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CONCEPTUAL METAPHORS IN AUGMENTED REALITY PROJECTS

Purpose. *The objective of this study is to conduct a semiotic analysis of augmented reality projects, with the aim of establishing patterns and identifying the most common conceptual metaphors. The study seeks to determine the impact of these metaphors on functional and symbolic form.*

Methodology. *To achieve the research goal, the visual materials were subjected to visual-analytical, formal, functional, and semiotic analysis methods.*

Results. *The present study identified the eight most common metaphors used in AR project design, namely the magic mirror, false window, active print, X-ray vision, geo-layer, aquarium, visor, and flashlight. The impact of these metaphors on the functional-figurative form can vary depending on the metaphor chosen, and may set more blurred or specific boundaries. It was found that metaphors differ not only in their figurative-semantic differences, but also in the viewer's position regarding representation, the type of first or third-person view, the impact on the imagery of the content, and the nature of interaction with space. While most metaphors benefit from the use of three-dimensional graphics, some, such as mirrors, active print, and sights, can use two-dimensional graphics without depriving AR of the feeling of naturalness. One technique for playing with metaphors is to go beyond conventional boundaries and manipulate space. The study also revealed that AR based on video mixing more frequently uses metaphors than optical mixing, which can directly merge with the environment. It was demonstrated that using the same metaphor does not limit the creative potential in solving tasks, and leaves the designer sufficient space for maneuvering and the possibility of both literal and formal following of the metaphor. Overall, the findings of this study contribute to a better understanding of the role of metaphors in AR project design and provide insights for designers to effectively use metaphors to enhance user experience.*

Scientific novelty. *An analysis of augmented reality (AR) projects was conducted with the aim of identifying conceptual metaphors. A synthesis of these conceptual metaphors was performed, followed by a typology-based classification of the AR projects grounded in the identified metaphors.*

Practical significance. *The findings of this research contribute to the theoretical foundation of designing AR products by providing a framework for representing AR design concepts. The identified metaphors can be utilized as a guide for designers to develop effective AR interfaces.*

Keywords: *interface design; AR design; spatial AR; video mixing.*

Introduction. Augmented reality (AR) has been actively utilized and developed in recent years, owing to advancements in the technologies employed to create it. The creation of a design product necessitates a designer to address numerous design tasks, one of which is the search for a representation form. Augmented reality projects, owing to their amalgamation with physical objects, are represented in a broad spectrum of possible conceptual forms. Several approaches aid the designer in selecting the form, including working with an existing solutions database. However, the theoretical development of creating augmented reality design significantly lags behind practical experiments in this field,

and the "dictionary" of possible solutions has not yet been formed.

The analysis of works utilizing augmented reality reveals that designers frequently employ a variety of techniques for representing content that can be characterized by metaphors from reality. Such techniques facilitate the conceptualization of functioning principles and outline the figurative component. In accordance with M. Black's definition, cognitive metaphor aids in rendering the object of cognition more accessible, providing categorization and conceptualization of reality [8]. Furthermore, G. Lakoff and M. Johnson suggest that it enables the differentiation between linguistic means of expression and understanding of one phenomenon in terms of another [9]. A well-

utilized metaphor, therefore, not only enhances visual expressiveness but also contributes to better cognitive comprehension of the principles of functioning by users.

Analysis of previous research. Isolated mentions of certain metaphor names and hints at their principles of operation can be found in various comprehensive studies related to augmented reality (AR). R. Azuma mentions the possibility of X-ray vision [1; 2], while O. Bimber discusses aquariums in the context of considering various types of displays, in particular, video-transparent screen displays [3, p. 8]. A more detailed discussion of metaphors in augmented reality interfaces was conducted by F. Bork and J. Scholz, N. Smith [6], and V.D. Ulriksen [7]. In discussing the metaphor of the "Magic Mirror", Felix Bork draws attention to the possibility of mirror and non-mirror visualization and concludes that the choice of approach depends on the subject area [4]. Vilde Dirnes Ulriksen shares personal impressions of studying the metaphor of the magic mirror in the beauty industry, which seems potentially promising but still quite raw [7]. J. Scholz and A. N. Smith considered the metaphors of the magic mirror, false window, active printing, and geopositioning from the perspective of "marketing paradigms" [6]. Although metaphors are used in practice, there is still a lack of research on their use in the design of augmented reality interfaces.

