



Sh<sup>o</sup>CK!

Sharing of  
Computable  
Knowledge!

eCAADe 35

20 - 22 September 2017 Rome

## **Editors**

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**eCAADe 2017**

**Sh<sup>o</sup>CK!**

*Sharing of Computable Knowledge!*

Volume 2

Proceedings of the 35<sup>th</sup> International Conference on Education and Research in  
Computer Aided Architectural Design in Europe

20<sup>th</sup>-22<sup>nd</sup> September 2017

Rome, Italy

Dep. of Civil, Building and Environmental Engineering

Faculty of Civil and Industrial Engineering

*Sapienza* University of Rome

Edited by

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## Theme

### **Sh<sup>o</sup>CK! – *Sharing of Computable Knowledge!***

The theme of the 35<sup>th</sup> eCAADe Conference is *Sharing of Computable Knowledge! – ShoCK!* so, we have invited eCAADe community, members of Sibling Organizations and CAADFuture friends to face this exciting theme.

Why such a strong theme? Mainly for three reasons.

The first one, is that we live in a city that has been witness of several revolutions of the conceptions of architectural space: most turning points of space perception are present here by means of architectural masterpieces as Bruno Zevi stated. I like to quote Rem Koolhaas: “It is a platitude that the presence of history in Rome is detriment to the development and display of modern art. But if that were true, Rome – *a city of successive modernities* – would never happened.”

Secondly, as my DaaD research group states “Rome is an open-air museum of architectural avant-garde masterpieces of an *uninterrupted history* where styles are juxtaposed, intertwined and *stratified* other than culturally also physically...” This concept is very close to the modern concept of cognitive sciences: to think by means of several abstraction levels of intelligence. And the third reason is that we live in a Faculty founded in 1817 – right two centuries ago - has always had a multidisciplinary approach to understand and solve problems: from the outset Architecture, Civil engineering, Bridge construction, Topography, Geometry and Mathematics subjects were present. As a matter of facts this approach it is not limited to technical aspects as – most importantly – the Faculty, now Civil and Industrial Engineering, lives in *Sapienza* University of Rome – established in 1303 – a university that pursuits the “universal” approach where each discipline enhances the others.

Going back to the theme, it involves in turn several subjects: Internet of Things, pervasive nets, Knowledge ‘on tap’, Big Data, Wearable devices and the ‘Third wave’ of AI, ... All of these disruptive technologies are upsetting our globalised world as far as it can be predicted henceforth.

So, academicians, professionals, researchers, students and innovation factories... are warmly invited to further shake up and boost our innovative and beloved CAAD world – we already are in the post-digital era – with new ideas, paradigms and points of view.

I said “*CAAD world*” as I think that it contains and involves several disciplines but it is a new subject it its own that overcomes the former ones.

The underlain idea of this International Conference is that as a catalyst of creative energy it pursuits with determination founders’ purposes and to be a shocking vanguard, a melting

pot of novelties, in words: to become an “incubator” of innovative and seminal ideas, to generate enthusiasm, to be an occasion for new friendships and to facilitate the establishment of effective researches’ networks. The title of the conference reflects well these intentions:

## ShoCK! – Sharing of Computable Knowledge!

So the aim of the Conference was to knock our habitual design activities out, to compare the various methodological and technological trends and to disseminate the latest research advances in our community. Will our fine buildings and design traditions survive? Or, will they ‘simply’ be hybridized and enhanced by methods, techniques and CAAD tools? Obviously, computation is needed to match the ever-growing performance requirements, but this is not enough to answer all these questions we have to deal with the essence of problems: *improve design solutions for a better life!*

Obviously, **computation** is needed to match the ever-growing performance requirements, but this is not enough... As life is not a matter of single individuals, we need to increase collaboration and to improve **knowledge** and **sharing**. This means going back to focusing on human beings, and involves the humanistic approach, and the long history of architecture... from handicrafts to thinking to technology... to handicrafts again.

A large spiral of the *architectura* as *eternal* as our city.

### A.

*Antonio Fioravanti*

eCAADe 2017 Conference Chair

\* This second volume of the conference proceedings of the 35<sup>th</sup> eCAADe conference contains 81 papers grouped under 14 sub-themes; both volumes contain altogether 155 accepted papers. The Conference was held at the Faculty of Civil and Industrial Engineering, *Sapienza* University of Rome, Rome, Italy, in via Eudossiana 18, Rome, on 20<sup>th</sup> – 22<sup>nd</sup> September 2017.

In addition to the accepted papers, the first volume contains *Keynote* speakers’ contributions concerning the themes of their keynote lectures and the *Workshop Contributions* including the contents of workshops given; the second volume furthermore includes the *Poster Session* contents.

All the papers of these proceedings will be accessible via CuminCAD - Cumulative Index of Computer Aided Architectural Design, <http://cumincad.scix.net>

## Acknowledgements

Authorities, colleagues, researchers, professors, students, professionals all of you are welcomed to the 35th eCAADe conference, in Rome the *eternal city*.

