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Visual Comfort as a Design Approach for Intelligent facades: A review

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ABSTRACT
Undoubtedly, light is a key element for human beings to adapt to their environment and to see the form, the color, and the perspectives of different objects in their immediate surroundings. Almost 80 percent of the information we obtain daily through our senses we obtain through sight. The correct design of the illumination system and building facades should offer optimal conditions for visual comfort. To achieve this aim, a collaboration between architects, lighting designers, and engineers should be established to improve citizens' quality of life. This paper sought to bridge this knowledge by finding the link between daylighting, the building façades, and visual comfort. Accordingly, the paper conducts a theoretical review to evaluate the existing studies in an attempt to present this linkage focusing on kinetic façades. Then, an analytical review is conducted for 38 eligible records, that are extracted from different scholarly databases to find the assessment methods and tools used to determine the most favorable conditions of daylight for intelligent facades. Ultimately, the outcomes of the research will provide insights for further studies, in addition to that these connections can inform policy development to assist architects to design effective facades and more adaptive capabilities designed for the building envelope. Kinetic facades were found to provide visual comfort in addition to various productivity, economic, and environmental benefits, which in turn enhance the quality of life.

Keywords: *Intelligent Façade -Kinetic Façade - Visual comfort – Daylight – Sustainability*.

1. Introduction

Human beings have a significant ability to adapt to their environment and their surroundings. Light is an essential type of energy that humans can utilize. The illumination system correct design should provide comfortable visualization. Besides, the air quality, visual, acoustic, and thermal comfort should be strongly considered in buildings designs promoting the occupant wellness. Visual comfort is distinguished by enough natural light and artificial one, secondly. In addition, it is characterized by access to outdoors views and good glare control. Considering that color and light influence the psycho-physiological well-beings and productivity of individuals, the physiologists, ergonomists, and illumination technicians should seek studying the light's favorable conditions in different spaces. To achieve visual comfort, illumination systems should fulfil the illumination combination, luminance contrast, colors selection, light's color, and distribution(Calleja et al., 2011). The techniques of building façade also have an essential role in the delivery of daylight to the building's interior spaces. Moreover, they protect the building from external factors like cold, sunlight, and others. Hence, the daylight can be a good replacement for artificial one by improving the interrelations between indoor and outdoor environments(GhaffarianHoseini, 2013). Also, many studies stated that building façade contributes to 36% of total costs of energy in humid and hot climate environments with a high relation to daylighting performances and energy(Athienitis & Karava, 2007; Haase & Amato, 2006a, 2006b).

In this regard, intelligent façades are proposed to be an innovative solution to the sustainability enhancement in building environments. Intelligent facades include open joint ventilated, kinetic, double-glazed, double-skin, solar facades, parametric louvers, and parametric pattern facades. The literature agrees that intelligent facades should be responsive to three main parameters including occupants, context, and weather. Therefore, the interrelations between the parameters and intelligent façade should be non-linear, stochastic, dynamic, immeasurable, and multi-dimensional (GhaffarianHoseini, 2013). As a matter of fact, kinetic façades are ideally significant to develop and design facades that are responsive and interactive to the environmental attributes. They have the potential to adjust their forms, orientations, shapes, or openings to automatically react with environmental parameters including temperature, humidity, wind, etc.

There is abundant literature that attempted to review the studies with two major orientations (1) the visual comfort of artificial light and other aspects in relation to kinetic façades, and (2) the thermal and visual comfort in relation to kinetic façades. However, there are limited studies that focus on the kinetic façades and daylight. Accordingly, this research paper is an attempt to tackle this gap by providing a useful synthesis of existing studies to determine the assessment methods and tools, design factors affecting daylight, and visual comfort performance metrics. Therefore, this paper seeks to examine the following research question:

Q: What are the most favorable conditions of daylight for kinetic facades to attain visual comfort?

2. The Methodological Framework

In this paper, a review is performed to synthesize the state of different research linking daylight, kinetic façades, and visual comfort. The review is conducted using the eligible studies published in the last two decades which were obtained from different electronic databases. Then, it provides a literature analysis (descriptive and analytical), which will be discussed with regard to the research question. Finally, the paper presents the conclusion of this review by providing a summary of insightful findings for further research.

