

An Investigation on Approaches of Different Interactive Technologies on the Industrial Building Surface

Rabaya Nusrath Niva

Faculty of Engineering, Department of Architecture,
Premier University, Chittagong, Bangladesh
M. Arch Student, Department of Architecture,
Bangladesh University of Engineering and Technology
Dhaka 1000, Bangladesh
snniva@gmail.com

Jannatul Ferdous Binti

Department of Architecture,
Bangladesh University of Engineering and Technology
Dhaka 1000, Bangladesh
jannatbinti459@gmail.com

Abstract

"Interactive" means reaction to action, action to action, or action to response instead of reaction. Physical constructions don't react to other people and are static. Interactive architecture, on the other hand, reacts to its users as if they were already living things. Interactive architecture refers to the connectedness of interaction in design and construction. The notion. The kinetics component satisfies the need for adaptation and is based on embedded computation (intelligence). A setting will be able to change and automate important reactions in order to respond, interact, adapt, and connect to the combination of intelligence and kinetics. Interactive environments are intended to address people's demands on an individual, societal, and environmental level. To adapt is to develop intelligent, modern human behavior and surroundings that could advance both our capabilities and the built world. This study aims to research interactive architecture for use as a building surface in industrial buildings to reduce energy consumption and ensure a comfortable indoor environment considering different dimensions of interactive building surfaces through true interaction.

Keywords

Interactive technology, Embedded computation, Smart material and Building façade.

1. Introduction

Architecture technologies aim to provide a human-tech-architecture system to develop an interaction for improved environmental quality. Usman Haque defines interaction as the exchange of information among two systems, and these interactions should be continuous in nature (Haque 2006). A single or multiple-loop response mechanism may be used in a machine-human interaction. When a setup observes, it responds to humans or the environment using a predetermined algorithm, and communication happens between the installation and the user. Thus, the exchange of information generates an adaptive system and this can be dubbed an "interactive installation". We are currently surrounded by sophisticated, integrated architectural equipment. "Interactive architecture" refers to the comprehensive integration of the disciplines of interface design and architecture (Fox 2010). A particular model controlled by a systems administrator may be referred to as kinetic architecture. Furthermore, communication in interactive architecture is a two-way system. A really interactive system is a multi-loop system that interacts in continuous and meaningful information sharing. People who interact with this type of technology are referred to as "participants," not "users." "Although the popularity of interactive architecture is unclear, we may predict that these technologies will become important in building design in the future (Fox 2010). According to Usman Haque, the terms "interactive" and "high-tech" are not interchangeable. He claims that anything that is interactive but not high-tech can be created, and vice versa. If we regard a static structure to be a component of the environment, we can conclude that it is not interacting with it because it has no bearing on it. In another sense, we may say it has because it changes the climate

in a specific environment. However, it does not immediately interact with its environment. Similarly, louvres that follow the path of the sun to reflect sunlight into a building are just responding to inputs and should be referred to as "reactive" rather than "interactive." Interaction is defined as the exchange of information between two systems, such as two humans, two machines, or a human and a machine. According to Usman Haque, it could be regarded as cyclical interaction or "reacting" rather than "interacting." (Haque 2006). Architecture should be a "living, changing thing" in order to create dynamic surroundings. Architect, cyberneticist, and educator John Frazer. It should be adaptable, as is the case with all living things. Intelligent settings can be designed with adaptability in mind using various adaptability ideas such as responsive, biomimetic, parametric, and so on. As they begin to do more than just respond through communication, our buildings will become really dynamic in the sense of encouraging dialogues. Our buildings' conversations are no longer limited to one-on-one encounters. When architectural space has actual communicative capability, it generates a stronger sense of attachment. Buildings may actually communicate with their surrounds and convey knowledge based on information by conducting, imparting, giving, spreading, transferring, transfusing, and transmitting (megafaces by asif khan ltd). These facades have been used in the actual world to show how repurposing the building face as a mediator saves money while also improving space. Facades are the most inventive area in adaptive design, with kinetic screens that breathe. Microalgae that serve as culture systems inside panels to titanium dioxide-covered walls that purify the air. Interacts with an intervening agency via equidistant; innermost, innermost, between and between, borderline, gray (also grey), in-between. Mediate with the outer wall, which serves as an interaction medium between the environment and humans.

1.1 Objectives

The aim of this paper is to study the interactive technologies of various built form surfaces and installations that can be utilized in industrial building surfaces. The study's objective is to demonstrate the effectiveness of interactive architecture in the built environment as well as to evaluate the embedded computation implemented in the installation process.

2. Background Study

It took until the middle of the 1990s for interactive architecture to start gaining popularity. Prospective consumers can now have some confidence in this type of experimental architecture because numerous attempts outside the realm of academia have now been performed. Interactive architecture will continue to be impacted by and advance due to modernization from other industries with equivalent consequences. Technology has benefited humanity in numerous ways, including the transformation of traditional mechanical and hydraulic control mechanisms in the automotive industry with "drive-by-wire" technology. An explosion in the development of sensors has signaled the arrival of previously unthinkable technologies for knowledge/analysis capture (Fox 2010). The responsiveness of interactive architecture is preprogrammed to establish a connection between people and technology. We can define interaction as a "mutual reaction" between humans and artificial intelligence (Hoberman 1999) Although it has a long history, dating to the 1960s, interactive architecture has mainly consisted of notions and experiments. Different interpretations of Interactive Architecture are referred to as "smart architecture," "responsive environments," "intelligent environments," and "soft spaces," respectively. Around 10 years ago, interaction design started with a variety of initiatives, primarily using digital technology rather than robotics, such as building surfaces, promenades, and other public places.

