Segreteria: Ipsapa/Ipsalem

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Agribusiness Landscape & Environment Management
Agribusiness Paesaggio & Ambiente
Rivista internazionale interdisciplinare quadrimestrale
Print ISSN 1594-784X - Online ISSN 2038-3371
Registrazione Tribunale di Udine n. 5 del 4 aprile 1995
Direttore responsabile Margherita Chang Ting Fa
Vice Direttore Luca Iseppi
Vol. XVIII - n. 2, Marzo 2015

Progettazione grafica
Margherita Chang Ting Fa

Editing
Luca Iseppi

Coordinamento editoriale
Forum srl, Ed. Univers. Udinese

Stampa
Graphis - Fagagna (UD)

Con il contributo
Ministero delle politiche agricole alimentari e forestali - MIPAAF

Osservatorio dell'agribusiness

Controsservatorio ambiente e territorio

Paesaggio e risorse

Recensioni e informazioni

*Il testo integrale delle norme per i collaboratori è diffusa via Internet ai seguenti indirizzi:*https://sites.google.com/site/agribusinesspaesaggioambiente/home/norme-per-i-collaboratori.
Archivio riviste fino al 2009 http://www.ipsapa.it/archive.htm e dal 2010 https://sites.google.com/site/agribusinesspaesaggioambiente/home.

Dynamic Façades in the Contemporary Man-made Environment

From Tradition to Innovation

Dynamic Façades in the Contemporary Man-made Environment. From Tradition to Innovation. *Contemporary architecture should focus on the ability to react, adapt, and change rapidly according to the environment or profiles (Oosterhuis, 2003). This flexibility/adaptability has materialised in recent times in various ways. Today the façade is the place where we most often experience the concept of adaptability. Within this framework, the façade returns to communicate through smart technologies and adaptive systems, mainly thanks to dynamic devices. We often deal with dynamic or kinetic façades. This paper aims to examine the relationships that contemporary dynamic façades shall determine with the context and with the users through three survey instruments: the shape of the dynamic elements, the pattern, and the colour of the façade. The investigation will be made with reference to examples of recent buildings and architectural projects.*
Keywords: architectural design, dynamic façades, kinetic façades, environmental quality


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A kinetic façade could be generically identified "as a convertible object dynamically occupying a physical space, or as a moving physical object that can share a common physical space to create new adaptable spatial configurations" (cf. Fox M., Miles K., p.27). The word "kinetic" comes from the ancient Greek word κινητικός - Kinetikos, "one who sets in motion" (Gasparini, 2012). Façades characterised by moving elements are thus defined as kinetic façades or dynamic façades. The moving elements may have only an expressive (architectural) function, but in most cases they act as mobile shading systems able to regulate sunlight and thus temperature.

Within a broader scheme, the building is conceived as a flexible system. This flexibility/adaptability has materialised in recent times in various ways. Buildings with a reconfigurable internal distribution; buildings in which internal comfort can be regulated according to external environmental conditions; buildings that are able to interact at different levels with the user, etc. All these aspects are inspired by more or less distant origins. The Maison du Peuple in Clichy (1938), designed by Marcel Lods, Eugène Beaudouin, Jean Prouvé, and Vladimir Bodiansky, has walls, floors, and a roof that can reconfigure the interior space depending on the requirements of use. The Ministry of Education and Public Health in Rio de Janeiro (1936-43) designed by a team including Oscar Niemeyer and Lucio Costa, and with the advice of Le Corbusier, features brise-

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soleil sun-shades with adjustable slats (also inspired by another tradition) to optimise interior comfort depending on the height of the sun. The design for the Peugeot Skyscraper in Buenos Aires by Maurizio Sacripanti (1961) features a façade composed by orientable brise-soleil plated with coloured elements and lights upon which messages could be communicated to the outside. Incremental architectures (additive, subtractive etc.) such as the Plug-in City by Archigram (1964), or the Stadtsystem by Eckhard Schulze-Fielitz (1966) had a structural grid on which they could insert/remove the housing units, while the canopy systems were made of mobile sheets. This is to mention just a few of the more famous examples.

