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Spatial function of light in staging of contemporary choreography

Función espacial de la luz en la puesta en escena de la coreografía contemporánea

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ABSTRACT

The principles of using light in choreographic performances are the basis of image perception integrity. The novelty of the study is determined by the fact that the illumination as a component of the performance can be based not only on the physical laws of light, but also on its imitation. To look into the matter of illumination, the authors consider it necessary to use a polygonal model, which can also form a spatial picture if necessary. The paper defines the general illumination model, which uses ray tracing technology and allows to determine the structure of lighting in the hall and to distribute the light to understand the director's intention among the entire visual sector. The practical significance of the study is determined by the structure of using lighting as part of staging choreography in the postmodern genre.

Keywords: Spectator; Staging; Structure; Concert-hall.

RESUMEN

Los principios del uso de la luz en las interpretaciones coreográficas son la base de la integridad de la percepción de la imagen. La novedad del estudio está determinada por el hecho de que la iluminación como componente de la actuación puede basarse no solo en las leyes físicas de la luz, sino también en su imitación. Para analizar el tema de la iluminación, los autores consideran necesario utilizar un modelo poligonal, que también puede formar una imagen espacial si es necesario. El trabajo define el modelo de iluminación general, que utiliza la tecnología de trazado de rayos y permite determinar la estructura de la iluminación en la sala y distribuir la luz para comprender la intención del director entre todo el sector visual. La importancia práctica del estudio está determinada por la estructura del uso de la iluminación como parte de la coreografía escénica en el género posmoderno.

Palabras claves: Espectador; Puesta en escena; Estructura; Sala de conciertos.

1. INTRODUCTION

The acting space, on which the director and the production designer work, appears as a result of the creative transfer and efforts of the lighting designer, since it is the artistic light that creates a new reality on the stage, conquering the dullness of the shadow and building order amid chaos. Thus, a designer, creating a light design, is an intermediary between technology and art. The idea of performance will be understandable only when the lighting designer interacts with the production designer and director. Their joint creative efforts should be aimed at achieving harmony in the construction and implementation of the concept of the stage performance. For this, the production director must have a certain technical knowledge, a general methodology regarding the light, and participate in the creative process.

Light is vital to every person. It accompanies us in the day and night, acting on us biologically, thanks to it we see the objects and perceive reality around. The spectrum of colours is also important for humans. It is the colour that prompts us to action, inspires and causes concern, warns of danger, soothes and guides our subconscious. Mimicking the natural light with artificial lighting in an enclosed space is one of the important challenges facing a lighting designer. Using technical means, it must create a certain mood, atmosphere on the stage, corresponding to a particular moment of the action. Empirical models of lighting in computer graphics are based on a certain set of qualitative knowledge about the physics of light, which can be summarised as follows (Melendez, 2012):

- different surfaces reflect light in various ways;
- there are diffusing surfaces for which light is reflected in all directions;
- some surfaces reflect the light falling on them equally in all directions;
- there are specular surfaces that reflect light in a small area around the direction of reflection;
- some specular surfaces reflect light exclusively in the direction of reflection.

The second category includes theoretical models based on physical concepts of the light theory (Butler, 2012). Provide accurate lighting calculations, and when combined with secondary lighting algorithms, these models allow lighting complex scenes (Porter, 2003). Images obtained using these models correlate very well with experimental data (Willmert, 2006). Therefore, these models are used when the accurate imitation of light behaviour is important (Watson, 1997).