The early 1990s saw the emergence of interactive architecture as the ideas became both technologically and commercially viable. Architecture's kinetics was carefully researched with the goal of enhancing computing information and processing to control adaptability in contemporary society. Embedded robotics classes employing kits like the Arduino are common in architecture schools, allowing students to exhibit and explore concepts that weren't even possible ten years ago. Recently, a lot of efforts outside of academia have been started, giving clients some confidence in this type of experimental design (Fox 2010). unpredictability and open-endedness, interaction, cybernetics, adaptability, emergent behavior, True interaction: Reaction is recognized as a single loop. Interaction can be thought of as the interface between people and computers. Action and reaction are how it functions. To create a loop, or behavioral pattern generator, a circular input is needed. Only then can a computer open a folder in a predictable, predetermined way. It provides us with output based on input. But because we have no control over another person's thoughts or actions, human to human engagement through dialogue is open ended and unexpected. Emergent behavior is the term used to describe the open-ended character of interactions in living things. However, we could refer such an engagement as unpredictable or open-ended. Cybernetics is the source of the definition. In line with the cybernetics description, many architects try to imagine how a structure may resemble a living thing. Reaction is recognized as a single loop. Interaction can be thought of as the interface between people and computers. Action

and reaction are how it functions. To create a loop, or behavioral pattern generator, a circular input is needed. Only then can a computer open a folder in a predictable, predetermined way. It provides us with output based on input. But because we have no control over another person's thoughts or actions, human to human engagement through dialogue is open ended and unexpected. Emergent behavior is the term used to describe the open Reaction is recognized as a single loop. Interaction can be thought of as the interface between people and computers. Action and reaction are how it functions. To create a loop, or behavioral pattern generator, a circular input is needed. Only then can a computer open a folder in a predictable, predetermined way. It provides us with output based on input. But because we have no control over another person's thoughts or actions, human to human engagement through dialogue is open ended and unexpected. Emergent behavior is the term used to describe the open-ended character of interactions in living things. However, we could refer such an engagement as unpredictable or open-ended. Cybernetics is the source of the definition. In line with the cybernetics description, many architects try to imagine how a structure may resemble a living thing. Open-ended character of interactions in living things. However, we could refer such an engagement as unpredictable or open-ended. Cybernetics is the source of the definition. In line with the cybernetics description, many architects try to imagine how a structure may resemble a living thing. They transform a behavioral pattern from nature into an algorithm to produce actual interaction (ex. a swarm of birds, or fish, or bees). Many projects make advantage of this idea. Although a bird in a swarm will interact with other birds at the same time that the swarm interacts with its environment as a whole, there are several ways to predict a single bird's behavior in a swarm. Researchers want to know why they interact with the environment in this way. A bird's individual behavior differs from its flock behavior. Emergent behavior is the solitary behavior or distinct behavior that a flock or swarm of birds exhibits. Emergent behavior is wholly unpredictable, unstructured, and novel. Emergent behavior, which is behavior that is entirely unanticipated, open-ended, unique, and novel, occurs when a flock of birds interacts with its environment as a whole. Because individual behavior is unpredictable, emergent behavior, which is also known as unpredictable and open-ended behavior, develops a pattern based on an algorithm used in drones. A flock of drones composed of these interact with one another, work as a unit with nature, and perform a single action. It performs as a biological organism in a variety of natural settings. A structure may be considered interactive architecture if it can foster unrestricted interactions with people, the environment, and other living things. True interaction happens when a conversation is both surprising and open-ended. Humans would not be able to pinpoint the source of the building's erratic output in the event of genuine interaction. The foundations of iterative systems and interaction can be found in the field of cybernetics, where adaptability is a key concept. According to human needs and behavior as well as environmental needs and behavior, a building can adapt to itself as a living being. Interaction can be three types. These are Interaction with climatic elements and man-made actions, Interaction with climatic elements and Interaction with human participation.

3. Methods

A mixed-methods approach is adopted in this investigation. Through a study of the literature, using techniques to gather data and look up similar data from publications like books, the internet, journals, and other sources with a physical survey of a case study. Information output can be produced using words, images, and physical objects. To comprehend the idea of interactive technology in architecture and the development of design concepts, some case studies are taken into consideration.

4. Literature Review

Different technologies, such as augmented computing, cybernetics, nanotechnology, virtual reality, and sensors may have a significant influence on the built surface of industrial settings. number of case studies of different interactive installation is described below:

4.1 Interaction with Daylight

Subject 1. Kiefer Technic Showroom

Basically, the Keifer Technic Showroom building has a dynamic solar shading with electronic control. This structure responds to its environment in order to benefit its occupants. (The Dynamic Solar Shading of Kiefer Technic Showroom | Design Indaba 2016). Means of embedded computation (EC) refer to the outside structure is made up of 112 tiles that can be moved and folded into rows following the command. The surface can control the quantity of light let into the interior. This process can reduce the need for air conditioning (shown in figure 1). The external shield against external heat that is continuously moving so that the facade can be programmed to move automatically. It can also manually have controlled by inside user's comfort.



