JOURNAL OF ENGINEERING AND APPLIED SCIENCE, VOL. 67, NO. 1, FEB. 2020, PP. 139-158
FACULTY OF ENGINEERING, CAIRO UNIVERSITY

APPLICATION OF KINETIC SYSTEMS TECHNOLOGY IN DESIGN

M. R. ABDALLAH[1], A. G. ABDELAZEM[2] AND H. Y. ESSA[3]

ABSTRACT

Kinetic installations are the modern architectural trends of our time .It is important to trace the origins of these advanced systems, which influenced the idea of the architecture of the mass. Those modern architectural trends further changed the functional concept, with the salient presence of advanced technological capabilities and methods of design and simulation, and the ability to exchange information using the modern program. Thus, they have contributed to meeting ever-changing human demands, and the increasing need for economic sustainability. In fact, many architectural solutions have enabled the changing of the Space from static to dynamic, adaptive, interactive or hybrid constant depending on the external influences of the environment including light, wind, and heat or user requirements. Those innovative solutions have enabled the modern architect to discover new concepts, and architectural applications that leveraged greatly from the technology of mobility in architecture catering for present designs and futuristic designs as well.

KEYWORDS**:** Kinetic, adaptive, responsive, interactive, smart.

1. INTRODUCTION

Kinetic architecture has brought together a plethora of design approaches addressing newly environments to classify a new cultural, social and economic concept in exhibition design at all levels in terms of control systems, structure systems, and variable materials for the nature of the surrounding perimeter. Kinetic architecture encompasses endless features such as time, weather, and functionality, information, marked with an interactively responsive design compatible with rapidly changing needs. A new development is emerging in the concept of architecture and the abandonment of the idea of a fixed form to a motor. This paper presents the main components, and the analytical options. Those developed materials and methods of

[1] Professor, Department of Architecture, Cairo University, Faculty of Engineering.
[2] Lecturer of Architecture, Architecture Department, Benha University, Faculty of Engineering.
[3] PhD Student, Architecture Department, Cairo University, Faculty of Engineering.
hesham_fantasy2008@hotmail.com

construction, and the use of computer in the design processes have been integrated to form more interactive and a responsive system. Consequently, those developments in designing have bolstered the ability to address, integrate the sustainable features, esthetic options, and dynamic responses to both the environment and user simultaneously. Furthermore, those designs have been proved to be cost-effective, allowing modern architecture to create a space that provides users with opportunities to expand their creative, social, environmental and aesthetic knowledge.

2. KINETIC BUILDINGS ARCHITECTURE COMPONENTS

There are a number of interconnected elements that make kinetic building: structures, connections, actuators, materials and control systems. It is noted that it is not mandatory that all elements that have been mentioned to be kinetic [1] as shown in Fig. 1.

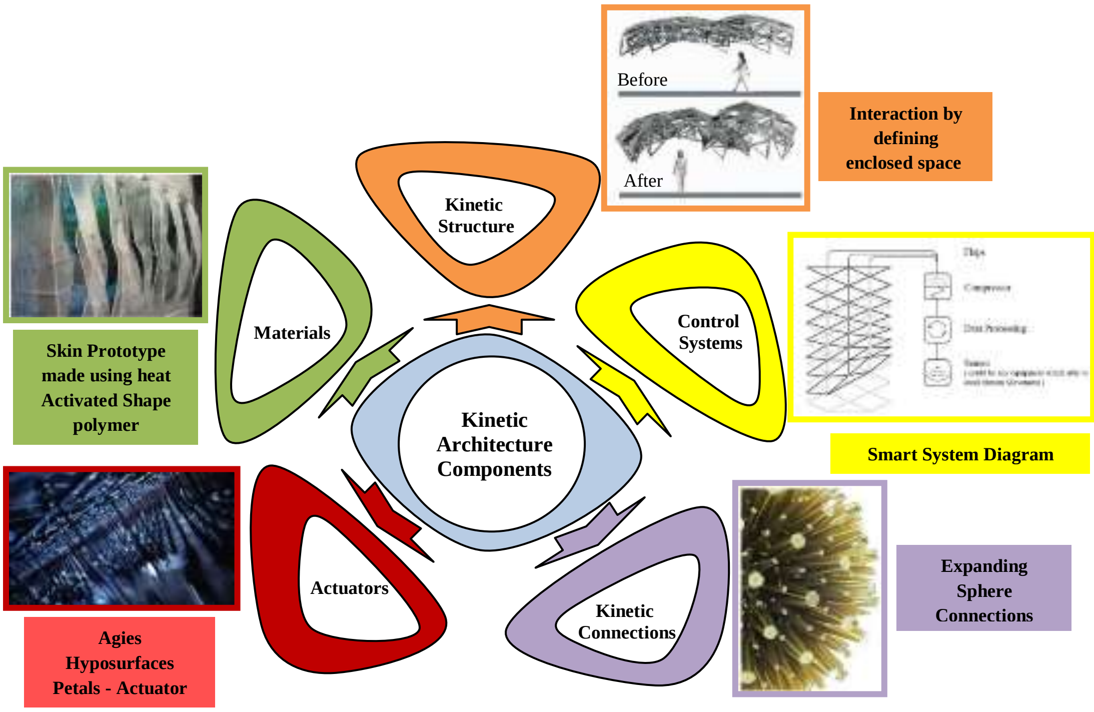

Fig. 1. The concept of kinetic architecture components.