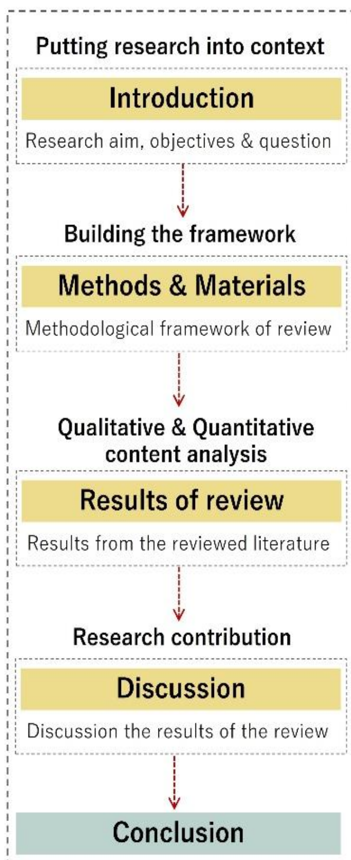


Fig.1. The methodology followed in this paper.
Source: Authors

3. Literature identification and Search Strategy

The selection of publications follows a four-level structure identification, screening, eligibility, and inclusion. At first, the different electronic databases were screened for relevant studies. The search used different combinations of the generic terms 'Intelligent Façade', 'Visual comfort', and 'Day light'. The scholarly databases are searched to determine which ones provide relevant results, through an extensive search of international journals, articles, books, dissertations, conference proceedings, and other scientific web resources. Accordingly, the literature search is conducted across seven databases: Science Direct, Web of Science, Scopus, Google Scholar, Springer, SAGE, and ProQuest.

The authors attempted to gain access via scientific communities (e.g., Egyptian Knowledge Bank (EKB)) in case some publications appeared relevant but are not accessible. Then, a combination of search terms was used (with some syntactic variants) and applied to the title, abstract, keywords, and full text of the aforementioned databases. After the initial database searches, preliminary criteria were established to narrow down the results, focusing on studies that were: 1) written in English, and 2) published between 2000 and 2022. Finally, the search was further refined based on specific inclusion and exclusion criteria.

4. Selection procedure of eligible literature

Through an initial screen, some papers were eliminated because they did not meet the scope of the current study. During the second stage, titles and abstracts were screened to determine which ones are accepted for full paper screening. This was attained by selecting eligible literature resources based on the following inclusion criteria:

1. Papers must focus on Kinetic façades.
2. Papers must include at least visual comfort as one of the studied aspects or metrics.
3. Papers must include daylighting in their study.
4. papers must include either the assessment methods of different elements or an applied study (measurement foci).

Finally, after removing the duplicated records, a total number of 38 potentially relevant papers that matched the search criteria were identified for further analysis. Following each step in the previously mentioned databases, the final search results were exported into Mendeley.

Table 1: Results of Eligible Results sorted by their type.
Source: The authors

Reference	Year	Case study	type
(Filipe et al., 2020)	2020	Experimental	Thesis
(Gamal & Hassan, 2016)	2016	Simulation	Thesis
(Roy, 2018)	2018	Simulation	Thesis
(Elkhatieb, 2016)	2016	Simulation	Thesis
(Motevalian, 2014)	2014	Simulation	Thesis
(*Building Performance Simulation for Design and Operation*, n.d.)	2011	-	Book
(Hensen & Lamberts, n.d.)	2019	-	Book
(Tekce et al., 2021)	2021	Simulation	Research Paper
(عبد الفتاح عمار et al., 2017)	2017	Measurement, Simulation, Test	Research Paper
(S. N. Hosseini et al., 2020)	٢٠٢٠	Simulation	Research Paper
(Moazzeni & Ghiabaklou, 2016)	2016	Simulation	Research Paper
(Wanas et al., 2015)	2015	Simulation	Research Paper
(Dong et al., 2021)	2021	Simulation Intelligent optimization	Research Paper
(S. M. Hosseini, Fadli, et al., 2021)	2021	Simulation	Research Paper
(Elakkad & Ismaeel, 2021)	2021	Measurement	Research Paper
(Eltaweel et al., 2020)	2020	Simulation	Research Paper
(S. M. Hosseini et al., 2020)	2020	Simulation	Research Paper

(Tabadkani et al., 2019)	2019	Simulation	Research Paper
(Bakmohammadi & Noorzai, 2020)	2020	Simulation	Research Paper
(S. M. Hosseini, Mohammadi, et al., 2021)	2021	Simulation	Research Paper
(Luo et al., 2022)	2022	Simulation, Measurement	Research Paper
(lo Verso et al., 2021)	2021	Simulation	Research Paper
(S. M. Hosseini, Mohammadi, & Guerra-Santin, 2019)	2019	Simulation	Research Paper
(Fakhari et al., 2021)	2021	Simulation	Research Paper
(S. M. Hosseini, Mohammadi, Rosemann, et al., 2019)	2019	Simulation	Research Paper
(M. ElBatran & Ismaeel, 2021)	2021	Simulation	Research Paper
(Elrawy et al., 2019)	2019	Simulation, Measurement	Paper conference
(Setiati & Budiarto, 2021)	2021	Simulation	Paper conference
(Seftyarizki et al., 2021)	2021	Simulation	Paper conference
(Kutlar & Mengüç, 2019)	2019	Simulation	Paper conference
(Seftyarizki et al., 2020)	2020	Simulation	Paper conference
(Inan, 2013)	2013	Simulation	Research Paper
(Davoodi et al., 2020)	2020	Simulation	Research Paper
(Park et al., 2004)	2004	Mathematical equations, Simulation	Research Paper
(Hassan et al., 2019)	2019	Simulation	Research Paper
(Wasilewski et al., n.d.)	2019	-	Research Paper
(A Mahmoud et al., n.d.)	2021	Simulation	Research Paper
(Samadi et al., 2020)	2020	Simulation	Research Paper

