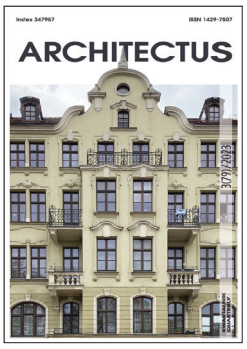

Architectus

2024
3(79)

DOI: 10.37190/arc240311

Alina Lipowicz-Budzyńska*

Visual interference – artistic possibilities of linear mixed arrangements

Abstract

The aim of the author of the article is to investigate the possibility of using the phenomenon of visual interference in architecture. The research is experimental and serves to develop a module consisting of two layers, which will be multiplied and placed on a glass façade. The research can be used to develop an image processing method using interference. In the introduction to the article, various forms of interference in graphics composed of linear elements are discussed. Examples of flat, non-transparent projects in graphics and painting are cited. Then, a group of spatial images was presented in the form of installations or placed on two layers of glass. Research aimed at developing a graphic layout to be placed on a glass façade is presented. The article briefly describes the creation of a module – a graphic element that is used to develop more complex compositions that can be used in a glass façade. This is a step towards creating a compendium of knowledge about this phenomenon and existing solutions. The results of our research can be an inspiration for artists and architects, as well as an incentive for designers and investors to use them in architecture.

Key words: visual interference, moiré, glass façade, façade graphics

Introduction

Visual interference, known as the moiré effect, is one of the physical and optical phenomena used in art. It is a valuable way of making an intervention, and a key artistic tool paving the way for new compositional values in architecture. The effect occurs between at least two layers of an image made up of fine elements with a periodic or aperiodic structure.

The author's interest in the phenomenon of interference results from her search for new ways of expression and creating ornamentation in architecture. The moiré effect is an important phenomenon, used in various forms of artistic expression. Keeping the building's shape simple, it enables the introduction of modern ornamentation, both inside the building as well as on its façade.

Using transparent mediums like glass is especially justified here. When the graphic layers are set at a distance from each other, it creates a visually mobile image, i.e., one that changes as the observer moves. This has a significant potential for application in building façades and interiors.

A visually mobile image may, in some cases, replace multimedia façade systems. It is perfect for environmentally-friendly-architecture: it does not require electrical power and is resistant to weather conditions.

The prediction of moire formation is difficult at the design stage. Resulting optical effects are therefore equally suprising for architects and investors (Brzezicki 2011, 291). While working on interference images, an artist usually needs to rely on chance. The expected result of the following experiment is the development of a method for creating interference images that would allow the artist to have control over the outcome of such work. The development of the method shall support the author as well as graphic artists and architects in their work creating images that generate visual interference. The experiment was based on the specific approach to taking decisions that is typical for artistic exploration[1].

* ORCID: 0000-0002-5428-0082. Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland, e-mail: a.lipowicz-budzynska@pbs.edu.pl

[1] *open mind* […]; *independence and courage when expressing opinions and taking actions; spontaneity and expressiveness, no fear of*

The main purpose of the project is to analyse the visual interference occurring in art, with a view to using it in architecture. The research is experimental, and aimed at developing a module consisting of two layers that could be multiplied and placed within a glass façade. Also, the behaviour of visual interference in each arrangement – due to change in the input graphic parameters – is discussed.

Design criteria and assumptions for the development of a module:

a) the ability to place an image on two glass layers,

b) the image generates visual interference,

c) module graphics efficiency – the nature of the image should make it possible to create varied compositions:

– textured,

– artistically varied,

– with vertical or horizontal structure.

One of the objectives is to examine how useful visual interference is for advanced façade systems, e.g., with the use of photovoltaics.

The article presents a historical overview and various cases of visual interference in graphics and architecture. The questions related to the perception of an image placed on two layers of a transparent medium are discussed. The subsequent part presents research aimed at developing a graphic system that can be used for placing images in glass façades.

The research results, being the developed module together with compositions, have been reported to the patent office.

State of research

Publications and literature showing the state of research as regards the subject of the moiré effect can be divided into several groups. Research in this field can be found in mathematics, optics, physics, graphics and mechanics. The phenomenon is analysed in terms of its presence in the currently very popular raster images, or its use in materials science for analysing deformation of components.

One of the first studies of raster image can be found in the *Raster imaging and digital typography II* conference report, where, in the article *The moiré phenomenon in color separation*, Isaac Amidror discusses digital images (Amidror 1991).

There are several studies on preventing the moiré effect. As an undesirable phenomenon, visual interference occurs, for instance, in printing. A paper by Isaac Amidror, *The theory of the moiré phenomenon* (Amidror 2012), is an example of this effect being analysed. The initial objective of the analysis by this author was to understand the nature and reasons of raster images overlaying each other, in order to find a way to avoid the negative impact in colour printing. The interest in this topic within the scientific community prompted the author to continue his research, and publish more papers, where his focus is on analysing the periodic (Amidror 2007a) and aperiodic images (Amidror 2007b). The research concerns mathematical analyses of how the moiré effect occurs in both these types of images.

One of the first publications on what causes interference effects in graphic elements placed on two separated layers is *Advances in optics. Reviews*, which includes an interesting chapter titled *Moire effect in 3D structures*. It was compiled by Vladimir Saveljev, and concerns spatial forms. The author discusses the visual interference phenomenon occurring between flat structure layers, such as steel mesh, linear structures, open weave fabrics (Saveljev 2018).

Research conducted by graphic designers and visual artists is often presented in albums and lexicons, in which the authors display designs and graphic projects they themselves have created. One of those is a book by Carsten Nicolai titled *Moiré index* (Nicolai 2010). It is also worth mentioning the article by Stelli Baraklianou – *Moiré effect: index and the digital image* (Baraklianou 2014), where the author looks at the occurrence of visual interference in digital images.

Studies on how this phenomenon is used in architecture are also available. One interesting study in this field is a book which analyses the works of Dutch architecture firm UNStudio. In the *UNStudio: diagramma struttura modello pelle ibridazione* publication, the *Pelle come nuovo paradigma: superficie digitale* chapter lists buildings in which visual interference is used (Corsi et al. 2015).

Further research focuses on the perception of visual interference. *The perception of movement and depth in Moiré patterns* by Lothar Spillmann (Spillmann 1993) is an interesting example of this. It contains a mathematical description of the effect of "optical lines interference", which occurs as recurring visual stimuli, such as grids, which overlap and move relative to each other. The study reviews the laws of physics that the moiré phenomenon is based upon, as well as discusses their relation with psychophysics. The origins of stereoscopic depth are described in the study. An explanation is provided on how we perceive the movement of the image that occurs in different directions and at different depths. Furthermore, the basis for perceptual "irritations", which often appear in relation to the interference image, is also discussed.