Figure 1. Kiefer Technic Showroom
Source: The Dynamic Solar Shading of Kiefer Technic Showroom | Design Indaba 2016

The building gives a “new look” in different time of the day shown in figure 1. It reacts with the rays of the sun shifting. The total building façade is divided into grid pattern with computerized simulation at the program generated based on perforated aluminum façade shifting system. The folding panels are active by automated shutter system (Yoneda 2010).

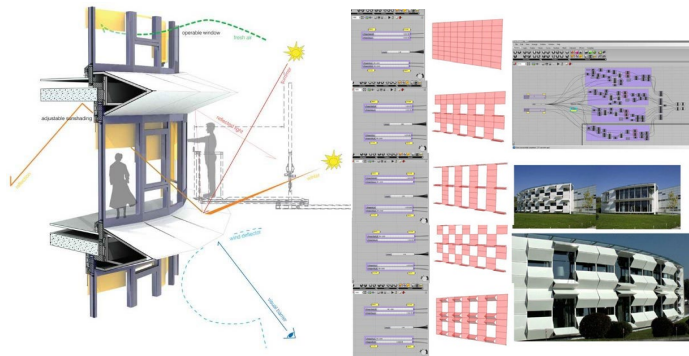


Figure 2. The control system of Kiefer Technic Showroom
Source: The Dynamic Solar Shading of Kiefer Technic Showroom | Design Indaba 2016

Used sensors are shown in Figure 2 which are light sensors central based and the control system is central control individually. The project is based on an active control system shown in Figure 2 where the combination of active means and passive system (daylight, air temperature). The configuration is on a user-led system since it is controlled by the user. Although the building is not adaptive to human behavior rather it is controlled by human. (The Dynamic Solar Shading of Kiefer Technic Showroom | Design Indaba 2016)

4.2 Interaction with Environmental Changes

Subject 2. Tessellate

This is a glass and metal kinetic art wall installation that regulates the amount of sunlight entering into the interior space of the campus. The adoptive feature of this project responds to the environment by a sensor-based system and controls the sunlight through processing the input signal (shown in Figure 3). (Simons Center | Zahner — Innovation and Collaboration to Achieve the Incredible 2016)



Figure 3. Tessellate: Using four basic geometries: hexagons, circles, squares and triangles
Source: Simons Center | Zahner — Innovation and Collaboration to Achieve the Incredible 2016

Means of embedded computation (EC) refers to the glass and metal kinetic surface can respond to environmental changes. Temperature, moisture, and light these are the environmental parameters that can be sensed. It can make opening or closing an aperture to control sunlight and create shade and shadow. The ways of control of the façade installation are ceiling metal surface with four panels layered perforated stainless steel (shown in figure 4). One layer collects the sensor-based data and 3 layers open and close due to temperature difference. The 3 layers perforated surface have motorized system. The motor is functioned due to designed components. The functional capacity to dynamically change its opacity and sculpt the quality of light within. The sensor used in the project are light sensor, temperature sensor and moisture sensors. The control system is single computer processor, motor-based actuators.

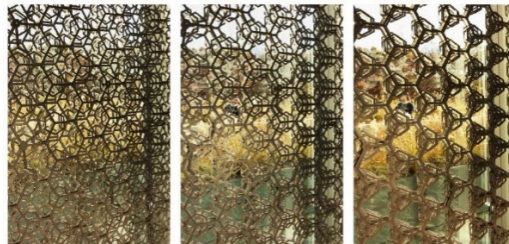


Figure 4. Three layers perforated surface of Tessellate
Source: Simons Center | Zahner — Innovation and Collaboration to Achieve the Incredible 2016

The project is based on location based sensory data so this can be an example of adaptive control system. The configuration is on machine led system. Although the building is adaptive to environment behavior rather it is not controlled by human. (Simons Center | Zahner — Innovation and Collaboration to Achieve the Incredible 2016)

4.3 Interaction with Sound and Noise

Subject 3. May/September

May/September uses a palette of architectural components derived from the perceptual aspects of dithering and error-dispersion in printmaking to create a noise-based textured building enclosure. Three basic typologies with three sized subsets, combined with part mirroring, result in an eighteen-part palette. These elements, together with a binary color palette of yellow and blue, establish a complicated. The use of digital image mapping and pixel data-extraction techniques in the production of architectural form isn't new or revolutionary. In fact, pixel analysis could be the most basic method of obtaining data for digital abstraction and modification. However, it is quite unusual. Each change in an assembly component results in a significant increase in time, effort, and expense. This puts the concept of waste front and center, both intellectually and practically (shown in figure 5). The production of images has always been constrained by the restrictions of print (and, later, digital technology).

May/September makes a noise-based, textural construction enclosure by using the good attributes of tone mapping and defect absorption in printmaking to create a palette of building parts (shown in figure 6). Throughout this, three basic types with three subsets of different sizes and part mirroring create a palette of 18 different parts. With these parts and a yellow/blue binary color scheme, a relatively small number of variables can be used to make a condition

that is both complex and nuanced. Changing and translating a small number of parts is a more exciting exercise than just introducing additional more parts that are different.(Fox 2016)



Figure 5. May/September
Source:Fox 2016

The project is especially interesting because it shows how binary situations in the world of printmaking led to a greater focus on getting the most out of the least. This means being able to make complex images with only one color, even if they look like they have varying colors of gray or different colors (shown in figure 6). Half toning is the common method used today, and it's a fine example of an approach that employs a limited color palette, spacing, and the size of the dots to make an image that looks complicated (Fox 2016).