It has been a long time ago – 31 years – since the previous eCAADe conference was held in this Faculty, hosted by our University - “La Sapienza”.

That time, Gianfranco Carrara, one of the eCAADe founders, chaired the 4<sup>th</sup> eCAADe conference in 1986. That time on, there was only one eCAADe conference in Italy precisely in Palermo in 1995 chaired by Benedetto Colajanni and Giuseppe Pellitteri. This Faculty – now Faculty of Civil and Industrial Engineering – inspired by Parisian and Austrian academic models, is quite old as it was funded by Pope Pius VII in 1817, so now it celebrates its Bicentennial!

But it is quite young compared to our mother University “La Sapienza” that was established by the Pope Bonifacius VIII in 1303.

The original idea of bringing the eCAADe conference back to Rome goes rather back in times, I remember it was in 2009 at eCAADe conference in Istanbul. You know things take their time in Italy, so only in 2013 my Faculty approved and on 21<sup>st</sup> March 2015 eCAADe Council granted us the permission to organize the 35<sup>th</sup> conference. Over the last years several people have helped us to make this conference happen. We thank the former Dean of Civil and Industrial Engineering Faculty, Prof. Fabrizio Vestroni and especially the present Dean, Prof. Antonio D’Andrea for their supports.

During the process of organizing the eCAADe 2017 we have had the privilege to experience the supportive, collaborative and frank atmosphere of eCAADe Council, whose members, no one excluded, have helped us with all organizational aspects.

Let us be touched in remembering for his humanity the former eCAADe President, Johan Verbeke, who recently passed away. We all are sad in this moment thinking is no more physically with us now, but at the same time we are grateful to have met him and exchanged ideas on equal terms as his habit. In spirit, he is present so we can tell him: Johan, special thanks for your open-minded support, we warmly thank you! We miss you, and we do not forget you!

How cannot we mention Joachim Kieferle a friend, who is also the eCAADe President, for his encouragement and unswerving support during the last years and his ability to cut up dead-

locks into pieces? A special thanks to the great Bob Martens for his ability in organizing complex tasks and simplifying processes – Dutch origin helps – his daily support was precious and helped us relentlessly. And a “suupper” thanks to a “super” friend as Gabriel Wurzer for his optimism and silent help in difficult issues.

Also, we wish to thank all the other previous conference organizers, Henri Achten, Rudi Stouffs and Emine Mine Thompson, for sharing their experience and knowledge. A special thanks to more recent conference organisers Bob Martens, Gabriel Wurzer, Thomas Grasl, Wolfgang E. Lorenz and Richard Schaffranek together with Aulikki Herneoja, Toni Österlund and Piia Markkanen!

Quality is the vital issue concerning conference proceedings.

To improve it we used different means: *OpenConf* conference management system that easily ensured that none of the reviewers came from the same institution as the authors; through special relationships between Liverpool University and eCAADe thank to Martin Winchester’s support we were able to overcome program bugs; a second and handcraft check of interest conflicts among authors and reviewers was made during the reviewing phase; a double-blind peer review process; and an accurate reviewers’ selection. The selection was fair, and only extended abstracts with high grades were admitted to full paper phase.

Quality means also typographic quality control in two ways: for printing results and for respecting author’s layout; so, thanks to the well-known *ProceeDings* formatting management system eCAADe could fulfil these two needs.

Authors uploaded their extended abstracts (length of 1000 to 1500 words, two optional images, 5 to 10 references) by 1st of February 2017; each abstract was evaluated anonymously.

Altogether, we received 309 extended abstracts from 46 different authors’ countries, shortly after 5 were withdrawn. Each extended abstract had three blinded peer reviews so 912 reviews were accomplished in a short time and 188 papers were accepted for full paper submission. After a while 11 of these ones were withdrawn and eventually 155 papers were published in the eCAADe 2017 Proceedings.

Let us express our very grateful appreciations for all the 132 reviewers from all over the world for their constructive and thorough comments for each author. A special thanks to reviewers who spent their time to review more than 8 extended abstracts – Joachim Kieferle and Anand Bhatt - not to mention members of “Joker Reviewers’ Team”: Stefano Cursi, Salma Elahmar,



Paolo Fiamma, Silvia Gargaro, Gianluigi Loffreda, Wolfgang E. Lorenz, Davide Simeone, Gabriel Wurzer and me that were able to review abstracts during the last days to accomplish missing reviews on time.

We thank and congratulate all authors for their hard work and support on using the ProceeDings tool and finalizing their full papers carefully in time. In this last phase of editing full papers we want to thank for his “extra-ordinary” work Gabriel Wurzer, the Master of the ProceeDings and Wolfgang E. Lorenz and Ugo Maria Coraglia, who with high sense of responsibility worked with us and to successfully produce high quality proceedings.