2. MATERIALS AND METHODS

Based on the illumination model, we can determine the surface intensity at any projected pixel position. In addition, the illumination model can be applied to several selected points and approximate the intensity at other points on the surface (Caddy, 2012). Surfaces are usually rendered using scanline algorithms, which reduce processing time because they only use polygonal surfaces and only calculate intensities at the vertices of those polygons (Williams, 2019). Vertex intensities are then interpolated to other points on the polygonal surface (Camacho, 2019). When not only the direct illumination of the scene is taken into account, but also the secondary illumination, which is created by rays reflected or refracted from surfaces, the problem of global illumination is set (Moody, 1995). One of the main methods for solving this problem is tracing light rays using the Monte Carlo method (Fabiszak, 2018). For correct physical modelling of illumination and the construction of photorealistic images, methods of forward and backward ray tracing are used. One of the main problems with ray tracing is choosing the optimal paths from all possible options. In the general case, the tracing process is stochastic, and for convergence in complex scenes, it may be necessary to calculate so many paths that it deliberately removes the algorithm from the category of interactive ones (Figure 1) (Lehmann and Primavesi, 2009).

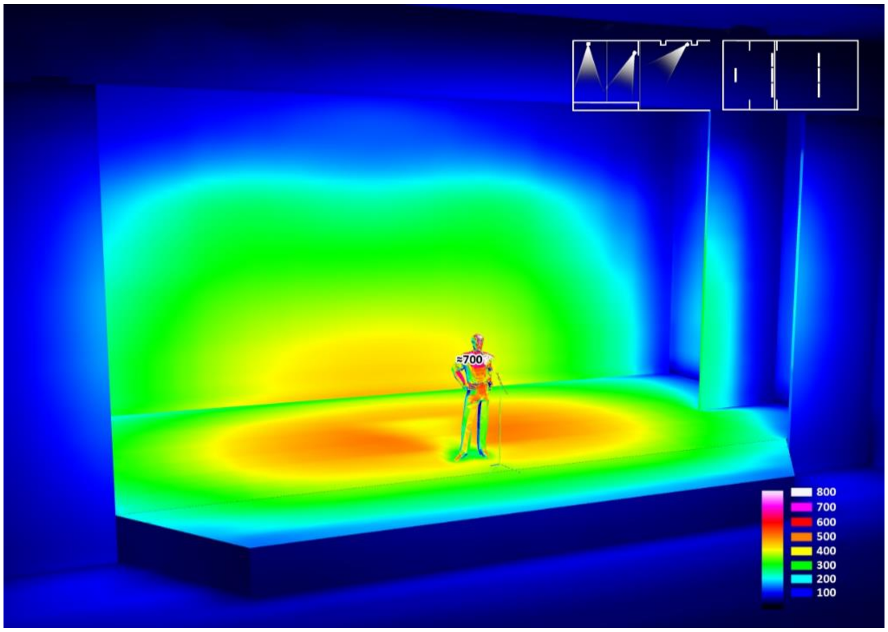

Figure 1. General light setup.

Acceleration structures reduce the time required to calculate the photorealistic illumination of virtual objects using ray tracing. They are spatial data structures that organise objects in a scene according to specific criteria. In this case, tracing of one ray no longer iterates over all the triangles of the scene to check the intersection with this ray, but with the help of this structure selects some rather small subset of them. A common drawback of existing methods and algorithms for acceleration tracing structures is the lengthy process of constructing/rebuilding these structures in the case of three-dimensional scenes with a high-order polygon number. Therefore, these methods and algorithms cannot be applied when calculating the illumination of dynamic high-poly three-dimensional scenes in real time, which is necessary to simulate a smooth and realistic movement of objects in virtual reality.