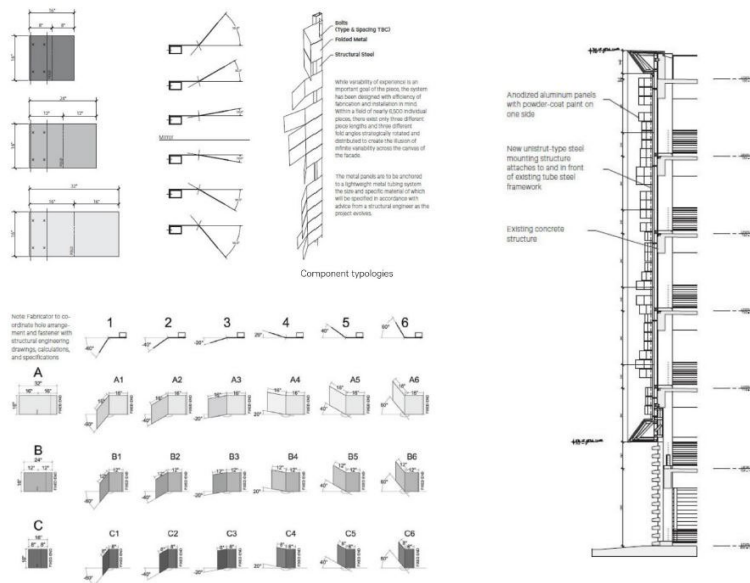


Figure 6. Subsets of different sizes and part of a palette in May/September
Source:Fox 2016

Noise, both as an idea and as a way to do things, becomes an important part of how the facade is made. Noise is usually thought of as something bad that happens when images or sounds are copied, but in this case, it is being used to describe a condition. In the innovation of May/September, the study of images started further upstream, at the point where the image is made, taking into account the distortion, abstraction, and optical computation that happens so that the image can be shown on a screen (shown in figure 5).The goal of this study was to look for connections between two-dimensional picture production techniques and tectonic building enclosing considerations. A system for the articulation of complicated arrangements of patterns and edges across a building facade was devised after a thorough investigation of digital image alteration and replication techniques. The project's goal was twofold: first, to question

the concept of optimization in relation to understanding of fabrication, using image as a conceptual link between the efficiency of a digital system and the performance of a real-world tectonic system; and second, to reduced resolution enhances the spatial qualities.

4.4 Interaction with climatic elements

Subject 4. Al- Bahar Towers

The classic curtain wall of glass is found in the Al Bahar Towers, designed by Abdulmajid Karanouh of Aedas Architects and located in the intense desert of Abu Dhabi. The inventive ways in which the project's mediating architectural border transforms into a moving, adaptable facade are a pleasure to watch. The triangular fiberglass rosettes, based on the cultural significance of the ancient Islamic Mashrabiya, are precisely positioned to preserve vistas while limiting the direct glare of light. The surfaces of the structures vary during the day, like a real plant, and react artistically to biological and environmental factors ([Karanouh](#) and [Kerber](#) 2015).

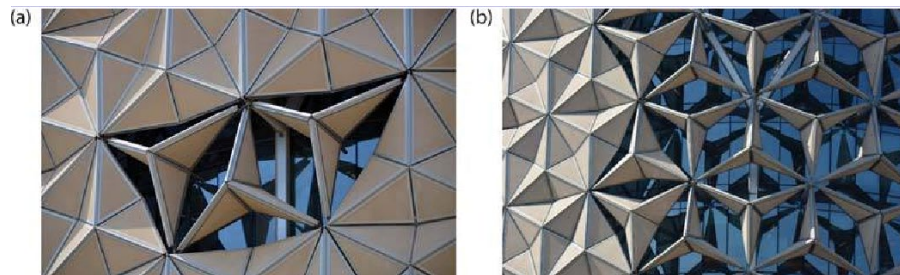


Figure 7. The classic curtain wall of glass, Al- bahar towers

Source: Evaluation of adaptive facades, The case study of Al Bahr Towers in the UAE by Shady Attia

The windows are open when the intensity of the sun is low (Figure 7.a) and closed when the intensity of the sun is high or the heat is high (Figure 7.b). It works as a group through heat gain from the sun or atmosphere in the form of direct or indirect heat through the wind (Figure 7). The environment's climate changes in an open-ended way when a group of algorithms works together. According to needs, the project changes the form, shape, temperature control, and self-regulating process. The building could be able to adapt to the environment, such as by opening or closing windows due to changes in temperature or solar radiation. It will be able to calculate the amount of heat needed so that it can open or close the window based on need. Here, the building adapts to humans or the environment as living beings ([Karanouh](#) and [Kerber](#) 2015).

