Between Light and Shadow: How adaptive environments can sculpt the immersive experience?

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Abstract

The way a space is illuminated has a significant impact on its aesthetic appeal, improving visual comfort and accentuating textures and colours. This paper offers guidelines on how lighting can be employed as a design strategy in 3D spaces and adaptive environments. The primary focus is on architectural lighting, examined in a theoretical context in Chapter One and further explored through a cultural lens in Chapter Two. Additionally, the use of shadow and darkness is discussed as an equally essential aspect of lighting design. The argument on architectural lighting in the virtual environment is supplemented by investigating the strategic use of light in the theatre. The final chapter applies the introduced techniques to 3D spaces and emphasizes the implementation of theory to the technical aspects of lighting. The objective of this paper is to contribute to the design conversation in an accessible way to readers outside academic circles without sacrificing depth and insight.

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Introduction

Lighting is a vital aspect of orientation in built spaces. Practically, it guides movement along paths and through areas. Poetically, it defines focus and hierarchy. Light is particularly interesting in projects with a narrative element like games and virtual reality environments. The contemporary lighting design can have a significant impact on the appearance of a space, enhancing visual comfort, and highlighting textures and colours. This paper aims to explore how lighting can serve as a design strategy in 3D spaces and adaptive environments, with a primary focus on architectural illumination. The objective is to contribute to the design conversation in a way that is accessible to readers outside academic circles.

When discussing the relationship between luminescence and 3D space, it is important to first define the nature of the digital background. With the ability to move images to transcend the limitations of a two-dimensional screen, the viewer is provided with an opportunity for intellectual engagement and perceptual manipulation of image space within a distinct dimensional realm. Recent discourse in this field highlights the emergence of innovative visual and spatial terminologies. The advancement of digital technologies has facilitated a shift in cinema from a passive viewing experience to one in which the boundaries and framing of the screen are culturally redefined (Jukes, 2018, p. 120).

In his approach to the concept of space, Alex Jukes draws a comparison of adaptive environment to a sculptural object. Academic research has revealed that the relationship between 3D CGI and space can be understood through the ideas of borders, limits, and edges. These notions might aid in comprehending spatial visuals while moving away from a reliance on perspectival space. Visual edges can function as passive boundaries whereas an indistinct boundary can encourage active exploration of space. To establish interior spaces, containment is crucial, rendering them inaccessible to viewers outside. Typically, such spaces are three-dimensional and defined by two-dimensional surfaces. Thus, a dialogue between the 'edge' concept and its corresponding space is vital in understanding how lighting functions in CG. It would be highly beneficial to explore how the consistency or inconsistency of the edge can enhance the viewer's understanding of space, particularly for the narrative aspects of lighting design in virtual environments.

Literature Review

The critical analysis of the studies about lighting design in architecture and its use in 3D environments has been conducted in this thesis proposal through the review of several books or articles investigating those subjects. In particular, *The design of lighting,* the study by Tregenza and Loe (2014) covers the comprehensive architectural approach to lighting. It emphasizes the technical aspects of lighting in the context of architectural design, providing a solid foundation before delving into more advanced topics. Their approach focuses on imagination in architectural light while offering practical knowledge in the presentation of the tools necessary for creative design. On the contrary, Barker (1997) takes a more theoretical approach in his book, *Lighting: lighting design in Architecture*. He delves into the natural and artificial illumination of interior and exterior spaces, considering both the scientific and aesthetic aspects of light and colour theory in architecture.

Light as an inseparable part of architectural design is the common thread also in the *Fundamentals of architectural lighting* by retired architect Samuel Mills (2018*).* This guide provides a thorough understanding of the visual and psychological perceptions of the luminous environment, aiming to bridge the gaps in current research on the topic. In his book *Light: The Shape of Space: Designing with Space and Light* Lou Michel considers other important factors that impact light design, including the effects of light and its influence on perceiving form and space. As an architectural lighting educator, he takes a practical approach to design. Michel analyses constructions based on how users perceive their surroundings while moving through space. He also offers insights into the interaction between lighting, spatial design, and colour theory. An interesting strategy for how vision and perception can be applied to architectural spaces has been presented in Christopher Cuttle's *Lighting Design: A Perception-Based Approach* (Cuttle, 2015). Rather than prioritizing efficiency or aesthetics in lighting, his alternative approach seeks a balance of brightness to enhance visual elements (such as sharp edges or colourful spaces). Offering valuable insights into the role of light in architecture, the book *Made of Light: The Art of Light and Architecture* (2005) delves into how light is utilized for communication and visibility. The authors, Speirs and Major, who are award-winning Lighting Architects, discuss various approaches such as security, ambiance, and entertainment. The authors stress the importance of light and shadow control in shaping people's visual and emotional responses to buildings.

