LOGO

Biomimetic design techniques and conceptual models in graphic composition on glass facades

Técnicas de design biomimético e modelos conceituais em composição gráfica no vidro nas fachadas

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ABSTRACT

Biotechnology studies produce diverse solutions in models inspired by plant cells to improve the subsystem constituted by the interface between the internal and external environment of a building. Adequate supply focused on the ecosystem is responsible for filtering stable comfort conditions to the outside world of buildings, allowing for the creation of sustainable envelopes and a multitude of other artistic resources. Thus, this article addresses the relationship between technique and conceptual model regarding the use of surface design strategies for the process of graphic composition on glass façades. To this end, it will take into account natural resources; concepts and typologies of glazed buildings and elements of surface design. The methodological process is characterized as qualitative, descriptive and of a systematic theoretical nature in recent literature.

KEYWORDS

Smart facades; Biodesign; Digital technologies on glass.

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1. INTRODUCTION

At the present time, the complexity of Contemporary Architecture requires innovation every day and has increased its peculiarities due to the characteristics of each location. The paradigm shift is the result of technological advances, supported by new methods and tools that help design to think of new, useful and innovative solutions.

In the implementation of new façade construction techniques, informational and conceptual projects have been an idealization in recent decades. Due to the constant evolution, glass facades, in the 1960s and 1970s, began to appear in Brazilian cities, and have been increasingly diversifying in terms of construction systems (Cardoso, 2019). According to Pinto et al. (2015), due to Brazil's tropical climate, it is suggestible that there is a need to develop protections for facades, as an optimization of thermal and light comfort within the built environment.

From the 1970s onwards, extruded aluminum systems identified as columns were implemented, where it began to fulfill a structural function, giving a vertical effect of markings and hiding a little the flatness of the glass. Ten years later, the most advanced architecture chose to show more glass – a material that also had considerable technological advancement – incorporating thermoacoustic and safety features. Consequently, the entire façade structure gained a new design, ensuring a more visible view of the glass (Ferreira, 2022).

With the concept of sustainability, glass plays an important role in the façade, as it is one of the most versatile materials in terms of use, assuming today the condition of an indispensable product for modern architecture and decoration. According to Queiroz (2023), the interference of glass with the thermal comfort of the building is associated with the level of transparency, the opening area, the combination with sun protection elements and low-emissivity coatings that help reduce heat loss in winter and heat gain in summer.

Generally speaking, construction has entered the era of cutting-edge technology. New materials and systems reduce to a new scenario that starts to be assembled. It can be said that one of the items that begins to be perceived in the reading of the buildings is the glazing system of the buildings (Figure 1), where it assumes the function of

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closure and gains the status of a coating, starting to cover the entire façade. This system makes it possible to meet a series of demands and requirements from an aesthetic, functional, technical and rational point of view.

Figure 1 : Great visual impact.

Source: Cardoso.

As each project has its own specificities, the predominance of the system is according to its local climate, depending on latitude, vegetation, season and orientation of the façade. Therefore, with the advancement of technology, architects and designers create solutions to improve the performance of the internal environment, through construction techniques and choice of materials in favor of thermal insulation.

1.1 Brief history

Among the significant changes that proposed the use of glass in architecture, several innovations and advances occurred in the field of

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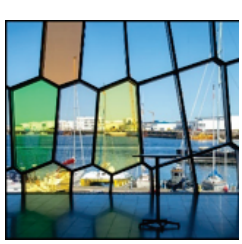
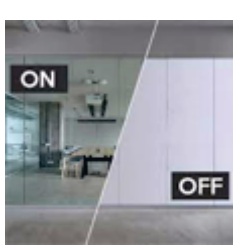
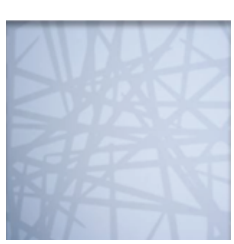
civil construction and industry. According to Westphal (2022), it is estimated that about 70% of the total glass production is used in Brazil, mainly in new buildings or façade renovation. With the modernization of the product, the glass market has been allowing creative professionals to conceive true works of art with aesthetic and functional characteristics and the possibility of using large dimensions, favoring a resource of transparency and integration between environments.

