ABSTRACT: The Zsolnay Light Festival in Pécs is the only light festival in Hungary. The light show on the cathedral’s façade was a significant part of the 2010 European Capital of Culture programme. This paper investigates the impact of this dynamic art on the audience’s sensory experience using biometric technology. We evaluate six patterns projected onto buildings, which were distinguished parts of the animated light shows. For the attraction analysis of the animations’ key visual pattern frames, we use 3M’s VAS eye tracking simulation software. Furthermore, in parallel with Nikos Salimgaros’ engagement-theory on architectural facades, we explore how visual stimulation changes when projecting artificial light works on them. By establishing comparative groups of visual contrasts (i.e., figurative, space simulating, dynamic, or abstract), we obtain various levels of engagement.

KEY WORDS: Artificial lighting, architectural facades, monument preservation, pattern language, visual attention, and user engagement

Introduction

As a significant part of the living environment, the information presented by architectural facades affects the viewer (Lavdas et al. 2021). This gave rise to the concept of biophilic healing design, which proposed ten elements that can allow the viewer to establish more
intense connections with their environment (Salingaros 2020). We consider that a light show creates an equally important media facade for architecture. Unlike still images, it also enriches the buildings’ external membrane with a timeline (Colangelo 2021). In the post-pandemic era, projected architectural animation and art’s healing effect are topics worth exploring (Maturana et al. 2021).

3M’s VAS (visual attention software) is an artificial intelligence software that predicts visual tracking with decades of theoretical basis (Salingaros and Sussman 2020). In the validation of visual neuroscience, it became a biometric tool that can visualise unconscious human attention. However, the software analysis is a simulation – we cannot specify a living audience within our experiment. The results, therefore, are not influenced by demographic, psychographic, or cultural differences. Still, public engagement can be metrified in terms of first-glance visual attention by applying a heatmap, gaze sequences technique, etc. This method has been used lately in multiple researches of architectural psychology, built environment, product design, user experience, and miscellaneous fields (Lavdas et al. 2021, Salingaros and Sussman 2020, Sussman and Hollander 2014). This paper focuses on the effects of animated projection on the Cathedral of Pécs. We analyse the degree of viewer attraction of different types of visual works, and discuss the resulting eye-fixation paths. The latter propose which patterns are more suitable for architectural media facades in public spaces.

1. Theoretical fundaments in neuroscience and cognitive architectural psychology

1. Traditional architecture design matters
According to Nikos Salingaros and Ann Sussman, unconscious human engagement could stimulate a structure’s organised complexity. In other words, it draws visual attention, which could be interpreted as the fractal geometry of facade patterns (Katona 2021). Edges, joints, and ornaments help to formulate their self-similarity and complexity. It is feasible whenever it meets an architectural structure. A series of comparison studies are conducted between traditional architecture design and contemporary buildings. The results demonstrate how fractal geometry works to attract human engagement with the built environment (Lavdas et al. 2021, Salingaros and Sussman 2020, Sussman and Hollander 2014).

2. Eye-tracking technology with user experience and engagement
Eye-tracking technology has been developed and utilised in various domains to help understand the users’ visual attention. Moreover, besides widely-applied physical facilities, such as screen-based monitors and glasses, the simulation software is also convenient for researchers. The terms of the pre-attentive processing vision from neuroscience provide
academic support and help build algorithms to validate VAS, which could use artificial intelligence to predict the first glance of vision, i.e., the subconscious gaze (Visual Attention Software 2022).

II Comparative groups of visual patterns

With projection mapping, we could classify the dynamic visual patterns of the projected animations along with their architectural background. For the classification, we set up three comparative groups with different foci. The first group examined the spatial effect and structural intensity generated by the projected images (2D space versus 3D space). The second group focused on the visual content (realistic compared to abstract). Finally, in the third group, the sequential changes of tween animations were compared to random keyframe animations according to their dynamic effect.

1. 2D spatial versus 3D spatial

The two-dimensional spatial animation clips from Spain and France used visual patterns that occupied the building’s shape with tiling. The two European participants adapted the picture content to the exterior outline of the building, while Thailand produced three-dimensional spatial segments. However, all the animations were derived from the actual space of the building as a prototype with the following specific features:

a) Reducing the building into general geometric spaces (Thailand),
b) Leaving windows, doors, pillars, and sculptures as spatial elements, while dismantling the overall architectural space (France), and
c) Reconstructing the three-dimensional space by combining the structure of architectural elements (Spain).