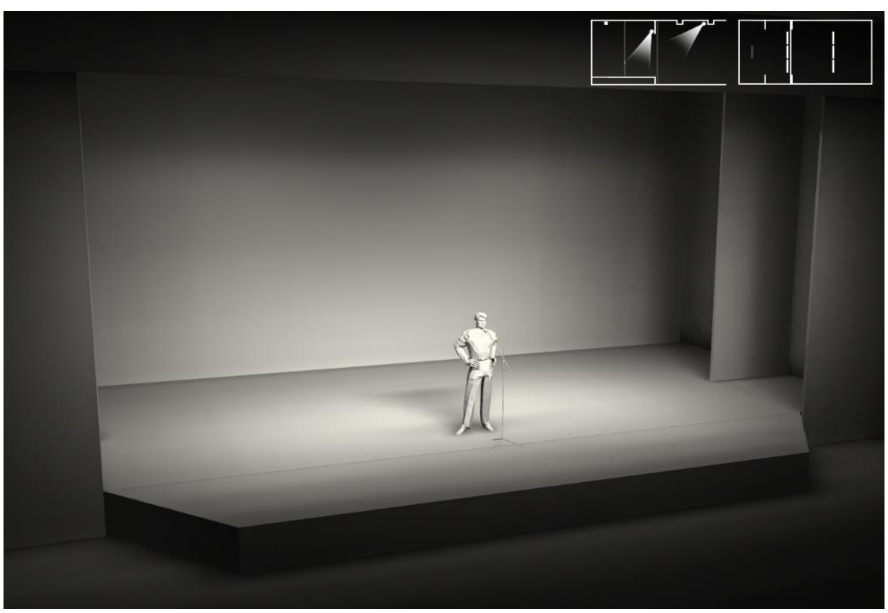

Figure 2. Rendering model based on the position of the speaker.

The use of hybrid methods of combined visualisation of high-poly virtual scenes makes possible to achieve high realism of synthesised images while maintaining the real-time rendering mode (Figure 2). For example, in the combined use of ray tracing and shader processing, where not all objects in the virtual scene require full photorealistic display quality. Objects located far from the observer will look almost the same to him regardless of how they are rendered. Therefore, it is advisable to reduce the computational costs on them by reflecting them using shader processing, which is performed faster than ray tracing, but provides lower quality rendering.

3. RESULTS AND DISCUSSION

To design the base of the light, it is essential to understand that it must highlight the participants in the stage production as three-dimensional figures. Creating realistic lighting in a scene is one of the biggest challenges when designing 3D graphics. In order for 3D models to look natural in the rendered image, they must be properly lit (Carnegie and Taylor, 2012). The scene is only a simplified physical model, so the rendered image does not always resemble natural. But despite this, lighting in a three-dimensional scene can still be brought closer to reality. To do this, it is necessary to follow two rules: install light sources and select their brightness so that the scene is evenly illuminated; set the lighting rendering settings.

In accordance with the approach adopted in computer graphics, the light calculation is divided into two main tasks:

- determination of the method for light calculation at an arbitrary point in three-dimensional space. It is solved by building a local mathematical illumination model;
- the use of a local mathematical illumination model for computer calculations of the illumination of three-dimensional objects with a specific geometry and surface properties, is solved using the shading model.

The construction of photorealistic images of complex scenes containing objects with these properties of transmission, reflection and scattering requires the use of physically accurate models for calculating the brightness generated by these objects. The choice of a lighting model depends on the number of objects that reflect the properties of their materials, as well as on the scene geometry, what type of light source is used. For example, a direct light allows to focus on a specific object, while an omnidirectional light illuminates the entire scene. Illumination models are approximations of the laws of physics that describe the effects of surface lighting. To reduce the amount of computation, most packages use empirical models based on simplified photometric calculations. More accurate models such as diffused reflection algorithms consider the propagation of radiant energy from a light source to various surfaces in a scene to calculate light intensity (Taylor, 1989). Existing local lighting models can be divided into two categories. The first category includes empirical models. They are usually efficient in terms of performance and some of them provide a reasonably realistic picture. They usually do not operate with such physical quantities as light energy or light flux. However, these models are widely used in areas where accurate physical lighting information is not required (Holland, 1987).

Stage performances are events where artistic illumination is necessary to create visual effects. Lighting should suit performers first of all, so it is artificial. However, artificial lighting cannot be as effective as natural lighting, because it cannot be repeated by technical means. There is no identical response to light, its sensory perception is rarely unambiguous. Light, like music, is perceived subjectively, so the light score will always be a subject of controversy (Perez, 2018). Visual effects are designed for maintaining the action on stage and to escalate the viewer’s emotions. With skilful handling of lighting equipment, light can become an independent aesthetic entity and take on its own visual form (Vasiliou and Schofield, 2019). As Plato believed, the Sun, being the brightest source of light, is the messenger of reason, and the shadows are the places of human insignificance designated by it. Light sometimes acquires the qualities of a material substance, becoming a kind of echo of natural phenomena that cannot be comprehended.