2.1 Kinetic Connections

Linking the various functional components because the method of Connections ensures the individual components and the relationship between materials and their communication methods and the information required for the building, the connection should be integral to all. There are two main categories that can be divided into joints [2, 3] as shown in Table 1.

Table 1. Types of kinetic connections.

Static Connections	Unlimited possibilities to connect the various parts and elements of the structure in a harmonious manner and provide space between the connected elements allow movement, and vary by type. Size of the space can be dismantled, and transferred and reassembled again.
Dynamic Connections	Is a connection method, allowing change, and movement that allows users, and the environment to change the components of the building to adapt, and respond to different functions and patterns of usage and requirements.

2.2 Kinetic Structures

Specialized studies to generate designs for kinetic structures are very important, so that the architect is well- versed in newly designed methods, meeting the needs of users to adapt and respond to the continuous changes of the structure with future developments and sustainability [4] as shown in Table 2.

Table 2. Types of kinetic structures.

Operable	Is characterized by the integrated structure of movement structures in the scope of the building; is fully spreadable ,and can be transferred
Adaptive	Structural, behavioral ,and physiological adjustment environmental control, power generation, conservation, transportation ,and usage principles with physical changes for each component
Responsive	Transformations that occur between more than two different forms to create more flexible alternative to adapt to constantly changing requirements and conditions.
Soft	Based on the material based non- material operation using built- in memory cables for surfaces; the movement is enhanced by physical operation through an inflatable soft robot surface, while all sensors distributed throughout the surface help exchange information between surface, environment and users.
Portable	Are those moving from place to another for better function; use relationship between the portable space to create internal functions or different qualities of space.
Retractable	Roof structures are transformed from one configuration to another; open or closed to provide a variable cover for the space in accordance with the changing roof or functional requirements.

Table 2. Types of kinetic structures (cont.).

<table>
<tr><td>Folding</td><td colspan="2">In the first case, the surface is made of flexible materials by means of membranes by the solid elements, supported by a spatial structure with articular elements that allow motion, or are constructed in the second case with one or more overlapping materials.</td></tr>
<tr><td>Deployable</td><td colspan="2">They are lightweight articulated structures that can be converted from a closed shape to an expandable form with load bearing capacity.</td></tr>
<tr><td>Cable-Membrane</td><td colspan="2">It has ability to adapt to earthquakes, and stiffness against orthogonal loads, and transport from houses, roofs and streets; are manufactured from industrial textiles.</td></tr>
<tr><td>Tensegrity</td><td colspan="2">Is a lattice of rails and cables established from intermittent pressure elements, interacting with the continuous set to determine a constant heat in the space.</td></tr>
<tr><td>Pneumatic</td><td colspan="2">Consists of a single structural membrane characterized by natural distribution due to the control of hardness through the pressure divided into air supported and inflated structures.</td></tr>
<tr><td>Adaptable</td><td colspan="2">Single Lattice, Double Lattice or Spine.</td></tr>
<tr><td>HYPAR</td><td colspan="2">At different levels of structures, they work together through exchange, and interaction to obtain pressure or multiple systems or increase rigidity through the opposite system or multiple uses to multiple support conditions.</td></tr>
<tr><td colspan="3">Transformable Structure</td></tr>
<tr><td>Expanding Sphere</td><td>Designing Mechanisms</td><td>Expanding Structure</td></tr>
<tr><td rowspan="3">Is a dynamic element of engineering principles such as symmetry, Surface Tessellation and the Structural integrity of triangulated shapes , represented in the form of a sphere for the concept of Biomimicry; does not resemble the continuous expansion into sequential patterns</td><td rowspan="3">The binary dimensions on an extended level ,and its application to different forms when taken in the third dimensions can be connected lines that determine the fixed angle of any surface of the three dimensions to create points with the cross lines and then filled with folding connections.</td><td>Variable structures, whose parts are scattered, but do not change, and are still in their original form using angle cutters lead to radiative expansion.</td></tr>
<tr><td>Transforming Space</td></tr>
<tr><td>Transformable elements to extend thought about how to make the void change based on the sensor of the user.</td></tr>
</table>

2.3 Materials

There are new types of materials that depend on the engines, and sensors with different sources of energy according to their response. They can be adapted to environmental changes to be balanced, and have the ability to transform their properties, which allows the development of the concept of materials in the modern century of designers, and architects on the evolution of design ideas from where we consider the relationship between architecture and material in the development kinetic system of building [5] as shown in Table 3.

Table 3. Types of materials.

Self-Assembly	Programmable	Based Actuation
In the process that assembles Disordered parts by building, and arranging structure through Local Interaction with identification of main components through Materials, Geometry, Interactions, and Energy.	Physical material design that has the ability to change shape or function in a multi-programmable way.	The Material depends on changes in shape, or size on mechanical operation, antenna or material Interaction with external influences.
Active materials		
Dynamic mechanisms	Static strategies	
The ability to grow or shrink in volume, or change in shape through the properties of materials through stretching, expanding, folding or bending depending on the environmental influences.	Change the properties of the internal structure of the active substances by reflecting light, absorbing it or exchanging energy from one form to another.	
Responses in materials		
Thermal	Light	Moisture
The thermal behavior of the material when stimulating the thermal energy absorbed by the material chemical or phase transformation, which leads to change the color.	Changing the chemical composition of the material; changes the color or the photovoltaic cells into electrical energy or changes the shape photomechanical.	It depends on the water, and has the ability to change its properties, and react chemically with other materials.