With the innovation and technological evolution in the glass industry, new product needs have been incorporated into glass for improvement and sustainable monitoring. Currently, there are different types of smart glass for special demands in civil construction, such as thermochromatic glass (A), which changes color and transparency depending on the amount of light they receive; electronically controlled liquid crystal laminated glass (B), also known as polarized, changes its transparency characteristic to translucent at the push of a button; photovoltaic glass (C), with the capacity to generate electricity from solar energy; bio-inspired glass (D) in a natural organism, glass that has internal fibers that, in the eyes of birds, resemble a spider's web (Table 1).

Frame 1: Sustainable glass grades.

A	B	C	D
			

Source: Authors.

Studies are increasingly improving the thermal and optical performance of glasses. With the transformation and paradigm shift in buildings, it seeks a new look at the evolution of Architecture. Not to mention the examples of contemporary ideas that are awakening different alternatives with the new designs.

In view of this, the creation of impact barriers to minimize shocks

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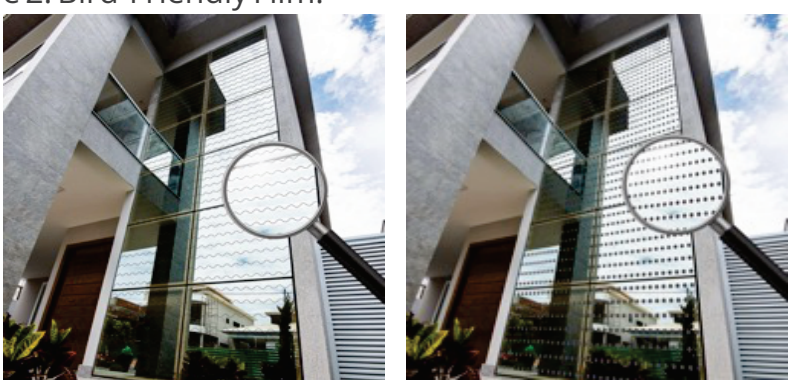
from skyscrapers arises in the envelopes. Good examples of the contemporary trend of design in harmony with nature are buildings with the application of smart adhesive films (Figure 2), called "bird-friendly", which minimize collision with glass surfaces by up to 98% (CHIC PELÍCULA, 2023).

Figure 2: Bird-Friendly Film.



Source: Schneider.

1.2. Strategies to the Principles of Nature – Bioinspired Facades

The term "bioinspired" refers to creative developments of new structures, processes, or devices based on the observation of phenomena, guided by configurations of biotic factors (corresponding to the living communities of an ecosystem) and abiotic factors (physical, chemical, or biological elements of the environment) that represent existing relationships and allow the balance of the ecosystem (Sá, 2021, p. 20).

The expression "biotechnical" describes the processes by which human beings carried out their constructive endeavors based on the observation of structures, many of them natural. According to Arruda (2018, p. 188), these processes involve the manipulation of living organisms to manufacture or modify products.

> Biomimicry or bionics are technical approaches oriented towards applying the design lessons of nature that seeks to solve the current problems of humanity. Therefore, science seeks to bring challenges and new perspectives by focusing on the ecosystem, aiming to contribute to new principles, forms,

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> processes and structures on the natural environment (Arruda, 2018 p. 199).

Bioinspired products, whether through bionics or biomimicry, consist of an innovative method that aims at sustainable solutions following the example of nature, in which patterns and strategies for the survival of biological systems are used. According to Detanico et al. (2010) it is a radically innovative approach, based not on what can be extracted from nature, but on what can be learned from it, where it is possible to change the way we grow food, produce materials, generate energy, heal, store information and conduct business. According to Brocco (2017), the concept describes, in addition to technology, an artistic manifestation of design, which seeks sustainable solutions in natural mechanisms, inspired by the ways of life that have adapted to the Earth during the long period of evolution of living beings.

The case study presented in figure 2 shows a conception of the geometric shape of a water cube. Known as the National Aquatics Center, built for the 2008 Olympic Games in Beijing. The concept of the project, conceived by the PTW Architects team, brought biomimicry exemplified by mimicking the shape of soap bubbles translated blue into architectural form. Its design brought an approach to biology, and the concept combined the symbolism of the square with the local Chinese culture.

The skin of the building was able to divide the spaces into equal-sized cells with about 3,000 giant-sized plastic bubbles. Designer Tristan Carfrae, with the studies of scientist Plateau, found that the polyhedron shape allowed the space to be divided into equal cells, giving sizes with the smallest surface area between them. Therefore, the approach was to visualize the foam matrix in a given orientation and then remove the block in order to obtain the geometry of the structure (Figure 3).