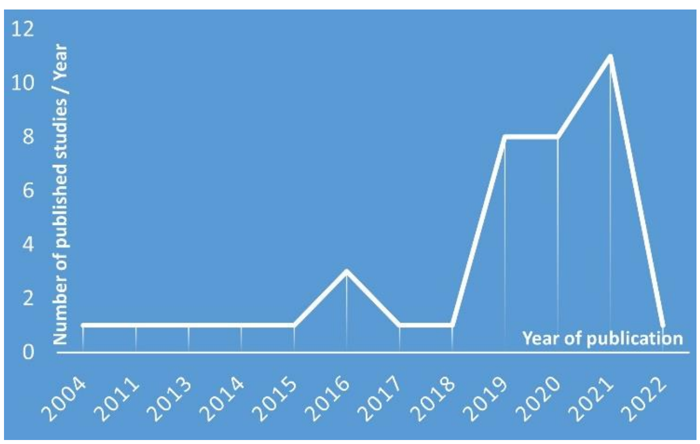


Fig.2. The eligible studies according to their year of publication.
Source: Authors

5. Synthesis of Results: Descriptive Review

Noticeably, fig. 2 depicts that the number of studies on has grown over the last five years. One study is found in the years 2004, 2011, 2013, 2014, 2015, 2017, 2018, and 2022; three in 2016; eight in 2019 and 2020; and 11 in 2021. Among the 38 records, two books were found relevant to the paper's scope. Further to this, only two studies found (S. M. Hosseini, Mohammadi, Rosemann, et al., 2019) (Wasilewski et al., n.d.) conducting a review either to

(1) review the spatio-temporal simulations for glare assessment, or (2) review the interrelated subjects including kinetic façade, biomimicry, building form, energy efficiency, comfort condition, and parametric design thinking.

The second observation is that 0.26% (n=10) of the selected studies are conducted in Northern African countries. While twelve studies (31%) took place in West and South East Asian countries, three in Europe, and three studies are conducted in North America, particularly in the USA. It can be seen that the literature is dominated by studies from Africa and Asia, particularly Egypt, Iran, and Indonesia, respectively. Egypt was the most frequently analyzed country for the case study (n=10) followed by Iran (n=7) then Indonesia (n=3).

The notable thing about the reviewed studies is that they have common research aim, however attained through different methods. Accordingly, the common aims of the reviewed studies were grouped by the authors of this paper into ten different aims:

1) Measure the useful daylight lux.
2) Determine the exceeded amount of daylight entering the space.
3) Measure the amount the daylight glare probability.
4) Assess the double skin façade in daylight and its effect on visual comfort.
5) Assess solar screen facades' effect in daylight and their effect on visual comfort.
6) Identify 3D and 4D animation kinetic façade affecting visual comfort.
7) Assess how parametric louvers affect visual comfort.
8) Assess how geometrical patterns and daylight can have a good effect on visual comfort.
9) Assess window ratio and orientation effect in Daylight and visual comfort.
10) Identify the type and color of the glass that have a good effect on visual comfort.

The most extensively used aims in the studies on this topic were aim number one (n=36) followed by aim two (n=32), then aim three (n= 28) and aim ten (n=14) (see fig. 3).