4.5 Interaction with Climatic Elements, Environment and Man-Made Actions

Subject 5. Lightswarm

It exemplifies true interaction designed by future cities lab. This project connects inside and outside by translating sound into light. The outside of a building frequently creates a barrier between the inside and the outside. The façade, in my opinion, should be open and connected. They could be informative and dynamic urban interfaces. Activated interaction from inside to outside encourages interaction across the façade (Figure 8). Sensing sounds from inside and outside trigger sensors across the facade, and sensor data is then fed into a swarming algorithm (see Figure 8). The algorithm activates the LED modules. Feedback allows the façade to continuously adapt. It is comprised of 450 individual LED modules. Each is crafted from 3D-printed and laser-cut parts and custom electronics. Any kind of sound enables the lights to glow, like clapping or outside sounds created by vehicles; a 20-to-30 decibel sound enables a light, and an algorithm is used here (DOMUS 2014). The project creates a true interaction concept derived from cybernetics (system design).

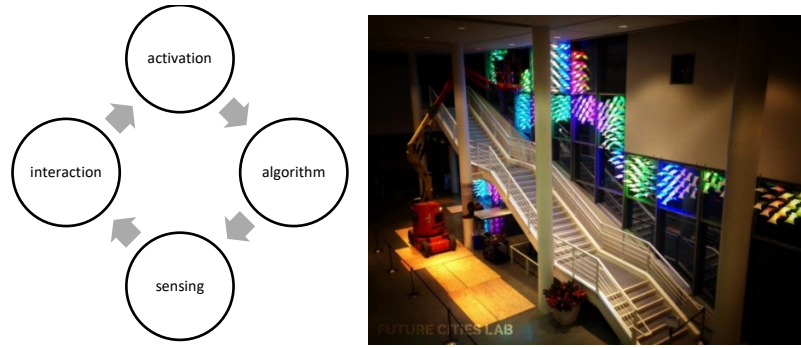


Figure 8. Lightswarm

Source: <http://www.future-cities-lab.net/lightswarm>

Sounds from the environment that isn't distinguishable from interactions with it. A wide range of sounds and surroundings are featured here, including climatic aspects, humans, machines run by humans, the atmosphere, static sounds of the atmosphere, and a variety of other elements. This swarm creates a pattern that we can observe in nature, whether it's a flock of birds, bees, or fish. The flock pattern was the inspiration for this project. As if a building were a machine, the input of a sound lit up a light according to the given command, which is a simple action-reaction. The algorithm's pattern, which was inspired by a flock of birds, allows for a wide range of input from sounds and produces output in the form of sound and light intensity as it passes through the algorithm. The architecture is truly interactive. Sonic data, which contains a wide range of data sets as input, is used for this type of project. Based on uncertain behavior, it could be unpredictable. It's hard to determine what kind of sound is used to create the swarm's output, which is called the Wade range, or natural environment. Every sound is collected into sonic data and piled up with the input data. When the input data is huge, the computer's work is unpredictable. The complexity of computing makes the pattern unpredictable. Here we see a façade that is the collective output of many different inputs from the environment. Sounds from inside and outside trigger sensors across the façade. Researchers say swarm behavior is perfectly applicable when designing patterns in a swarm. Here, action and reaction are unpredictable swarm algorithms. For example, in "Windswept" by Charles Sowers Studios, where magnetic fins were used (DOMUS 2014).

4.6 Interaction with Solar Energy

Subject 6. Bloom

The Materials and Application Gallery in Los Angeles is now featuring "Bloom," an architectural research project by DOSU Studio Architecture which is interactive technology and architecture have improved the environment and human experience. Using a materialism experiment, structure modernization, computational system, and pattern building into an environmentally conscious model. The research aims to demonstrate period and thermal linking sensors. It has a smart thermos bimetal shell and twists up in reaction to temperature from either the solar or ambient variations in the surroundings. According to the report, a lengthy detached approach has indeed been designed to decrease the requirement for synthetic systems for climate management.



Figure 9. Bloom, Los Angeles, 2012

source: <https://www.archdaily.com/215280/bloom-dosu-studio-architecture>

The immersive exterior adjusts to the heat and replies to provide coverings and breathability inside a part of the body that is usually without electricity or actuators through the capacity of computer intelligence for sophisticated modeling. The self-supporting superstructure that forms the shell is composed of almost 14,000 laser-cut components which are already assembled into 414 permanent hyperbolic paraboloid-shaped screens (Figure 8). It featured a cutting-edge architectural method with an assigned spread of dynamic tensions as its primary emphasis and the least amount of technology involved(Furuto 2021).

4.7 Interaction with Human Participation and Behavior Awareness

Subject 7. Electroland

Indoor and outdoor pavement communicate, however, there is an algorithm as a formula in the indoor interactive system. The building generates a pattern based on human activity and produces different lights in different spots using an algorithm. It seems as if visitors are playing video games. The building uses human movement as input and generates an output on the ground, internal walls, and building façade using an algorithm. The structure reacts to the sounds and movements of the people around it. A brilliant field of LED lights embedded in the entry walkway that responds to the presence of guests, a vast show of lights on the building's façade that replicates the access patterns, and video shows in the lobby and entry sections are all part of this project. Environmental awareness and human movement observation is integrated with gaming sensibility. Enormous light projections on the building's facade are also triggered by actions on the promenade. Users can see their imprint on the building's facade via a video screen when the pathway interaction is activated. The time it takes for a response to appear is instant. Why we might want our designed objects and spaces to be "interactive"(Anon 2021).