In addition, the book delves into the essential properties and characteristics of light, while providing a wealth of creative ideas and observations.

Insufficient attention has been given to the vital role that the distribution of light plays in shaping our spatial perceptions. Ulrika Lindh, an Assistant Professor at the Department of Construction Engineering and Lighting Science at the School of Engineering at Jönköping University, in her thesis *Light Shapes Spaces Experience of Distribution of Light and Visual Spatial Boundaries* (2012), takes a design-focused approach, delving into the connection between spatiality, enclosure, and the distribution of light. Through this exploration, the author aims to deepen the audience's understanding of the nature of physical spaces and highlight the powerful impact that light can have on their character. The research examines user experiences and interpretations, drawing a link between the distribution of light and perceived spatial dimensions and atmosphere. The findings reveal that brightness can create an impression of spaciousness, although sometimes it can have the opposite effect. Conversely, darkness can contribute to a sense of spaciousness in certain contexts.

Throughout art history, the representation of light and its derivative shadow modified architecture's appearance and meaning. Tadao, Sverre and Gerhard (2002) in their book The *Secret of the Shadow: Light and Shadow in Architecture* address the aspect of shadow. The first chapter describes its link to visual history, while the last section is dedicated to the shade in contemporary architectural concepts. Moreover, the absence of light can be an essential tool for adding emotional depth and animating spaces. This theme is explored by Jukes (2018) in *the Emptiness Is Not 'Nothing': Space and Experimental 3D CGI Animation*. The chapter examines space as a material in experimental 3D CGI animation practice. This utilizes Heidegger's ideas on space and investigates the concepts of emptiness and void as means of inquiry. The exploration is both theoretical and practical.

With the absence of multiple cinematic features, Gallardo (2001) attempts to explore digital spaces from a practical point of view. His book *3D Lighting: history, concepts, and Techniques,* studies the art of lighting in 3D graphics including detailed fundamentals of 3D graphics and general lighting techniques. This source provided insight into architectural lighting from a rendering point of view. In addition, it describes types of light used in basic lighting techniques which helps to better understand the limitations of 3D works. While it proved a solid base for the industry techniques that are not discussed in previous papers.

On the other hand, *Stage lighting explained* (Fraser, 2002) and *Light Fantastic: The Art and Design of Stage Lighting* (Keller, 2010) analyse theatre illumination through modern lighting theory. Max Keller highlights the importance of emotional focus in transferring it to architectural interior design, while Neil Fraser provides an overview of the underlying theory. Combined, both sources offer an alternative method for lighting design, connecting the real world and digital spaces.

These sources have been thoroughly examined to create the concept map of architectural lighting design in 3D spaces. The research about the luminous environments in this thesis provides a wide panorama of the approaches to lighting in digital surroundings. Due to the scope of the paper, I will not be discussing the semiotic perspective or colour temperature of light.

Methodology

This paper predominantly focuses on qualitative research. The researcher's objective is to investigate academic sources about lighting design in adaptive environments. The thesis includes concept and method research. To gain a deeper understanding of the subject, qualitative studies were selected to examine the process and use of architectural lighting methods. The focus was on peer-reviewed academic sources from several fields that explored the topic in a theoretical manner, with a few technical manuals included to provide accurate fundamentals and practices. The research was centred around theatrical and architectural approaches. After collecting the sources, they were cross-examined and analysed to identify main design questions. In addition, this thesis includes topics and terminology used by architects and 3D artists as part of the creative process. It aims to create the basis of the dialogue by observing examples of light both in nature, built environment and virtual spaces.

Chapter 1. Luminous Architecture; light as an inseparable part of architectural design.