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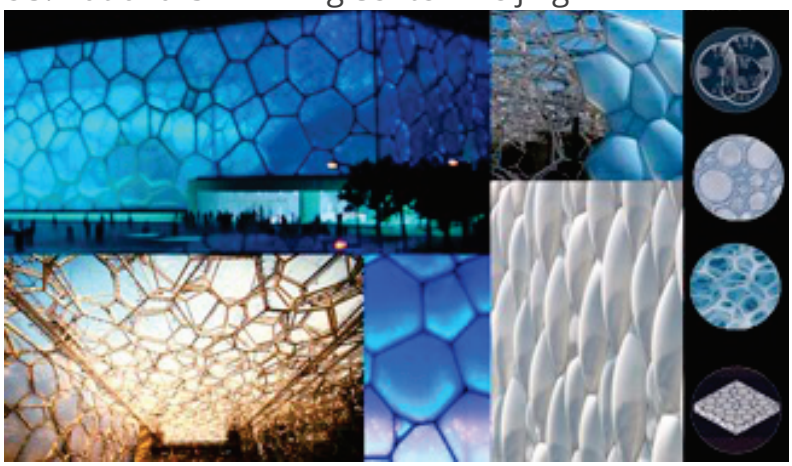
Figure 3: National Swimming Center - Beijing



Source: PTW

For the façade of the building to arrive at the correct study there are three modes of operation to respond to summer, winter and mid-season. The clear, translucent fluorine-based thermoplastic polymer structures, designed to have high corrosion resistance and resistance over a wide temperature range, yet lighter than glass, have elements that make it more flexible. As a building material, in internal device in the design of the skin, they will allow high levels of daylight, which avoids the use of artificial lighting during the day.

The results obtained environmentally led him to achieve an energy-efficient project, maximizing natural light with solar energy captures to heat the internal environments, especially the swimming pools. According to the scientist, water efficiency has been achieved through rainwater harvesting, recycling, efficient filtration, and backwash systems.

For all creators, overcoming all challenges and goals through the application of biomimetic architecture demystified the mistaken idea of imitation and eccentricity, demonstrating in practice how much it was part of the future for Design (PTW Architects, 2003).

2. METHODOLOGICAL PROCEDURES

In this article we intend to rethink the graphic design method in glass for the climatic context in the enclosures from the biological analogy, experimentation of the intelligent material – thermochromic film – in transmission that can be imaged and composed of artistic

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analysis. It is expected, in this work, to identify possible hypotheses and strategies, in order to have definitive answers that contributed to the definition of developments in the investigation.

To conceive the theory, three questions were established that gave impetus to the research: How? Why? What? The answers to the questions are structured in two methodological processes that comprised different terminologies for biomimetic approaches: the first based on analysis, based on the climatic parameters of nature in solutions that describe, interpret and abstract the concepts for new projects and technologies; and the second based on problems related to the questions of how to abstract and transform innovative ideas into different types of constructions, according to the technique adopted by López et al. (2017) (Figure 4). The authors establish a parallel between these characteristics and specify that the advancement of biomimetic concepts for architecture and design requires some steps, since the use of complex and multidisciplinary approaches is subject to local climatic variations (Sá, 2021).

Figure 4: Design conception generation in biomimetic creation.

Source: Maciel et al.

The information displayed in the green position on the left refers to both climatic axes (nature and architecture). In this column, according to Sá (2021), the importance of considering the local bioclimatic context and its biological characteristics is highlighted. The proposed method is divided into two parts: first part – discovering strategies and mechanism in plant cells; and the second – conceptualize and solve ideas in technical solutions through experiments with new technologies that include advances in materials science, with the intention of tracing components related to the implementation of image and properties in an artistic modeling system.

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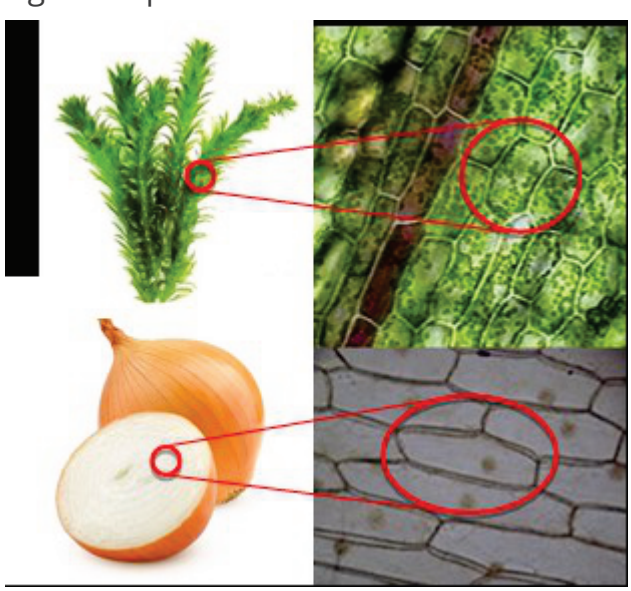
3. APPLICATION

