Agency of Interactive Environment in Shaping Users' Behaviour Through Actor–Network Theory

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Abstract The paper defines the role of interactive space in social relationships using Actor–network theory as a methodological tool. It examines interactive space from Actor–network theory perspective, as one of the actors in a heterogeneous network consisting of human and non-human components with their own agency. This methodology allows to consider interactive space as an active participant of social relationship, communicating with other participants of society using non-verbal means of communication. Applying Actor–network theory allows to understand the rules of communication between users and the space, evaluates responsiveness to the system signals and defines participants' stages of involvement into this communication. A full-scale interactive prototype was designed and built as a proof-of-concept to analyse the influence of interactive space on human behaviour and space perception, examining this communication in real time and assessing human responsiveness to different types of signals from the space (light/sound/motion).

Keywords Interactive space · Behaviour · Communication · Socio-Technological · Actor–Network theory

1 Introduction

The proof-of-concept used in this research incorporates creating a prototype as a part of the experiment as a programme with an inquiry-driven approach, in which prototype is a part of experiments meant to explore and open new design

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spaces [1]. The prototype interactive development is the programme, followed up by experiments—interactive communication between users and space, human and non-human components. The programme of this type of Research through Design (RtD) includes obtaining knowledge, developing observations and survey of the prototype construction and other research-related activities. Experiments introduced prototype operation related activities are developed, conducted, consolidated and processed, contributing to generation of the new knowledge. This RtD approach allows to take application of obtained knowledge beyond the created prototype and applies it in different conditions, contributing to design practice [2].

2 Methodology

Actor–Network Theory is applied as a set of prisms, through which interactive space is considered in order to obtain a different perspective and different properties are brought into the foreground for viewing. In later chapters the different views afforded by the techniques described here are used to explain features of how interactive features are used in design and to move towards a design of an interactive space.

Within the context of this research Actor–network theory (ANT) describes general forms of social, epistemological or ontological order. Society is comprised of actor-networks, therefore ANT to a large extent relies on communication and social relationships between human and non-human actors, considering the world around us as an agglomeration of actor-networks. Therefore, ANT can be described by social processes, activities, and various forms. of relationship and communication that create networks. These processes and relationships are integrated into behaviour of network components, combining being, perceiving and acting. ANT here describes the actors, their interactions and relationships, what they do, how their associations are transformed, maintained or dismantled, and how it influences other actors and relationships within network [3].

Within this research ANT is used as a set of prisms, through which interactive space is considered in order to obtain a different perspective and different properties are brought into the foreground for examination. Different views afforded by the techniques described here are used to explain features of how interactive features are used in design and to move towards a design of an interactive space. Each prism or a frame allows to consider various communication aspects and actors' conditions in order to understand in what ways they influence each other. In this manner ANT considers interactive space in order to obtain different perspectives and what properties are brought into the foreground for viewing. In later chapters the different views afforded by the techniques described above will explain how interactive features are used in design and move towards the creation of an interactive space.

The research relies on the prototype as proof-of-concept not only for the reasons of describing its' specifications, design process and interactive behaviour, but to a large extent because it allows to apply Actor–network theory as a research tool. This approach allows to consider various aspects of communication between user and

interactive space from different perspectives, considering various means of space communication effecting humans' perception and a variety of factors defining it. A proof-of-concept provides ground for qualitative and qualitative analysis that can be later translated into development of interactive space communication tools, techniques and methods. By reviewing different scenarios through the lens of obtained information, assumption about a different actor-network can be made, in order to predict its' actor's behaviour and contribute to design quality.

2.1 The Prototype Behaviour

The prototype was developed in collaboration of School of Architecture and School of Music. The prototype can be described as an audio-visual, immersive and interactive experience. From spatial point of view, the prototype is a 10-m diameter dome-like structure that moves, breathes and sings in response to human activity. The dome constituted robotic components inside and was equipped with LED lights and speakers. This tangible and emotional experience with its' own behaviour and various interactive components offers sensation of changing sounds and the spectacles of light produced by the life like creature. Several robotic objects within the dome have also been fashioned to resemble blossoming flowers to tie in with the theme of the festival. As a proof-of-concept for the study, the prototype communicates with visitors using audio, visual and kinetic stimuli.

The prototype setup allowed the space inside of the prototype to be fully enclosed yet inviting, with an entrance on one side of the structure, and the exit on the opposite side. While providing a shelter and creating its' own immersive environment inside, with its' ambient sound and changing colourful light, the light fabric cover was transmitting diffused light from the LED light inside, evoking curiosity among the people passing by, inviting them to approach and investigate the space (Fig. 1).