Problem statement. The aim of this article is to promote the development of a visual vocabulary for AR design by analyzing projects and examining the metaphors used to create functional and visual solutions. The impact of these metaphors on the functional and visual components of the project will be determined.

The results of the research and their discussion. There are eight common interface metaphors used in AR projects, including the magic mirror, fake window, active printing, geo-layer, X-ray vision, aquarium, visor (HUD, head-up display), and flashlight. These metaphors have various characteristics, such as the viewer's position in relation to representation, the perspective of first or third person, the impact on the imagery of the content, and the nature of interaction with space.

The metaphorical *"Magic Mirror"* represents an altered reflection of reality on a certain surface. The term "Magic Mirror" was coined because the display shows an enantiomorph, which is a mirror image of what the sensors capture. In this way, the system simulates a physical mirror of the real world [4]. This technology is typically used for displaying users or the surrounding environment and is widely used in various fields, including the cosmetic industry, fitting rooms, physical "mirrors" in stores, and masks in social media. This metaphor is particularly attractive because in real life, it is much easier to change the environment than our physical aspects, which are more limited and closely linked to personality [7, p. 11]. It is noted to have a positive impact on a person's well-being and self-definition [7, p. 38] due to the ability to change one's appearance and experiment with their image, as well as create dissonance in self-perception [24]. Examples of application include using artificial intelligence to age or rejuvenate photos in SnapChat (fig. 1, a); creating creative characters on Facebook based on the movie "Deadly Class AR Filters" from Sony Pictures (fig. 1, c); thematic backgrounds and effects. Scenes with this metaphor are very diverse and unlimited in terms of theme, style, and transformation capabilities, the range of effects and digital graphics, animations, and content (fig. 1, b) [33]. The only limitation is the consideration of the perspective of space and overlay objects.