In the first stage, an in-depth research was developed in the theoretical framework, on the issues involving intelligent facades and their evolution components in the face of typologies and their sun protection screens. We sought to determine trends in bioinspired technologies and materials that could contribute to the climate action of buildings in advantage of sustainability.

Regarding the biomimetic approach, a specific cut was defined on the concept of the "Water Cube" project in 2008, which has its structure developed from the soap bubble, according to PTW Architects (2003), its approach led to the construction of a thinking strategy, where the forms of water transform themselves and dematerialize the building into a molecule in its state of foam.

In this sense, in order to bring the biomimetic study in relation to biotechnology to the project, it was thought to develop, the first technique through plant cells (Figure 5), a feasibility of extracting its geometric shape in a model that could be adapted to an artistic modeling in the form of a mosaic as a function of a set of logical components.

Figure 5: Diagram of plant cells.



Source: ConceptoABC.

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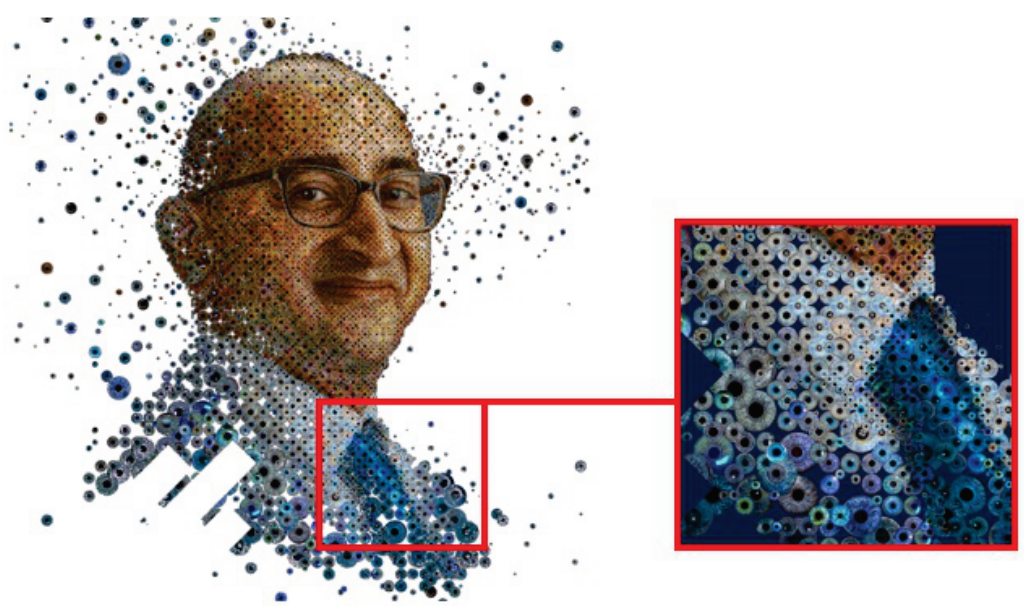
The initial challenge of the project is the observation in the leaves of Elodea sp or onion scale film. These plants have organelles with functions and textures in well-defined geometric shapes in different sizes, and it is possible to take them to an overlay in colors, which allows you to define models with different cell densities.

This study seeks to intend and develop a texture that can lead to adaptive intelligent mosaic mapping processes, inspired by the techniques created by Designer Charis Amazing Tsevis - a pioneer in custom scripts of complex mosaics - inserting curves and shapes into images extracted from the Photo Mosaic tool(Figure 6). The idea is to mix folders of images with text generated by a composition of cells by the computer, creating stylized and abstract effects. The modeling process will be shaped by Synthetik Artist Studio software.

Figure 5: Diagram of plant cells.



Source: ConceptoABC.