2. Realistic versus abstract

The animation included realistic characters or content. The projected motion pictures conformed to general animation rules, e.g., door opening, walking, etc. On the contrary, abstraction was represented by nonrealistic patterns or computer graphics. In addition, viewers could also experience particle effects or other special effects such as water ripples or flames.

3. Linear/tween animation versus nonlinear/keyframe animation

In the animated visual pattern, linear or tween animation follows sequential changes such as the filling of the progress bar, brush drawing, or filling. On the other hand, nonlinear or keyframe animation, specifically in this comparison group, means a random visual change in each frame or keyframe, and the effect of the animation achieves an intense sensory stimulation.
Method of dynamic analysis with eye-tracking simulation

1. Preparation of experimental materials

We used Adobe Premiere for editing video clips based on animation scenes, marking the keyframes, and exporting frame sequences in segments with 25 fps (frames per second), 1 second duration, and JPEG format.

2. Data processing and visualisation

3M’s VAS software can be applied to predict eye movements. Aided by its AI (Adobe Illustrator) extension, six grouped and intercepted sequence frames were imported for analysis (25 images × 6 = 150 images processed in VAS). We studied the results from the algorithmic heatmap and gaze sequence. The coloured area in the heatmap revealed the viewer's attention. In the meantime, the gaze sequence was numbered (from 1 to 4) according to the order of eye fixations with the highest probability.

The VAS AI extension could demonstrate multiple results within one image layer. We imported each sequential frame in individual layers to execute the results, and then selected the first gaze sequence fixation to mark the position of the visual point. After this, we analysed the flow direction graph and lined up the visual points with white arrows to visualise the patterns' complex impact on viewer engagement. We looked upon this as an offset flow graph that informed us about the initial (one second) visual attention cast on the examined six animated visual patterns (Fig. 1).

Algorithmic results and discussion

The result from Group 1 shows that the first gaze fixation keeps stable in the central axis of the facade (Fig. 2), while in Group 2, the gaze sequence always follows the appearance of natural characters and keeps tracing their path. In comparison, abstract images do not affect attention – their heatmap colour stays blue or around average yellow (Fig. 3). The concept of motion rules comes from physics: the graph shows a red pathway that assumes linear movement (Fig. 4).

The offset of the gaze fixation reveals the degree of the audience's focus on the animated works (Fig. 1). Another significant parameter is the frequency of the long-distance path between two sequential gazes. When the motion graphic includes figural or ornamental art, or the movements are linear, the flow graph remains stable, and animations attract the attention of the audience. In contrast, marked with the letters K and L in Fig. 1, due to the irregular movement or nonfigurative abstraction, animation will result in measurable confusion. However, abstract objects may also provide locally intense stimulations (Fig. 4). In this case, attention on the tectonic building frame
drastically decreases, while the effectiveness of lighting stimulation relatively grows.

Conclusions

Artificial lighting artwork projected on facades provides a vibrant experience for the public, and contributes greatly to the visual quality of the built environment. Eye-tracking simulation is an effective tool for evaluating and comparing the effects of these projected animations, given that the generated patterns are superimpositions of the projected images and the buildings’ structural layers. The results draw a flow graph of fixation points that help understand user engagement with the involvement of time. Our research has shown that figurative art and linear or tween animation are more suitable for public attention. This investigation foreshadows some positive effects on the design of architectural environments, which support mental balance on the basis of Salingaros’ critical pattern theory. However, we must admit that, with only the visual component of the buildings’ complex experience evaluated, our algorithmic comparison has its own limitations. Animation is a combination of both visual and audio art. We selectively examined visual attraction without audio effects, yet we extended the use of VAS analysis to the unexplored field of architectural lighting design.

References


Figure 1. Three-dimensional gaze sequence flow chat of six visual patterns. (Drawing by the authors)

Figure 2. Gaze sequence (A1, B1) and Heatmap (A2, B2) from VAS. Colour scheme marked the first fixation-point-flow graph (A3, B3). (Drawing by the authors)
Figure 3. Gaze sequence (C1, D1) and Heatmap (C2, D2) from VAS. Colour scheme marked the first fixation-point-flow graph (C3, D3). (Drawing by the authors)

Figure 4. Gaze sequence (E1, F1) and Heatmap (E2, F2) from VAS. Colour scheme marked the first fixation-point-flow graph (E3, F3). (Drawing by the authors)