2.4 Control Systems

A control system is a device or a set of devices that manages, behaves, directs or organize the behavior of devices or other systems. Industrial control systems are used to control the device or the machine. The system consists of two main components [6]:

2.4.1 Inputs

Are the sensors and multiple input methods that give different information about the surrounding environment, and there are five types of inputs [6] summarized in Table 4.

Table 4. Types of inputs.

Manual Input	Direct commands from the individual operating without the need for different means of control as operation and stop key
Sensors and Detectors	An operating system to collect information ,and data of all types inside or outside building to monitor the sun , pollution, noise, ventilation, sufficiency.
Prior Internal Information	Provide the system with prior information, which is referred to sensors and detectors to take information from the environment, and accordingly the decision is taken or the system takes the decision without the need for sensors.
Manual Programming	Used for conditions of operation building that achieve thermal comfort for the user or the individual responsible for the operating system to comply with all different circumstances.
Internet	The system is connected to an electronic control circuit to obtain updates on the climate roof modify the system by the manufacturer.

2.4.2 Controllers

Are represented in the computer responsible for the decision of the kinetic, and information from input systems, and facts to the engines that move the element. There are different types, and levels of the controllers systems [7-9] as presented in Fig. 2, Tables 5, 6.

2.5 Actuators

A device that moves the system supplied with a power source that is electrically, hydraulically or pneumatic. It is responsible for body movement according to the orders issued by the control system [10] as shown in Fig. 3 and Table 7.

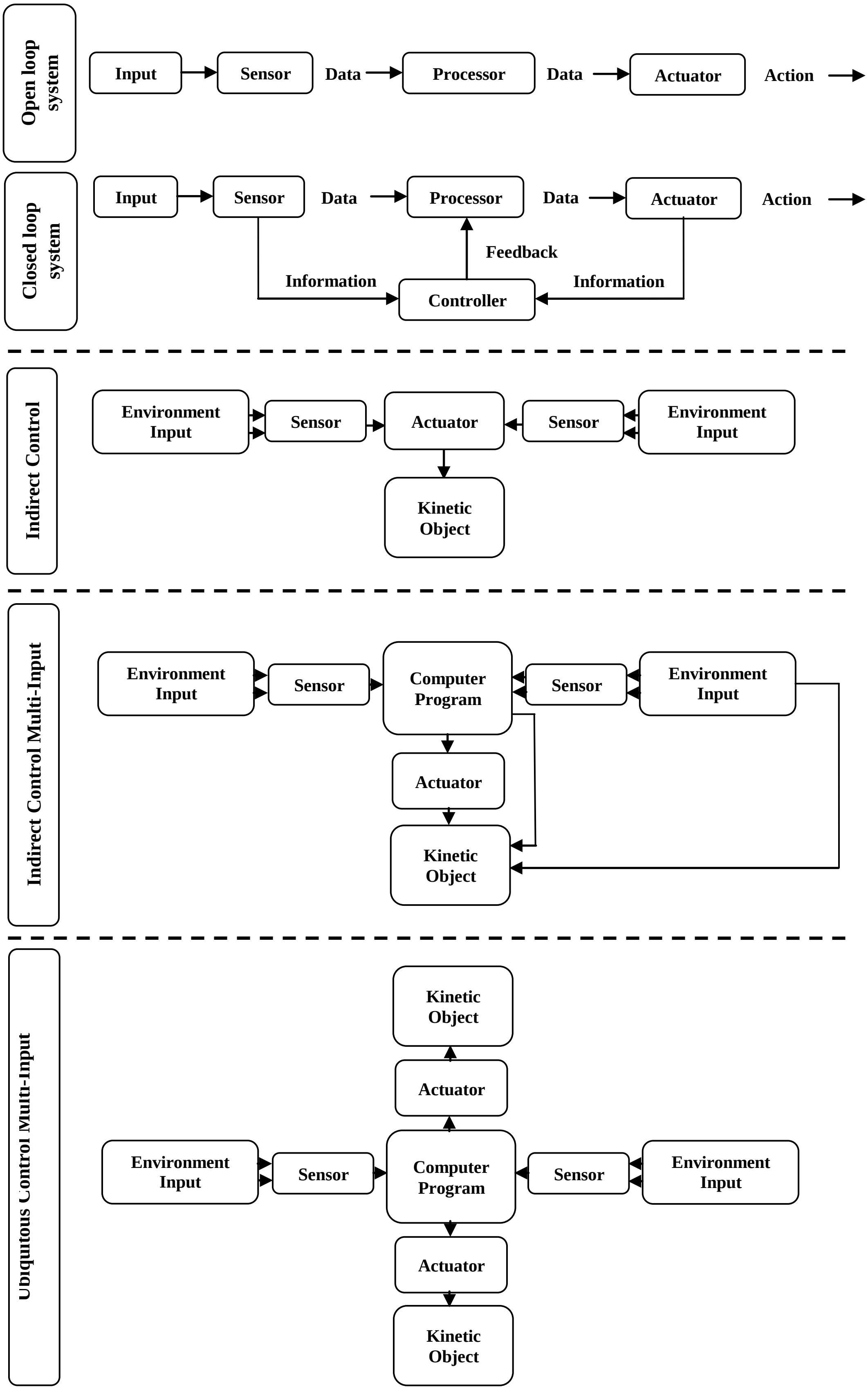

Fig. 2. Controllers' systems types and levels.

Table 5. Control systems levels.