After the diagramming of the projected images in the software with the Tsevis technique, another methodology will be inserted as an implementation for digital printing reproduction on thermochromic smart film (material that changes color in response to temperature changes) transforming the standard flat technique for translucent images into colors. The film is produced by incorporating heat-sensitive pigments into a material, usually polymers or paints. These pigments change color in response to temperature variations, and are

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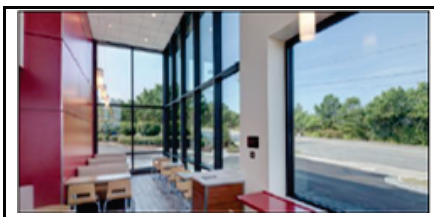
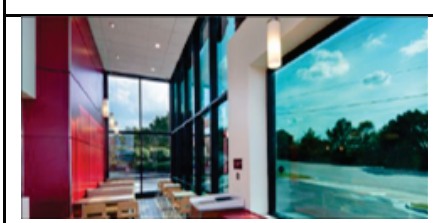
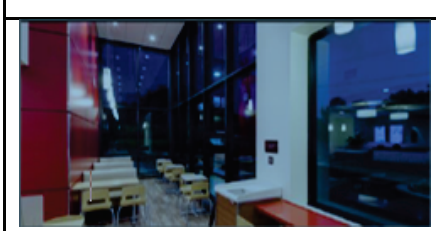
composed by a combination of thermoplastic polymers, thermochromic dyes (chemicals extracted from vanadium that change color when exposed to different temperatures). Frame 2 shows how the film acts in favor of the air temperature and changes its vision according to sunlight.

Table 2: Solar effect of the thermochromic film.

	Morning	
	Afternoon	
 Internal environment	Night	 External environment

Source: Authors.

4. APPLICATION OF THE METHODS

The proposal has two segments to be considered for its realization: thermal performance and natural light performance in the internal environment of a glazed building. The selection of the simulation method for thermal performance is an important aspect for the progress of the optimization model, although the research on desirable materials is evolving, which can affect the prediction of the results and consequently, the design decisions.

In view of the initiative of ideas and later the implementation of the application of the methods, a simple simulation was carried out with the intention of the visualization alternative, with a composition of image and transparency. implemented to feel the applied view of

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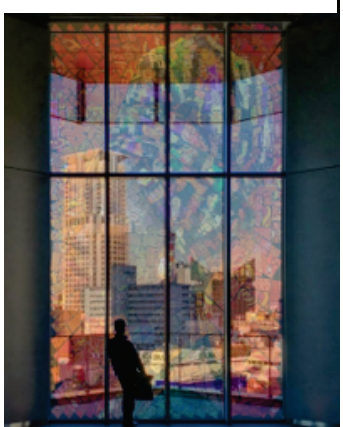
the suggested technique, and to have as a suggestion the user's view within the environment internally and externally in the building (Chart 3).

Table 2: Solar effect of the thermochromic film.

1	2	3
		
Morning at 6 a.m.	Afternoon at 12 noon	Evening at 8 p.m.

Source: Authors.

For future understanding and simulation of the implementation of the model, images that show the effect of the user's vision within the built environment, the three times of the day were estimated: in the first figure (1), in the morning at 6:00 am, when the weather provides a low temperature, in the second (2) in the afternoon at 12:00 pm, the glass remains darker, Due to the temperature being quite hot, the third (3) night at 8:00 pm, the weather appears in cold temperature, providing an extremely translucent view, with little view of the mosaic.

To approach the technique of printing on the film according to the image extracted from an abstract model of the cells, the process consists of transferring from a digital file in graphic formats in a way that differs in terms of thermochromic pigments in primary colors printed and pressed between laminated glass subjected to 600°C quenching, causing the paint or polymers to form a vitrified layer, fully incorporated into the glass (Figure 7).