Designer's controlled and randomly generated moiré patterns in architecture by Marcin Brzezicki (Brzezicki 2011) is one of the articles that present visual interference in architecture. The author takes a detailed look at various aspects of the occurrence of the moiré effect in the architectural space. The part focused on research includes an image analysis, and lists factors that affect the control of how moiré stripes are created: controlling line inclination, and intensity. One of the subchapters discusses the mobility of an interference image and its perception.

Another set of studies focuses on the application of visual interference in optics, optical engineering (Malacara, Thompson 2001) and microscopy (Hawkes, Spence 2019). They present the results of research on how to improve image quality.

It is interesting to look at the studies on using optical methods for measurements in engineering, mechanics, and physics. The discussed techniques include the classic interferometry, photo-plasticity, spatial filtration, holographic

risk, ability to focus and being fascinated with the task at hand, ability to integrate opposites (Dorobczyńska-Semeniuk 2024, 11).

interferometry, laser speckle interferometry (Cloud 1995). The *Moiré fringes in strain analysis* book contains a comprehensive description of deformation measurements in engineering structures. The authors describe the details of methods and techniques for analysing deformations using the moiré phenomenon. They also discuss the topology of curved surfaces determined with the moiré effect (Theocaris 1969).

Methods

The research presented in the article was conducted in early 2023. It included a number of sketches and experiments aimed at developing a base module, from which compositions are to be made. Design criteria and assumptions for the development of a module are presented in the Introduction. The base module is to be composed of two graphic layers placed on a transparent medium and at a distance from each other. The shape of linear arrangements is constant; it may provide a matrix for the screen in screen printing. The things that change are as follows: image quality – in monochromatic graphics; and the colour arrangement – in colour graphics.

The experimental method was applied in creating the image. Four stages of the procedure were set (Fig. 1). In the first part (Level 1), the type of image was selected. Based on an analysis, an image was selected for further analysis (the selected one was a linear image). The second stage (Level 2) was compositional modification of the image (a mixed arrangement was selected). After that (Level 3), the type of image transformation was selected (the mixed nature of the image was retained, with a slight adjustment to the distance between the lines). Stage four (Level 4) was about methodically putting together the multiplied module and creating a large image.

The behaviour of visual interference in each arrangement – due to change in the input graphic parameters – was also examined. At each stage in all of the configurations, the shape and density of visual interference were analysed in relation to the modifications of parameters of each image option; the data are provided in Tables 1 and 2.

The potential of visual interference

The name *interference phenomenon* relates to the physical effect to do with waves that occur between at least two arrangements located within the area of their influence. Wave sources may either be spot or linear, and their range may correspond to the frequencies of visible light or sound. Where the waves overlap, they are either amplified or reduced (Fig. 2a). In linear arrangements, this depends on how the waves are located in relation to each other. In centric arrangements, this process occurs dynamically in a given area (Hariharan 2003).

Interference arrangements have no physical manifestation; they only appear between two layers of an image. Despite that fact, both 2D as well as 3D interference has its own parameters that shape how it is seen. These are:

a) frequency – determines the number of components (e.g., lines) per a given unit of length (Post et al. 1994);

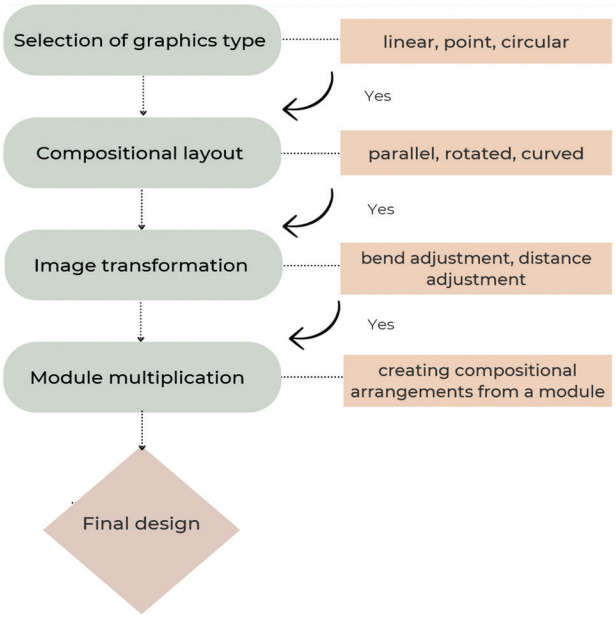

Fig. 1. Subsequent stages of image transformation in the experiment (elaborated by A. Lipowicz-Budzyńska)

Il. 1. Kolejne etapy transformacji obrazu wykorzystane w eksperymencie (oprac. A. Lipowicz-Budzyńska)

the frequency can be influenced by: component layer frequency, grid rotation, change of grid shape,

b) intensity – a parameter connected with the number of clear spaces versus black stripes in component grids (Lipowicz-Budzyńska 2023) (Fig. 2b), "describes the average rate of white (unused) space per a unit of area (Curcio et al. 1990, 497–523),

c) inclination – the inclination of visual interference *b* depends on the angle *a* between component grids (Fig. 2c); moiré lines appear at an angle equal to *a*/2, perpendicular to grids in any pattern. With acute angles, *the more acute the angle is, the clearer the moiré pattern* (Amidror 1991).

The parameters of 2D interference systems depend on the visual parameters of the component images of the so-called grid. In 3D interference systems, there are two extra variables that affect the shape and parameters of an interference image. The first of these parameters is the distance between the component images (Lipowicz-Budzyńska 2023). In the case of glass, or other transparent mediums, it will be the distance between the planes on which the grid image is placed. The second, dynamically changing parameter, is the distance of the observer from the image plane (Lipowicz-Budzyńska 2024).