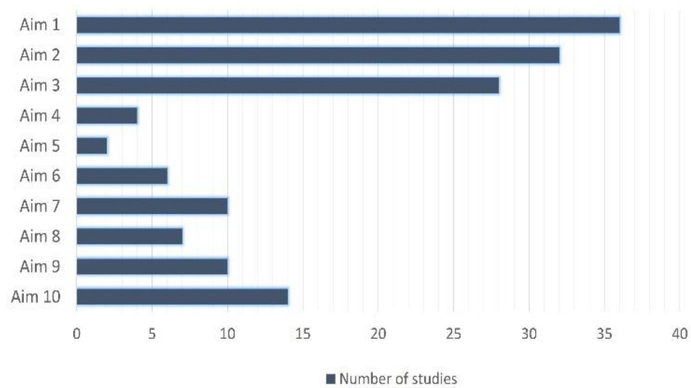


Fig.3. The number of studies worked on each aim.
Source: Authors

Concerning employed methods, the reviewed literature demonstrated a variety of methods being used, divided between experimental, mathematical, analytical, and simulation-based methods. From Table 1, the measuring methods depends on different analytical techniques that used mathematical equations, devices, or performing a test on an existing space. Among the most reliable methods was the simulations 87% (n=33) using different tools were most common, followed by the analytical methods then the measuring methods using mathematical equations. Some studies used combined methods, which accounted for 13% (n =5) of the total studies.

Table 2 analyzing kinetic façade included in each study regarding the type of the studied building, the climate of the region, the effective parameter of the building or space, façade condition by movement types, indoor comfort condition (i.e., thermal comfort, visual comfort, daylight performance, and energy Efficiency), and the employed tools. First, the studies utilized different tools such as surveys, interviews, or software including Design Builder, Rhino, Grasshopper, Ladybug, Honeybee, Dialux Evo, ENVI-met, Energy Plus, ECOTECT, and 'Konica Minolta CMM6' multi-angle spectrophotometer. Among the different functions, visual comfort, energy efficiency, day light performance, and thermal comfort are the most affected by the kinetic facades. From the results, it can be seen that the parametric louvers have a significant effect on the orientation of light and amount of air entering the space, and shading factor.

6. Analytical Review of literature results

Based on a comparative analysis, the different foci of kinetic facades of the 19 studies (i.e., climate, characteristic element, function, movement types, and effective parameter) revealed from the literature analysis are shown in Table 3. Twenty studies were omitted from the further analysis as they were focusing on other elements (i.e., analyzing the space itself) rather than the façade. With respect to the analyzed elements in table 3, the following points were noticed:

1) Most of the case studies have been constructed in the mild temperate-fully humid region with warm summer.
2) The kinetic facades are the second façade layers which interact individually regard to environmental stimuli.
3) Folding, rotating, and sliding are frequently used, while extracting contracting is rarely applied.

Though in most of the case studies, kinetic elements are EWE Arena are considered as parts or volumes in the façade

Table 2: Synthesizing the different methods, software's, functions, elements, parameters used by each studies as indicated. Source: the authors

Reference	Climate	Method/ Software	Function	Element	Effective Parameter	Building type
(Filipe et al., 2020)	T	R, DY, EP	VC, TC	louvers	SH, GT	Office space
(Gamal & Hassan, 2016)	HA	RH, GP, LB, HB	DP, TC, EE	Solar screen	SH, GT, WR, NF	Office building
(Roy, 2018)	T	RH, GP, LB, HB	VC	Light shelf	SH, GT, LS	Office space
(Elkhatieb, 2016)	HA	RH, GP, DI	VC, TC, EE	Tabs	G, P, SH	Office building
(Motevalian, 2014)	n.a.	RH, GP, DI	VC, DP	Double skin Façades	SH, O	Office building
(Tekce et al., 2021)	n.a.	CSFS	VC	n.a.	n.a.	Office building
(عبد الفتاح عمار et al., 2017)	HA	RH, GP, DI	DP, EE, VC	louvers	O, M, SH, GT	Office building
(S. N. Hosseini et al., 2020)	HA	CSFS	DP	Islamic geometry pattern façade	P, GC	Office space
(Moazzeni & Ghiabaklou, 2016)	HA	RH, GP, DI, R	DP	Rotate light shelf	O, LS	Educational Building
(Wanas et al., 2015)	HA	RH, GP, DI	DP	Kinetic façade louvers	O, M, SH	Office Building
(Dong et al., 2021)	C	R, DY, R, DY	DP, EE	n.a.	n.a.	Office Building
(S. M. Hosseini, Fadli, et al., 2021)	HD	RH, GP, DI, EP	VC, DP	Kinetic Shading Facade	WR, G	Office space
(Elakkad & Ismaeel, 2021)	HA	RH, GP, DI	DP	n.a.	WR	Office Building
(Eltaweel et al., 2020)	HA	RH, GP, DY, RD	EE, DP	2D and 3D parametric louver	O, SH, OP, GT	Office Building
(S. M. Hosseini et al., 2020)	HA	RH, GP, DI	EE, VC, TC	kinetic façade	O, SH	Office Building
(Tabadkani et al., 2019)	HA	RH, GP, HP, LB	DP	Smart facade	GT, WR	Office Building
(Bakmohammadi & Noorzai, 2020)	HD	RH, GP, HP, LD	EE, TC, VC	n.a.	O, GT, NF, WR	Primary school
(S. M. Hosseini, Mohammadi, et al., 2021)	n.a.	RH, GP, DI	VC, DP	Kinetic facades with biomimicry	O, G, M	Office Building
(Luo et al., 2022)	HA	KMC, GP, RH	VC	Parametric louver, shading	SH	Office Building