We also continued the practice started in eCAADe 2015 conference in Vienna of having all the session chairs to give prospective comments of the papers and to evoke the discourse at early stage between the author and session chair for the 27 sessions of the conference. All the session chairs also participated the peer review process of the extended abstracts.

We owe great gratitude to the session chairs for their commitment and their long-term contribution to the process until the final paper presentations.

We thank the keynote speakers and their contribution of writing the keynote papers concerning their lecture themes: Gianluca Peluffo, Chair in *Exhibition Design and Art & Architecture*, IULM - International University of Language and Media; John Gero, Research Prof. in *Computer Science and Architecture*, University of North Carolina at Charlotte and Krasnow Institute for Advanced Study George Mason University; and Gernot Riether, Director of *School of Architecture*, NJIT – New Jersey Institute of Technology, Editor of *DCA Journal*.

Workshops are part of eCAADe conferences, so we thank all the organizers for their workshop and for their contribution of short papers (non-peer reviewed) about the contents of their own workshop.

We are also grateful to Wolfgang Dokonal and the eCAADe Council for organizing the traditional PhD workshop for young researchers and supporting the grant winners with a subsidy for traveling to Rome.

We recovered an old tradition of previous eCAADe Conferences bringing poster session to life again, so during the conference we had 4 free lectures on interesting themes.

This year for the first time we launch an international competition linked to the Conference, the “eCAADe2017 Logo Contest” that helped in disseminate the spirit and values of eCAADe in new areas. We thank the International Jury that was made up by Antonino Saggio (President, Chair in *Information Technology applied to Architecture and Urban and Architectural design*), Eleonora Fiorani (Vice president, Chair in *Cultural Anthropology and Sociology of Innovation*),

Henri Achten (former eCAADe President, Chair in *Computer Aided Architectural Design*), Maria Argenti (Chair in *Architectural Composition* and Editor in chief of *Rassegna di Architettura e Urbanistica*), and Antonio Fioravanti (Chair in *Architectural Engineering*). Two Winners and three Honourable mentions were awarded (see on website <https://www.daadgroup.org/result/>). We would like to express our gratitude for the administrative help in organizing this conference to eCAADe council and especially Nele De Meyere that has provided us valuable input and lessons learned from past conferences.

We have also had support from DaaDgroup for managing the conference services, ranging from the registration process to the actual on-site registration services. A big thank you goes to PhD students Ugo Maria Coraglia and Francesco Rossini for their extra-work in critical situations.

Thanks to the sponsors we were enabled to organize an international conference as eCAADe is. Financial supports, apart Sapienza University of Rome, was generously provided by A-Sapiens, AT Advanced Technologies, Autodesk; 3TI Progetti and Bentley Systems International Ltd. Technical support was provided by Epson Italia, Gangemi Editore, Geores, it solution, Noumena and ProceeDings.

We wish to also thank Gangemi Editore in person of Giuseppe and Fabio Gangemi for their very fast and accurate printing process and the high quality of both volumes.

As a special form of sponsorship, all members of the Organizing Team and students of Architecture-Building Engineering M. Course that donated their time to help prepare and organize this conference. Thank you all !!!

Rome, 1<sup>st</sup> September 2017

*Antonio Fioravanti*

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*Angelo L.C. Ciribini, Gabriele Novembri and Armando Trento*

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# Kinetic Shading System as a means for Optimizing Energy Load

## *A Parametric Approach to Optimize Daylight Performance for an Office Building in Rome*

Alireza Jahanara<sup>1</sup>, Antonio Fioravanti<sup>2</sup>

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*Current research, as a part of on-going PhD research, explores the possibilities of dynamic pattern inspired from biomimetic design and presents a structured framework for light to manage strategies. The experiment stresses the improvement of daylight performance through the design and motion of kinetic facades using various integrated software. The impact of kinetic motion of hexagonal pattern was studied by integrating triangle and triangle covering through blooming pyramids on south-facing skin to control the daylight distribution, using a parametric simulation technique. The simulation was carried out for a south oriented façade of an office room in Rome, Italy over three phases. The first optimized results represent the static base case, which were compared to the other two proposed dynamic models in this research. Results demonstrate that dynamic façade achieved a better daylighting performance in comparison to optimized static base case.*

**Keywords:** *Bio-Inspired Pattern, Parametric Design, Dynamic Façade, Daylighting*

### **INTRODUCTION**

Architecture and its dynamic facilities are important ways to actively respond to variable ambient conditions and requirements while also meeting the needs of occupants and addressing issues of building performance. Within contemporary architecture, there is a growing interest in motion buildings and their components are gradually shifting from static to dynamic to improve performance and occupant satisfaction (Goia et al., 2013). A dynamic 'filter' the envelope- between interior and exterior unquestion-

ably allows for a desired change in building use or a rapid adaptation to new ambient conditions only through its modification. Moreover, mechanical shading device systems allow not only light, view, sound, or smell to be filtered, but also a 'filter' motion that can also enhance aesthetic architectural experiences (Mahmoud, A. H. A., & Elghazi, Y., 2016). A building façade plays a vital role in reducing artificial lighting and heat transfer by improving precise control over the use of natural light in interior spaces. To obtain appropriate natural lighting for indoor work