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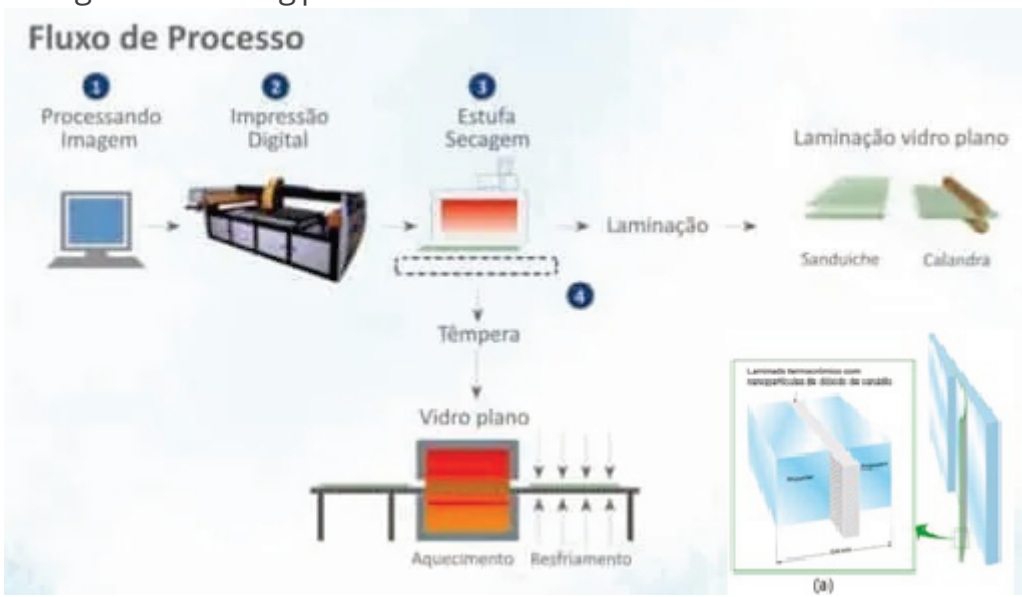
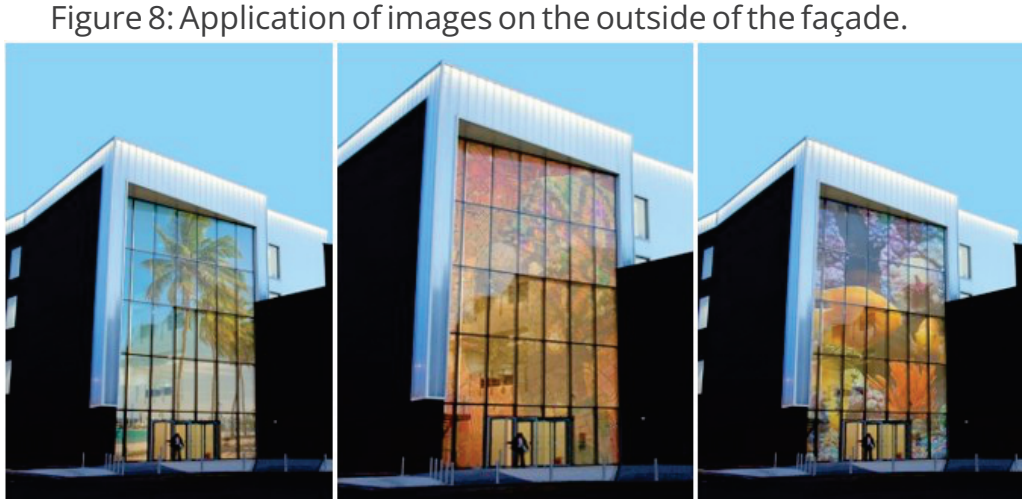
Figure 7: Printing process flow.



Source: Portal Belo Horizonte

In accordance with the result after the simulation of image superimposition in the mosaic technique, the perspective for the buildings as a fundamental part in the solar interaction and in the outside air temperature, will influence to give probability and define the focus of the development and progress of the research, which from these studies, began to encourage the evolution to new artistic materials in the glazed facades (Figure 8).

Figure 8: Application of images on the outside of the façade.



Source: Authors.

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The models used as a prototype of external visualization consist of ensuring the reliability of the proposed façade optimization processes based on solar protection, thermal performance, natural lighting and aesthetics.

5. FINAL THOUGHTS

The methodological proposal, based on multidisciplinary integration, was aided by a dynamism of the strategies in favor of technological diversity. He contributed, both to the context of design making and to exploratory research, such as the development of advanced practices in the use of new inspired designs, which enabled a wide range of inventive possibilities.

The knowledge and appropriation of relevant tools were considered to rethink, together, about the design concepts, techniques and conceptual models that allow decision-making, based on specific data from alternative materials in the use of biomimicry and biotechnology. In the case of building skins, the main function of these building subsystems is to map the external and internal environments and to promote the importance of sun protection without using electromechanical devices. In this way, it would also be possible to investigate improvements in materials adaptable to facades for the sake of sustainability.

In future developments, the knowledge and appropriation of relevant graphic tools will be considered to rethink the techniques and conceptual strategies that allow decision-making, based on specific data from alternative procedures and materials, which provides protection against the penetration of sunlight and overheating in the skins of glazed buildings.

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