Architecture is dependent on luminescence. It is through light that the forms of construction and the spaces it creates are revealed, conveying the underlying meaning and intentions. Christopher Cuttle is an educator who advocates for a perception-based approach to lighting design. This reasoning requires a balance of different illumination concepts that align with the specific design objectives of the location. The space is perceived as a three-dimensional light field creating interactions with room surfaces and the objects within the environment. Perception is linked to the recognition of surface and object attributes. The role of lighting in this process is to create patterns that interact with the surrounding field. Three types of object lighting practices are identified, being shading, highlight, and shadow patterns. By controlling the balance of them, designers can influence how room surfaces and object attributes are perceived (Cuttle, 2015, p. 3).

The brightness, hue, and direction of any light source are influenced by four key factors: the characteristics of the source, the spatial configuration of the environment (including the positioning of the light source and the surfaces it illuminates), the reflective and refractive properties of the surfaces themselves, and the individual observing the light and its interaction with the surrounding space. Through careful observation of light's behaviour, we gain valuable insight into the nature of the world around us. Proper distribution of light within an architectural interior is a critical aspect of designing interior environments. Each design requires a unique interpretation of the space and its visual elements to reflect the human activities involved. Lindh, U. (2012, p. 9) notes that previous research on lighting has not focused on the distribution of light, which is essential for spatial experience. The Assistant Professor at Jönköping University in Sweden conducted a study on how variations of brightness and darkness affect the perception of spatial dimensions. It revealed that subjects may view space differently, including light zones, causing shifts between physical and perceived place, which might lead to a sense of inclusion or exclusion. The relationship between a lit surface or object and its background is crucial in determining whether the lit surface appears closer or farther away. The study also showed that the movement of the gaze towards brightness contrasts can impact size perception. Moreover, the distribution of light contributes to surfaces being perceived as curved. In terms of the cost-effectiveness of virtual rendering, proper light distribution can make a room appear more spacious than building larger areas or volumes.

Exploring this concept further, the dispersion of light in a room is influenced by multiple factors, including the size, shape, and placement of windows and light fixtures, as well as the reflectivity of surfaces. A monotonous lighting design creates a dull environment, lacking visual interest. According to Flynn, J.E. (1973, p.17), when people enter an unfamiliar space, their attention is involuntarily drawn to areas of bright light that contrast with the background. In urban areas, brightly lit landmarks serve as focal points that capture attention. By creating contrast between brighter and dimmer areas, such as in corridors, designers can add visual interest. Texture is achieved in light through various methods, including the use of light and shadow to reveal an object's surface. Diffuse reflection communicates volume, while specular reflection conveys information about the object's surroundings. Light passing through an object affects the way it is perceived. Form can be utilized to establish visual composition through lighting, while movement involves manipulating light over time. All the design aspects mentioned above are necessary to provide visual stimulation throughout the scene.

When devising a lighting plan, it is crucial to consider both the primary and secondary characteristics of light. In an architectural setting, the surfaces that reflect light also serve as secondary light sources. The strength of the light that bounces off these surfaces determines the prominence of the objects in the space. This type of light is often soft and can help mitigate shadows, decrease contrast, and provide an even, consistent feeling of brightness. Surfaces with a low reflectance level absorb much of the light, generating a gloomy atmosphere. Conversely, surfaces with a high reflectance level create a brighter environment with more diffusion and better visual clarity Employing architectural surfaces as secondary light sources can make a significant contribution to the interplay between light and design (Mills, 2018, p. 26). An alternative method to tackle the lighting for space would be to consider the visual impact of luminaires as an element of the interior design. The size, shape, and material of the light fixtures should complement the architectural style and interior design. Lamps and windows, as objects, carry meanings. Furthermore, our brains associate certain meanings and patterns of brightness with different light sources. Thus, if the objective is to create a recognizable environment, designers should utilize familiar lighting design techniques. However, if the aim is to establish an unexpected atmosphere, innovative lighting fixtures are preferred, but one must be mindful of how atypical lighting might disorient individuals. In certain contexts, such as a horror game with a supernatural theme, unusual lighting is beneficial as it can generate confusion or even fear. To maintain visual harmony amongst spaces, designers frequently restrict the number of luminaire types and patterns employed in similar spaces and applications.

Chapter 2. Shadow; the interplay between light and dark.