Inside the dome, ambient sound (4 large subwoofer speakers) and floor LED strips were creating unique and changing immersive environment. Sound and light were synced, creating a soundscape pattern that would define the prototype behaviour. Several robotic objects resembling blossoms were hanging from the internal ends of

Fig. 1 in.bloom exterior

the rods. The blossoms were equipped with independent speakers, LEDs and motors, demonstrating their individual behaviour and responding to the visitors' proximity by means of ultrasonic sensors.

The prototype continuously communicates with visitors in real time, responding to their presence, creating immersive experience and encouraging visitors to continue communicating with it and discover more about its' behaviour.

The prototype creates interactive environment that triggers various senses have proven to be immersive and stimulate further communication. Using unique space qualities and tangible means of interactive space design visitors can be guided through space and get engaged into various activities as part of communication with the space. Visitors would approach the prototype to explore the space and its' behaviour, being non-verbally offered to understand the rules of communication with the space and to act in a certain way to continue this communication. During this process they can be brought through different modes of space cognition requiring their active or passive participation in this real-time communication.

Communication between visitors and the prototype begins before they even come in, the prototype invites them with its light and sound perceived from the outside. Observations show that people, especially students that were passing by, tend to be curious about light effects and would be willing to come in and investigate.

When the visitors respond to the invitation positively and step into the prototype area, they get immersed into the space, where the LEDs light is reflected from the white fabric surface and its' pattern and changing rhythm follows the soundscape ambience (Fig. 2).

Then the visitors start noticing the objects (blossoms) hanging from the end of the rods, they begin wondering what these are and what they do. Shortly it becomes evident to most of the visitors that each of the robotic blossoms demonstrates different behaviour. The robotic blossoms perceive visitors with embedded pair of ultrasonic sensors and if the visitors are willing to interact with the blossoms, they need to figure out how to be perceived by them. Each blossom has its own communication manner, its own sound effect and light, which makes each object unique. When the visitors' approach, the blossoms light gets brighter and sound gets louder. Finally,

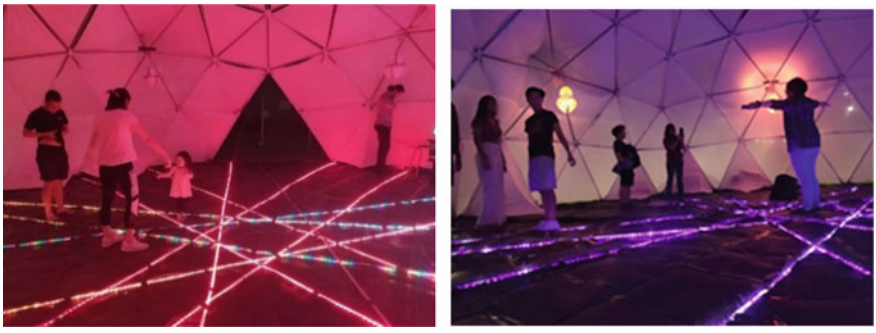

Fig. 2 in.bloom prototype, interior

the blossoms open their petals (individual motors are placed above the blossoms) as an expression of the final stage of communication with visitors.

According to Callon,[1] ANT allows to focus the research on features of a socio-technical system that are relevant for the analysis. It consists of four connected overlapping stages that define how firm the networks can be.

- Interessment
- Enrolment
- Points of Passage
- Trial of Strength [4].

Status quo is represented by a firm actor-network. This research tool can be used to define how stable networks became or find the reasons why certain connections within it fail.

The interessment stage refers to actors being introduced to the network. Within the framework of this research this step was considered as a moment when the visitors (new actors) decide to explore the prototype and see the activity inside, the invitation by an interactive prototype. Each actor of the network has a unique experience of discovering this new situation, therefore each connection within this network is unique and exists only in this moment.

Enrolment stage happens when actors choose to follow the rules of the network and play their role in it, they commit to the program of the interaction. Applied to this research, this stage includes establishment of communication between interactive space and users, when users discover the signal from the space and learn how to interpret them, when the space and visitors begin to interact, the exploration mode of the visitors discovering the space and getting familiar with its components and their communication means.