The changes introduced by technological development, following the High-Tech Architecture style (of the 1970s, 80s, and 90s), have led to an evolution in the design of all the elements mentioned above, transforming them from technical elements into architectural ones (e.g. the Centre Pompidou in Paris). Art (and architecture if conceived as art) has nothing to do with morality (Cacciari, 2000), but its job is to convey the message that the author wishes to convey. The rules and the techniques of that specific art remain essential. The design of the façades in contemporary architecture seems to be free from any ideology (such as that of "form follows function", but also of more recent ideologies such as "sustainability tout court"), and everyone seems to be free to choose their own language. The only constraints are represented by the relationship of the building with its environment and with its users, budget, and function.

In the design of contemporary façades, mobile devices for sun shading play a very important role. According to NBN EN 12216:2002, they can be classified into: awnings, shutters, and sunscreens. In dynamic façades, adaptive sunscreens are the most important. We are all familiar with adjustable louvers. They have been, since the nineteen-thirties, the first system that can generate dynamic façades. Among the early examples can be counted the Obra do Berço in Rio de Janeiro by Oscar Niemeyer, built in 1937, in which the façade of the building is characterised by the presence of moving vertical blades. In this context the Ministry of Education and Public Health in Rio de Janeiro (designed in 1936) is also important, featuring a large façade screened entirely by horizontal metal slats. Significant, too, are the patented designs by the French blacksmith Jean Prouvé in the late nineteen-forties for prefabricated houses in tropical climates (Maison Tropique, Maison Coloniale, etc.). Today, dynamic sun shading can be achieved with blades of any material (metal, plastic, wood, glass, ceramics, etc.), and is commonly used with the large glass façades typical of contemporary architecture. These blades can now be connected to external sensors capable of determining the light conditions and which, thanks to computers that control the actuators, can be operated automatically in accordance with changing climatic conditions (adaptive shadings). This integration of different technologies has led to the development of adaptive shading systems.

The first attempt at adaptive shading was applied to the façade of the Arab World Institute in Paris, designed by Jean Nouvel and completed in 1987. On the south-facing side, 240 square panels (each of 2 square metres) of chiselled and motorised aluminium are embedded in the criss-crossing structure of the façade, sandwiched between two stretches of transparent glass. Covered with variable mobile apertures of different sizes, the pattern of which derives from the geometrical motifs of the Alhambra mosaics in Grenada, and whose movement depends on variations of the weather. The 73 diaphragms composing each panel work in the same way as camera diaphragms: mobile metal slides close, widen, or narrow the opening as required. Two small electric motors, sliding cables, and stainless steel rods, allow the movement of each panel. "The opening and closing is controlled by a photo-sensitive cell located on the roof, but manual operation is feasible" (Nouvel *et al.*, 1995, p. 28). However, whilst this shading system was very innovative for its time, it never worked well.

In the last few years, designers and manufacturers have developed shading systems based on the adaptive modulation of sunlight using external sensors that detect changes in climatic conditions. They differ from the classic brise-soleil with their horizontal or vertical blades. Some prototypes are based on the brise-soleil model but work on the torsion of the blades, thus creating a dynamic rapidly changing surface (i.e. the SemiIntelligent Shader by SCAPIRAN). Other systems are made of sliding perforated sheets of metal or plastic, modulating the intensity of incoming light (i.e. Hoberman-ABI: Tassellate®). Yet others are constituted by panels that open in various ways (i.e. Hoberman-ABI: Strata® and Permea®). Finally there are those that exploit the principle of homeostasis using membranes capable of reacting to different external temperatures (smart materials Homeostatic Façades). The objective of this paper, however, is not to investigate the performance of these elements, but to analyse them from the perspective of design and environmental integration. For this reason it is necessary to analyse what appear to be the key design features of these mobile elements.

2. Design of mobile elements

Firstly we will investigate shape. Designers in recent years seem to have indulged in creating screening elements with varying and original shapes. Some examples that confirm this hypothesis are the shielding triangular/star-shaped modules in the towers of the Abu Dhabi Investment Council Headquarters (2012), the umbrella-shaped sunscreens of drilled COR-TEN® steel utilised in the conversion project of the Madrid Pavilion at the Shanghai Expo (3Gatti, 2010), and the triangular metal sail-shaped sunscreens in the Q1 building of the ThyssenKrupp Headquarters in Essen, Germany (2010).