The metaphor of the magic mirror is primarily aimed at enhancing the user's experience, but it can also enhance the surrounding space and objects. However, the main difference from "active printing" is that the enhancement is located opposite the display. The result of the enhancement can be displayed not only through portable devices such as phones or tablets but also through digital displays such as monitors, televisions, billboards, disguised as ordinary mirrors, or located in an open view.
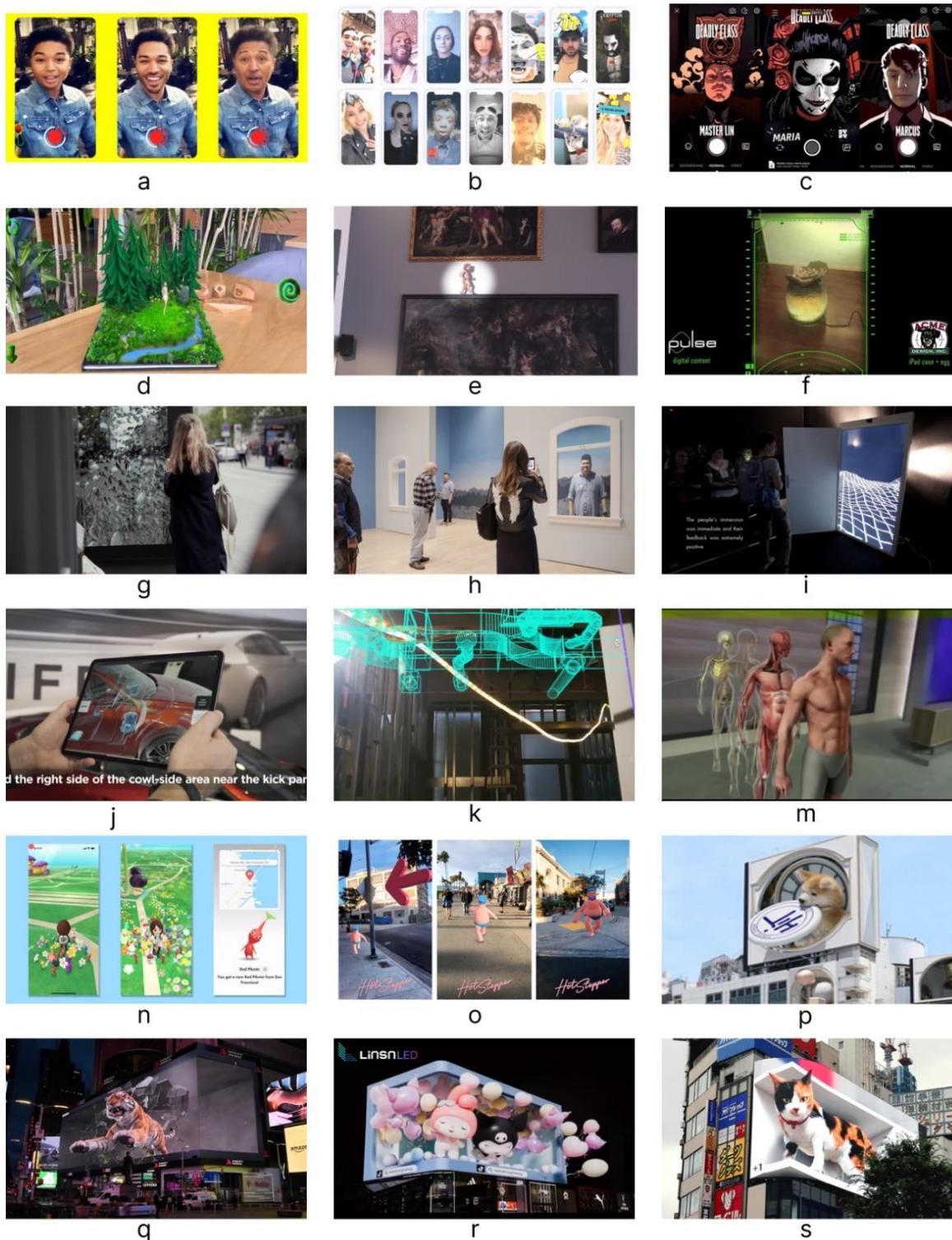
Fig. 1. Examples of metaphors. "Magic mirror": a – a mask that changes age © SnapChat [13]; b – creative masks © Facebook Sparkle; c – masks of comic book characters © Deadly Class AR Filters Sony Pictures. "Flashlight" and "Visor"; e – Rubens Cupid © Skullmapping; f – Alien Egg @ Pulse Studio. "Active print"; d – overlaying an image on an object-marker [35]. "Fake window"; g – an image from a camera supplemented with fish shoals [15]; h – a window showing an image from another window [16]; i – doors to the digital space [12]. "X-ray"; j – the internal structure of a car audio system [19]; k – placement of communications according to the construction plan [36]; m – studying anatomy with layers [21]. "Geo-layer"; n – a virtual map that corresponds to the real location [26]; o – a guide character walking the streets of San Francisco [23]. "Aquarium"; p – Shibuya dog [32]; q – jumping tiger [31]; r – Hello Kitty family characters [27]; s – Shinjuku cat [25]

The user can see themselves as part of the enhancement, from a first-person perspective or, by observing their actions on the screen, from a third-person perspective.

For example, in 2019, Grand Visual created an augmented reality (AR) system to promote the new Amazon Prime series "Good Omens" [22]. Using AR, the creators released the Kraken's tentacles, UFOs, and fish rain on Times Square, immersing the crowd in apocalyptic scenes from the series. Viewers could see themselves surrounded by virtual creatures through a digital billboard, and the scenarios were played out in real-time, encouraging visitors to pose for photos. This metaphor sets certain functional frameworks but almost does not limit what can be "reflected" in the mirror.