Our perception of light is shaped by the places with which we are familiar. The light patterns encountered during formative years, as well as those that captivate us later in life, carry meaning. Some of these connotations are universally recognized, while others are unique to culture or personal history. Our collective exposure to light in diverse settings is complex, nuanced, and rich. During the medieval era, the concept of radiance was highly valued. As Ramos (2015, p. 81) explains, Gothic cathedrals throughout Europe were intentionally designed to balance the flow of light inside and create a sense of separation from the outside world. The intricate decorative features and stained-glass windows allowed bright, colourful light to fill the interior of the cathedral. The complex structural systems enclosed a highly transparent, illuminated space that united light, structure, and ornamentation, resulting in a profound effect. Light worked to visually diminish the physical elements of the building, creating a less tangible appearance. Later, during the Baroque and Rococo periods, illumination was seen as a transformative tool. For example, the Hall of Mirrors at the Amalienburg Pavilion (1739) used mirrors to reflect light and extend the visual boundaries of the space. With the advent of artificial light in the 19th and 20th centuries, luminescence technologies became more theatrical, using colour, changing states, and dramatic effects to enhance the experience (Major, Speirs & Tischhauser, 2005, p. 47).

The introduction of more bright sources has undoubtedly transformed the way we live, work, and play. However, despite the advancements in technology, the relationship between light and dark still holds deep cultural significance. Their interplay is a fascinating experience that can evoke diverse reactions due to its association with the unknown and the suppression of visual perception. By dissolving form and obscuring material firmness, darkness creates a mysterious ambience that is crucial to the form of architecture as it exposes space and surface. Contrast is a key element that not only reveals form, but also triggers emotions, expressions, and meanings. It is essential to maintain darkness by eliminating light or casting shadows. Like light, shadow possesses quality, quantity, direction, and focus. In a space with artificial illumination, the contrast between light and shade can be anticipated and regulated, but it can also be impacted by multiple sources.

Notre Dame du Haut in Ronchamp (1955) stands out as a departure from the traditional approach to architectural lighting design and its purists' brightness. Its interior space is designed to allow light to filter in throughout the day, resulting in a mesmerizing interplay of

light and shadow on the curved walls (Ramos, 2015, p. 127). The contrast between the brightness of daylight and the dimness of the interior space creates a subtle, sfumato effect, which conceals the exact form of the structure. By expertly using orientation, openings, and textures, the design incorporates hidden diffuse lighting, resulting in dynamic layers of light that transcend the static building volumes and create a metaphysical scene. The ambience of a space is heavily influenced by its lighting. The strategic placement and height of light sources are critical factors in shaping the overall spatial experience. To cultivate a clear spatial envelope, it's important to minimize the number of dominant spatial boundaries. Visible vertical surfaces assist with orientation since relying solely on ground-level scenery can be challenging. For optimal results, non-uniform lighting is recommended. Precise placement of the appropriate amount of light is crucial in highlighting distinct architectural surfaces. Both the lighting intensity directed to this surface and the reflectance of the surface contribute to this brightness contrast and visual focus (Mills, 2018, p. 13).

The way light is dispersed or filtered has varying effects on us. When light is fragmented, it appears discontinuous and fluid, while pierced light can feel invasive. Diffused light scatters and blends light rays, resulting in a softer and more inviting ambience. On the other hand, perforated light is more rigid and can come off as invasive. Diffused light is abundant and produces a gentle radiance that makes light almost tangible. Strong patterns of light and shadow can also decompose our perception of form by overlying strong figures on the ground of a building form. For example, the fragmented daylight streaming through the grated windows of Hagia Sophia in Istanbul (537), softens the contours of the carved stone walls, giving them a dematerialized appearance. Lindh, U. (2012, p. 72) suggests that achieving a balance between light and darkness is crucial in avoiding light pollution and visual noise. A uniform light can create an inclusive atmosphere that welcomes everyone, while a focused light may result in excluding some individuals. When used in a darker environment, a directed light can enhance focus and reduce noise levels. Additionally, it can create a sense of clarity and activity. Uniformed light, though good for functionality, leads to creating permanently overcast spaces, devoid of contrast and monotonous. High contrast, achieved through light and shadow, stimulates the eyes, and adds texture and depth to spaces (Major, Speirs & Tischhauser, 2005, p. 63). In virtual environments, multiple light sources can cause sensory overload. Therefore, it is essential to consider darkness as well as light sources in the design process.

Chapter 3. Theatre Lighting, the art of dramatics.