Secondly, we will investigate the repeatability of elements in the façade (i.e. the pattern). The moving elements may have the same or different dimensions, and are joined together to cover the surface required. This "rhythm" helps to decisively characterise the façades. The elements may be joined: vertically (all the same) as in the One Ocean Pavilion for Yeosu Expo (2012); form a diamond pattern (or other geometric shapes) as in the Abu Dhabi Investment Council Headquarters (2012); constitute a "liquid" façade, thanks to the sinuous shapes of the shading elements (Homeostatic façade by Decker Yeadon, 2010); or integrated in the façade with algae bio-reactors (BIQ House in Hamburg by Splitterwerk Architects, 2013).

Finally, the third "key point" is that of colour. The colour of the moving devices indisputably affects the appearance of the façade. In many cases they are white (One Ocean Pavilion, Kinetower etc.). In other situations, designers use very colourful elements. The Novancia School of Business, designed by Architecture Studio (2010), has a glass shell consisting of blades of frosted glass coloured in red and yellow. Many buildings designed by Sauerbruch & Hutton Architects have coloured mobile screenings. The façades made of textile awnings are often characterised by saturated colours.

Let's see in detail the analysis of some façades based on the three fundamental characteristics identified, sometimes combined with each other: shape, pattern, and colour.

3. Shape

Architectural research seems to be directed towards the analysis of shapes that go beyond the standard concept of blades or louvers, moving towards more complex geometric elements or organic shapes. The research of fluid forms in architecture does not seem to concern only the building envelope (see blobitecture etc.). Even the moving parts of the shading system can be created following organic or fluid lines generated by the powerful software available today. Examples of this type of dynamic systems are represented by the Homeostatic Façade System by Decker & Yeadon, and the ShapeShift project of ETH Zurich.

Homeostasis, as defined by the historian of science Claude Bernard (1865) and later by the physiologist Walter Bradford Cannon, is the property of a system, either open or closed, that regulates its internal environment and tends to maintain a stable, constant condition. All homeostatic control mechanisms have at least three interdependent components: the receptor, the control centre, and the effector. The receptor is the sensing component that monitors and responds to changes in the environment. When the receptor senses a stimulus it sends information to the control centre. The control centre determines an appropriate response to the received stimulus, and sends signals to an effector. After receiving the signal, a change occurs to correct the deviation, either by enhancing it with positive feedback or depressing it with negative feedback. Human sweat is an example of our homeostatic response to a high level of heat gain. In 2010 the architects Martina Decker and Peter Yeadon applied the homeostasis principle to a new adaptive sun-shading system. This system fits into a double skin façade and takes advantage of the unique flexibility and low power consumption of dielectric elastomers. "The actuator is an artificial muscle, consisting of a dielectric elastomer wrapped over a flexible polymer core. Expansion and contraction of the elastomer causes the flexible core to bend. A roller at the top of the polymer core ensures smooth motion as the elastomer moves.

The dielectric elastomer includes silver electrodes on both faces. The silver assists the system by reflecting and diffusing light, while distributing an electrical charge across the elastomer, causing it to deform" (Decker & Yeadon, 2010). The shape taken by this type of shading appears as a venous network: these sinuous lines contract and decontract like muscles, closing or opening the building to the natural light. The colour is a metallic grey (Fig. 1).

The ShapeShift project explores the potential application of an electro-active polymer (EAP) on an architectural scale. EAP is an ultra-lightweight, flexible material which has the ability to change shape without the need for mechanical actuators. "As a collaboration between the chair for Computer Aided Architectural Design (ETHZ) and the Swiss Federal Laboratories for Materials Science and

Fig. 1
Homeostatic Façade by Decker & Yeadon (©Decker & Yeadon)

Technology (EMPA), ShapeShift bridges gaps between advanced techniques in architectural design/fabrication and material science as well as pushing academic research towards real world applications" (Kretzer, 2010). The shading elements look like the bellows of an accordion that, opening and closing like a tent, allow the passage of light inside the building.

Another project with special shading blades is the "One Ocean" Thematic Pavilion designed for the EXPO 2012 in Yeosu (South Korea). The twisted blades designed by Soma Architects are made of GFRP, a composite material with shape memory capabilities, consisting of a polymeric matrix of an organic nature reinforced with glass fibre and integrated with LED. At night the dynamism of the façade is intensified by the lighting system. LEDs are positioned on the inner side of the front edge of the slat. When the slats are in the open position the LED can illuminate the neighbouring lamella in function of its opening. Geometry, material, light, and motion are perfectly correlated. The longer the blade is, the wider is its opening angle and thus the wider is the area that is illuminated.

