreciation to User Action

In traditional animation, the audience is the main viewing group seeking audiovisual enjoyment. Animation communicates with the audience through the characters' physical behavior and personality language, and the audience interacts with the animation by physically experiencing and understanding the narrative[4]. The audience is passive when watching a movie. Although they can

choose the carrier of animation presentation, the audiovisual experience they get through animation is under the control of the creators. The plot evolution, camera changes, and sound effects in animation are always in a definite state, and the creators are firmly in control of the discourse of animation. This top-down discourse often relies on the strength of animation content, time, and space. It seeks to exclude the external control of animation discourse and maintain the stability of animation to master the absolute discourse of animation.[5] The animation dialog mode is a new concept in the animation industry, which connects creators and audiences in traditional animation. The creators and the audience use animation works as the medium for spiritual and emotional communication, and animation works serve as the bridge between the creators and the audience's dialogue channel.

In the interactive animation of each level interface of the mobile terminal, the audience uses the product to realize their needs. Users trigger all kinds of animation effects when interacting according to their personal needs, making the animation open and uncertain. In the mobile interactive animation system, the user changes from the original passive appreciation to active participation and holds some right to speak. However, this right of speech is not absolute, as users can choose when and how to trigger the animation but cannot formulate the animation trigger mechanism. The concession of the right of speech of the animation part effectively establishes and guarantees the code of conduct of the system interface to a certain extent, which helps users to improve the operation efficiency. In the dialogue mode, the interactive animation is connected to the user and the product; the one-way communication mode of the creator, the work, and the audience in traditional animation is broken; the interactive animation and the static graphics in the interface jointly construct and enrich the dialogue space between the user and the product, thus realizing the real-time dialogue between the user and the product.

4. Visual performance of mobile terminal system interface interaction animation

The basic elements of mobile system interactive animation are mainly graphics, text, and color, and the combination of the dynamic effects of the basic elements constitutes the movement change form of interactive animation. The most common movement change forms include movement, zoom, rotation, gradient, and their combinations. These basic forms are the foundation of interactive animation, which determine how the information is intuitively perceived by the users and creates the final and most superficial perception experience for the product; it is the last link to realize the value of interactive animation.

4.1 Basic Compositional Elements

Mobile system interactive animation utilizes graphics, text, and color as the basic composition elements. The presentation state of graphics generally includes simple graphics of circles, rectangles, and irregular shapes, as well as icons and patterns of various applications in the system, with intuitive visibility being its main characteristic. Different graphics can introduce different psychological experiences to users due to their external characteristics: for example, rectangles with sharp corners give a psychological experience in favor of regularity and sharpness, whereas circles with full and smooth shapes give a psychological experience in favor of completeness and gentleness. The basic forms of all types of components, icons, and cards in the mobile interface adopt the form of rounded rectangles, which not only retain the regularity of a rectangle but also contain the affinity of the circle. Text is an important carrier of information and content. Compared with the intuitiveness of graphics, text has a stronger ability to carry information content, accommodating a greater amount of information, and information details are richer. Further, reasonable text animation can not only focus on the key points but also convey detailed information, which is a complementary graphic expression and an in-depth explanation. Color is the most intuitive composition element of interactive animation, and color changes to the user's sensory

stimulation are the most intense, and the hue, brightness, saturation, and transparency of the dynamic changes are mainly utilized to convey information. The specific content carried by color is limited, and its role is mainly in hints and atmosphere creation, giving the user a quick and direct emotional experience. For example, red is often used for warning, green is often used for smoothly completed operation in prompts, higher brightness can enhance the sense of vitality of the interface, low brightness can create a sense of depth and stability, high saturation contrast is strong and lively, low-saturation is used to make the user feel comfortable and natural, and transparency in the changes can make the interface transition smooth and natural. The combination of these basic elements constitutes the carrier of the interface information conveyance, bridges the user and the product interaction, and determines how the product design will be perceived by the human sensory organs in the end.