The importance of illumination in theatres is closely tied to architectural lighting, particularly Renaissance and Baroque techniques. Stage lighting serves four primary purposes, as outlined by Stanley McCandless: visibility, naturalism, composition, and mood (Palmer, 1985, p. 4). Visibility involves manipulating light and shadow to control what is perceptible on stage. Naturalism establishes the setting's reality, reinforcing other production elements and implying a reality beyond the stage. Composition arranges light to create an overall visual design, providing context for human figures. Mood evokes specific emotional responses from the audience, often through high-contrast environments that capture and hold attention. Flynn and Mills (1962, p. 41) noted that "high brightness contrast is a well-established technique in theatre for gaining and holding attention". Chiaroscuro, or the interplay between light and dark, creates visual interest, while reflective surfaces and illuminated objects can serve as dominant elements in the space.

In the context of composition, positive space refers to forms that appear to have volume, while negative space refers to the area between these forms or the background around them. The positive space usually dominates the attention of the audience as it contains vital information. However, negative space also has a distinct shape, which is defined by the limits of the positive form. A clear negative space can provide unity to a series of scenes. Interestingly, light has the ability to create a feeling of negative space even when there's no physical space around the object. The amount of negative space in a composition can affect the overall feeling of openness. A composition with more negative space than a positive form will appear more spacious. It is impossible to have a form without any background contrast, so there will always be some negative space. However, if the negative space is too small or indistinct, the composition can end up feeling cluttered, flat, and boring. High contrast and a high ratio of negative space to positive form make stronger, more dramatic visual statements. (Palmer, 1985, p. 146-148)

Like architectural spaces, lighting design in theatre depends heavily on the surfaces provided by the scenic designer. It encompasses various design elements, including colour, brightness, spatial organization, focus, balance, gradation, and tonal effects. To create effective lighting structures, Palmer recommends identifying structural features that bring character to the setting or help define the space. The lighting should interpret the form of these elements accurately. For instance, if the space has a layered look, the lighting should highlight the differences

between each layer to separate the planes and accentuate the depth of the composition. In some cases, large unbroken surfaces in the scenery require variegation in the lighting to avoid monotony, or if the scenery is busy, it needs lighting that blends and calms it down. Shapes that unify the setting, repeat themselves or have unusual shapes should be preserved or enhanced for most of the scene. Analysis of scenic design should aim to identify sources of harmony, preserve, or disrupt them when appropriate, and factor in scene changes and moving scenery's influence on production rhythm.

A variation of Richard Kelly's approach emphasizes ambient or general, task, and accent lighting (Livingston, 2014, p. 71). There, ambient light plays a crucial role in setting the tone of a space, while task lighting is used to provide additional light in areas where specific visual tasks are performed. Accent lighting is used to add visual interest to a space by highlighting specific architectural features or objects and can serve as a guide for people moving through the area. Fill light, on the other hand, provides the audience with a familiar scheme, which is important for establishing credibility and authenticity. By using these two sources in combination, designers can create a starting point of normalcy, which can be used as a basis for more dramatic or realistic lighting depending on the desired effect. The credibility of these two light sources is particularly enhanced when the key light comes from an expected quarter, typically from above the object, like the sun or other natural light source. This in turn is made more recognisable if the key light comes from an angle other than at right angles to the observer (Fraser, 2002, p.41). Backlight promotes the idea of dimensionality, the reality, or the depth of an object. As with other key sources, an 'off-centre' backlight lends itself to the better creation of verisimilitude, or naturalness, in a stage picture. Side lighting can appear most striking. Cross-lighting, on the other hand, is softer and can be used to create a more natural appearance. Up-lighting creates the most unreal appearance, while oblique angles are best for conveying depth. In the context of 3D modelling, having full control over peripheral and key lights can give artists more creative direction help to focus attention on specific items and guide the viewer's eye. In general, hard edges are perceived as aggressive, while soft edges are seen as passive. Soft-edged beams often have imperceptible edges, which can add to the context of a scene.

To perform a thorough analysis of scenic design, it is crucial to closely examine the setting to comprehend how the design operates and honour the designer's intentions. Furthermore, it is essential to uncover ways in which lighting can enhance or appropriately alter the appearance

of the scene and identify opportunities within the setting for intriguing lighting. In most theatrical productions, the illusion is blended with the enhancement of reality. In virtual spaces, lighting should be utilized to establish mood rather than to replicate reality. While locations can imply the quality of illumination, they should not constrain artists. They can take numerous liberties without compromising the illusion of reality, as the narrative always takes priority over realism or precision.