Visual interference was introduced into art together with the traditional printmaking, while artists have been using it consciously since the 1950s, for example, in op-art. Artistic experimentation was initiated by the artists Ludwig Wilding, Victor Vasarely, Caren Nicolay, Jesus Rafael Sotto (Wade 2016, 311), Bridget Riley (Kudielka et al. 2014), Michael Kidner (*Michael Kidner…* 1993). The phenomenon occurs as a result of overlapping of graphic layers composed of repeated geometric shapes. Where image components overlap, it increases the density (Hariharan 2003, 792, 793) of the graphic structures that make up

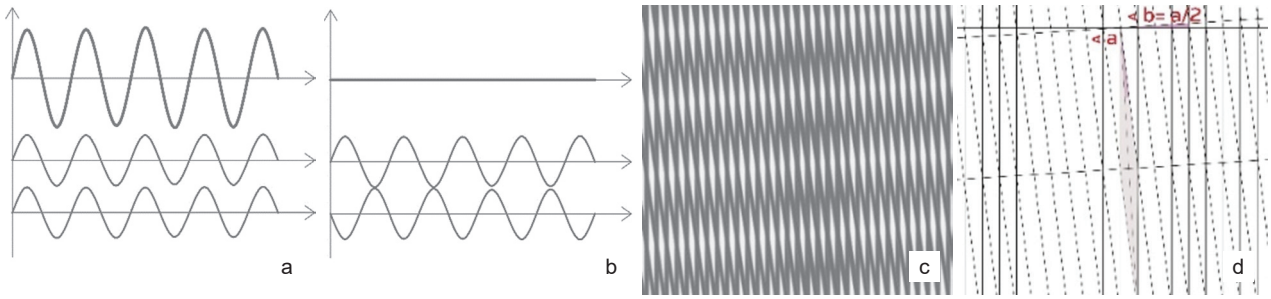

Fig. 2. Interference appears as a result of waves overlapping:
a) wave amplification, b) wave reduction, c) interference image intensity, d) the inclination of visual interference – image is magnified
(elaborated by A. Lipowicz-Budzyńska based on: Hariharan 2003, 792–793)

Il. 2. Zjawisko interferencji powstające w wyniku nakładania fal:
a) wzmocnienie fal, b) redukcja fal, c) intensywność obrazu interferencyjnego, d) kąt nachylenia interferencji wizualnych – powiększenie obrazu
(oprac. A. Lipowicz-Budzyńska na podstawie: Hariharan 2003, 792–793)

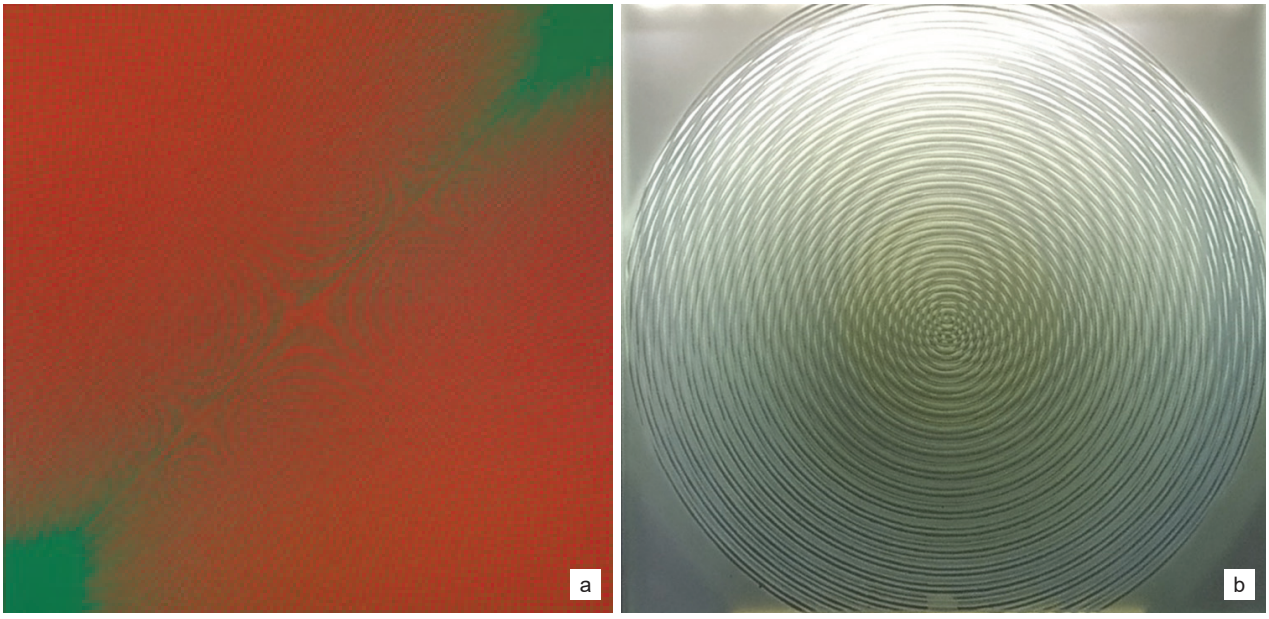

Fig. 3. Example applications of interference phenomena:
a) flat picture – painting: Michał Misiak I-1 (2011, oil on canvass, 100 × 100 cm) (Misiak 2023),
b) spatial glass installation – Alina Lipowicz-Budzyńska, *Interferencje* (author's original technique, 40 × 40 cm)

Il. 3. Przykłady aplikacji zjawisk interferencyjnych:
a) obraz płaski – malarstwo: Michał Misiak I-1 (2011, olej na płótnie, 100 × 100 cm) (Misiak 2023),
b) przestrzenna instalacja szklana – Alina Lipowicz-Budzyńska, *Interferencje* (technika własna, 40 × 40 cm)

organic compositions of various shapes: lines, circles and polygons (Amidror 2007a, 2–4). The art forms in which the image is visually stable – not changing in relation to the moving observer, include graphics, or painting (Fig. 3a). A visually mobile image, in which interference graphic arrangements change as the observer moves, is present in spatial works: installations, sculpture, artistic glass (Fig. 3b). In each of the art forms, the image is generated differently, using different dependencies and the characteristics of each form of artistic expression.

In the architectural space, the most commonly used images are spatial ones, namely those in which the graphic layers are at a distance from each other. As recurring visual stimuli from separated layers overlap, the *stereoscopic interference* phenomenon occurs (Spillmann 1993). This phenomenon is created as a result of binocular disparity and motion parallax. The effect on the viewer of a 3D image is much stronger compared to a flat image. The graphic layers move slightly relative to each other and interact, creating mobile visual interference. An increased distance between two graphic layers gives new properties to an interference image. Such an image has its depth, speed and orientation of movement. And in the case of curved graphics, also rotation.