4.8 Micro-Scale Carbon Sequestering Network

Subject 8. Natural Fuse

In order to help towns, reduce their overall fuel usage and carbon emissions, Natural Fuse builds a metropolitan network of electric-powered potted plants that serve as both energy producers and electronic equipment to prevent carbon emissions excess. Usman Haque, a well-known system developer with training in architecture, creates both the physical spaces and the technological infrastructure. A design and construction firm called Umbrellium is dedicated to enhancing urban environments and actively incorporating communities (Haque 2021). Utilizing the capacity of plants to absorb carbon, Natural Fuse is a micro-scale CO₂ monitoring and overload prevention system that operates locally and globally (Figure 10). People can use a power outlet to charge or power their electrical devices, and the development of the plant reduces the carbon footprint of the energy used. Natural Fuses are networked so that any unused carbon offsetting capacity in the network as a whole can be taken into consideration as necessary. This is because average energy use necessitates the utilization of many plants to offset one appliance's carbon impact(HAQUE 2008).

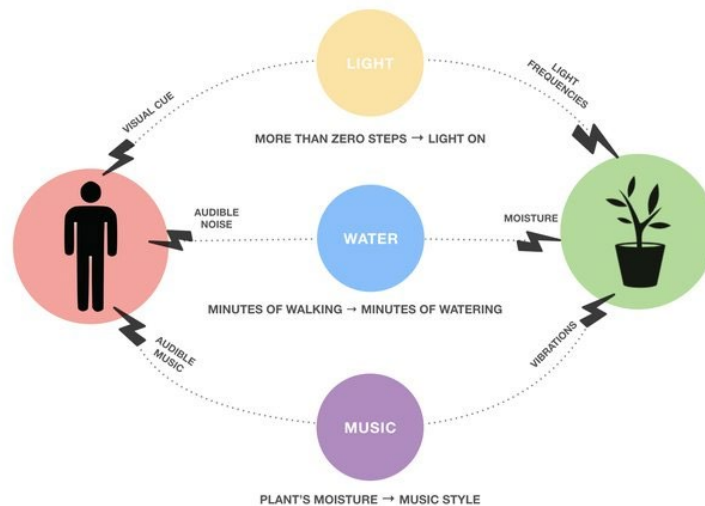


Figure 10. The interconnections involving individuals and plants while bearing in mind that each interruption has a unique impact on each participant (Cercós 2017).

IoT-enabled plant pot that regulates the plant's water supply and irrigates it assesses carbon sequestration and promotes "cooperative" behavior changes in relation to energy consumption. Micro-scale demand response system that regulates the power usage of connected devices (Figure 10). A group of owners can control their energy usage more effectively to lessen their group's carbon footprint. People feel empowered to choose which circumstances call for energy use while still consuming less energy in other areas. Encourages behavioral modification through collaboration as opposed to rivalry (as in other shared energy initiatives). In order to help communities, control their collective energy consumption and carbon footprint, Natural Fuse builds a citywide network of electrically assisted plant pots that serve as both energy producers and circuit breakers to prevent carbon footprint overflow (HAQUE 2008).

5. Smart & Intelligent, Adaptive, Responsive Materials

The term "smart material" refers to materials that have an inbuilt ability to respond quickly to external stimuli. Other objects are regarded as "smart" due to brilliant design, such as those whose original structure or material composition is nanoscale and confers unique capabilities. These materials appeal to architects on a practical as well as an aesthetic level due to their consistent reproducibility and reversibility of color shifts, physical states, temperature changes, and form adjustments (Beesley 2021). Self-cleaning building envelopes, self-repairing concrete, switchable transparency "electrochromic" glass, energy-producing highways, and materials that harden at the point of impact to endure extremely high forces are a few examples. Shape-memory alloy actuators that open and close exterior louvers or polymeric coverings that mimic the action of living skin are utilized to create facades (Roosegaard 2022). According to new findings on "intelligent materials," "adaptive integration with realistic ecological parameters" enables increasingly useful applications. Shape-memory alloys and phase-changing compounds are two instances of technological applications that can change their biochemical, electromagnetic, tensile, electrical, or thermodynamic conductivity in response to particular environmental circumstances. As an illustration, a shape-memory alloy (SMA, intelligent metal, memory metal, memory alloy, muscle wire, smart alloy) is a type of material that, once exposed to heat after being twisted, "remembers" its prior form and adapts to it (Futurium 2021).

- Auxetics, an application of smart substance developed by MIT, can be adjusted and simulates how human skin changes size in response to temperature variations. Building components with connected sensors and wireless connections, such as intelligent concrete and brick, may monitor velocity, humidity, and other factors related to natural catastrophes (Lin 2021).
- WallSmart by inventor Jonas Enqvist is the newest sophisticated paint option that enables consumers to alter the color of their walls using a smartphone.
- Smart coatings and colors are high-performance, variable-property materials that can change their coloration, texture, or sound in response to environmental elements (including weather) and communications from a busy city.
- Smart materials that emit light can work when they are activated by power, illumination, or an electromotive force.
- "Smart Wrap," a programmable polyester film substrate, composite material skin that can vary its degree of transparency, light, or color, and show images.
- When exposed to changes in temperature or light, smart glass with electro-chromatic technology can change color, opacity, or lighting.
- Artificial intelligence, Wi-Fi capabilities, and built-in cameras in smart mirrors can recognize faces and gestures, understand voice commands, give skin analysis, and track health goals.
- CoeLux is a smart window that mimics the effects of natural light inside interior spaces by simulating an artificial sky. This LED lighting system mimics the Rayleigh scattering of sunlight in the atmosphere to provide the illusion of dispersed solar radiation and sky blueness from a distant light source. Nanoparticles (including titanium dioxide) are organized in variable sizes, densities, and composition in clear polymer calibrated to duplicate the many wavelengths of sunlight in an optical system only a few millimeters thick. The device can simulate a wide range of "warm" and "cool" light and shadow conditions from across the world (Freeman 2021).