(lo Verso et al., 2021)	Te	CSFS, RH, DI	DP	Window	GT, WR	Classroom
(S. M. Hosseini, Mohammadi, & Guerra-Santin, 2019)	HD	RH, GP, DI	DP	Interactive kinetic façade	GC, WR	Office Building
(Fakhari et al., 2021)	T	CSFS	VC	window	GT, WD	Classroom
(M. ElBatran & Ismaeel, 2021)	HA	GP, DI	PR	Double skin facades	n.a.	Office Building
(Elrawy et al., 2019)	HA	RH, GP, LD, CSFS	DP	n.a.	WR	Office Building
(Setiati & Budiarto, 2021)	T	DE	VC	n.a.	WR, GT	Classroom
(Seftyarizki et al., 2021)	T	EC	TC, VC	n.a.	GT, WR	Classroom
(Kutlar & Mengüç, 2019)	C	DR, R	DP	n.a.	GT, WR	Office and studio in a university building
(Seftyarizki et al., 2020)	T	EC	EE, VC, TC	n.a.	GT, WR, NF	Educational Building
(Davoodi et al., 2020)	HD	RG, GP, DI	DP	n.a.	GT, WR, NF	Office Building
(Park et al., 2004)	n.a.	EN, MS	Tc, Vc, EE	Louvers	n.a.	EN, MS
(Hassan et al., 2019)	HA	RH, GP, DI, EP	DP, Tc	Solar screen	O, GT, WR	Office building
(A Mahmoud et al., n.d.)	HA	RH, GP, DI, EP	VC, TC, EE	n.a.	WR, O	School Building
(Samadi et al., 2020)	HD	GP, LD, HP	DP	Kinetic facades with parametric louver	SL, O, WR, NF	Office Building

Notes:
- 'n.a.' not applicable.
- Method/Software: CSFS: Case Study Field Survey, DB: Design Builder, RH: Rhino, GP: Grasshopper, LB: Ladybug, HB: Honeybee, DE: Dialux Evo, EN: ENVI-met, EP: Energy Plus, E: ECOTECT, KMC: Konica Minolta CMM6 multi-angle spectrophotometer;
- Climate: HD: Hot-Dry, HA: Hot-Arid, T: Tropical, Te: Temperate, C: Cold;
- Function: TC: Thermal Comfort, VC: Visual Comfort, DP: Daylight Performance, EE: Energy Efficiency;
- Effective Parameter: G: Geometry, O: Orientation, GT: Glazing Type, NF: Number of Floors, M: Material, LS: Light shelf, SH: Shade, WR: Window Ratio, NF: Number of Floors, P: Pattern, GC: Glass Color.

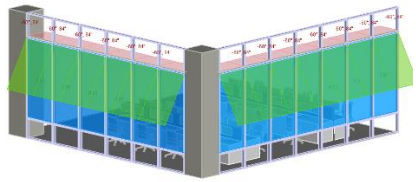
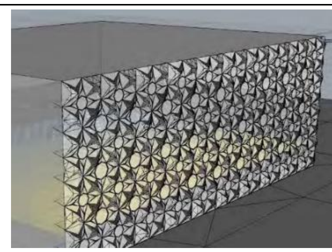
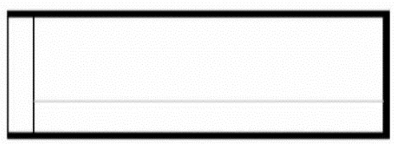
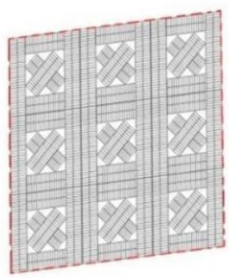
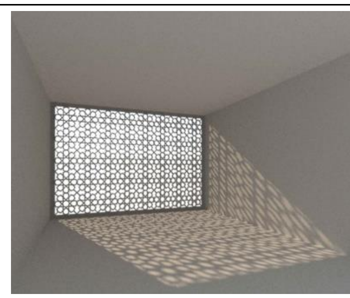
Being interactive to dynamic daylight is identified as the most important function for kinetic façade. However, being interactive due to functional scenario is an under developing target in the recent years.
Daylight performance and controlling solar heating, derived from the kinetic façade function, are the remarkable factors which improve indoor environment quality specifically thermal and visual comfort.