Macro	It is operated by an input of the sensors using external power inputs that are mechanically controlled, and adapted to all switching patterns.
Micro	Changes at a smaller level in the properties of the material as a physical change in the external envelope/, which changes the properties of the thermal, or use it as motor to drive a larger system.

Table 6. Control systems types.

Open Loop	The sensor read by the processor sends the signal to the engine for the configuration according to specific pattern.	
Closed Loop	The control units can measure the output procedure, and the collected information can then be used as notes for the processor.	
Internal	The system is divided into smaller systems, which gives property to the decision-making system such as the self-folding roof without external control.	
External	The system must be taken by itself or another source as a component that can be transferred by manual control.	
Complex System	Integrates the two former systems in terms of decision making or use inputs and is classified into four types	
	Direct	Control and movement through a direct source of electricity, human energy.
	Indirect	Depends on the sensors that effect the engine to get desired interaction.
	Indirect Control Multi-Input	A set of sensors that send signals to the controller that makes an appropriate decision with variables that cause the surrounding environment to move the system.
	Indirect Control Intelligent	The system has the ability to learn to choose its style of movement as it has learnt from previous experiences in an attempt to find the best solutions and decisions.

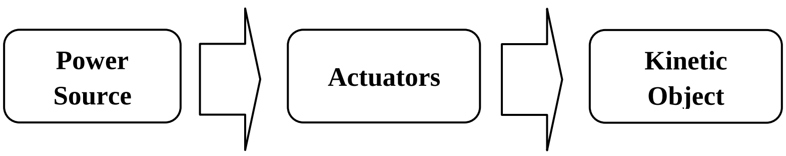

Fig. 3. Integrated system of Kinetic system by actuators.

Table 7. Types of actuators.

<table>
<tr><td>Actuators by Material</td><td>Adapts the changing environmental conditions that may be intelligent or transformable to build operational and sensor capabilities.</td></tr>
<tr><td>Pneumatic</td><td>It consists of lightweight ETFE that can be inflated or discharged based on a network of control systems that senses various changes to the external environment.</td></tr>
<tr><td>Hydraulic</td><td rowspan="2">Interaction and adaptation to the different effects to give changing patterns of kinetic, which gives the ability to control the levels of transparency and transfer of coatings ,vision and rest comfort through the transformation of layers of the external envelope by determining the movement.</td></tr>
<tr><td>Dynamic</td></tr>
</table>

3. CASE STUDIES:

In this part use the analytical descriptive methodology to identify and compered the modern architectural applications that will effect of kinetic pavilion. Samples selection is from a range of applications covering various technological aspects utilizing the concept of Kinetic system technology with external influence.

3.1 Hyundai's Interactive Olympic Pavilion [11]

- Inside, the pavilion comprises 5 rooms representing water, solar energy, electrolysis, hydrogen fuel stacks, and the recreation of water.
- Its use of Vantablack VBx2 on the exterior walls. The pitch-black facades and sparks of light were designed to embody the moment of the Big Bang and the creation of Hydrogen.
- The New Seed upon entering the pavilion; the first thing visitors will encounter is a brightly-lit white room housing a large, interactive water display. The staff on site handed out cups to all the entering guests and invited them to play with the water channels.
- Ergonomic air switches push water into the channels when a visitor hovers his or her hand over the air holes.
- A circular bead at a speed of 0.5 to 0.8 meters per second, water droplets flow across the water channels coated with hydrophobic material. This makes the water

droplets maintain its spherical shape, resembling a seed.2500droplets of water freely glide across the channels [11] as shown in Fig. 4.

- Hydrogen fuel stack is a white room looked like the void; this room certainly reminded us of The Matrix. The room is designed to resemble a hydrogen fuel stack, the place where hydrogen ions create electricity [11] as shown in Fig. 5

Fig. 4. Ergonomic air switches push water into the channels when a visitor hovers his or her hand over the air holes.

Fig. 5. Hydrogen ions create electricity in Hydrogen fuel stack.

3.1.1 Project analytical data of kinetic system

In this part the research studies the chosen applications the following criteria as shown in Table 8.

Table 8. Analytical data of kinetic system.

Project Name	Hyundai's Pavilion	**Goal of the Project**	Culture-Entertaining
Location	South Korea. Laurian	**Kinetic Object**	Skin
Architect	Asif Khan	**Type of Kinetic**	Interactive
Year	2018	**Purpose**	User

Table 8. Analytical data of kinetic system (cont.).

Space Type	Create	Adjust	**Change**	Connect	Move	
Structure	Operable	**Interactive**	Adaptive	Responsive	Soft	
	Mobile	Retractable	Cable-Membrane	Pneumatic	Deployable	
	Pantograph	**Foldable**	Tensegrity	Hybrid	Transformable	
Pattern	Wave	Sliding and Retracting	Contracting and Expanding			
	Inflate and Deflate	Expand and retract	Transformable			
Envelope	Responsive	Digital	Dynamic	**Interactive**		
	Adaptive	Hybrid	Soft			
	Actuators	Dynamic	Hydraulic	Pneumatic	**Material**	
Materials	Self-Assembly and Programmable	**Based Actuation**				
	Photochromic	**Responsive**				
	Photochromic	Thermal Paint	light	Heat	Moisture	Air pressure
	Interactive	**Metals**				
	Dynamic	**Static**	**Ferrous**	**Non-Ferrous**	Thermal Metal	Shape Memory
	Polymers	Thermoplastics	Elastomers	Thermosetting Plastics		
Control System	**Factors influencing the use of the system**					
	Environment	Function	**Human Perception**	Urban Design		
	Airflow	Solar Radiation	Thermal Loads Responsive	Moisture Responsive	Interaction with light	
	Interaction with Human	Interaction with Sound	Interaction with Wind			
Inputs						
Manual Input	Sensors and Detectors	Prior Internal Information	Manual Programming	Internet		
Controllers						
Internal Control	External Control	Complex System				
		Direct	Indirect	Indirect-Multi-Input	Indirect Intelligent	
Control Systems Levels						
Macro-level	**Micro-level**					