spaces, much research has been conducted and current technology focuses heavily on optimizing the architecture composition of façade properties opening. Hence, parametric design and a computer simulation prepare the grounds for a research to generate dynamic facades and evaluate it in accordance with daylight transmittance in the early design stage (Goia et al., 2013). Contemporary office building facilities require tremendous energy consumption to meet the comfort level needs of their users, and that results in adopting active technologies such as lighting and HVAC systems. Biomimicry's inspiring design has become a promising approach, as it provides different design alternatives that attain adaptability of the environmental concerns (Mahmoud, A. H. A., & Elghazi, Y., 2016). While the type of office building is used as a particular illustrative case study for the on-going PhD research, a part of it is used in this research paper (Jahanara and Fioravanti, 2016). Here, the biomimicry and parametric design process for designing a kinetic pattern are point out which are formed by multiple singular movements through the lens of morphology. The proposed bio-design approach has been employed as a prototype to generate an adaptive dynamic façade in relation to daylight. This paper explores the possibilities of kinetic composition afforded by geometry's façades in motion. Composition is analysed in terms of pattern, being defined as the relative movement of individual kinetic parts in time and space - the way in which multiple singular kinetic events cluster, or propagate across a façade, over time. That exploration results a better understanding of adaptations in relation to the organisms, their environment and biological mechanism. In addition, the study explores dynamic façade that parameterises and evaluates its performance in regards to integrating motions as a response to dynamic day lighting.

## **BIOMIMETIC STRATEGY FOR MANAGING LIGHT**

Biomimetic brought about a design approach that applied nature as a guide for innovation technologies which carry out the future of building facades. It rep-

resents an innovative alternative that reconciles energy efficiency with integrating adaptability that responds to high-quality indoor climates needs. Therefore, innovative techniques in constructions and designs are now offering more adaptive facades that respond and 'behave' as a living organism to their environmental context (Goia et al., 2013). Efficient light management is necessary as a design requirement aspect of building's facades that are exposed to solar radiation. Taking biomimetic-living organisms, as design solutions for buildings, is a unique strategy to manage light: it is a design framework that facilitates the selection of appropriate strategies of nature. Not only the framework enhances the light management by elaborating on the involvement aspect which too many organisms' nature systems can provide, but also it behaves as an analogical design development that responds to light (Fox and Kemp, 2009). Nevertheless, biomimetic is not about creating an exact replica from nature, but is about translating its functional biology aspects into the architecture in a performativity level (Goia et al., 2013). Morphological, behavioral, and physiological means influence light management efficiency strategy and its ability to manage light intensity. For instance, some plants are able to transmit light because of their intricate structural assembly, while others optimize light by solar tracking and enhancing body exposure (Goia et al., 2013). Through exploration and learning from those strategies and techniques of nature, a design discipline for a new light system management is emerging, aiming at building skins. Biomimetic design field is still in a challenge with architecture, especially with the growing integration between the biomimetic design, engineering, and material science (Fox and Kemp, 2009). In this regards, many experiments have been carried out to represent biophysical information systematically in a similar context to buildings. However, a systematic representation of building application for light management strategies is limited. Figure 1 shows schematic diagrams of Biomimetic impacts on architecture with the light management efficiency.

Figure 1  
 diagram of  
 Biomimetic  
 influences on  
 architecture,  
 Archdaily, Alireza  
 Jahanara

Morphology	Behavior	physiological
Hazza Bin Zayed Stadium - UAE Project Year: 2014	Water Reaction -Royal College of Art - 2015	Pavilion - Germany Project year: 2013
<p>Stadium inspired Pattern design is the rotating fractal geometry of the date palm fronds as an outer facade. In addition, facade movement responds to the daily heat to act as a passive cooling device; shading the building during the day and allow fresh air to flow. Hence, movement depends on sensors' respond to the daylight factors. (Archdaily, 2015)</p>	<p>Pattern inspired by a pinecone, that open and closes naturally to protect seeds from the wet weather and spread it when it is dry. That happens when outer layer expands more than the other layer which therefore causes different scales to bend and close its cone. The cone is a tile where the outer layer elongates and curves the material away when wet. (Archdaily, 2015)</p>	<p>Pavilion is a particularly interesting way in moisture-driven movement which is observed in spruce cones. This movement takes place through a passive response to humidity changes, just like plant movements from cell pressure metabolism. Hence, movement is independent with no energy consumption from the plywood sheets' metabolic function. (Archdaily, 2013)</p>
		

Based on the schematic diagram in figure 1, this research paper is considering and underlying the environment process at initial stages of a design process, taken by the morphological strategy. Therefore, the order in nature can promote and develop adaptive solutions for building envelopes. The current paper consequently focuses on how the morphological applications of biomimetic can produce an adaptive geometry pattern which responds to the efficient design factor of the daylight.

