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Source: Forum A+P 28 | Invited Papers

ISSN: 2227-7994

DOI: 10.37199/F40002806

Publisher: POLIS University Press

Exploring the Intersection of Speculative Design and Adaptive Surfaces

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Introduction

In the realm of architectural innovation, speculative design has emerged as a transformative discipline, pushing the boundaries of conventional aesthetics and functionality. At the intersection of creativity and technological advancement, the incorporation of Artificial Intelligence (A.I.) into speculative architecture design introduces a paradigm shift, offering unprecedented possibilities in adaptability, sustainability, and user experience. Speculative design envisions possibilities beyond the existing constraints, and AI plays a pivotal role in realizing these visions. The integration of AI in facades introduces a new type of adaptability by enabling real-time responsiveness to environmental factors. Machine learning algorithms can process data from sensors, weather forecasts, and user preferences to dynamically adjust the facade's properties. This adaptability could enhances energy efficiency, occupant comfort, and overall building performance. Adaptive architecture and facade systems differ from more common kinetic and media systems because they can self-regulate, manage unforeseen variations, and implement spatial transformations in response to environmental factors, safeguarding building safety and user comfort.

This paper explores the ongoing paradigm shift that has occurred in the last fifty years in architecture, generated by the intersection of the creativity of visionary architects, speculative design, and digital technologies. Thanks to this convergence, technology, through A.I., could become a crucial ally in shaping the built environment to meet human needs and address environmental challenges.

The origins of change

The conditions of this change have a complex and multifactorial origin. The city itself can be considered a complex and open system, characterized by adaptability, in the sense of "possessing the quality of naturally assimilating diverse realities" (Ciribini, 1984, 59). When the variable of time is introduced, Ciribini argues, the systemic state of the city undergoes constant changes in the form of a "succession of states" that are often challenging to control. Additionally, according to Virilio, that of speed has supplanted the order of time. It can be likened to contract time condensing around a fleeting event, such as the immediacy of the message transmitted by media-building. Therefore, we could argue that media-building has embedded itself in an era of rapid changes for architecture (Gasparini, 2023). Media architecture was born in the 1960s but widespread since the late 20th century. It could be considered the link between traditionally conceived architecture and the digital world. Thanks to its fusion of physical and digital elements, media buildings have introduced interactivity into architecture, initiating transformative approaches at various project scales (Andaloro, de Waal, Suurenbroek, 2022). Visionary architects such as Robert Venturi and Archigram conceived the pioneering projects of this new interactive and adaptive role in architecture in the 1960s. Archigram's visionary projects outlined what could now be concretely realized by Artificial Intelligence: Plug-in-City is a mega-structure without buildings, a compact mass of similarly shaped elements where dwellings are standardized cells or components; Instant City is a mobile technology fair that develops in degraded neighbourhoods, a squalid flying city (like a balloon) with temporary structures; the Walking City consists of intelligent buildings or giant robot forms that could roam the city.

Robert Venturi, on the other hand, worked on two-dimensionality and conceived an architecture that, surpassing the functionalist imperative, could become a support for other media with infinitely greater communicative potential: television screens, billboards, and iconically characterized

objects. He likens the city to a kind of theatre. The show as "simulation" (urban spectacle), an artifice where it is no longer possible to distinguish the copy from the model and the real from the virtual (Venturi, 2010, 30). A few years later, in the renowned "Delirious New York," Koolhaas presents his "Theory of Bigness," or extreme architecture as the only tool that can activate the regime of complexity involving the full understanding of architecture and related fields. Koolhaas captures the transformation of the architectural surface, where the link between core and envelope is severed to the point that the facade can no longer reveal what happens inside and becomes a vehicle of misinformation—providing the city with the apparent stability of an object (Koolhas, 2006, 13-15). In the screen-facade, the cladding becomes a new mask that coexists closely with every mechanism, enveloping and protecting it, safeguarding users from tampering, like a casing (Zennaro, 2009, 83-109). From the second half of the 20th century, the functions of a building no longer reflect the utilitarian purpose described in architectural treatises, the Utilitas of comfort and usefulness. Firmitas lost its role in the first half of the 20th century: from the project of Jean Prouvè's Maison du Peuple, new construction systems confer adaptability to new formal configurations that we will find later in the initial design of the Beaubourg (with mobile floors). The metamorphosis of Venustas, then, translates into communication on the surface, instantaneous and hyper-technological. With media buildings, the facades produce a rapid succession of colourful and chaotic frames, purely for commercial purposes, ignoring any historically established principles in the entire Vitruvian triad. There is a reversal of priorities between technique and design (Gasparini, 2023). Toyo Ito argues that since ancient times, architecture has been a means to adapt humans to the natural environment; contemporary architecture must also be a means to adapt humans to the information environment. 'Architecture in the electronic era is an extended form of medial clothing' (Ito, 1998, 26).