The perception of visual interference in a multi-layer image depends on:

a) static factors – permanently linked with the image:
– the pattern of graphics placed on each layer,
– grid density,
– the distance between image layers,

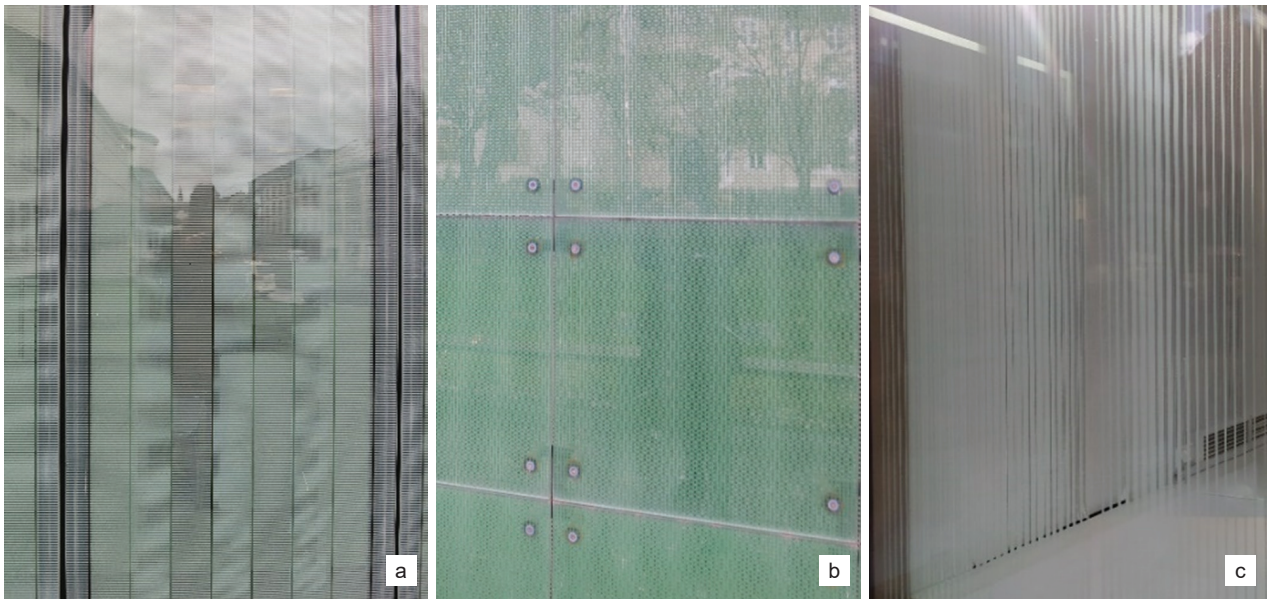

Fig. 4. Various ways of using visual interference in a glass façade:
a) the façade in the extension of Clarunis Universitäres Bauchzentrum Basel Standort Universitätsspital, Basel, Switzerland,
b) the façade of the Institute for Hospital Pharmaceuticals, Basel, Switzerland, c) an H&M shop window, Zakopane, Poland (photo by A. Lipowicz-Budzyńska)

Il. 4. Różne formy wykorzystania interferencji wizualnych w fasadzie szklanej:
a) fasada rozbudowy Clarunis Universitäres Bauchzentrum Basel Standort Universitätsspital, Bazylea, Szwajcaria,
b) fasada Institute for Hospital Pharmaceuticals, Bazylea, Szwajcaria, c) witryna sklepu H&M, Zakopane, Polska (fot. A. Lipowicz-Budzyńska)

b) factors related to the observer's location:
– distance separating the observer from the image,
– location of the observer relative to the image.

Frequently, the moiré effect in architecture appears by chance. It can commonly be seen in visually overlapping structures that involve waves. They can be seen in a layer view of images on balustrades, façade grids, perforated panels, multimedia displays. Visual interference is becoming more common in elevations as a result of controlled accident, a type of artistic intervention in architecture. In the micro scale, they are used in two-layer façade graphics, i.e., located in double glazing and façades with a buffer space.

A two-layer image may be placed on various mediums in different configurations:
– glass–glass (Fig. 4a),
– glass–steel mesh (Fig. 4b),
– glass–graphics placed on a non-transparent background (Fig. 4c).

In the macro scale, the moiré effect is used in architecture in the form of two-layer glass façades, where the structural components of both create the graphics of the so-called grid. As part of artistic interventions, spatial installations are used, where with the use of a two-layer image, the moiré effect is generated.

An example of a controlled use of interference in a façade can be found in Galleria Centercity in Cheonan, Korea. The façade in this building is composed of two vertical layers, integrated with a glass façade and a computer-controlled multimedia system (Fig. 5a). There is a buffer zone between the two façade surfaces. An area with a changing image is created around the building (Fig. 5b), while the façade visually changes as the observer moves. At night, the visual mobility effect is magnified by projections of smoothly changing colours.

More graphically advanced elements of the moiré effect appear on the Girls Grammar School in Brisbane, Australia. As opposed to the previous examples, images based on visual interference are much more complex here. The western façade of the building has been covered with two layers of lines, namely the outer layer is composed of black-painted aluminium panels, and the internal layer is an image composed of black lines on a white wall. The shapes of the elements placed on both layers, as well as the distances between them, were consciously chosen by the designer. Based on the example of this building, interference shape changes can be seen as the observer moves (a different distance and location relative to the image) (Fig. 6a, b).

The abstract and experimental façade that is visually mobile conveys a message, which according to its authors refers to the dynamics observed in the school (m3architecture "Brisbane Girls Grammar School…"). The example of this façade shows how much visual interference means in artistic and ornamental terms in architecture, which is still not fully appreciated and utilised.

Results

Linear images were selected for the experiment. In a two-dimensional image, visual interference of the linear type appears as a result of a change in the density of components, at least in one of the layers (Fig. 7a) or angular rotation of the image (Fig. 7b), or a modification to the shape of an arrangement in at least one layer (Fig. 7c) (Weisstein 2023). Wherever the graphical components overlap, swelling occurs, which is seen as dark linear arrangements or geometric shapes.