4.2 Movement patterns

In a mobile system interface, the interface elements should help the users accomplish their tasks while being easy to understand and use[6]. A task is often accomplished across multiple interfaces, each of which contains a different set of interface elements, and the adroit movement of elements can reduce the cost of learning how to operate across interfaces and understanding the separate components and their interrelationships. In the mobile system, each element moves differently, and the most common ways are displacement, scaling, rotation, and gradient, which are either performed independently or in combination. The speed of the interface in showing different dynamic effects can help users quickly find useful information. Each of these modes of movement has its characteristics and advantages in conveying information. For example, displacement is characterized by strong directionality, intuition, and calmness and is often used in the performance of high-frequency sliding operations; scaling causes a larger visual difference, easily attracting the attention of users and is, therefore, often used in the conversion of interfaces of different levels and operational feedback effects. Rotational movement is more directional, with a larger amplitude of transformation, and is more relevant for the natural state of hardware equipment. Deformation can transform the perceivable separation of nodes in the operational experience into a series of seamless and efficient movements and help users quickly discover useful information. Deformation can transform the separable nodes in the operation experience into a series of seamless events to be better perceived, remembered, and tracked by the user, and it is mostly used for the most prominent and direct feedback of the information change after the user's operation.

In most cases, the interactive animation of mobile terminal system involves a combination of multiple elements and multiple motion modes as well as the combination of various elements, and different changes can reflect the spatial relationship between elements. The most important element combination movement methods are overlay occlusion, spatial parallax, offset delay, parent-child level, mask, and clone. Among them, overlay occlusion can clearly reflect the hierarchical relationship and make up for the lack of hierarchy in flat space, thus improving the usability of the experience. Spatial parallax creates a strong sense of space through the differences in the speed of movement and the degree of blurring of the different elements, imitating visual effects in real life and letting the user appreciate the sense of hierarchy beyond the flat surface. The offset delay method combines both change and unity and is rich in a sense of order, helping the user to judge the relationship between elements. It helps users to judge the relationship and difference between elements and lets users perceive the next result in advance in a natural way.

5. Realization of the functional value of mobile terminal system interface interactive animation

The value of all types of mobile terminal equipment is mainly reflected in the functions provided for users, and the interactive animation in the system facilitates the smooth realization of the

functional values of hardware and software and improves the usability of the product. Functionality is the main value of interactive animation in the mobile terminal system; if the interactive animation with rich and beautiful visual effects is separated from functionality, it loses its significance.

5.1 Main types of system interface interaction animation

Mobile system interaction animation exists in each level of architecture and interaction response, guiding users to transition between levels and helping them understand information. From the user's point of view, mobile system interaction animation can be divided into active interaction animation and passive interaction animation. Active interactive animation refers to the animation triggered by the user during operation, that following the user's operation, and real-time changes in the animation. The presentation and development of this type of animation is always influenced by the user, who maintains absolute control. Passive interactive animation refers to the animation played after the user triggers it, and the user's control over the process of animation is limited to triggering and shutting down or the information in the process of loading or the state changes in the element through the kinetic effect of drawing the user's attention and conveying product information. In addition, mobile system interaction animation plays an important role in carrying information content and responding to user operation and guiding user operation. Mobile system interaction animation can be categorized based on a variety of dimensions, such as the use of scenarios, functional characteristics, design style, and other aspects. The classification of interactive animation from the two dimensions of scene and functional characteristics can be categorized into guidance animation, feedback animation, and content presentation animation.

Feedback animation refers to the dynamic change effect triggered by the user interaction behavior or operation behavior in the mobile system. This type of animation has a direct cause-and-effect relationship with the user interaction behavior, which can show the visual changes caused by the user operation promptly and effectively inform the user about whether the operation is successful. The interactive animation that follows the user's operation and shows in time is the process feedback animation, and the subsequent animation is called the result feedback animation. Common feedback animations in the mobile system include switching on/off, unlocking, charging, application installation and uninstallation, screenshot, button switching, loading, and transition animations. Among them, the transition animation involves more layers and scenes, playing the role of the transition between the two levels of the interface, in which each system provides a different form of transition animation for the user to customize their choices, such as direct movement, zoom, fade in and out, page flip, and square box. Transition animation, as the most common interaction animation, can help users effectively understand the principle of page jump and hierarchical division and clarify their current "position" while enhancing the smoothness of different interface switches.