Contemporaneity

In contemporary times, many projects showcase solutions to address social and environmental issues in public spaces through responsive technologies. In doing so, they create a narrative on specific topics, generating awareness towards a more resilient approach to the city. Often, these projects take the form of temporary installations that utilize data in an intangible manner and, despite aiming to create an immersive experience, do not intervene in the spatial configuration of the places (Andaloro, de Waal, Suurenbroek, 2022). From this perspective, some immersive installations in recent years are noteworthy. The experiment of the immersive installation created by teamLab inside the Japan Pavilion (Fig.1) at Expo 2015 in Milan (Italy) is intriguing: the interactive installations span two rooms, featuring an immersive projection space that beckons visitors to traverse a technological expanse.

This journey leads them to a digital cascade of information, imparting descriptive knowledge about Japanese cuisine (Azzarello, 2015). The concept of global immersiveness materialized in the visionary project of the Blur Building designed by Diller&Scofidio+Renfro for the Swiss Expo in 2002 in Yverdon Les Bains. "The Blur Building is an architecture of atmosphere a fog mass resulting from natural and manmade forces where a smart weather system reads the shifting climatic conditions of temperature, humidity, wind speed and direction and regulates water pressure at a variety of zones. Contrary to immersive environments that strive for visual fidelity in high-definition, Blur is decidedly low-definition. In this exposition pavilion, there is nothing to see but our dependence on vision itself. It is an experiment in de-emphasis on an environmental scale." (Diller&Scofidio+Renfro, 2002).

In more recent times, the project ADA by Jenny Sabin in collaboration with Microsoft is notably intriguing for its use of A.I. In this undertaking, Sabin delved into the realm of human emotion in collaboration with Microsoft's sentiment researchers, exploring the dynamic relationship between an individual's surroundings and mood. She crafted a cellular-like textile structure, symbolizing the heart of the research hub (D'Angelo, 2019). Cameras and microphones strategically placed within Building 99 gather anonymized data, which AI algorithms then interpret into changing intensities of color and light. These dynamic visual elements are manifested through addressable LEDs intricately woven into Ada's textiles, complemented by stage lights enveloping the installation (Roach, J., 2024). Technological advancements play a pivotal role in realizing these speculative visions. Smart materials, responsive sensors, and advanced data analytics could become integral components of adaptive facades, allowing for real-time adjustments and personalized user experiences. The fusion of augmented reality and responsive architectural elements might redefine spatial boundaries, offering immersive and transformative environments. Numerous experiments and projects in contemporary architecture showcase the intersection between speculative design and adaptive spaces. At the 2018 Architecture Biennale, an "alien" installation

Figure 1: Immersive installation, Japanese pavilion, Expo 2015. (Image © Alberto Piva)