3.2 MegaFon Sochi Winter Olympics Pavilion [12]

- The practice's design was a building that could physically transform to take on the appearance of the people visiting it: a Mount Rushmore for the digital age, each element of the installation was conceived, designed, and developed specifically for this project. The LED volumetric-kinetic display is a world first.
- The system also sends an SMS message to participants, relaying this information as well as a permalink to a live stream of their respective avatars appearing on the building.
- An electronic queuing system manages the face data using individual QR-code cards, issued to each participant through a registration app, and enables participants' names to be displayed within and in front of the pavilion on screens, which also indicate the exact time the visitor's face will be appearing.
- This allowed scanned participants across Russia, who were without tickets to be part of Olympic history; their avatars were present even if they were not able to be at the park in person [12] as shown in Fig. 6.
- The kinetic facade measures 59 feet (18 m) wide by 26 feet (8 m) high and consists of eleven thousand telescopic actuators, each with 120 internal components, arranged in a trigonal grid.
- Each actuator carries at its tip a translucent sphere that is a high-power RGB LED lamp. The actuators are connected in a bidirectional system that makes it possible to control each one individually and at the same time report back to the system its exact position. Each actuator acts as one pixel within the entire facade and can be extended by up to eight feet (2.4 m) as part of a three-dimensional shape or change color dynamically as part of an image or video that is simultaneously displayed on the facade. To maximize facial recognition of each portrait, a scaling and positioning algorithm was developed that transforms the faces on the fly by considering day lighting, scale, rotation, form, and additional color [12] as shown in Fig. 7.

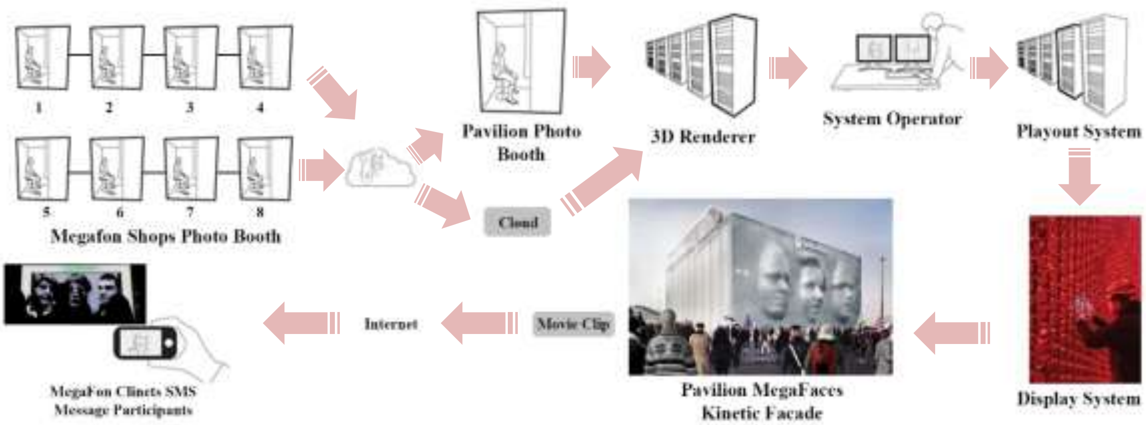

Fig. 6. Diagram of megafon pavilion kinetic system concept.

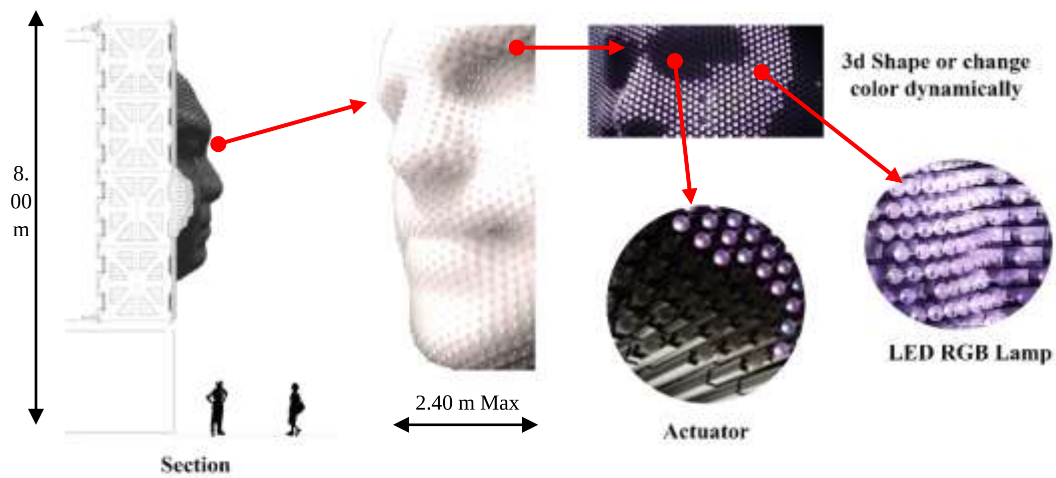

Fig. 7. 3D - shape or change color dynamically as part of an image or video that is simultaneously displayed on the façade.