According to the general method, human eyes notice: brightness, colour, shape, movement, distance. Light not just makes it easier for our eyes – it makes us able to see in the first place. To perceive and recognise visual images, a certain minimum of light is required. Visual perception is an individual process itself, caused by physiological changes in the body. These changes occur in accordance with how the brain perceives the interaction of the five factors listed above. Light is a type of emission that spreads evenly in all directions in the form of waves. Waves differ in longitude and frequency – parameters that determine the speed of their propagation. The wavelength of visible light ranges from about 380 nm (blue) to 780 nm (red). One nanometre is one millionth of a millimetre. The human eye does not perceive wavelengths less than 380 nm and more than 780 nm. However, there are technologies for converting invisible radiation into visible light (Figure 3).

Figure 3. Formation of closeness in choreography using lighting.

Light with different wavelengths is perceived by the eye as a variety of colours. The composition of white colour can be seen as a spectrum. The most intense colours in the spectrum are: violet (440 nm), blue (480 nm), green (510 nm), yellow (579 nm), red (650 nm). The following elementary colours can be distinguished in the spectrum: violet, blue, green, yellow, orange. The sixth elementary colour can be added to this row – purple. The arrangement of colours in the rainbow is similar to the arrangement of colours in the spectrum. Colour recognition is the result of a physiological process initiated primarily by physical stimuli. There are three types of photoreceptors in the retina of the human eye that are sensitive to different wavelengths. These receptors are called cones. Next to the cones, the other receptors, rods, responsible for the perception of brightness. Signals from photoreceptors are transmitted along nerve fibres to the brain, where they trigger a corresponding sensory response. The cones of different types of the sensory field overlap each other, so they respond to parts of the visible light range, and not to specific wavelengths. Such areas are called primary colours: violet-blue (448 nm), green (518 nm), orange-red (617 nm) (Holt, 2017) (Figure 4).

Figure 4. Illumination without directional light.

The eight elementary colours are determined by three types of receptors. The elementary colours black and white are called achromatic, others are chromatic. Mixed colours are created by combining multiple colours into one. Each shade receives a chromatic and achromatic component. The chromatic component is determined by the presence of chromatic colours in the mixture; achromatic – the presence of achromatic or their combination with chromatic colours. Primary colour indexing is used to identify individual colour shades. The index system establishes the potential of the three primary colours. The maximum possible colour perception corresponds to index 99. All other gradations are between indices 99 and 00. Eight elementary colours are arranged in this system in the following sequence: white, orange-red, black, cyan, violet-blue, yellow, green, magenta (Muza, 2009). To identify a colour, it is necessary to know its saturation, brightness, and what type it belongs to - chromatic or achromatic. A colour is considered definite if at least three of the four listed characteristics are identified:

- Chromatic type. The human eye can distinguish approximately 200 chromatic colours. These are the colours that we define in words: red, blue, green, yellow, etc.
- Achromatic type. The human eye can distinguish about 50 achromatic colours. Achromatic colours include white and all shades of grey and black.
- Saturation. This is the degree of paint, colour. The more intense the colour, the more its saturation.
- Brightness. The intensity level corresponds to the value at which the perception of chromatic colour is balanced with the perception of a specific achromatic colour.

Chromatic type, achromatic type, saturation, brightness – all these are collectively called colour perception. Both vision and hearing are integrative. However, if the ear can be taught to perceive the overtones of sound, then the eye, by its nature, is not able to distinguish between the individual components of a light ray. With the same brightness and the same chromatic type of colour, the human eye can see about 120 of its shades. There is also a relationship between the temperature of a heated body and the colour of the light emitted by it. The colour rendering index is of great practical importance. To determine the colour rendering index, it is first necessary to determine the position of the colour in the chromatic wheel. Light sources are classified based on their colour temperature. Their spectra are called standard types of emission. Colour rendition depends on the spectrum of the source illuminating the object. The colour of the light, in turn, depends on the colour temperature of the light source.