emerged within the Swedish Pavilion designed by Sverre Fehn (Fig.2-3). The exhibition, titled "Another Generosity," seeks to delve into the connection between nature and the constructed environment. Curators Eero Lundén and Juulia Kauste aim to illustrate how humanity can embark on creating architecture that harmonizes with the surroundings. Inside the pavilion, they have introduced four large inflatables resembling cells, equipped with sensors monitoring carbon dioxide levels, humidity, and temperature in the vicinity. These cells "breathe" in response to environmental conditions. They either inflate or deflate based on carbon dioxide levels and change color to indicate temperature variations. This concept revolves around re-establishing a relationship with architecture, challenging the common perception of simply viewing buildings without deeper engagement (Mairs, J., 2018). In these visionary projects, the aesthetics of surprise prevail, pushing the materials' performance to the maximum, and the structural component is often concealed. The technique is at the service of an emotion, a symbol; it is merely a means to achieve a result. This has been the role of technique since ancient times when, according to a mythical perspective, the gods, to whom it belongs, bestowed it upon humans (Galimberti, U., 1999). The design process is the time of technique guided by human intentions, and utilizing technique, doing something "téchne" also presupposes the possibility of being able to do it and possessing the means, namely, science. AI is the tool through which architects today can design futuristic scenarios and then bring them to life: from parametric design to digital technologies that manage the functionality of the "living machine." From the perspective of A.I. tools for design, today, the Midjournei platform, with its AI capabilities, empowers architects to explore novel design alternatives, foresee potential challenges, and optimize resource utilization, ultimately leading to the creation of more responsive and innovative built environments (Fig.4-5). From optimizing building layouts for energy efficiency to predicting user behavior patterns for urban spaces, the platform demonstrates its versatility in addressing a wide array of design challenges. Furthermore, the study examines the role of AI-generated insights in fostering sustainable urban development and improving the overall quality of life for inhabitants.

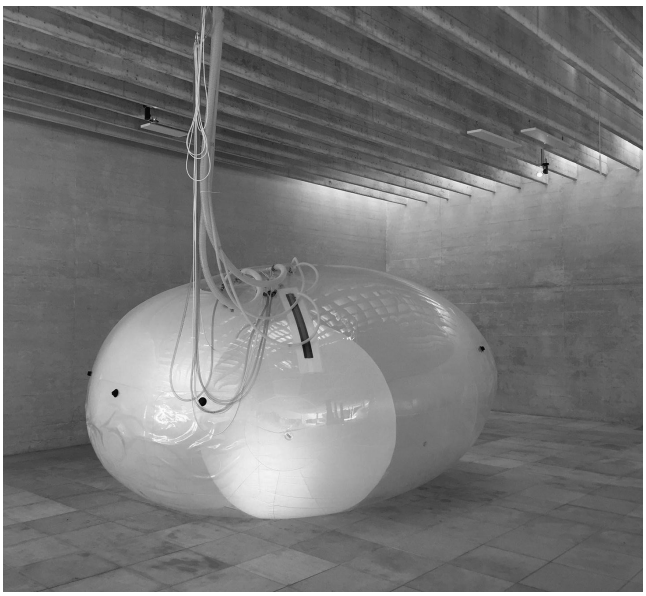

Figure 2-3: Installation “"Another Generosity," at Svedish Pavilion at Architecture Biennale, Venice (Italy), 2018 . (Image © Alessandro Premier)

Challanges and final considerations

The evolution of speculative design in contemporary architecture reflects a shift from merely imagining alternative futures to actively engaging with real-world challenges. Designers and architects increasingly use speculative methods to address issues such as climate change, urbanization, and social dynamics. The emphasis has shifted from fantastical scenarios to practical solutions, with a focus on sustainability, inclusivity, and resilience. Technological advancements play a pivotal role in realizing these speculative visions. Smart materials, responsive sensors, and advanced data analytics could become integral components of adaptive facades, allowing for real-time adjustments, personalized and inclusive user experiences. The fusion of augmented reality and responsive architectural elements might redefine spatial boundaries, offering immersive and transformative environments. However, while the integration of AI in speculative facade design presents exciting possibilities, it also raises ethical considerations. Issues related to privacy, data security, and the ethical use of AI algorithms require careful attention. Striking a balance between innovation and responsible implementation is crucial to ensuring that AI-enhanced facades contribute positively to the built environment without compromising quality standards. The ongoing evolution of artificial intelligence in the architectural domain signifies a paradigm shift, where technology becomes an ally in shaping the built environment in harmony with human needs and environmental considerations, as demonstrated in recent intersections between architecture and neuroscience.

Acknowledgments

For the pictures, I would like to express my gratitude to: prof. Giuseppe Fallacara, eng. Alberto Piva, dr. Alessandro Premier.

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Figure 4-5: Projects developed by prof. Giuseppe Fallacara with Midjourney platform (Image © Giuseppe Fallacara)