The following metaphor is referred to as the "fake window" or "portal to the world". This metaphor involves enlarging the user's field of view to the surrounding environment through digital objects, typically via devices such as television screens or monitors that simulate conventional glass windows [6, p. 3]. Users who perceive augmented reality through this fake window do not consider themselves as part of the augmented environment; instead, they see the world situated behind this window.

An example of this case is the project created by A1 Slovenija (formerly Si.mobil) in 2017. The company collaborated with the advertising agency Gray Ljubljana and the street advertising system integrator Europlakat JCDecaux Slovenia. The advertising campaign was launched using a special city light on the busiest promenade in the city center. It contained a series of animations that embedded elements from the television commercial [20] into the surrounding environment, using the advantages of street planning and surprising passersby with visual and sound effects [15] (fig. 1, g). At first, people at the bus stop thought that the transparent city light or the city light with a camera showing what was further down the street was nearby, but suddenly dolphins appeared in the frame or jellyfish swam by, and so on. The project used a combination of real street background with animation that was programmed to adapt to the changing environment. Pepsi also chose a similar approach, launching the "Unbelievable Bus Shelter Pepsi Max" campaign in partnership with AMV BBDO, OMD, Talon, and Little Dot in 2020 [28; 29]. Passengers waited at a bus stop on New Oxford Street in London and saw scenes of people being abducted by flying saucers, falling meteorites, alien attacks, wild animals walking down the street, underground tentacles, and so on. Although such projects are technically difficult to create, they provide enormous audience engagement. Design based on this metaphor requires more meticulous development of augmentation scenarios and active involvement of space, spatial composition, and realistic placement of embedded objects. Unlike a magic mirror where 2D graphics can be used without being embedded in space, this metaphor blends with the base (real) environment.

Often, instead of a transparent "window", a "portal" is used, which displays not "the world outside the window" but "a door to another world". This approach can be accompanied using physical objects, creating a more dramatic effect. In this case, real doors can metaphorically serve as a means of transportation from one place to another. In the research article "Doors, Between Reality and Virtuality," developers from the Théoriz studio [12] in Lyon experiment with the perception of infinite space. They created anamorphic software that calculates the perspective of the nearest person. By opening real doors, viewers observed virtual audio-reactive landscapes that also responded to their movement in space opposite the doors to adjust the visible perspective.

"The Interpretive Gallery" created by the San Francisco Museum of Modern Art (SFMOMA) in collaboration with Frog, a global design and strategy firm [16], is designed to allow visitors to experience the paradoxes of reality that Magritte explored in his later works. The gallery contains a series of altered and augmented "windows" inspired by the visual puns and paradoxes found in Magritte's works.

The digital scenes in the windows become both portals and puzzles as to how they are related to each other. For example, in one window, visitors may see what was happening near another window some time ago (fig. 1, h).

The use of this metaphor has a direct impact on the visual tools employed in design. Specifically, the visual representation of the "portal" is designed to closely resemble real perspective and scale. Additionally, plot twists and opportunities for interaction are closely linked to the depicted space. The representation of the space "outside the window" can vary from a transparent screen that closely resembles reality, to the transfer of the action to other worlds. This metaphor can be realized through both mobile and stationary means, but the latter offers a more immersive experience due to the use of real props, which facilitates a more natural integration of the addition into the environment.

Active print is a metaphor that pertains to the concept of primarily supplementing physical printed materials [11], such as posters, magazines, billboards, packaging, and catalogs, with digital objects accessible through personal devices. However, it can also be used for other surfaces and objects that work as markers. Interaction using this metaphor is initiated by the user who launches the digital supplement by scanning or pointing their device at the target (marker). The augmented content using active print is not visible until the interaction begins, but it is closely contextually related to the corresponding marker, which often becomes images and objects that have a completely understandable figurative form. It differs from a magic mirror in that the augmented object is located behind the display and from a fake window in that it is focused on supplementing individual objects and obtaining information from the environment, while a fake window can display a fully generated environment.