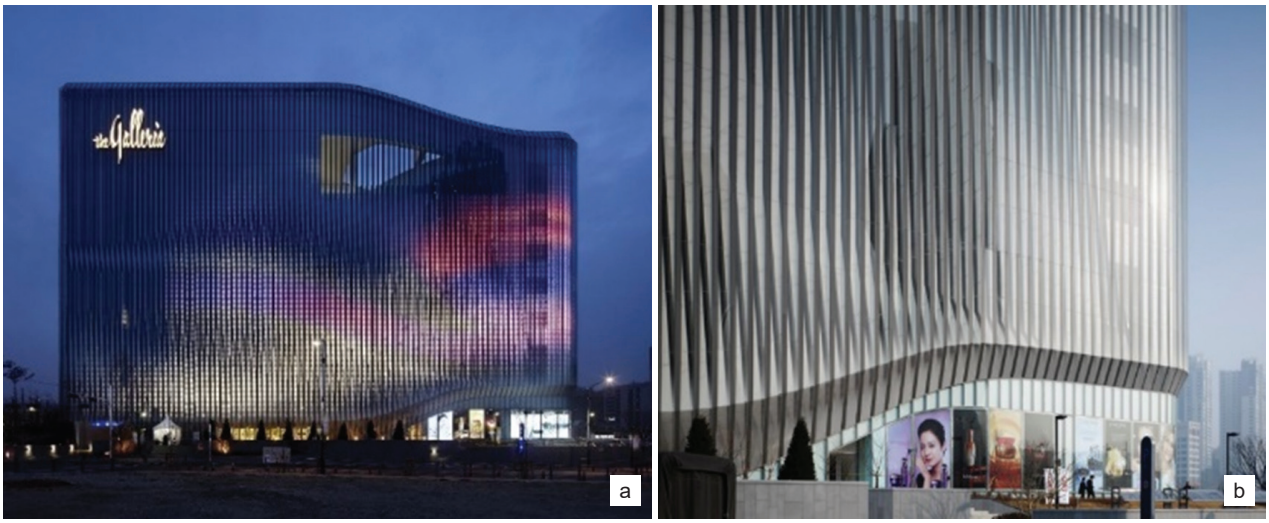

Fig. 5. Galleria Centercity, Cheonan, Korea, UNStudio, 2010
(photo by Kim Yong-Kwan) (UNStudio "Galleria Centercity…")

Il. 5. Galleria Centercity, Cheonan, Korea, UNStudio, 2010
(fot. Kim Yong-Kwan) (UNStudio "Galleria Centercity…")

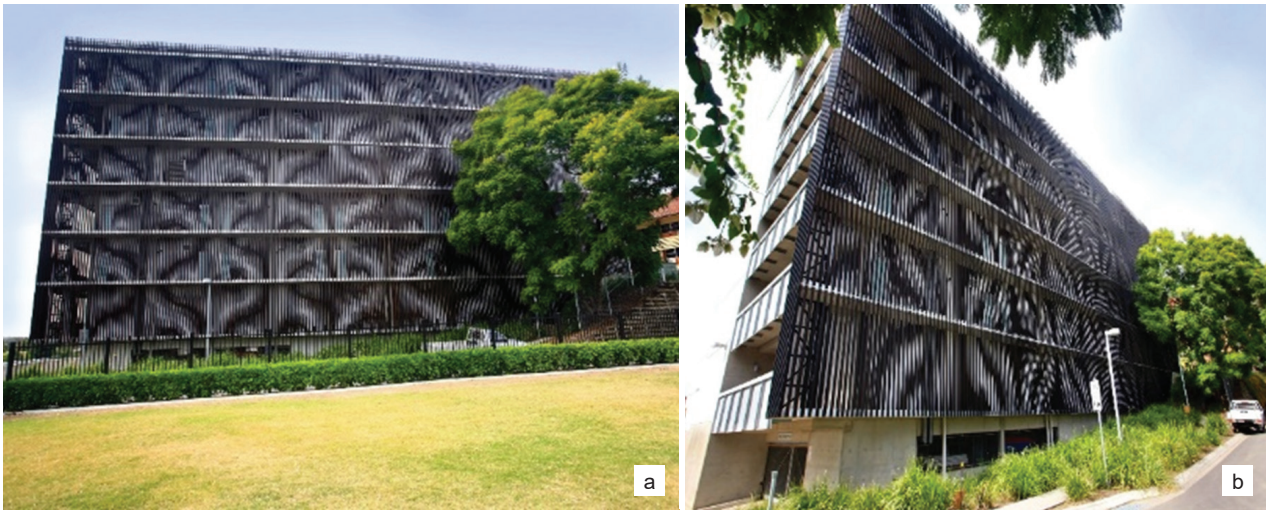

Fig. 6. Brisbane Girls Grammar School, Brisbane, Australia. Designed by m3architecture, 2007,
a change in the form of visual interference in connection with the observer changing his or her location
(distance, location relative to the façade):
a) photograph taken in front of the façade, distance of approximately 15 m, b) taken from the left corner, approximately 7 m from the façade
(photo from the Brisbane Girls Grammar School collection)

Il. 6. Budynek Brisbane Girls Grammar School, Brisbane, Australia. Proj. m3architecture, 2007,
zmiana formy interferencji wizualnych w związku ze zmianą lokalizacji obserwatora (odległość, lokalizacja względem fasady):
a) zdjęcie zrobione na wprost fasady, odległość około 15 m, b) wykonane z lewego rogu około 7 m od fasady
(fot. z kolekcji Brisbane Girls Grammar School)

The above base compositional arrangements have been analysed in terms of their usefulness for further research. The mixed arrangement was found to be the most effective (Fig. 7c). This type of image was selected for further analysis (Table 1).

The mixed arrangement (Fig. 7c) has been selected for further research. The arrangement was transformed in several configurations:

– image layers made up of straight and curved lines – the arrangement was kept due to its promising articulation (Fig. 8a),

– image layers composed of lines that are slightly bent and curved – the straight lines from the previous version were subjected to bending (Fig. 4a), resulting in a new arrangement (Fig. 8b),

– image layers composed of curved lines on each layer – the same multiplied curved component was used in both layers (Fig. 8c).

Following an analysis, it was decided to prepare a module composed of graphic layers made up of straight and curved lines (Fig. 8a). It was considered the most interest-