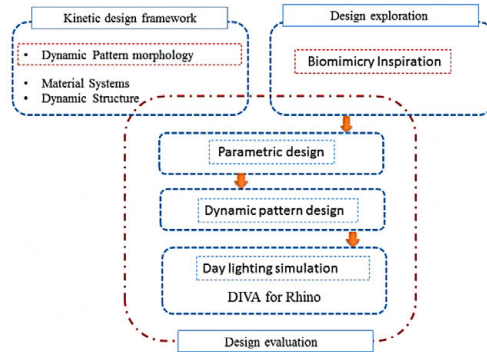
### **ASSESSING BUILDING FAÇADE'S DAYLIGHTING PERFORMANCE**

Daylight is the best source of light as it most closely matches the human needs. It is free and does not increase energy consumption for lighting (Li and Tsang, 2008). Accordingly, a design pattern is proposed for building facades which is responsible for the amount of daylight in indoor workplaces to achieve a better performance with respect to light quality, energy consumption and occupant satisfaction. The proposed dynamic façade's geometry is inspired from the structure of living organism responses to daylight in Lotus plant. The geometry optical structure is aiming to adapt the building to control the natural light and reduce the need of artificial lighting so to respect visual comfort and environmental concerns (Nabil and Mardaljevic, 2005). The "Useful Daylight Luminance" (UDI) predictive method was then used to measure the amount of natural light. The UDI method divides annual daylight illuminance in a workplace into three sections. The first one includes areas that receive less than 100 lux, which is not appropriate, and thus demand additional artificial lighting; the second section corresponds to the range of 100 to 2000 lux, which is suitable for working activity; and the last one includes illuminance exceeding 2000 lux which results in potentially visual discomfort. This method is more realistic than the conventional "Daylight Factor Approach" -DFA- which only considers a single factor (Nabil and Mardaljevic, 2005)

### **RESEARCH AIMS AND METHOD OF INVESTIGATION**

Current research aims to create an adaptive kinetic folding pattern which highlights the significant effect of dynamic facade design on indoor day lighting quality inspired by Biomimicry. Biomimicry has become a trend in interactive architecture as an inspiring concept. It uses the organism as a successful case which is able to control and utilize energy in harsh environments. The natural organism uses minimum amounts of material to build intelligent structures so to successfully optimize its energy in reaction to the environment. The proposed design pattern in this study has also been inspired by the blooming motion for Lotus flower that mitigates over-lit conditions. There are many types of plants in nature that open their flowers and leave them under the sunlight and close them when it is dark at night (Fox and Kemp, 2009). They have a basic behaviour guided by this simple rationale that can be performed by 'agents'. The structure scheme of the blooming shape defines the spatial design and how the pattern reacts to the sunlight. The Lotus flower's geometry reacts to the sun by changing from a triangular shape to a hexagonal, maximizing the differences between its extended and folded states. This pattern acts as a receptive unit to control the daylight conditions, affecting occupant satisfaction while saving A.C. energy (Mahmoud, A. H. A., & Elghazi, Y., 2016). In this regard, a case study for a geometry which applied in an office building's façade, not in an urban area, was conducted to simulate the environmental setting similar to Rome's geographical location. Likewise, a proposed pattern was generated by integrating performance analysis tools with parametric modelling i.e. implementing Rhino and Grasshopper programs. Hence, it was determined that evaluating the office workspace conditions by means of DIVA software analyses to enhance energy saving, daylight, glare, and performance, depends on balancing these objectives, (see figure 2).

Figure 2  
Geometry design  
methodology.  
Source: Alireza  
Jahanara



### PARAMETRIC OFFICE MODEL

A side-lit office space was constructed as the base case study model for an office building located in Rome, Italy. The area is 37.31 m sq. and dimensions of 4.10 m width, 9.10 m depth and 3.20 m height, facing south and located at the third floor (Figure3).

Figure 3  
façade and plan of  
the office building,  
Source: Alireza  
Jahanara



Although the façade's configuration sets in the case study changes, the space dimensions remain the same throughout the entire study. Initially, the simulation was run for clear and overcast skies for different types of motion test. The interior surfaces were assigned a reflectance of 80% for the ceiling, 50% for walls, and 20% for the floor. The kinetic skin was made of sheet metal material. The opening was assigned a doubled-glazed material with 65% visual transmittance. The kinetic skin is an external layer of a double façade which acts as a shading screen coupled with glazed interior layer that has an in-between buffer of 35 cm, see (figure 4).