6. Condition of RMG Factories in Bangladesh

RMG buildings in particular in Bangladesh have inadequate day lighting conditions, despite the fact that their excessive utilization artificial light generates the spaces extremely heated and glare. Figure 11 shows some pictures of the inside of a typical RMG, where huge amounts of artificial lighting are used to help people work. In the RMG sector, rules about health and safety are often broken. The garment and ready-made garment (RMG) industry in Bangladesh has poor working conditions as compared to those set forth by the ILO. When there is enough and the right

kind of lighting, it improves the way people work and how much they get done. Proper lighting should be kept up not only to make it easier on the eyes but also to boost productivity (Sultana and Joarder 2015).



Figure 11. Existing condition of Bangladeshi RMG production space
Source: (Md. Nahid Iqbal and Joarder, 2017)

6.1 Potential Application for Futuristic Progression in the Context of Bangladesh

Industries are the largest energy consumers and a cause of safety and health risks in Bangladesh. Industries can achieve the greatest amount of success by adopting interactive systems that save energy and ensure health and safety. The initiatives that were just described are chosen as examples of futuristic advancements in several industries. There are two ways to carry out the process: Indoors and Outdoors.

The exterior or façade of an industry can alter in response to heat gain, either producing or reducing energy. A futuristic façade installation can be suggested to lower a building's energy usage. The structure's approach will be designed to reduce the need for artificial temperature control systems by utilizing smart thermos-bimetal surfaces. Intelligent systems can be implemented inside the building or on its exterior to improve the relationship between people and the structure. The high-intelligence sensor-based surfaces of the structures might adjust with the solar system throughout the day in order to adapt ingeniously to biological and environmental factors as needed. The surface also modifies its self-regulatory mechanism and morphology. Using an algorithm, the building facade creates a pattern depending on human activity and changes the lighting in various locations to engage with the worker and encourage them to love their work and behave as a living component. Adequate use of natural light can enhance the comfort of indoor spaces and save energy in ready-made garments factories. For this solution, the using of climate-responsive and interactive façade can be a suitable option for Bangladesh's RMG factories

A website might be utilized inside the factory to obtain data from the employees in order to comprehend their emotional responses and provide them with guidance for a healthier lifestyle or job. Each day, a survey requesting input will be given to the residents. The questionnaire will be followed by inquiries regarding other emotional states, including happiness, sadness, loneliness, love, anger, and depression. Depending on their psychological condition at the time, workers must select one emotion. All individuals can communicate with this equipment and provide feedback. The device will choose one mental condition about which most people are concerned and change its hue to reflect the workforce's communal emotional notion, enabling users to be aware of other people's emotional states and so improve their work environment and interpersonal communication. The interior façade of the building responds to the actions and feelings of the individuals passing by. This will be put in the building and offer massages to users, excite visitors by making sure the building illuminates, thrills, and transforms in ways that rouse, incite, inspire, evoke, and enhance; charm, seize, allure, pleasure, empower, enchant, deceive, astound, rivet, and spellbind; and involve, seduce, and tempt the impact of various factors to foster a pleasurable and stimulating environment for visitors. uses sensors to communicate with motion, producing music and illumination as people approach an installation. The process is then repeated. The use of this device will guarantee safety.

7. Conclusion

Although static architecture, such as buildings, cannot be moved, we can propose some integrated, interactive, and adaptable architectural interventions that could be built anywhere in the industries while keeping the Bangladeshi

environment in mind to avoid drawbacks. This type of intelligent surface installation can benefit both industry and the environment. The use of architectural interface design is becoming more common. There will be no pauses in the conversation. However, as we develop interactive technologies, we must recognize that the function of usable design is to convey interaction visually (Fox 2010). Users might benefit from an interactive system that links the entire system. The suggested futuristic installations in Bangladesh are viewed as experimental installations since some interactive building surface installations are acknowledged as installation projects on the industrial building surface. Bangladesh's industrial building surfaces can take design cues from interactive technologies. A parametric, imaginative, and intelligent surface installation might be present on the generated shape. The user's comfort as well as outside elements like noise, solar, and other considerations can be taken into account by the interactive facade. The facade can be configured to move independently thanks to the ability to permanently alter the external heat shield. Through this technique, the surface may regulate how much light enters the interior.