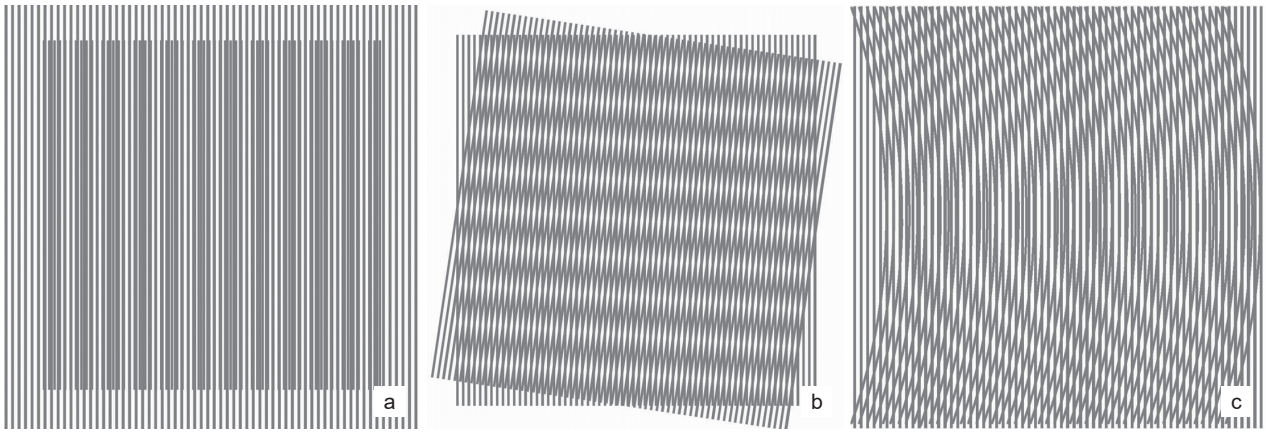

Fig. 7. Possible combinations of linear graphic elements: a) parallel location, b) bipolar location, c) mixed arrangement (Lipowicz-Budzyńska 2020)

Il. 7. Różne możliwości zestawiania ze sobą grafiki o charakterze liniowym: a) lokalizacja równoległa, b) lokalizacja bipolarna, c) układ mieszany (Lipowicz-Budzyńska 2020)

Table 1. Image analysis in linear graphics (elaborated by A. Lipowicz-Budzyńska)
Tabela 1. Analiza obrazu grafiki o charakterze liniowym (oprac. A. Lipowicz-Budzyńska)

Image structure	The shape of interference components	The density of interference depends on	Image perception versus the façade	The assessment of possibilities of using graphics in a façade (1–5)
Parallel location (Fig. 7a)	parallel to linear components	the difference in the line spacing between the two layers	disciplines the façade, directly referencing the building's shape	2
Diagonal location (Fig. 7b)	perpendicular to linear components	the angle between the lines of each image	adds dynamics to the architectural space	3
Mixed arrangement (Fig. 7c)	ellipsoid, going parallel to the arrangement of straight stripes	the difference in the line spacing between the two layers (Wade 2016) Arrangements bent opposite to the component graphics layer Increasing the distance between the graphic stripes along the curve results in a higher density of the interference components Increasing the distance in the layer between the straight stripes results in the reduction of interference components	an image with organic articulation that contrasts with the geometric shape of the building	5 the mixed arrangement was selected for further research as the one with the most varied form of visual interference, the shape and density of which can be controlled with the spacing in the image

ing due to the type of visual interference that contrasts with the building's shape (Table 2).

The next step was to develop final compositions to test the effectiveness of the selected module:

– the module was reflected and multiplied along the horizontal axis – textured arrangement (Fig. 9a),

– two directions of the mirror image axis were introduced – an arrangement with a horizontal symmetry axis and vertical symmetry axes (Fig. 9b).

A similar experiment was performed on colour graphics. A decision was made to develop an image – an arrangement with a horizontal symmetry axis, artistically diverse (Fig. 9a). The research included interference arrangements with intersecting magenta and green colours that created parallel surface interference arrangements. The colour version was placed on the façade of the architectural model (Fig. 10b).

Conclusions

In keeping with the original premise, the image that was developed has a potential to be used in glass façades, and can become a part of larger compositions. The graphics fulfil the adopted criteria:

– the image can be placed on two glass layers,

– visual interference develops in between the graphic layers,

– the module has the required compositional potential, i.e., it can be used in compositions of various different structures.

The developed graphics may become a part of larger arrangements in which different artistic and compositional qualities are present.

As per the original premise, the publication presents three types of compositional arrangements:

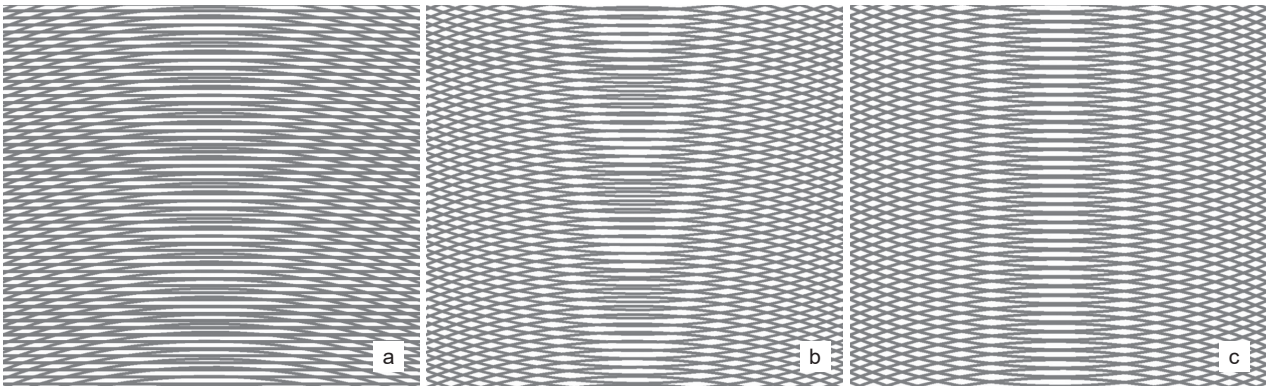

Fig. 8. Possibilities of combining two graphic layers in a mixed arrangement:
a) image layers composed of straight and curved lines, b) image layers composed of slightly bent and curved lines,
c) image layers composed of curved lines on each layer (elaborated by A. Lipowicz-Budzyńska)

Il. 8. Możliwości zestawiania ze sobą dwóch warstw grafiki w układzie mieszanym:
a) warstwy obrazu zestawione z linii prostej i łukowej, b) warstwy obrazu zestawione z linii lekko zakrzywionej i łukowej,
c) warstwy obrazu zestawione z linii łukowych na każdej z warstw (oprac. A. Lipowicz-Budzyńska)

Table 2. An analysis of the image composed of two graphic layers of a curvilinear nature (elaborated by A. Lipowicz-Budzyńska)
Tabela 2. Analiza obrazu grafiki zestawionej z dwóch warstw grafiki o charakterze krzywoliniowym (oprac. A. Lipowicz-Budzyńska)

Image structure	The shape of interference components	The density of interference depends on	Image reception versus the building's façade	The assessment of possibilities of using graphics (1–5)
Image layers composed of straight and curved lines (Fig. 8a)	uniform pattern, curved shape, parallel arrangement	the difference in the line spacing between the two layers	a cohesive image with organic articulation that contrasts with the geometric shape of the building	5 – the mixed arrangement was selected for further research, made up of straight and curved lines; it was considered to be the most interesting and effective
Image layers composed of slightly bent and curved lines (Fig. 8b)	non-uniform pattern, partly curved shape, parallel arrangement	the difference in the line spacing in the graphics of one of the layers	Non-uniform arrangement of the image, results in a chaotic composition	3
Image layers composed of mirrored curved lines (Fig. 8c)	uniform pattern, linear arrangements perpendicular to the direction of graphics – arched lines	the difference in the line spacing between the two layers; increasing or decreasing the distance between the stripes in one of the layers results in a denser and modified shape of the interference components	uniform textured image, composed of parallel straight strips, tidies up the façade	2

– textured,
– artistically varied,
– with a vertical or horizontal structure.