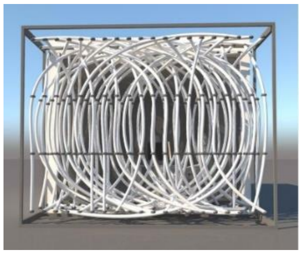
7. Analyzing the different parameters

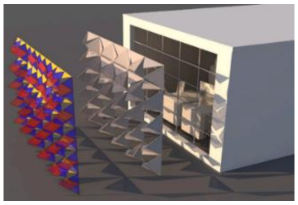
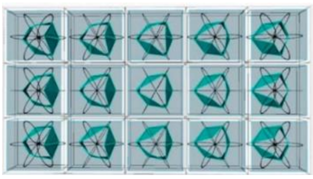
In the analysis of this study, three daylight louver systems with different methods based on collecting and redirecting sunlight to the ceiling inside the building envelop:

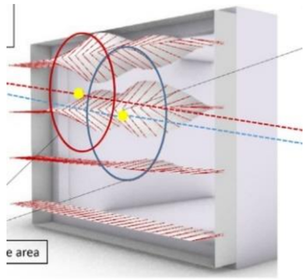
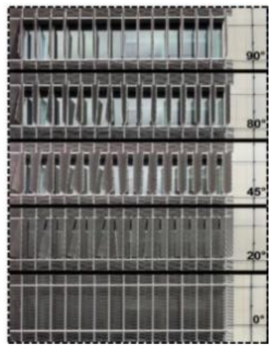
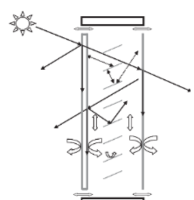
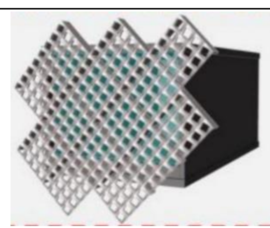
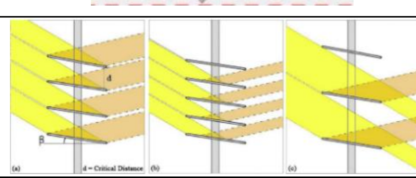
One-axis parametric louver, Bi-axis parametric louver and Two-layer parametric louver (Eltaweel et al., 2020). The three systems of parametric louvers can all cover more than 70 percent of daylight for the most part working hours (Eltaweel et al., 2020). The One-axis louver achieve 70 percent for working hours (Eltaweel et al., 2020). Bi-axis louver and Two-layer louver achieve 80-90 percent of daylight illumination for working hours (Eltaweel et al., 2020). but the Two-layer louver More practical about Bi-axis louver in operation (Eltaweel et al., 2020).The notable thing about the reviewed studies is that they have common research result relationship between the angle of parametric louvers and the amount of illuminance and the ceiling area(Eltaweel et al., 2020; Luo et al., 2022; Moazzeni & Ghiabaklou, 2016; Roy, 2018; Samadi et al., 2020; Wanas et al., 2015).

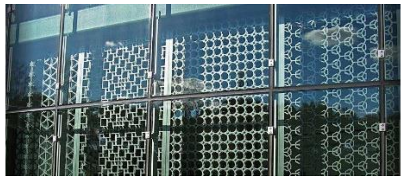
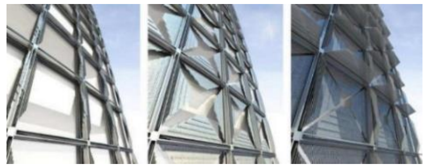
Table 3: Comparative analysis between different facades regarding shape and movement type. Source: Authors.

R	Characteristic element (shape)	Movement Type
(Roy, 2018)		R,PH
(Elkhatieb, 2016)		P,SC,EC
(Motevalian, 2014)		F
(عبد الفتاح عمار et al., 2017)		FO,R,P
(S. N. Hosseini et al., 2020)		R,EC
(Wanas et al., 2015)		F,R

(S. M. Hosseini, Fadli, et al., 2021)		FO,SC

(S. M. Hosseini et al., 2020)		FO,EC
(S. M. Hosseini et al., 2020)		F
(S. M. Hosseini et al., 2020)		R,P, FO,EC
(Tabadkani et al., 2019)		R,F, FO,EC

(S. M. Hosseini, Mohammadi, et al., 2021)		R,SC
(S. M. Hosseini, Mohammadi, & Guerra-Santin, 2019)		FO,S
(S. M. Hosseini, Mohammadi, & Guerra-Santin, 2019)		SC,R
(Park et al., 2004)		R
(Hassan et al., 2019)		SC,R,FO
(Samadi et al., 2020)		P,R