Due to its technical ease of implementation and broad interpretability, the "overlaying" metaphor is widely used in augmented reality. As a result, it has diverse visual embodiments. One such example is the "Mavka. Forest Song" project [37; 35], which premiered in 2021 at the Ukrainian supermarket chain "Silpo". This comprehensive project includes a book-game with stories and AR, special marker objects (wooden figures with carved runes), a dedicated AR application "Mavka Silpo" from LiveAnimations Corp (fig. 1, d), and a full-length animated film from the Ukrainian studio Animagrad, supported by the State Agency of Ukraine for Cinema. Mavka, the soul of the forest, represents nature itself, complex and contradictory. The plot is based on Lesya Ukrainka's eponymous play, Ukrainian myths, and cultural traditions. The book's illustrations feature additional scenes and animations that can be modified using physical gaming elements. These elements can be overlaid on the illustrations, changing the animation or triggering game events.

The metaphor of active printing evokes the principle of "a window to the world", although it is typically associated with portable display devices and lacks a strong figurative connotation.

X-ray vision is another metaphor commonly employed in augmented reality educational programs, such as those focused on anatomy, geography, and physics. This metaphor describes the ability to see the internal structure and composition of objects or spaces, much like how X-rays function. X-ray vision can also be utilized to visualize layered data, internal structures and cross sections, assembly or disassembly over time and space, as well as evolution. While active printing and X-ray vision share similarities, active printing is a more general metaphor that can be applied to any overlay using markers, while X-ray vision embodies a specific approach to representation that may differ in form or visual style.

The advertising video for Bose Automotive [19] effectively demonstrates how the internal frame of a car can be utilized to display the placement of speakers in relation to the car body, both in traditional and innovative ways (fig. 1, j). This design approach can be considered a classic example of the use of non-

textured volumetric graphics with shadows and 3D mesh for this metaphor. Another example is the educational video [21] for HoloLens, which showcases the use of X-ray vision for studying human anatomy and individual body parts (fig. 1, m). In this case, fully textured realistic models are employed. In the Argyle Build construction industry program [36] (fig. 1, k), which allows for the visualization of structures through communication layers while moving around a construction site, linear skeletal graphics are used. While X-ray vision in augmented reality is primarily a metaphor, there are already developments utilizing RFID tags that enable users to locate items, even those hidden in boxes [17; 14].

The metaphor of *geopositioning* or *the geo-layer* is based on the tradition of mapping, digital maps and navigation systems, and non-visual data. Augmented reality with a geo-layer utilizes geolocation data, GPS, and/or spatial recognition to enhance the user's environment with digital objects, both related and unrelated to the location. Applications include placing virtual art, sculptures, and installations in a specific location, marking landmarks, and aiding in navigation. Unlike active printing, the geo-layer uses geolocation data instead of camera streams, making it more focused on promoting physical movement and exploration. Scalability must be considered from a design and object embedding perspective.

A concrete example of geo-layer application can be found in navigation products. Companies such as Apple Inc. and Google have incorporated augmented reality (AR) navigation capabilities into their apps to simplify route orientation [34]. During visual navigation, markers and hints are overlaid directly onto the camera's field of view. The planned route is represented by lines or other graphical elements on the floor, as well as arrow indicators. Nexus Studio has taken this a step further by proposing to entertain the user during the route by offering the use of a companion guide service (fig. 1, o). The Hotstepper app [23] features an eccentric character who leads the way, placing signs,

dancing, and looking around. Another example of an app is Pikmin Bloom [26], developed by Niantic and introduced in 2021. It requires players to move in the real world but does not directly enhance it with visual information. Although the game uses real coordinates, all actions are displayed on a stylized digital map (fig. 1, n).

While there is currently no virtual map available for users to locate all digital artifacts, many artists are experimenting with virtual sculptures by selecting a specific real-world location and developing its appearance. Although a digital sculpture can technically be viewed from any location, its attachment to coordinates promotes physical activity and real visits. Among the innovators in this field are Ilya Novgorodov, Petro Gronsky, Mykola Mylyshko, Artem Volokitin, Oleksiy Zolotarov, Mykyta Kadan, Ksenia Hnylytska, Vartan Markaryan, Vitaliy Kokhan, Roman Minin, Vitaliy Kokhan, Kostiantyn Zorkin, and Vlas Bielov [10].