Chapter 4. Movement in Light.

Light is a remarkable architectural element that exists in an intangible form. Similar to sound and heat, it disperses through materials and their shapes, impacting our daily routines and providing structure and regularity. The movement of light, whether it's a natural effect or a cue, can be visually striking and powerfully instructive. The speed of changes dictates mood, while split timings can provide greater control over its movement. In an architectural environment, direction is experienced in subtle ways, such as changes in intensity, colour, and distribution caused by variations in daylight entering through windows, automatic control system adjustments, and movement from one area of a room or building to another (Livingston, 2014, p. 64). The natural light of the sun is a crucial element that links various fields, including art, science, religion, and philosophy. For artists, it provides a means to create realistic scenarios by adjusting their quality and quantity to achieve the desired outcome. Understanding the sun's movement and position based on location and calendar aids in achieving a more convincing effect. Effective lighting design should be integrated in such a way that it is barely noticeable to the occupants of a space. Lighting should inspire and highlight scenes, improve the appearance of subjects, and foster emotional connections. As Gallardo (2001, p. 370) notes, "Lighting is intended to accentuate a scene, enhance a subject's appearance, and create an emotional connection."

Artists have complete control over all aspects of light in virtual environments. From a theoretical perspective, this type of lighting is more like theatrical lighting than architectural lighting. Various elements of light can be controlled, such as brightness, colour, direction, beam spread, illumination angle, beam edge softness/hardness, location, and depth of shadows. While the software is able to simulate real-world lighting with multiple-point sources and three-dimensional light arrays, it can never fully replace natural light. Instead, these solutions should be viewed as artificial luminaries. Given the many possibilities and aspects to adjust, having clear lighting guidelines is crucial to avoid overexposing the scene and confusing the viewer.

Upon reviewing the information presented in the preceding chapters, there are several vital inquiries to pose. Firstly, what are the objectives of the lighting designer? Secondly, what is the purpose of lighting? Thirdly, what visual tasks are at play, and are they compatible with one another? Lastly, who are the intended users? The significance of lighting is contingent on the production concept and its function within the performance at that moment. It is essential to have a clearly defined main key light with sufficient contrast to establish the primary focal point. Complete control over peripheral and key lights grants artists greater creative direction and enables them to direct the audience's attention to specific elements, guide the eye, replicate photography, and more. Ultimately, artists should be mindful of how the distribution of light impacts the visual perception of spatial confinement.

Results

This paper serves as a foundation for more comprehensive analyses of architectural lighting and its ability to create immersive virtual environments. Future research would greatly benefit from applying these findings to specific 3D examples in the context of gaming, virtual reality, and installations. As a source of inspiration, this paper encourages those in the CGI field to further explore lighting and create meaningful works of art. To note, due to the paper's limited scope, the topic of colour in lighting was not explored, and various detailed aspects of architectural luminescence were either condensed or omitted. The presented questions could be expanded upon to explore the cultural context and interactive methods in which immersive lighting can be investigated in greater depth.

Conclusion

Lighting plays a crucial role in the design of 3D spaces and adaptive environments for aesthetic and functional purposes. As such, it is a function that cannot be overlooked. The effective use of lighting not only enhances the visual appeal of the environment but also contributes to the overall experience of the space. It is therefore imperative for CGI artists to give due consideration to lighting as an integral part of their design strategy. Its role in connecting or separating indoor and outdoor spaces needs to be acknowledged. The interplay between light and the form of a space either harmonizes or differentiates it, or even creates the illusion of a larger area. The placement of illuminated areas, whether central or peripheral, can greatly impact the viewer's experience. Brighter contrasts tend to draw more attention and affect perception, while a flickering of light towards the edges creates a wider impression. Moreover, brighter areas in the ceiling give an impression of height. All these elements together have a significant impact on the audience's interaction with both real and virtual environments. While designers use light to influence movement and the path people take through space, it cannot replace signage, barriers, or architecture in controlling movement. Nevertheless, light is a crucial design aspect that should not be overlooked and, when analysed and used properly, can greatly enhance the immersiveness of artwork.

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