### DESIGN PROTOTYPE

The concept of dynamic façade' geometry is influenced by the adaptive behaviour of the plants and the concept of Lotus flower that reacts to the sun by changing from a hexagonal shape to a triangle one, and the triangle part being covered by a blooming pyramid. The geometry pattern has two parts: dynamic and static states are created by integrating the triangle shape into the hexagonal. The dynamic part is maximizing the differences between its extended and folded states' receptive unit to control the daylight conditions when day lighting increases and affects the occupant satisfaction while saving A.C, see figure 5. Likewise, in the proposed design, two methods are used to operate the blooming panels. The first method is the regular plane of the dynamic blooming pyramid, (see figure 6), while the second model eliminates some blooming part to provide more visual comfort for occupant spaces and decreases the mechanical part of structure ,see (figure 7).

### DAYLIGHTING EVALUATION

Research work was divided into three consecutive phases to evaluate the daylight by Diva for Rhino. The case study model with the two phases of proposed pattern was then simulated. The simulation was planned to perform for four months per year (March 21, June 21, September 21, and December 21) at three hours per day (9:00 am, 12:00 pm and 3:00 pm). Those times and dates were chosen, to have a fairly accurate evaluation of the performance in the case study model for its two proposed patterns as well as the base case: a) The first simulation focuses on the analysis of delighting performance for a window with dimensions of 3.20m width and 1.2 m height. The Window Wall Ratio (WWR) is set to 25% as the base case model, (see table 1).b) The second simulation represents a daylighting performance, using parametric tools for kinetic hexagonal geometry to a triangle, and the triangle being covered by a blooming pyramid. The blooming motion has intelligence sensors to achieve the near optimum day

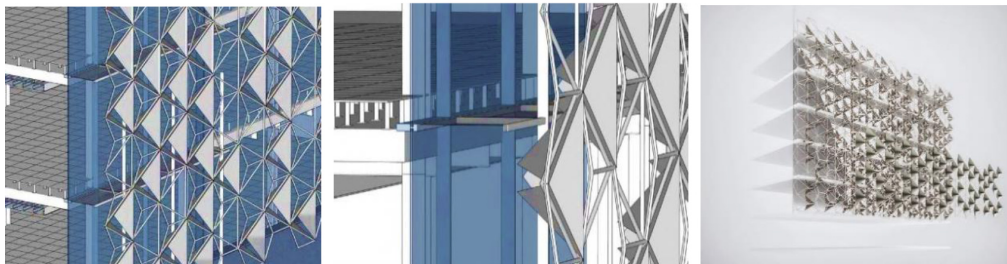


Figure 4  
Geometry  
assembly, Source:  
Alireza Jahanara

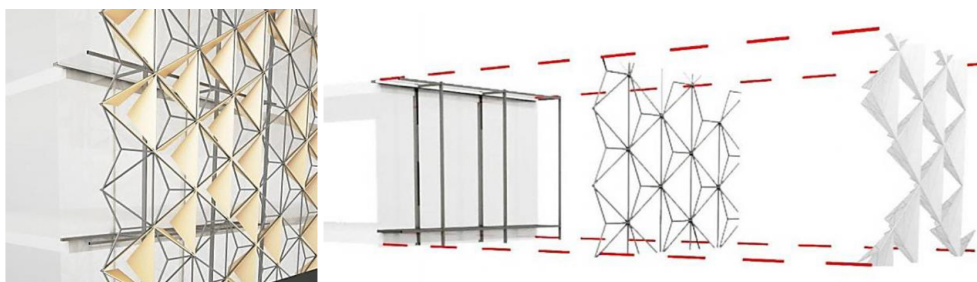
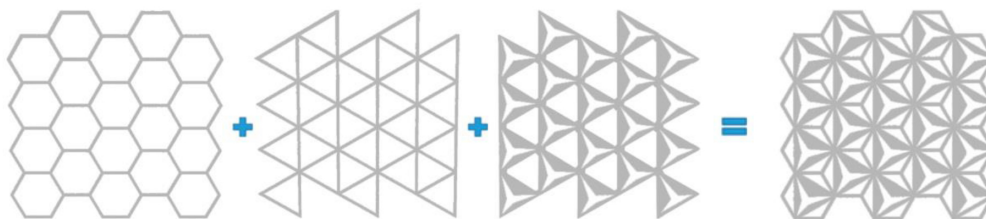


Figure 5  
Proposed geometry  
layers – façade,  
Source: Alireza  
Jahanara



a) Hexagonal

b) Triangular

c) Blooming pyramid

proposed geometry

Figure 6  
Proposed  
geometry's – A,  
Source: Alireza  
Jahanara

lighting adequacy. In the case of first set A, the daylight's assessment for the dynamic facade was simulated at three circumstances: when the assemblies are closed, partly open and fully open, see (table 2).c) The third stage of the simulation represents the dynamic facade's pattern set B. The blooming pyramid's

geometry was assigned according to the visual workspace comfort, see (table 3).