4. Pattern

Rudolph Arnheim has made some observations on the concept of pattern. When a pattern is composed of units of the same weight, the "hierarchical gradient" of the image approaches to zero, i.e. there is a hierarchy of the elements within the composition. "The repetitive pattern of a wallpaper or the windows of a skyscraper gets the balance by homogeneity" (Arnheim, 1954, p. 45). Attilio Marcolli defines "pattern" (constitutive models or tiling) as flat modular structures. These can be either modular regular or semi-regular structures. "The three flat modular structures are configured respectively by equilateral triangles, hexagons and squares" (Marcolli, 1978, p. 58). There are eight semi-regular types. They are a fully repeatable geometric pattern consisting of several different polygons. In respect to architectural surfaces, Marcolli prefers to use the term *texture*, "modular plots, partial or general" (Marcolli, 1971, p. 123). As in Arnheim's definition, Marcolli highlights the concept of homogeneity of pattern. In flat modular regular structures the elements are all identical, whilst in semi-regular structures they differ in shape or size. In the second case, there is the hierarchy of elements referred to by Arnheim. A necessary condition for pattern seems to be repeatability. The pattern can be homogeneous, i.e. formed by elements all equal in shape and size (no hierarchy), or inhomogeneous, formed by elements of different size or shape (with hierarchy). In some cases it is not possible to discern a pattern. A homogeneous pattern of dynamic elements is constituted by a set of all identical modules, repeatable in sequence over the entire façade. One could consider, for example, large façades with all identical sunshade screens or blades. An inhomogeneous pattern is formed by dynamic elements that are different from each other in shape or size. One example of this could be a façade with different curtains.

An effective example in which the designer seems to concentrate mainly on the design of the sunscreen pattern is the dynamic envelope of the Abu Dhabi Investment Council Headquarters, designed by Aedas and Arup (2012). It consists of specifically designed sunscreen elements made of fabric and moved by robotic arms. The design of the shading elements is inspired by the Arab tradition of Mashrabiya. However, we can clearly recognise a precise reference to the shading system designed by Jean Nouvel for the south façade of the Arab World Institute in Paris (1987). The pattern of the façade is extremely regular. It is formed by a sequence of triangles able to open and close. The shading material is a beige colour, like the sand of the desert. When an element is closed there is a vacuum that creates a shadow on the glass skin behind it. They are modules in the shape of a large triangle, which consist of another 6 smaller triangles. When seen in three dimensions (3D), it appears like a triangular pyramid with three sides, each subdivided in two parts (6 folding elements in all). The scheme is very similar also to origami.

When the shading elements are closed the geometric shape of the triangle looks like a star, because you see mainly the structure that holds them.

Dynamic elements, with their movement, constantly change the façade pattern. This is the case with Kinetower, designed by Kinetura. Kinetura is a design team led by Barbara van Biervliet and Xaveer Claerhout, established in 2006. They have run the Claerhout-Van Biervliet architecture office since 1995, and are mostly engaged in more "down-to-earth" design. The architects don't seem to have concrete specifications about the system itself, as they are still in the process of developing the technology for Kinetower (2010). Nevertheless, they emphasise that the project was an architectural exercise in conveying their design philosophy. Metamorphosis of space, the adjustment to functional and environmental demands, can lead to what may be referred to as the "controlled spontaneity" of buildings. In a strictly visual sense the term "object" becomes obsolete. The design's transformable nature shifts the discourse from the realm of the static into the world of the moving image. It represents an unconscious, progressively stronger, architectural desire to move, to break loose from the master plan. Mobile structures, with their own intelligence, free to roam the world, have always been a part of the architect's dreamscape. "It is light that this creature thrives upon. Its energy-regulated outer skin has the ability to control the level of sunlight, depending on the needs of users, as well as the motion-based reaction to weather conditions. Flexible material of the skin can be rigidified, giving it a different appearance" (Kinetura, 2010). The façade of the building is marked by regular structural lozenges, as in the John Hancock Centre in Chicago designed by Bruce Graham (1965-69), but more dense. The non-structural translucent spaces of the façade are covered with linear cuts (slats) that emphasise the rhomboid pattern. The scheme is perfectly geometric. But when the slats are opened, the image of the building changes completely. The pattern is broken. The blades of shape memory material fold together like the fingers of a hand, creating an undulating and sinuous façade.