The system can be used together with semitransparent photovoltaic cells.

The multi-stage procedure used in creating the image proved to be helpful in the development of a recurrent module, and eventually a complex composition.

The analysis of the module's image, and therefore also the compositional arrangements that it was used to create, has shown that as the distances between the stripes are increased along the curve, which results in a higher density of the interference components, while increasing the distances in the layer between the straight stripes causes reduction in the interference components (Fig. 4c).

In colour arrangements, partially using transparent and opaque graphics, the obtained image surfaces have a visually changing colour as a result of an additive and subtractive synthesis.

The graphic components constitute an additional element that integrates the building's façade; the image composed of fine elements removes the division in the glazing and partly constitutes a curtain for the space between the graphic layers of the structure.

The distance between the images acts as a buffer zone for the building. In two-layer glazing, it improves sunlight protection and affects thermal as well as acoustic protection of the building (Edwards 2011).

The fact that the façade arrangement is based on a module makes building it simpler. Graphics placed on two

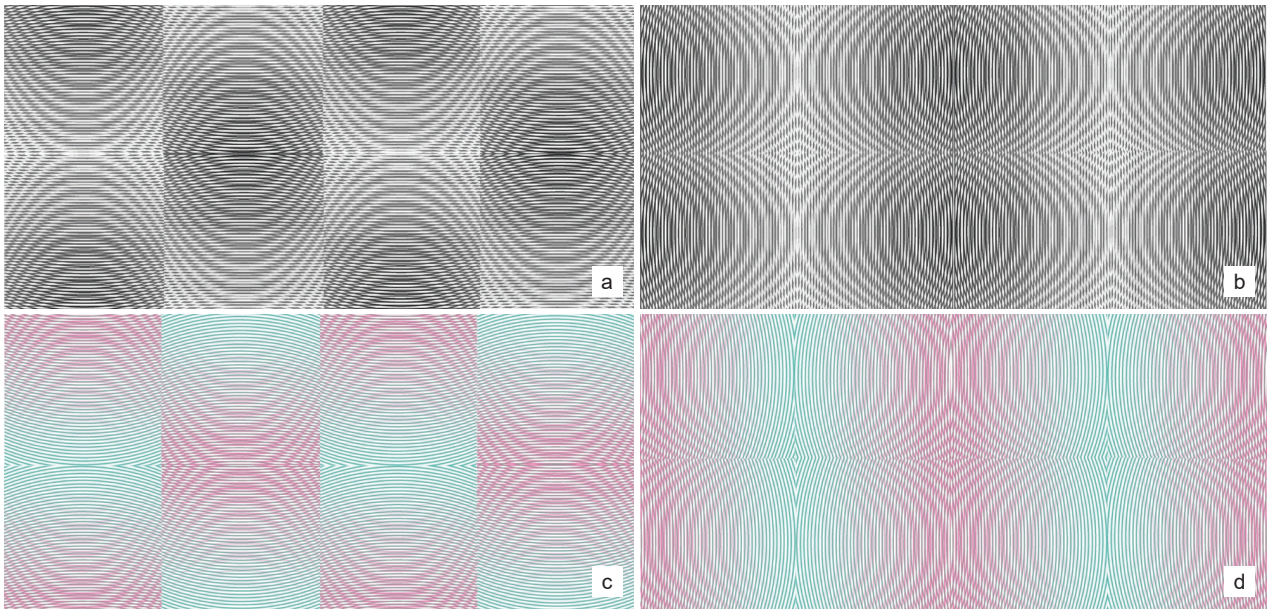

Fig. 9. Façade image built of a base module: a) textured arrangement with a horizontal axis, b) an arrangement with horizontal and vertical symmetry axis (elaborated by A. Lipowicz-Budzyńska)

Fig. 9. Obraz fasadowy zbudowany z modułu podstawowego: a) układ teksturowy z osią horyzontalną, b) układ z osiami symetrii horyzontalnymi i wertykalnymi (oprac. A. Lipowicz-Budzyńska)

Fig. 10. The application of a monochromatic image in an architectural model placed in an urban environment (elaborated by A. Lipowicz-Budzyńska)

Fig. 10. Aplikacja obrazu monochromatycznego na modelu architektonicznym umieszczonym w środowisku zurbanizowanym (oprac. A. Lipowicz-Budzyńska)

glass layers can be made using the screen or digital printing technique. One of the methods used in creating these graphics is taking the image onto glass using a cut-out film and sanding. This technique results in grooves, which add space to the image and can be lit on the edge.

It would be worth continuing the research presented in the article by analysing different paths. The author intends to find out more about the aesthetic potential of façades that contain the moiré effect. She would like to conduct simulations, apply the model in an urban environment, and examine the perception and significance of such interventions in public spaces as well as their impact on the users.

Translated by
Paweł Mrozik

References

Amidror, Isaac. "The moiré phenomenon in color separation." In *Raster imaging and digital typography II: Proceedings of the Conference on Raster Imaging and Digital Typography, Boston 1991*, edited by Robert A. Morris, and Jacques Andre. Boston: Cambridge University Press, 1992.

Amidror, Isaac. *The theory of the moiré phenomenon*. London: Springer Science + Business Media, 2012.

Amidror, Isaac. *The theory of the moiré phenomenon: Volume 1: Periodic layers*. London: Springer, 2007a.

Amidror, Isaac. *The theory of the moiré phenomenon: Volume 2: Aperiodic layers.* London: Springer, 2007b.

Baraklianou, Stella. "Moiré effect: Index and the digital image." *Footprint Delft Architecture Theory Journal*, no 14 (April 2014): 81–95. https://doi.org/10.7480/footprint.8.1.803.