(Majed & Alkhayyat, 2013)		SC,EC,P
(Majed & Alkhayyat, 2013)		P,R,F

Note: 'R' refers to the reference number
Movement type: F: Flop, R: Rotate, FE: Fold, P: Pivot, S: Sliding, SC: Scale, EC: Expand & Contrast, PH: Pneumatic or Hydraulic

The building's architectural form defines how the facade interacts with the ambient environment, which has a basic effect on the useful daylight allowed in indoor spaces (S. M. Hosseini, Mohammadi, & Guerra-Santin, 2019). The simulation results explain the entire visual discomfort for the plain window with values for DA, UDI, and Exceed UDI of 93.4 %, 13.8 %, and 79%, respectively (S. M. Hosseini, Mohammadi, & Guerra-Santin, 2019).

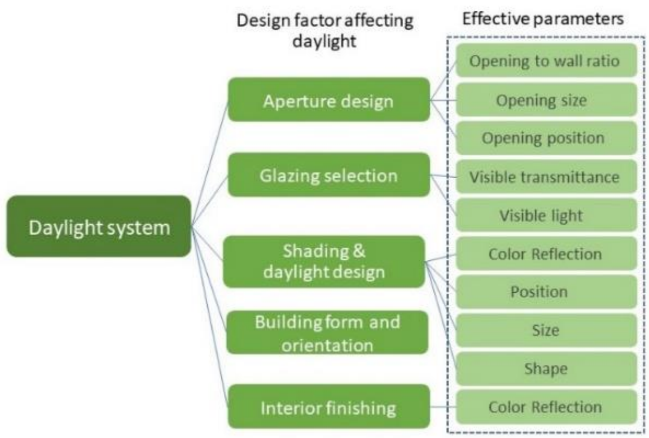


Fig.4. The Architectural parameters with direct effect on

The kinetic interactive facades consist of a two-dimensional shape change facade (2D-SCF) and a three-dimensional shape change interface (3D-SCF) is proposed to improve visual comfort (S. M. Hosseini, Mohammadi, & Guerra-Santin, 2019). The simulation results show a significant improvement in daylight metrics, with average UDI for (2D-SCF) and (3D-SCF) ranging from 54% to 70% and 67% to 82%, respectively (S. M. Hosseini, Mohammadi, & Guerra-Santin, 2019). Similar to Exceed UDI, the parametric simulation for both kinetic facades comprising (2D-SCF) and demonstrates remarkable decreases from 37% to 78% and 56%-98.5% (3D-SCF). The 3D-SCF provides (17.8%–24%) more useful daylight than the 2D-SCF (S. M. Hosseini, Mohammadi, & Guerra-Santin, 2019).

Additionally, compared to 2D-SCF, 3D-SCF is significantly efficient in decreasing Exceed UDI from 26.88% to 93.4%(S. M. Hosseini, Mohammadi, & Guerra-Santin, 2019). The results highlight the three-dimensional shape-changing façade's multifunctional features as well as an advanced interactive daylighting system that can control decrease gain solar radiations(Elkhatieb, 2016; S. M. Hosseini, Mohammadi, & Guerra-Santin, 2019; S. M. Hosseini, Mohammadi, Rosemann, et al., 2019; S. N. Hosseini et al., 2020). In this study the simulation results explain adaptive solar skin (hexagonal Kaleidocycle pattern) is comprised of six repeatedly repeated hexagonal grid, a combination of triangle and hexagonal shapes with an exciting rate of rotation movement, geometric proportions in a regular set, pressing the entire interface, and a system that automatically reacts to changes and provides Useful daylight UDI 300 at 65% for working plan and DGP 0.35 at the south façade in hot arid climate (Tabadkani et al., 2019). Concerning the daylight performance evaluation criteria, the researchers agreed on the following climate-based metrics and luminance-based metric:

1) Climate-based metrics, including spatial Daylight Autonomy (SDA), Useful Daylight Illuminance (UDI), Exceeded Useful Daylight Illuminance (EUDI), and luminance-based metrics, including Daylight Glare Probability, have been used to evaluate the complex kinetic facade's daylight performance (DGP) (Building Performance Simulation for Design and Operation, n.d.).

2) useful daylight UDI define (UDI 100-3000 Lux), while EUDI (UDI > 3000 Lux) flags on over-supply of daylight near the façade"(Building Performance Simulation for Design and Operation, n.d.). The categorization of DGP has also been divided into four groups imperceptible (30–35), perceptible (35–40), disturbing (40–45), and intolerable (45–100) (Building Performance Simulation for Design and Operation, n.d.).