5. Colour

Colours, especially highly saturated ones, seem to represent a point of reference for some contemporary architectures that want to be noticed. But there are other issues at play here: the complexity of contemporary life; its mutability; the continuous transformation of things; the insecurity that characterises our liquid society. An emblematic example of the use of colour in a shading system is represented by a static façade that appears dynamic. This is the Parking Structure Art Façade in Indianapolis, USA (2014) by Urbana Studio. "This project began with an interest in challenging the typical notion of the parking structure as an unappreciated infrastructural typology by transforming the new Eskenazi Hospital parking structure into an interactive, synthetic terrain. A field of 7,000 angled metal panels in conjunction with an articulated east/west colour strategy creates a dynamic façade system that offers observers a unique visual experience depending on their vantage point and the pace at which they are moving through the site. In this way, pedestrians and slow moving vehicles within close proximity to the hospital will experience a noticeable, dappled shift in colour and transparency as they move across the hospital grounds, while motorists driving along W. Michigan Street will experience a faster, gradient colour shift which changes depending on their direction of travel" (Rob Ley, 2014). The large flat façade of the structure is characterised by metal strips coloured in blue and yellow. The strips, looking like a mass of post-it notes, are bent and positioned so that the building appears completely blue from one side, and completely yellow from the other. The building is designed to be seen in motion, so that the façade, despite being static, seems dynamic due to the change of colour between yellow and blue. The tension that one feels when looking at the surface of the façade is produced by the combination of

shape and colour. All this from a project that started with the elaboration of a special software to be realised through metal panels (Fig. 2).

Colour is strategic in many other projects with mobile elements in the façade. Among the buildings that could be cited, there is the glass envelope of the Novancia School of Business in Paris (2010), designed by Architecture Studio. "The Novancia Business School extension asserts its modern features while being in line with the heritage building that date back to 1908 and in harmony with the entire neighbourhood. Contrasting with the steady and rough bricks of the 1908 building, the extension is smooth, dynamic and kinetic. Its morphology is a result of the Haussmann-inspired template and the will to open the block onto outward urban space. The historic and contemporary aspects of the project strengthen each other and express the idea of evolution. The building has a simplified outline and glazed façades composed of mobile vertical coloured shutters. They control solar gain according to the seasons. From the outside, different angles of view allow for different perceptions: depending on the degree to which the shutters are opened, the building seems closed when seen from afar and transparent when standing next to it. Interior areas are user-friendly and have readily legible layouts, set around a main atrium" (Architecture Studio, 2010). The interior spaces are not all translucent because the external louvers are not all sunscreens, and they constitute a real over-cladding for the entire envelope. Thus, the entire envelope is characterised by blades of frosted glass in red and yellow. In certain places the alternation of the two colours produces an effect of interpenetration. The contrast of primary colours is in the façades of the building. The opening and closing of the mobile screens does not dramatically change the colour perception of the façade, as the slats are very dense.

In dynamic façades the colour combinations seem to act in relation to the shape and to the pattern of the elements, so reading them becomes much more complex and allows the designer to play very subtle expressive games.

6. Conclusions

The dynamic façades (or the set of elements that make them up) seem to be characterised by the combination of three basic reading instruments: shape, pattern, and colour. Shape and pattern seem to belong to a reading of a geometric type following, from time to time, the Euclidean geometry or other logic such as, for example, the fuzzy logic, fractals, or shapes generated by computer. Colour seems to be a more complex tool. Thus, most of the buildings that use very advanced technologies seems to

Fig. 2
Parking Structure Art Façade © Rob Ley (Urbana Studio)

be characterised by colours such as grey or white (e.g. Homeostatic Façade, One Ocean Pavilion, Kinetower…), whilst buildings with multiple colours can be perceived as the visual equivalent of 'background noise' (a sort of non-colour). In fact, "we can see the special case of media and smart façades and their relationship with the visibility and colour perception. It is difficult to lay down a rule of colour design for these façades and find a measure of their interaction with the environment. The reasons are to be found in the components and materials used" (Gasparini, 2015).

