Kinetic Architecture
Development of a responsive structure prototype

Luís Filipe Quelhas da Silva Marques

Extended Abstract

October 2010
Extended abstract

The main goal of this dissertation is to enquire into the concepts of movement, adaptability, transformation and interactivity between the built space, its users and the surrounding environment, in order to find the appropriate responses to the variation of spatial and functional needs. The research is based on both theoretical and practical components.

It is intended to investigate the contemporary kinetic architecture, focusing on the technological development as the foundation of a constantly changing society and mainly on the architectural evolution in terms of flexibility, mobility and adaptability in response to the evolutionary process of the human being and his continuous dynamism (Kronenburg 2007).

In this dissertation, kinetic architecture was studied from its nomadic origins to recently developed complex and interactive kinetic systems.

The aesthetic and functional influence of Nature and its kinetic systems on the architectural development throughout the history of mankind is also a relevant issue covered in this study. These natural kinetic systems not only allow the exploration of new architectural concepts but also contribute to the evolution of kinetic architecture based on the implementation of specific biological principles. Some natural kinetic systems were then analyzed in terms of functionality and interactivity, thereby demonstrating their potential, which can be explored and implemented in the field of kinetic architecture, particularly through its own dynamic and sensitive capabilities and their consequent adaptability to the surrounding environment.

Various kinetic systems implemented in architecture at different scales and levels of control, were also analysed, focusing primarily on their structural, functional and mechanical importance for the project development, taking into account both the ways and means of kinetic actuation (Fox & Kemp 2009). Through the categorization of several existing kinetic structures in an architectural level and its various types of control, it was possible to emphasise the different transformation capabilities and operability of those same structures, accordingly to their specific use and desired functionality.

As for the practical component, the specific goal of this thesis was the development of a small flexible and adaptable kinetic structure, based on the previously investigated concepts, which should enable an efficient response to the users’ spatial and functional needs.

This structure was materialized as a multi-purpose pavilion, with a simple spatial and formal configuration, consisting of an adjustable interior space with variable dimensions, which can be regulated either in real time or asynchronously in order to accommodate various events or activities. The potential of kinetic systems for the development of new flexible structural solutions was also explored, particularly through the study and implementation of scissor mechanisms.

Two different structural solutions were developed, each one of them with different transformation and adaptation capabilities according to the spatial and functional needs, especially in terms of its accessibility and re-dimensioning. As for the covering and protection of the interior space from external conditions, two types of surfaces were also analysed, applicable on the
previously developed structural solutions, ensuring its formal adaptation to the constant structural transformations. These same surfaces have, however, different physical properties. One of them is flexible, consisting of elastic membranes, while the other one is rigid, consisting of fully articulated rigid planar surfaces organized in a specific geometric pattern. Some principles and techniques from the traditional Japanese art of paper folding - origami (Lang 2009) - were also studied and applied, in order to explore the geometric transformation capabilities of this type of rigid covers.

Taking into consideration the functional and energetic performance of the multi-purpose pavilion, several types of materials as well as some technologically innovative products were also investigated, focusing on their implementation in rigid and flexible covers, still ensuring their total adaptability corresponding to the structural configuration.

In order to effectively study and evaluate the previously developed solutions, two prototypes were conceived using various constructive, mechanical and robotic components from Lego Technic, Lego Mindstorms NXT (The Lego Group nd), Mindsensors (Mindsensors sd) and HiTechnic (HiTechnic sd), thereby allowing greater ease and efficiency in the construction of the structures and their various mechanisms.

The implementation of interactive robotic systems, consisting of sensors, controllers, actuators, allows an interactive control of the structural movements and transformations. This type of control was consequently achieved by studying the graphical programming language NXT-G (Kelly 2010), and developing specific programs within LEGO Mindstorms NXT software.

Due to the standardized dimensions of the various components and simultaneously due to programming software restrictions in terms of memory and performance, the creative development of the prototypes was also limited in both constructive and functional ways.

However, this investigation revealed the immense potential of the implementation of interactive kinetic systems in architecture, exploring the dynamic possibilities of the built form as a response to our constantly developing society.