3.2.1 Project analytical data of kinetic system

In this part the research studies the chosen applications the following criteria as shown in Table 9.

Table 9. Analytical data of kinetic system.

<table>
<tr><td>Project Name</td><td colspan="2">MegaFon Pavilion</td><td colspan="2">Goal of the Project</td><td>Culture-Entertaining</td></tr>
<tr><td>Location</td><td colspan="2">Sochi, Russia</td><td colspan="2">Kinetic Object</td><td>Skin</td></tr>
<tr><td>Architect</td><td colspan="2">Asif Khan</td><td colspan="2">Type of Kinetic</td><td>Responsive</td></tr>
<tr><td>Year</td><td colspan="2">2014</td><td colspan="2">Purpose</td><td>user</td></tr>
<tr><td>Space Type</td><td>Create</td><td><u>Adjust</u></td><td>Change</td><td>Connect</td><td>Move</td></tr>
</table>

Table 9. Analytical data of kinetic system (cont.).

Structure	Operable	Interactive	Adaptive	**Responsive**	Soft	
	Mobile	Retractable	Cable-Membrane	Pneumatic	Deployable	
	Pantograph	Foldable	Tensegrity	Hybrid	**Transformable**	
Pattern	Wave	Sliding and Retracting	Contracting and Expanding			
	Inflate and Deflate	**Expand and retract**	Transformable			
Envelope	**Responsive**	**Digital**	Dynamic	Interactive		
	Adaptive	Hybrid	Soft			
	Actuators	Dynamic	Hydraulic	Pneumatic	Material	
Materials	Self-Assembly and Programmable	Based Actuation				
	Photochromic	**Responsive**				
	Photochromic	Thermal Paint	light	Heat	Moisture	Air pressure
	Interactive	**Metals**				
	Dynamic	Static	Ferrous	Non-Ferrous	Thermal Metal	**Shape Memory**
	Polymers	Thermoplastics	Elastomers	Thermosetting Plastics		
Control System	**Factors influencing the use of the system**					
	Environment	Function	**Human Perception**	Urban Design		
	Airflow	Solar Radiation	Thermal Loads Responsive	Moisture Responsive	Interaction with light	
	Interaction with Human	Interaction with Sound	Interaction with Wind			
Inputs						
Manual Input	Sensors and Detectors	**Prior Internal Information**	Manual Programming	Internet		
Controllers						
Internal Control	External Control	Complex System				
		Direct	Indirect	Indirect-Multi-Input	Indirect Intelligent	
Control Systems Levels						
Macro-level	**Micro-level**					

3.3 Responsive Pavilion Structural Joints [13, 14]

- The work process an ‘architecture of transition’, a series of transformations between forces, material, phases, people, spaces, and functions. Form does not always follow the functions that we cannot predict, but rather the phases that our new built environments can go through in their relationship with humans, nature, and existing buildings.
- During the design process, the collective worked with shape memory polymers (SMP) in order to apply it to a responsive prototype, it was necessary to use a material that could change phase from an external and controlled stimuli. Therefore, the SMP is able to reach a soft and flexible state upon exposure to heat above its glass transition temperature (Tg) of around 60-70°C, at which point it can undergo vast geometrical deformations.
- To best suit the need for structural adaptability, the students needed to find a geometry that could arrive on site in an original condition and then have the capacity to deform or expand into a desired shape from actuation forces. a somewhat foldable structure was proposed for its ability to render these results, which is why they looked into rigid origami patterns, namely that of origami pioneer, mathematician.
- Performing as a structural joint, the SMP is cut into a six-sided shape and placed at these intersections of the geometry’s mountains and valleys. Apart from these nodes, the rest of the folds are replaced by regular hinges, which act in tandem with the position of the panels around them.
- The final prototype is an attempt to push the concept to a functioning 1:1 scale, shown with a cluster of 7 units. This version is the introduction of a buffering wedge in between the SMP joint and the triangulated panel**.** The wedge’s function is two-fold. Firstly, it acts to take most of the shape memory property of the material. The polymer is in its original flat memory state when the component is at its most closed and acute angle. This means that reversion to the original closed triangulation condition is embedded within the material system. Secondly, the wedge introduces

physical constraints in the opening and closing of the modules. When it reaches its furthermost extents, the sides push against each other and limit any further movement.

- The heating is applied uniformly across the structure through a parallel circuit connected to the embedded constantan heat wires, which allows the group to pick and choose specific applications of temperature increases to the test model. the copper-nickel alloy takes under three minutes to manipulate the SMP into its rubbery glass transition state (Tg), after which a deformation can be made, and upon disabling of the heat, the material cools and stiffens (within 2 minutes) to hold the new shape [13] as shown in Fig. 8.
- The technological devices are used because they are the perfect mobile scaffolding system and represent a new breed of artificial intelligence that can both be pre-programmed or have the ability to learn based on specific parameters or act in a swarm fashion. From a flat position, where the entire structure is heated, the helicopters pull at specific points and raise the structure into the desired place, upon which holding until the polymers cool, at which point the new shape is held. The drone, either controlled by human or responding to specific environmental parameters, is also able to communicate with the microcontroller of each unit, establishing a communication between local nodes and global intentions.
- This process can be repeated indefinitely, as the structure is able to respond to a given atmosphere or user's preferences for various spatial configurations in a constantly transformable multi-purpose space. These transitions, whether they are ongoing, or frozen in a specific time or setting, define the evolving personality of our never-ending translatable geometries [13] as shown in Fig. 9.