### DAYLIGHTING SIMULATIONS - RESULTS

As mentioned, Grasshopper Simulation for Diva to assist the day lighting performance was used in plan-

Figure 7  
Proposed  
geometry's – B,  
Source: Alireza  
Jahanara

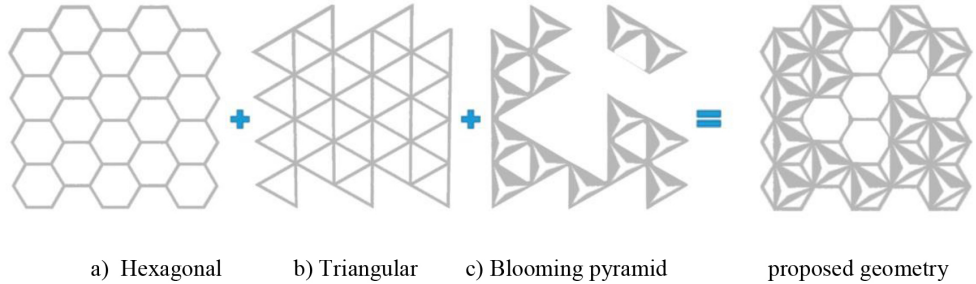
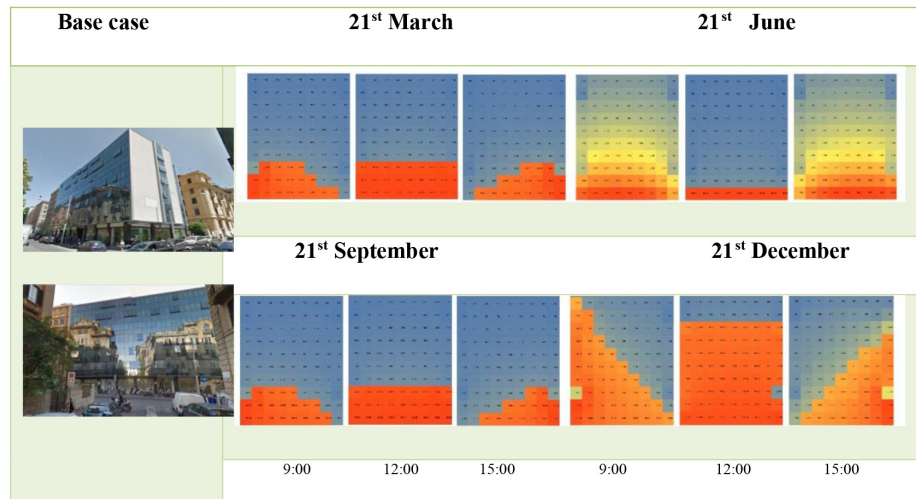


Table 1  
Results of case base  
model – simulation,  
Source: Alireza  
Jahanara



ning the models for the base case and the two sets of geometries. Grasshopper simulation was used to identify the parameters and inputs for the proposed model and set up the evaluation criteria for the daylighting assessment. Then Diva was applied to simulate the process of daylighting and send the results back. Daylighting requirement was set to three illumination evaluation levels for the floor area: "daylit", "partially daylit" and "overlit" areas. The "Daylit" area achieves illuminance levels between 100 lux and 2000 lux for the floor area; "Overlit" area achieves illu-

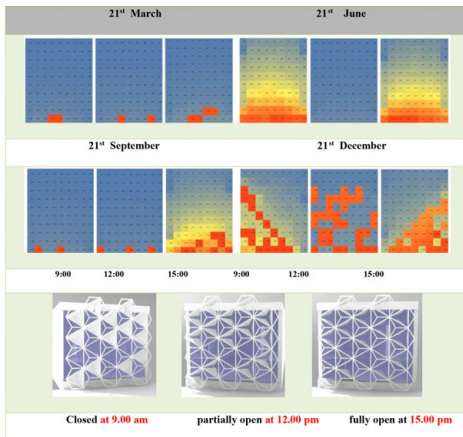
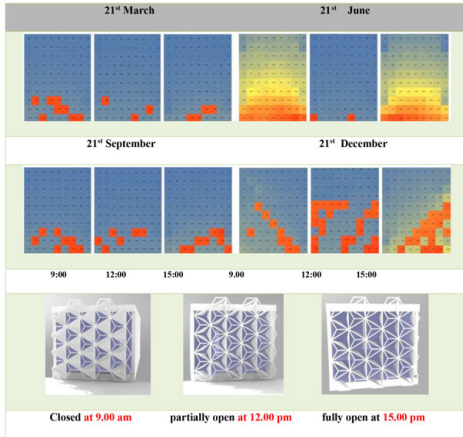
minance greater than 2000 lux for the floor area with potential glare; and "Partially lit" area achieves illuminance below 100 lux for the floor area. The simulation parameters were set to measure daylight illuminance sufficiency for the room.

DIVA parameters were set to calculate the percentage of analysis points that achieves illuminance levels between 100 lux and 3000 lux.

In this stage, the base case was evaluated for daylighting adequacy in summer; nearly half of the base case floor area was found to be "daylit". However, the



other half of the floor area has been “overlit” which causes problems with visualization and glare. On the other hand, in winter, the “overlit” was relatively high and nearly less than half of the area was found to be in “daylit” area, while the other half was divided into “overlit” and “partially daylit” areas.