For less complex situations, the researcher or designer can evaluate the chromatic project of a façade through a tool designed as part of a research study completed in 2010 by the author. This tool is the "Colour-Shading" software project, developed as part of the PhD research "Mobile Zone. Technologies for the architectural integration of mobile shading devices", at the University of Ferrara. This tool associates specific types of shading systems and façade systems according to some ideal colour combinations that were derived from the analysis of a sample of over one hundred case studies of contemporary architecture. For all other situations, and certainly for the more complex ones, a much more refined design study would be necessary.

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Sommario
Le facciate cinetiche e dinamiche sono molto diffuse nei grandi edifici vetrati contemporanei. Il design utilizza tecnologie avanzate e smart, sempre più innovative e a basso consumo energetico. Queste tecnologie sempre più spesso si combinano ad una ricerca di forme e geometrie sempre più complesse. Una chiave di lettura per meglio comprendere la progettazione di queste facciate può essere una scomposizione di queste in: forma (degli elementi schermanti), pattern (combinazione degli elementi) e colore degli stessi in relazione alla facciata nel suo complesso. Negli edifici che usano tecnologie più avanzate la forma degli elementi sembra sempre più fluida e svincolata dalle tradizionali geometrie euclidee (materiali smart a memoria di forma). I pattern geometrici regolari sono i più vari anche se in molti edifici sembrano prevalere logiche fuzzy o comunque derivate da software di modellazione tridimensionale. Più complessa sembra essere la lettura del colore. Ai colori saturi e ai contrasti di primari che sembrano caratterizzare buona parte dell'architettura contemporanea si affiancano situazioni più complesse dove la combinazione forma-pattern-colore è utilizzata per effetti particolari. Esistono inoltre situazioni dove l'eccesso di colori nelle facciate cinetiche/dinamiche sembra produrre una sorta di rumore di fondo. Molte tecnologie smart sembrano invece avere una sorta di non-colore.

Acknowledgement: "Eterotopie. Colore, Luce e Comunicazione in Architettura" Research Centre, Treviso

Bibliography

Arnheim, R. (1954). *Art and visual perception*. Berkeley: University of California Press

Cacciari, M., Donà, M. (2000). *Arte, tragedia, tecnica*. Milan: Raffaello Cortina.

Fox, M., Miles, K. (2009). *Interactive Architecture*. New York: Princeton Architectural Press.

Gasparini, K., Premier, A. (2012). *Il movimento in superficie. Sistemi di schermatura dinamici e facciate cinetiche smart*. Tenda in & Out no. 1/2012, pp. 36-41, Rimini: Maggioli.

Gasparini, K. (2012). *Schermi urbani. Tecnologia e innovazione: nuovi sistemi per le facciate mediatiche*. Milan: Wolters Kluwer Italia.

Kretzer, M. (2010). *Towards a new softness. The aesthetics of soft dielectric electroactive polymers and their application in an architectural context*. London.

Marcolli, A. (1971). *Teoria del campo: corso di educazione alla visione*. Florence: Sansoni.

Marcolli, A. (1978). *Teoria del campo 2: corso di metodologia della visione*. Florence: Sansoni.

Nouvel, J., Lezenes, G., Soria, P. (1995). *Institut du Monde Arabe*. Paris: Les Editions du Demi-Cercle.

Oosterhuis, K. (2003). *Hyperbodies: towards an e-motive architecture*. Basel: Birkhauser.

Premier, A. (2010). *Color-Shading Software: New Tools for Chromatic Integration Between Shading Systems and Built Environment,* in Zennaro, P., Editor. *Colour and Light in Architecture. International Conference Proceedings*. Venice 11-12 November 2010, pp. 534-539, Verona: Knemesi.

Premier, A. (2012). *Superfici dinamiche. Le schermature mobili nel progetto di architettura*. Milan: Franco Angeli.

Premier, A., Gasparini, K. (2015). *Chromatic integration of the architectural surfaces with environment: analysis and classification of case studies. Conference Proceedings of AIC 2015 Midterm Meeting*, Tokyo 19-22 May 2015.

www.deckeryeadon.com

www.kinetura.com

http://rob-ley.com/May-September