Brzezicki, Marcin. "Designer's controlled and randomly generated moiré patterns in architecture." In *GA2011 – XV Generative Art Conference, Rome 2011*. Accessed April 1, 2024. https://www.generativeart.com/GA2011/marcin.pdf.

Cloud, Gary. *Optical methods of engineering analysis*. Cambridge: Cambridge University Press, 1995. https://doi.org/10.1017/CBO9780511575013.

Corsi, Andrea, Martina Dedda, Elnaz Ghazi, Elisa Morselli, and Valentina Nunnari. "Pelle come nuovo paradigma: superficie digitale." In *UNStudio: diagramma struttura modello pelle ibridazione*, edited by Gaetano De Francesco, Elnaz Ghazi and Isabella Santarelli, Raleigh: Lulu 2015. Available from: https://www.researchgate.net/publication/326273394_UNStudio_PELLE_COME_ NUOVO_ PARA DIGMA_ SUPERFICIE_DIGITALE.

Curcio, Christine A., Kenneth R. Sloan, Robert E. Kalina, and Anita E. Hendrickson. "Human photoreceptor topography." *Journal of Comparative Neurology* 292, no. 4 (February 1990): 497–523. https://doi.org/10.1002/cne.902920402.

Dorobczyńska-Semeniuk, Bożena. *Materiały szkoleniowe. Podstawy psychologii ogólnej*. Wyższa Szkoła Handlowa, Kielce. Accessed April 1, 2024. http://zasobyip2.ore.edu.pl/uploads/publications/0b84364e4cad3e37c0206018e95db9a6.

Edwards, Brian. "Sustainability as a driving force in contemporary library design." *Library Trends* 60, no. 1 (June 2011): 190–214. https://doi.org/10.1353/lib.2011.0030.

Hariharan, P. *Optical interferometry*. San Diego: Academic Press, 2003. https://doi.org/10.1016/B978-0-12-311630-7.X5000-X.

Hawkes, Peter, and John C.H. Spence. *Springer handbook of microscopy*. Cham: Springer International Publishing, 2019. https://doi.org/10.1007/978-3-030-00069-1.

Kudielka, Robert, Paul Moorhouse, and Richard Shiff. *Bridget Riley. The Stripe Paintings 1961–2014*. New York: David Zwirner Books, 2014.

Lipowicz-Budzyńska, Alina. "Aspects of coexistence between art glass and architecture – façade graphics." *Arts* 13, no. 3 (June 2024): 110. https://doi.org/10.3390/arts13030110.

Lipowicz-Budzyńska, Alina. "Visual interference in the glass facade." In *IOP Conference Series: Materials Science and Engineering* 960, (2020): 042079. https://doi.org/10.1088/1757-899X/960/4/042079.

Lipowicz-Budzyńska, Alina. "Image using interference effects in the glass facade." In *AIP Conference Proceedings*, 2928, (September 2023): 020010. https://doi.org/10.1063/5.0171176.

m3architecture. "Brisbane Girls Grammar School Creative Learning Centre." Accessed January 15, 2024. https://www.m3architecture.com/projects/brisbane-girls-grammar-school-creative-learning-centre/.

Malacara, Daniel, and Brian J. Thompson, ed. *Handbook of optical engineering*. New York–Basel: Marcel Dekker, 2001.

Michael Kidner. W poszukiwaniu eudajmonii/In search of eudaimonia. Łódź: Muzeum Sztuki, 1993.

Misiak, Michał. "dr hab. Michał Misiak prof. ASP." Accessed August 5, 2023. https://waw.asp.krakow.pl/Michal-Misiak.

Nicolai, Carsten. *Moiré index*. Munich: Gestalten, 2010.

Post, Daniel, Bongtae Han, and Peter lfju. *High sensitivity moiré: Experimental analysis for mechanics and materials*. New York: Springer, 1994. https://doi.org/10.1007/978-1-4612-4334-2.

Saveljev, Vladimir. "Moire effect in 3D structures." In *Advances in optics. Reviews*. Volume 1, edited by Sergey Y. Yurish, 61–75. Barcelona: IFSA Publishing, 2018.

Spillmann, Lothar. "The perception of movement and depth in moiré patterns." *Perception* 22, no. 3 (March 1993): 287–308. https://doi.org/10.1068/p220287.

Theocaris, Pericles S. *Moiré fringes in strain analysis*. Oxford–London–Edinburgh–New York–Toronto–Sydney–Paris–Braunschweig: Pergamon Press, 1969. https://doi.org/10.1016/C2013-0-05523-5.

UNStudio. "Galleria Centercity, Cheonan, Korea, 2008–2010." Accessed December 1, 2023. https://www.unstudio.com/en/page/12104/galleria-centercity.

Wade, Nicholas. *Art and Illusionists*. Cham–Heidelberg–New York–Dodrecht–London: Spring, 2016. https://doi.org/10.1007/978-3-319-25229-2.

Weisstein, Eric W. "Moiré pattern." MathWorld – A Wolfram Web Resource. Accessed August 15, 2023. https://mathworld.wolfram.com/MoirePattern.html.

Streszczenie

Interferencje wizualne – możliwości plastyczne liniowych układów mieszanych

Celem autorki artykułu jest zbadanie możliwości wykorzystania w architekturze zjawiska interferencji wizualnych. Badania mają charakter eksperymentalny i służą opracowaniu składającego się z dwóch warstw modułu, który zostanie zwielokrotniony i umieszczony na szklanej fasadzie. Badania mogą zostać wykorzystane do stworzenia metody przetwarzania obrazu z wykorzystaniem interferencji. We wstępie artykułu omówiono różne formy interferencji w grafikach złożonych z elementów liniowych. Przytoczono przykłady płaskich nietransparentnych realizacji z grafiki i malarstwa. Następnie zaprezentowano grupę obrazów przestrzennych w formie instalacji lub umieszczonych na dwóch warstwach szkła. Przedstawiono badania mające na celu opracowanie układu graficznego przeznaczonego do umieszczenia na szklanej fasadzie. W artykule krótko opisano tworzenie modułu – elementu graficznego, który służy do opracowywania bardziej złożonych kompozycji możliwych do wykorzystania w szklanej fasadzie. Jest to krok w kierunku stworzenia kompendium wiedzy na temat tego zjawiska i istniejących rozwiązań. Wyniki badań mogą być inspiracją dla artystów i architektów, a także zachętą dla projektantów i inwestorów do wykorzystania ich w architekturze.

Słowa kluczowe: interferencje wizualne, moiré, fasada szklana, grafika fasadowa