This means that in case of using traditional windows, only 50% of the space has adequate daylighting for most of the year.

These results of daylighting performance for the pro-

posed dynamic geometry’s sets (A), indicate that a recommended dynamic façade as a shade device improves the daylighting conditions in the workspace. In all kinetic geometries cases results were acceptable and the required daylighting was achieved better than the base case.

The results showed that in the summer, the “daylit” area was significantly increased and there was a relative decrease in the “partially daylit” area, while in winter time, only the “daylit” area was increased. In the case of selected net for the proposed blooming’s geometry, set B, represented the best daylight performance see in table 4 below.

The proposed blooming geometry cases were found acceptable at all times where “daylit” percentage reached 99 % of the space at the value ranges in June, the closed and the totally opened geometry, in both case study sets, gave the most appropriate “daylit” area.

While, the partially opened geometry in both the case study sets, increased the “daylit” to almost 100% in March and September (table 2, 3).

In case study set A, the daylight performance was only achieved at opened and partially opened geometries of 95 % in the winter. Hence, some acceptable results where the “daylit” area percentage that was achieved at 12:00 pm to be 93%, and its performance in afternoon at 3:00 pm, while it was slightly low in the early morning, see (table 4).

In general, results indicate a significant impact of the geometry pattern’s parameters and types of geometry organization on the overall daylighting performance in the workspace. The proposed model coupled with the two proposed organizations of dynamic skin improved the daylight performance. The blooming geometry acts convincing as a dynamic shading device to control the excessive daylight level. It is also clear that the “overlit” area was relatively improved in winter time and was mainly concentrated at four working hours of the day.

Table 2  
Results of Set A-  
Model: regular  
plane, Source:  
Alireza Jahanara

Table 3  
Results of Set B-  
Model: Selected  
blooming pyramid,  
Source: Alireza  
Jahanara

Table 4  
Floor area achieved  
illuminance levels  
between 100 lux  
and 3000  
lux,Source: Alireza  
Jahanara

Month	Opening /motion	Hour	Base Case	Case A	Case B
<b>June</b>	closed	9 a.m	88.4%	100%	97.10%
	partially	12 p.m	88.80%	85.40%	98.80%
	fully opened	3 p.m	89.20%	97.10%	93%
<b>March</b>	closed	9 a.m	88.40%	100%	100%
	partially	12 p.m	84.60%	91.80%	93.60%
	fully opened	3 p.m	90.80%	95.30%	93.50%
<b>September</b>	closed	9 a.m	80.40%	100%	98.20%
	partially	12 p.m	80%	90%	98.80%
	fully opened	3 p.m	88.20%	93.60%	99.90%
<b>December</b>	closed	9 a.m	88%	99.40%	98.40%
	partially	12 p.m	70%	97.70%	99.40%
	fully opened	3 p.m	75%	99.40%	100%

## DISCUSSION & CONCLUSION

The research paper presents a bio-inspired geometry design driven by daylighting performance as a design factor for office workspaces in Rome, Italy. The proposed blooming geometry pattern was parametric by Rinho and simulated by Dive 4.0 to control daylight uniformity.

The geometry prototype was designed as a responsive dynamic system inspired by mimicking Lotus plant's response to light. The adopted methodology can therefore be interpolated for the annual daylighting performance of a dynamic geometry which can be used to generate various geometry motions using parametric exhaustive search. Moreover, the research experimented the idea of selecting partially opened dynamic pattern configuration and static part configuration for less material aligned with the daylight and visual comfort design factors. These types of configurations allowed for the different application purposes: closed for privacy, open for external visual interactions, and partially open to shade in "overlit" hours. Therefore, a full annual simulation gives a better guide to improve the pattern organization and its geometry parameterizes daylighting op-

timization for the space performance.

Running the simulation, hence, represented a year-round performance for the same blooming geometry motion in different sets of organizations. In order to trace the daily, hourly, and then monthly and annually facade responses to climate changes for testing the unusual luminance level, the bio-inspired geometry was improved as a dynamic screen. It is also suggested a further research and more exploration should be done to discuss the daylight as a parametric, yet a design target, which is going to be covered in the on-going PhD research. In addition, a physical fabrication mock-up for the geometries façade can indeed give another depth to the study. The on-going research of the PhD has a potential to become a basis for the future intelligent and adaptive dynamic patterns that respond to the daylight parameters, aiming to optimize the energy consumption and occupant visual comfortable. Furthermore, it will provide the daylight design factor as a framework to understand the responsive dynamic façade and optimize the office buildings' energy performances aligned with improving the indoor workspaces' comfort conditions.

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The proceedings took into account the most advanced research in Computer Aided Architectural Design: Internet of Things, pervasive nets, Knowledge 'on tap', Big Data, Wearable devices and the 'Third wave' of AI... These disruptive technologies are upsetting a globalised world as far as it can be predicted henceforth.

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