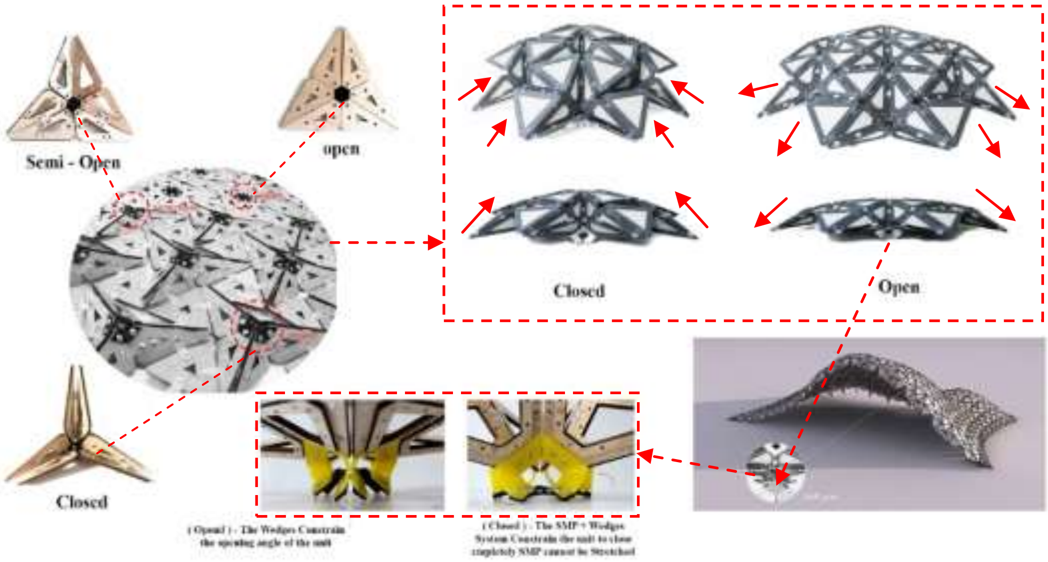

Fig. 8. SMP joint at each hexagonal node.

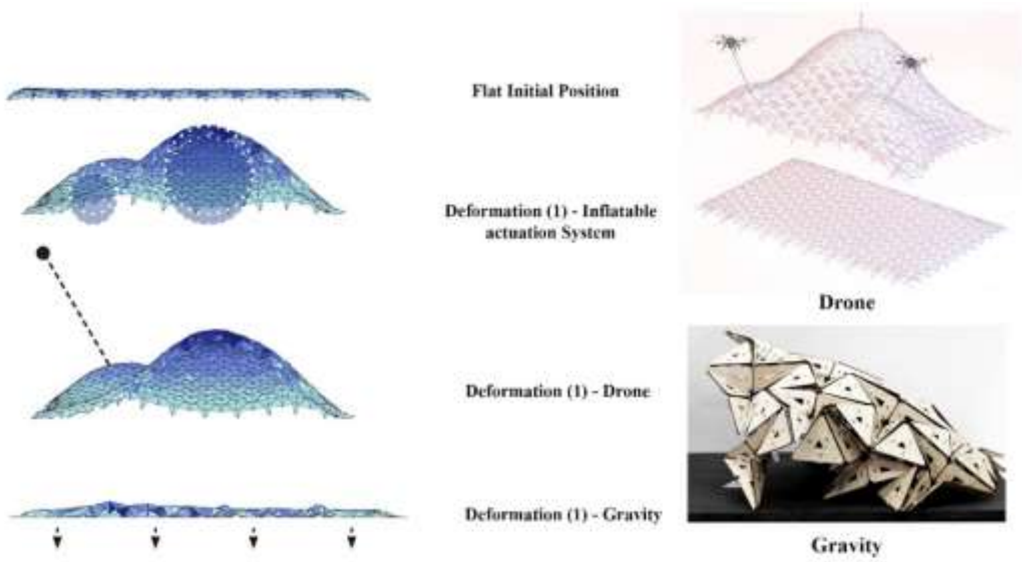

Fig. 9. Architecture simulations and drone actuation at hexagonal nodes.

3.3.1 Project analytical data of kinetic system

In this part the research studies the chosen applications the following criteria as shown in Table 10.

Table 10. Analytical data of kinetic system.

Project Name	Responsive Pavilion	**Goal of the Project**	Environmental
Location	IAAC	**Kinetic Object**	Structure
Architect	IAAC Students	**Type of Kinetic**	Responsive
Year	2014	**Purpose**	Environmental

Table 10. Analytical data of kinetic system (cont.).