Actually, everything that determines the direction and concentration of light on the scene, is determined by the laws of optics. Optical equipment is not only lenses, it is, first of all, lens systems and, of course, reflectors (reflectors) that help to utilise their capabilities. To implement a creative idea, which consists in plans for the placement (fixation) and installation of lighting equipment, a wide range of lighting devices is required that reproduce the light emitted by the lamp. Each type of lighting equipment has a specific purpose, for example, space lighting, profile lighting, dynamic lighting or projection, special effects and the like. It is difficult to overestimate modern lighting equipment, as well as to predict the lighting engineering developments of the future, their novelty and design. Today, all actions related to the movement of the light rays, colour change, the design of the light system are developed and programmed using computer programmes in advance and are reproduced in finished form right during the performance. Stage lighting in ballet, taking into account the color scheme, is shown in Figure 5.

Figure 5. Stage lighting in ballet.

The modern dynamic equipment includes not only "smart" lighting devices, but also any other lighting equipment that can change position, colour, brightness using remote control. The most popular among dynamic lighting are two categories of lighting fixtures – moving heads and scanners. A scanner is a system in which a light beam is quickly and accurately directed by a specular reflector. At the same time, the body of the device remains stationary. Fixing the beam, changing its structure, changing colour and other effects – all this happens in the inner part of the stationary casing. Therefore, changes in illumination with scanners occur even faster than with moving head. A moving head is an illumination device that directs a beam of light to the required place without mirrors, moving a part of its body horisontally and vertically. Almost all moving heads have dimmer units for brightness control located in one shoulder of the moving beam ("yoke", a U-shaped movable structure mounted on the base of the device). The rest of the traverse arm contains electronics for controlling other functions (Sargeant, 1997).

Dynamic lighting devices designed by the principle of moving heads can be roughly divided into two groups: spotlights and devices with a blurred light beam. These two types of moving heads can move the light beam very quickly in any direction, from which contributes to its creative potential. Most of these devices are equipped with gas-discharge lamps. The control panel is the central control for the lighting system, coordinating and adjusting the various types of illumination. The lighting controller is used to identify individual lamps and adjust their brightness using faders, fader wheels, numeric keypad or touch screen. The current state of illumination is determined by a combination of individual lamps of different brightness and their position. The combinations are imprinted by recording the electrical circuits used or in electronic data storage. The list of lighting configurations for a particular show is recorded in turn on the hard disk or on a USB memory stick.

Acceleration in the domain of hardware and software that keeps more and more computing power in a smaller and smaller space – all of this radically changes the lighting design. A lighting designer can obtain a realistic depiction of the entire scene and all lighting conditions on the screen of his control panel. He can also closely examine every point on the stage space with the director and production designer, looking at the stage from any angle and making adjustments to the lighting at any time (Naidoo and Wittenberg, 2017). Realistic 2D or 3D modelling of the entire lighting scenario allows to develop and plan performance far from the scene and long before the action takes place. When developing a lighting concept, it can be very useful to use computer-aided design programmes (CAD Software) such as "WYSIWIG", "Vectorwork Capture". The final design phase of these programmes will provide a real-time view of the entire lighting scenario. Design in general and design of stage lighting in particular requires an appropriate strategy in using a unique symbol language. Lighting design should be based on personal experience and the absence of any precautions. Imagination comes into play, all the nuances of colour theory and lighting fixtures. This is what gives unexpected harmony or disharmony of colours and extreme lighting conditions. When developing a lighting concept, the following are taken into account: the choice of the lighting type; choice of equipment; choice of lighting contrast; choice of light quality; selection of effects.