TABLE 4 : COMPARATIVE ANALYSIS MATRIX BETWEEN INTELLIGENT FACADES TYPE, DESIGN FACTOR AFFECTING DAYLIGHT, AND DAYLIGHT PERFORMANCE METRIC. SOURCE: AUTHORS.

	Intelligent Facades type					Design factor affecting daylight					Daylight performance metric						
Reference	Kinetic facade	parametric louver	Parametric pattern facade	Double skin facade	Parametric soler screen	Building Orientation	Top and side lighting	Glazing type	Interior Finishing	Glare control	Useful Day light	Day light anatomy	Direct sun light – shadow	Climate based metric	Luminance based metric	Indoor Glare evaluation	Building type
(Filipe et al., 2020)		●				●	●	●			●		●	●			Office space
(Gamal & Hassan, 2016)					●	●		●			●	●	●				Office building
(Roy, 2018)		●				●	●	●			●		●				Office space
(Elkhatieb, 2016)			●	●		●		●		●	●	●		●	●	●	Office building
(Motevalian, 2014)				●		●	●	●		●	●		●		●	●	Office building
(عبد الفتاح عمار et al., 2017)		●				●	●	●			●	●	●				Office building
(S. N. Hosseini et al., 2020)			●					●									Office space
(Moazzeni & Ghiabaklou, 2016)		●				●	●										Educational Building
(Wanas et al., 2015)	●	●				●			●		●	●	●		●		Office Building
(S. M. Hosseini, Fadli, et al., 2021)	●	●				●	●			●	●	●	●			●	Office space

	Intelligent Facades type					Design factor affecting daylight					Daylight performance metric						
Reference	Kinetic facade	parametric louver	Parametric pattern facade	Double skin facade	Parametric soler screen	Building Orientation	Top and side lighting	Glazing type	Interior Finishing	Glare control	Useful Day light	Day light anatomy	Direct sun light – shadow	Climate based metric	Luminance based metric	Indoor Glare evaluation	Building type
(Eltaweel et al., 2020)		•				•			•		•	•	•		•	•	Office Building
(S. M. Hosseini et al., 2020)	•					•		•			•	•	•				Office Building
(Tabadkani et al., 2019)	•	•						•		•	•	•	•	•			Office Building
(S. M. Hosseini, Mohammadi, et al., 2021)	•	•				•	•			•	•	•		•	•	•	Office Building
(Luo et al., 2022)		•				•	•			•	•		•			•	Office Building
(S. M. Hosseini, Mohammadi, & Guerra-Santin, 2019)	•					•		•		•	•	•	•			•	Office Building
(M. ElBatran & Ismaeel, 2021)				•				•			•		•				Office Building
(Park et al., 2004)		•		•		•		•			•	•		•		•	-
(Hassan et al., 2019)					•	•		•			•	•	•				Office building
(Samadi et al., 2020)	•	•				•	•			•	•	•	•		•	•	Office Building

The results proved its ability to achieve large number of solar screens alternatives efficiently for specific daylight and thermal performance (Gamal & Hassan, 2016; Hassan et al., 2019).
Responding to the climatic changes of the surrounding environment is what responsive motion systems achieve. components of the building feature different material properties, integrating different architectural systems with kinetic systems.to respond and adjust to environment changes in order to improve the building performance (عبد الفتاح عمار et al., 2017).

8. Conclusion

Concerning the publication year, although the review time frame was from 2000 to 2022, Light is required for people to adjust to their environments to see the shape, color, and perspectives of many objects in their immediate surroundings. Visual comfort must be given by the right design of the lighting system and building façade, as it is a major factor when designing buildings by discovering the relationship between daylight, building facade, and visual comfort. As a result, a theory was evaluated in order to analyses previous studies that investigated the determinants and consequences of visual rest, with a focus on kinetic facade. An analytic study of 38 certified studies extracted from several scientific sources to discover the methodology and assessment tools used to estimate the ideal daylight conditions for smart interfaces. Building façade strategies are critical for conveying daylight to inside building areas as well as protecting the building from external factors such as daylight, cold, and so on. As a result, daylight has the potential to replace a considerable portion of the continuous lighting used in buildings while also enhancing the inter - relationships between interior and outdoor surroundings. According to the literature, a intelligent facade must adapt to three primary criteria: weather, environment, and occupants. There is a large body of literature that aims to examine research in two primary areas: (1) the visual comfort of artificial light and other features related to kinetic facade, and (2) the thermal and visual comfort related to kinetic facade. The research' collection axes were the type of intelligent facade and design factors affecting the daylight performance scale. By reviewing and analyzing studies, 3D kinetic intelligent facade that move with sunlight are given the best results in visual comfort and daylight performance, with daylight glare probability.

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