Space Type	Create	Adjust	**Change**	Connect	**Move**	
Structure	Operable	Interactive	Adaptive	**Responsive**	**Soft**	
	Mobile	Retractable	Cable-Membrane	Pneumatic	Deployable	
	Pantograph	Foldable	Tensegrity	Hybrid	**Transformable**	
Pattern	Wave	Sliding and Retracting	Contracting and Expanding			
	Inflate and Deflate	**Expand and retract**	**Transformable**			
Envelope	**Responsive**	Digital	Dynamic	Interactive		
	Adaptive	Hybrid	Soft			
	Actuators	**Dynamic**	Hydraulic	Pneumatic	Material	
Materials	Self-Assembly and Programmable	**Based Actuation**				
	Photochromic	**Responsive**				
	Photochromic	Thermal Paint	light	**Heat**	**Moisture**	Air pressure
	Interactive		**Metals**			
	Dynamic	Static	Ferrous	Non-Ferrous	Thermal Metal	Shape Memory
	Polymers	Thermoplastics	Elastomers	Thermosetting Plastics		
Control System	**Factors influencing the use of the system**					
	Environment	Function	Human Perception	Urban Design		
	Airflow	Solar Radiation	**Thermal Loads Responsive**	**Moisture Responsive**	Interaction with light	
	Interaction with Human	Interaction with Sound	**Interaction with Wind**			
Inputs						
Manual Input	Sensors and Detectors	Prior Internal Information	Manual Programming	Internet		
Controllers						
Internal Control	External Control	Complex System				
		Direct	Indirect	Indirect-Multi-Input	Indirect Intelligent	
Control Systems Levels						
Macro-level	Micro-level					

4. CONCLUSIONS

The technological methods vary in the design of Pavilions based on the development of interactive and responsive materials and the control system used. These are experiences of innovative technologies for sensing, controlling, operating, and processing the envelope and structure with sufficient flexibility to react and respond to the internal environment. Users' needs are met via production of energy from the internal environment and from renewable sources to which the building is exposed. The purpose is to prove that it is not independent for the users, but rather a living organism that is influenced by environmental factors.

Intelligent kinetic structure maintains the structural performance, by recognizing changes in behavior, loads, light, and adaptability to meet the requirements and use of changing factors to improve future.

The development of Responsive and Interactive Materials has introduced a new concept of movement and change, which constitutes a new approach to architectural design, in terms of responsiveness demonstrating the enormous potential of the materials system for transformation and adaptive capabilities through the properties of the material.

The kinetic architecture can exceed the ability to interact, which restores the ability of the architect to design an adaptive and sophisticated building with the world around it, which allows it to be restricted, self-assembled with mass size and intelligent response capability that sets new standards, acting as a system for interpreting information, adapting to users and the environment.

The changing information reconstructs the building in both behavior and form to respond to environmental conditions and is determined by a panel responding to a variety of inputs: sensors light, detection, motion, touch, and motors or pump. Those motors rewrite programs to interpret future input values of sensors and produce outputs, which control the operation of engines, making the building more sensitive to what happens inside, around and more responsive to spatial changes or environmental conditions. Ultimately, this demonstrates the idea of mutable kinetic architecture, revealing technological possibilities that do not have specific dimensions.

DECLARATION OF CONFLICT OF INTERESTS

The authors have declared no conflict of interests.

REFERENCES

1. Sheriden, J., "The Engineering of Style, Naval Architecture, Current Thinking on Smart Products and Materials", Jonathan Sheridan Ltd., England, 2000.
2. Schumacher, M., Schaeffer, O., and Vogt, M., " Move: Architecture in Motion-Dynamic Components and Elements", Birkhauser, Germany, 2010.
3. Wachsmann, K., "Turning Point of Butting; Structure and Design", Reinhold Publishing Corporation, United States of America, p.10, 1961.
4. Dewidar, K., "A New Architectural Language", Tasmeem magazine, No.1, Egypt, p.75, 2002.
5. Naseem, A., "The Equilibrium in Architecture ", M. Sc., Faculty of Engineering, Cairo University, Egypt, 2000.
6. Nixon, P., Lacey, G., and Dobson, S., "Managing Interactions in Smart Environments", Springer Science and business Media, Germany, 2000.
7. Sherbini, Kh., and Krawczyk, R., "Overview of Intelligent Architecture", 1st ASCAAD International Conference, e-Design in Architecture, Dhahran, Saudi Arabia, 2004.
8. Kirkegaard, P. H., "Development and Evaluation of a Responsive Building Envelope ", International Adaptive Architecture Conference, Building Center, London, 2011.
9. Addington, M., and Schodek, D., "Smart Materials and Technologies in Architecture ", Architectural press, Oxford, 2004.
10. Moloney, J., "Designing Kinetics for Architectural Facades", Routledge, England, 2011.
11. www.asif-khan.com/project/sochi-winter-olympics-2104/ (Accessed 1/4/2018).
12. https://www.archdialy.com/546834/iaac-student-develop-material-system-with-responsive-structural-joints (Accessed 30/3/2018).
13. https://www.archdialy.com/546834/iaac-student-develop-material-system-with-responsive-structural-joints (Accessed 10/4/2018).
14. Abdalla, M.R., and Kandil, B. M. El-S, “Parametric and its Roles in the Design Process”, Journal of Engineering and Applied Science, Vol. 64, No. 5, pp. 345-363, 2017.

تطبيق تكنولوجيا الانظمة الحركية في المعارض الدولية

يقدم البحث المكونات الرئيسية والمفردات التحليلية التى طورت المواد وأساليب الإنشاء واستخدام الحاسب فى العمارة الحركية التى تم دمجها لتشكيل أنظمة اكثر تفاعلية واستجابة مما يتيح القدرة على معالجة ودمج الميزات المستدامة، والخيارات الجمالية، والاستجابات الديناميكية لكل من البيئة والمستخدم في نفس الوقت والتى توفر الخيارات الأفضل للتصميم وتتميز بإمكانية تخفيض التكاليف مما يتيح للمصمم إنشاء فراغ حركى يوفر للمستخدمين امكانيات لتوسيع قدراتهم الإبداعية والاجتماعية والبيئية والجمالية.