Guiding animation refers to the dynamic effect that provides guidance for user operation in the mobile system and r prompts the user to produce interactive behavior. Guiding animation can be divided into prompting animation and guiding animation according to its functional tendency. Hint animation focuses on triggering users' attention and reminding users that they can or need to perform a certain operation, such as incoming call hint animation, unlocking guide animation, message hint animation, and voice assistant calling animation. Guidance animations focus on instructing novice users on how to operate and reduce the learning burden of novice users, such as the guidance animation for answering and hanging up after an incoming call, the guidance animation for novice operators, and the guidance animation for new functions after system updates.

Content presentation animation refers to the dynamic effects in the mobile terminal system that show the information content of the page as the main function, such as information push, desktop clock, weather display, and music playing animations. Content presentation animation is based on the effective communication of information, and its information transmission method is unidirectional; the user's interactive behavior has a weak influence on it. Rich and interesting forms of expression can help enhance the acceptance of information content, create a relaxing and

pleasant atmosphere for users to read and understand the information content, enhance the physical and mental pleasure of users, and positively affect the effective communication of information.

5.2 Main functions of system interactive animation

5.2.1 Expanding screen space to display hierarchical information

The medium of human−computer interaction of the mobile terminal is a screen and interface, and the communication of information relies on the screen space. However, the screen space of smartphones is limited, and it cannot carry all the information in the same interface. Therefore, the information should be displayed using a multilevel structure and interface. The dynamic display of the content can ensure that more information can be displayed despite the existing display area remaining unchanged, inadvertently expanding the screen space. Simultaneously, animation in the different interfaces and layers between switching can strengthen the distinction between layers and logical relationships, giving the user a more intuitive feeling. This places the user in God's point of view of control in understanding the structure of each level, ensuring they always know where they (position).

5.2.2 Enhancing operational feedback to improve the interactive experience

Human beings always hope for responses and results when they perform actions. The mobile terminal represented by smartphones realizes interaction when the user clicks and slides their fingers on the screen, and the user's sensory feedback mainly comprises the visual and tactile senses, with the tactile experience being largely singular. The use of interactive animation means the user's behavior receives timely feedback and gives them a clear understanding of the correctness or otherwise of their operations, following the interactive behavior of the form, color, and speed changes presented to enrich the user's feedback experience. In addition, the simulation of natural effects compensates for the shortcomings of other sensory experiences, reducing the discomfort of the operation process, and enhancing the user's sense of immersion in the operation and the sense of pleasure.

5.2.3 Focusing attention and guiding operational behavior

Human perception of information varies from weak to strong in order of shape, color, and motion. Therefore, in the mobile system interface, dynamic elements are often better than static elements for attracting the attention of users, focusing the user's attention, and guiding the user's eyes on the interface to the key position. Meanwhile, interactive animation with clear directivity can guide the user's operation, improve the efficiency of information conveyance, and ease the use of the product, making the whole interactive process natural and smooth.

6. Conclusion

The improvement of the hardware performance of mobile intelligent devices and the optimization of operating systems create new application scenarios and development space for interactive animation. In a mobile operating system, the carrier of interactive animation is transformed from the traditional screen to the interface space, the functional characteristics are shifted from narrative expression to information conveying and feedback, the esthetic experience is shifted from audiovisual enjoyment to interactive experience, and the attribute of audience-oriented is transformed from the audience to the user. The transformation of the functional characteristics of interactive animation enables users to actively participate in the interactive links, enhances the immersion and sense of immersion in situations and emotions, and transforms passive appreciation to active participation in users. Functionality is the main value of interactive animation in a mobile system and covers multiple functions, such as expanding screen space, displaying hierarchical structure, conveying information, guiding users' behaviors, and enhancing interactive experience, and presents new characteristics in carrier, function, esthetics, and audience discourse. The three

major types of animation in each level of interface, namely guidance, feedback, and content presentation, determine how information is intuitively perceived by human sensory organs. Against the background of natural human−computer interaction becoming the mainstream trend of human−computer interaction, designers should consider product functions as the basis and the improvement of user experience as the basis for several dimensions of functional, sensory, and emotional layers. They should design and apply animation cautiously and scientifically while striving to build a natural human−computer interaction mode between products and users.

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