References

- Beesley, Philip Beesley Architect Inc. | Sculptures & Projects, Available: <http://www.philipbeesleystudioinc.com/sculptures/Futurium/index.php>, Accessed on October 29, 2021.
- Cercós, R., Coupling Quantified Bodies: Transformative Play Through Self-Quantification, University of Melbourne, pp. 1-135, July 2017.
- Comorris. Simons Center | Zahner — Innovation and Collaboration to Achieve the Incredible. Available: <https://www.azahner.com/works/stony-brook>, August 15, 2016.
- DOMUS, Available: <https://www.domusweb.it/en/news/2014/12/11/lightswarm.html>, Accessed on December 11, 2014.
- Fox, M. Catching up with the past: A small contribution to a long history of interactive environments, Footprint, vol. 6, pp. 5–17, 2010.
- Fox, M., Adaptive Architecture.pdf, Princeton Architectural Press. Princeton Architectural Press, 2016.
- Fox, M., Interactive Architecture Will Change Everything, *Zhuangshi*, Published by Academy of Art and Design, Tsinghua University, Beijing, 2010.
- Furuto, Bloom / do: Su studio architecture, Arch Daily, Available: <https://www.archdaily.com/215280/bloom-dos-studio-architecture>, Accessed on October 28, 2021.
- Futurium, Noosphere (EN), Available: <https://www.youtube.com/watch?v=JrPkxO8euKY&t=9s>, Accessed on October 27, 2021.
- Haque, U. Architecture, interaction, systems, AU: Arqitetura & Urbanismo, (August), pp. 1–5, 2006.
- Hoberman, P. The standard definition of interactivity is something with feedback, where you trigger something and get a direct response, Art Orbit No 4, Available: http://artnode.se/artorbit/issue4/i_hoberman/i_hoberman., *The emerging aesthetics of Interactive Art,* Leonardo Electronic Almanac, vol. 4, no. 4, 1999.
- Iqbal, N. M. and Joarder, D.M.A.R., STUDY ON THE POTENTIAL OF LIGHT WELLS IN DEEP PLAN READYMADE GARMENTS FACTORY BUILDINGS IN DHAKA, 2017.
- Karanouh, A. and Kerber, E., Innovations in dynamic architecture, *Journal of Facade Design and Engineering*, vol.3, no. 2, pp. 185-221, 2015.
- Lin, FoxLin Architects, Available: https://foxlin.com/portfolio_item/bubbles/, Accessed on October 30, 2021.
- Roosegaard, project DUNE.tudioroosegaard.net., Available: <https://www.studioroosegaard.net/project/dune>, Accessed on October 20, 2022.
- Roosegaard, Visions of Public Art: Social Design | DaanRoosegaard, Available: <https://www.youtube.com/watch?v=nf-q5zs8HgE>, Accessed on October 27, 2021.
- Sultana, R. and Joarder, D.M.A.R. Incorporation of Useful Daylight in Luminous Environment of Rmg Factories by Effective Use of, 2015.
- The dynamic solar shading of Kiefer Technic Showroom | Design Indaba Available: <https://www.designindaba.com/articles/creative-work/dynamic-solar-shading-kiefer-technic-showroom>, 2019.
- Usman Haque – sky ear (2004), Available: <https://haque.co.uk/work/sky-ear/>, Accessed November 1, 2021.
- USMAN HAQUE, Natural Fuse, Available: <https://haque.co.uk/work/natural-fuse/>, Accessed on 2008.

Biography

Rabaya Nusrath Niva obtained a Bachelor of Architect degree from the University of Asia Pacific (UAP). She works as an architect, teacher, and active researcher. In her ten years of teaching, she has been a senior lecturer at Premier University (PU) in Bangladesh since 2013. She had attended numerous international conferences and published her research papers in internationally renowned journals. She is an active member of the DoA, GoB's 4th Industrial

Revolution Committee. She is currently pursuing a master's degree in architecture in the history theory and criticism division at Bangladesh University of Engineering and Technology (BUET). She was awarded the 2nd position in the "Humdard University Complex" design competition with Ehsan Khan Architects Ltd. and an Honorable Mention in the Open Architectural Design Competition for the Design of a Centenary Monument Celebrating 100 Years of the University of Dhaka and the Golden Jubilee of Bangladesh's Independence at the Mall Area, University of Dhaka (DU) in association with the Institute of Architects Bangladesh (IAB), on December 4, 2021. Her B.Arch final thesis was chosen for the National Urban Forum (NUF) Exhibition in 2011 at Bangabandhu Sammelan Kendra (BSK) in Dhaka, Bangladesh, and was published in a national magazine that year. It was also chosen as the best student project for the Commonwealth Architecture Awards (CAA) Exhibition in 2013 at the Bangladesh National Museum (BNM), Shahbag in Dhaka, Bangladesh, and was published in the CAA book that year. She has done extensive research on urban issues, urban parks, housing issues for old Dhaka, conservation plans for historic buildings, housing, theories of settlements and their criticisms, housing for gender issues, housing for the third gender, sustainable architecture, climate, multisensory architecture, interactive technology in architecture, etc. Now she is working on human settlements for resilient communities, creating various configurations of spatial configuration, and exploring how these concerns operate in modern urban phenomena. Her research focuses on how resilient communities handle various social, political, and economic problems.

Jannatul Ferdous Binti is a Bangladeshi architect residing in Dhaka. She completed her Bachelor of Architecture degree at Military Institute of Science and Technology (MIST). She has been working as an Assistant Architect in the Department of Architecture, Ministry of Housing and Public Works, People's Republic of Bangladesh. She is an active member of the 4th Industrial Revolution Committee of the DoA, GoB. She is currently pursuing the Masters of Architecture degree at Bangladesh University of Engineering and Technology (BUET). Her M.arch division is Environment and Energy. Her area of research interest is in the field of day-lighting in architecture: specifically modeling and simulation, as well as green and sustainable architecture, environmental design and thermal comfort, building simulations and parametric optimization, and interactive architecture.