A lighting designer should be aware not only of the director's script, but also become a full-fledged member of the production team, because the impression that performance evokes in the viewer depends not only on the director or production designer, but also on the general concept of artistic light. Lighting designer should also take part in the stage design. Developing planning the position of lighting equipment is traditionally a preliminary work that starts in the imagination of lighting designer, taking into account the scenographic idea. In the process of preparing the layout of the lighting equipment, it is prepared using CAD Software. For planning, the following information is required: plan of the acting area on a scale (1:20; 1:50; 1: 100); longitudinal section of the acting area and the auditorium on the same scale; the height of the acting area; a list of lighting equipment, configurations and maximum permissible loads of electrical circuits in this lighting system; control panel name.

In order to obtain a full picture of the stage space, the contours of the stage design are introduced into the plan of the acting area. Only then we can proceed to designing. Knowledge of the technical characteristics of lighting devices, as well as all equipment involved in the event, will help significantly. The design, implementation of the staged lighting concept largely depends on the experience of the people involved. The decisions made in the discussion of the concept prior to its implementation must be carried out correctly. Lighting equipment must be properly secured and checked. The production director, set designer and lighting designer and his colleagues are provided with comfortable working places next to the lighting control panel. It is important to have in the workplace not only a script, a plan of lighting equipment position, but also a monitor and the means of communication with all lighting technicians. When working on a performance, pop or rock concert, it is necessary to remember that the duration of the technical and artistic rehearsals is limited in time, because the stage equipment is rented for a short period. This requires, first of all, a fairly accurate plan for the placement of lighting equipment and a preliminary elaborated light sequence. This can only be achieved if there are precise directorial staging ideas. The lighting equipment must be placed prior to building the stage design. Next, the process of focusing or the final stage of setting up all lighting equipment begins. Adjustments of lighting devices in the direction should be performed as accurately as possible and in a certain sequence: first, the main and directional lighting is built, then the background and contour lighting, and, finally, the lighting devices that provide special effects. This process is similar to folding a mosaic pattern. When implementing an approved lighting concept, one should not make changes to it until the lighting setup is complete.

In order to make sure of the continuity and clarity of the intermediate lighting stages that make up the sequence, each state must be compared with the previous and the next. It is also important to know that a computer-controlled lighting system can react to whatever happens on the stage. However, it would be a mistake to think that pressing a single button is enough. Lighting control during rehearsals or staging takes place according to the plan that is laid down in computer memory. In this case, it is possible to introduce changes, provided that the operator is a qualified professional and familiar with the equipment and the setup itself. General lighting rehearsals are a moment when a lighting designer, like a production director, need to feel the artistic integrity of the image. The figurative speech of a lighting designer is as expressive as a painter's brush. The magnificent light design is as harmonious as the piece of music. Scientists believe that when the viewers perceive illumination, they spend up to 25% of the total energy resource and up to 80% of the nervous system. And it doesn't matter how much time was spent on lighting preparation or what kind of lighting equipment was used, because the quality criterion is the correct interaction of light sources, the correct choice of angles and especially the use of colour. Modern lighting fixtures provide very specific forms of illumination – moving light and moving colour. Actually, without these forms, it is already impossible to imagine the current lighting design of mass performances. The contrast between colours and expressive forms of lighting creates a dynamic tension that allows artistic lighting to become an integral aesthetic component of not only stage design, but also the theatrical performance.

4. CONCLUSIONS

A staging of a performance is a product of content (script) and form (direction, scenography and lighting design). Thus, contemporary world design has raised requirements of direction and stage design. Light not only defines space, creating the illusion of its increase or decrease, but also creates performance in the virtual dimension. Stage light can simulate water, earth, air and fire, create every emotional state. The light creates music together with the orchestra, accompanying its main chords with colour tints. It creates the illusion of the third dimension in a flat two-dimensionality. The audience physically and metaphysically perceives light both as a source of knowledge and as an aesthetic phenomenon, actually getting into an optical spectacle.

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