An aquarium is a metaphor utilized to describe a specific enclosed space with a known depth that can be observed and explored. It differs from a fake window or a window to the world in that it has defined boundaries and depth, whereas a window can display infinite space beyond it. Holographic displays are a typical example of a direct realization of this metaphor, but not the only one. The most vivid and popular example is 3D billboards, also known as anamorphic OOH, Digital out of home, DOOH, or DeepScreen. The phrase "out of home" arose from playing with the boundaries of such a screen and creating the illusion of going beyond them. A billboard is essentially two screens placed at a 90-degree angle to each other, creating the illusion of space and a 3D effect.

Some of the world-renowned 3D billboards are in Times Square in New York, Piccadilly in London, Shibuya in Tokyo, as well as in other places with high concentrations of people around the world. Examples of works that have appeared on screens include the work of advertising agency Goodby Silverstein & Partners for the BMW North America division

in 2022 [18] (New York), "Cat Shinjuku" in 2021 [25] (fig. 1, s), "Year of the Tiger" [31] by Samsung in 2022 (fig. 1, q), King Kong, robot mechanic, Hello Kitty family (fig. 1, r), safari, giant whale, Vivo gadget, cyclops from ESKY MALL [27], "Resident Evil" from Netflix [30], Akita dog [32], which climbs onto a vertical screen of a tower and creates chaos there (fig. 1, p), and many others.

The visualization of the aquarium metaphor is closely related to the illusion of surpassing its boundaries. To create it, a frame is often utilized, which outlines the false boundaries of the screen and leaves space for parts that will protrude beyond these boundaries in the future. To enhance the feeling of a breakthrough, effects, and objects such as dust, smoke, floor or ground fragments, broken screen glass, splashes, etc. are used. Often, a confined space with an apparent perspective and angle relative to potential viewers is employed, such as a cage, room, box, cave, or contour of the ceiling or wall. One of the limitations of 3D billboards is that the full sense of volume is achieved only at specific angles, which may vary for different screens.

Most of the discussed metaphors utilize space as a basis for graphic placement. However, one metaphor is built on the reverse principle, which is the Heads-Up Display (HUD). This technique, borrowed from data transmission to the panel in front of the pilot, has been significantly developed in computer games. It applies a richer palette of visual styles and elements that can be placed in the simulated HUD. These solutions are now becoming an inspiration for augmented interfaces, either conventionally or literally imitating a transparent screen or the view of an imaginary helmet. The metaphor of the *visor* uses the peripheral zone of the screen to display relevant information not embedded in the context of the first-person view environment. The formal use of this metaphor does not impose stylistic limitations on the designer regarding the display of information. However, the literal interpretation sets quite

specific boundaries for the technological-futuristic style (fig. 1, f) and such realistic techniques as imitation of glass, electronic inscriptions, reflection of the viewer's face, etc.

The utilization of the metaphors is predominantly observed in augmented reality, which is produced through video mixing technology. Portable or stationary display devices are frequently integrated into these systems and are designed with a particular style in mind. The use of projection displays does not preclude the use of these metaphors, as the outcome of the augmentation can still be projected. Nevertheless, in the case of optical mixing, augmented reality that is based on direct projection seldom employs conceptual metaphors, instead blending seamlessly with the environment it enhances.

However, one metaphor that is effectively employed through direct projection is *the flashlight* metaphor. Although the projector itself serves as a large source of light, it is not always the focus of attention nor is it artistically manipulated. This metaphor is applied in Ramesh Raskar's experimental project [5] for interactive creation of shadow effects from virtual objects on real surfaces, as well as in augmented performances such as "Rubens Cupid" in 2014 (fig. 1, e) and "Die Invasion der Gallerie" in 2016 by the Belgian art collective Skullmapping. The projection simulates the illumination of virtual objects with a flashlight, enabling objects to cast digital shadows on the background, thereby enhancing the effect of volume and embodiment in the projection objects. The sharpness of the shadows varies depending on the distance to the wall, allowing for a more active differentiation of movements along the wall from flights. Virtual shadows create a potent cognitive cue and simplify spatial perception. Typically, the flashlight metaphor is combined with volumetric virtual objects, is independent of the viewing position, and necessitates a surface for display.

The conceptual form of augmented reality has the capability to integrate multiple metaphors simultaneously or incorporate diverse metaphors in specific segments of the project.

Conclusions. Metaphor is one of the artistic means that helps to form a functional-figurative solution. It is based on the transfer of features of recognized phenomena or functions to a new form. The use of a conceptual metaphor is aimed at creating a form of embodiment and does not limit the designer in terms of content, only outlining the boundaries of the functional-figurative solution and serving as a starting point that directs the development of the project concept.

The influence of conceptual metaphors on the functional and visual components of a project has been determined. Due to its close connection between visual form and function, augmented reality, using metaphor, solves both tasks. By using conceptual metaphors, the designer can independently choose the degree of imagery within the metaphor and play with it. Metaphors such as "X-ray," "window", "flashlight", "aquarium" and "visor" have a more defined form in advance, while "magic mirror" and "active printing", "geo-layer" almost do not limit the visual component of the content presented with their help, outlining only the viewer's placement and the nature of interaction with space. The projects considered demonstrate the possibilities of diverse, creative implementation of augmented reality, even based on the same metaphors. Further research is needed on other means that help create augmented reality design.

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КОНЦЕПТУАЛЬНІ МЕТАФОРИ В ПРОЄКТАХ ДОПОВНЕНОЇ РЕАЛЬНОСТІ

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Мета: провести семіотичний аналіз проєктів доповненої реальності, встановити закономірності та виділити найпоширеніші концептуальні метафори. Визначити їхній вплив на функціонально-образну форму.

Методологія. Для досягнення мети цього дослідження під час роботи з візуальними матеріалами було використано наочно-аналітичний метод, метод формального, функціонального та семіотичного аналізу.

Результати. Було виявлено вісім найпоширеніших метафор у дизайні AR-проєктів: чарівне дзеркало, фальшиве вікно, активний друк, рентгенівський зір, геопозиціонування, акваріум, візор та ліхтарик. Вплив на функціонально-образну форму може відрізнятися залежно від метафори, задаючи більш розмиті чи конкретні рамки. Визначено, що метафори, окрім очевидних образно-семантичних відмінностей, відрізняються позицією глядача щодо репрезентації, видом від першої чи третьої особи, впливом на образність змісту, характером взаємодії з простором. Більшість метафор набувають перевагу від використання тривимірної графіки, у той час, такі метафори, як дзеркало, активний друк та візор, можуть використовувати двомірну графіку, що не позбавить AR відчуття натуральності доповнення. Одним із прийомів обігравання метафор стає гра з простором та вихід за умовні межі. Встановлено, що AR на базі відеозмішування частіше звертається до метафор, ніж за оптичного змішування, яке має змогу на пряму злитися із середовищем. Продемонстровано, що використання однієї і тієї ж метафори не обмежує креативний потенціал у вирішенні завдання, та залишає дизайнеру достатній простір для маневрування та можливість як буквального, так і формального слідування метафорі.

Наукова новизна. Проведено аналіз проєктів із доповненою реальністю з метою визначення концептуальних метафор. Проведено узагальнення концептуальних метафор та типологізацію проєктів доповненої реальності на їхній основі.

Практична значущість. Дослідження робить внесок у розвиток теоретичної бази стосовно вирішення завдання пошуку форми репрезентації в процесі проєктування AR дизайн-продукту. Розглянуті метафори можуть бути використані, як засіб спрямування концепції дизайну *безпосередньо в роботі дизайнерів.*

Ключові слова: *дизайн інтерфейсу, дизайн AR, просторова AR, відеозмішування.*

ІНФОРМАЦІЯ ПРО АВТОРА

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