Points of passage stand for an emerging type of actors that attempt to represent another network participant or the network itself. Attempt of more than one actor to become a point of passage causes a conflict within the network. This conflict is solved by achieving the final stage—the trial of strength, when the actors accept their roles and act accordingly. This process is unavoidable in an actor-network and can be traced in the interactive space prototype when the actors overestimate their influence in signals altercation and try to cause effects that don't depend on their actions. Despite the ability to directly communicate with robotic blossoms of the prototype, visitors can't control the ambient light and sound. With trial and error, they understand their roles in the network and bring the network to equilibrium when they understand the rules of communication and interact effectively with other agents of the network: human and non-human.

[1] Michel Callon, is a professor of sociology at the École des mines de Paris and member of the Centre de sociologie de l'innovation, an influential author in the field of Science and Technology Studies and one of the leading proponents of actor–network theory with Bruno Latour Suggested distinguishing between actors and intermediaries.

Therefore, ANT offers a way to understand relationships between space and users (non-human and human actors) avoiding defined outcomes and protocol that would occur if the agency was granted only to human components [5].

2.2 *The Prototype Communication Means*

The in.bloom prototype uses different means of communication with visitors:

- Sound—volume, rhythm and tone of the soundscape
- Vision—intensity and colour of light,
- Motion—tangible change of the structure shape.

The prototype has two main levels of communication with visitors: ambient sound/light of the dome itself (subwoofer speakers, floor LED stripes) and individual sound/light effects for each blossom.

Ambient (or general) sound and light communication means were creating immersive environment of the prototype, articulating its attitude and declaring prototype as an active participant of social relationship, with its' own agency of behaving in a certain way.

Individual sound and light are represented by the robotic blossoms. Each blossom was equipped with its own set of LEDs, a speaker, a motor and ultrasonic sensors, the light and sound within the object would react to the presence of a visitor within close proximity and the petals would open up if the visitors would spend enough at the spot where the sensors would perceive them (Fig. 3).

As a person approached, the motor would open the petals and the LED saturation would increase; however, it would not light up unless there was audio produced from its speaker. The overall effect of this was that the object was singing out and glowing bright to the person as they approached [6].

Fig. 3 Robotic blossoms

2.3 Analysis

To estimate the influence of interactive space on visitors' space perception, visitors of the prototype were asked a series of open-end questions in a survey. These visitors interacted with the in.bloom prototype and described their experience. A survey is one of the most common ways of quantitative analysis and it allows to understand communication between users and interactive space in real time. The survey was examining participants' opinion about interaction with the prototype and shows factors and means of perception and motivation of the participants' actions.

The survey participants were invited to explore interactive nature of the prototype, experience various means of spatial communication (sound/light/motion), find the triggers of the prototype components that enable response to the visitor's presence, and evaluate their interaction with the prototype. The aim of the survey was to quantify interactive qualities of prototypes' behaviour, considering its kinetic, light and sound properties. The survey was conducted on an aggregate basis of the score translated in the table through three-point scale. The results of the individual survey were systemized according to the Delphi expert method that allows quantitative expression of the respondents' opinion and statistically evaluates their opinion consistency. Survey results are summarized in Table 1 and represented in the following diagrams. (Figs. 4, 5 and 6).

3 Conclusion

Considering Actor–network theory, design acts as a mediator of social relationships, space itself constitutes, recreates and modifies social relationships by inviting, regrouping and reconnecting the users in a different manner. Interactive space creates a cognitive environment by itself, where users get immersed and connected, and gain social or functional enjoyment. Through interactive space, users get linked through communication with the same space and its agency, participating in a dialogue with the space, exploring its responsiveness and committing to the rules of this communication [7].

By applying ANT to the prototype strategy both visitors and the space become a part of a social interaction where they influence each other. The way visitors perceive the space is shaped by its' interactive properties and can change depending on the character of this communication.

Interactive design allows coming across non-human components, like objects in space and various environments, that mediate interaction with other humans, while ANT proposes a network of heterogeneous components, which influence each other in order to create a balance, resulting in harmony of social collaboration, afford movement through it and bring comfort to its' human components. This way designed space is not merely the mode of connection that cannot be explained by other economic, social or political means, but has its' own diffusion, objectivity and

Table 1 Results of the prototype survey

Question	Average score
1. How difficult was it to understand that the prototype was interactive?	2,55
2. To what degree was the prototype attractive upon entering it?	2,55
3. How appealing was the design and component configuration of the pavilion?	2,82
4. How effective is communication method by means of: – robotic blossoms motion – light – sound	2,55 2,64 2,73
5. The difficulty of understanding the behaviour of: – robotic blossoms motion – light changing – sound changing	2,55 2,18 2,55
6. The degree of responsiveness: – of robotic blossoms – light – sound	2,73 2,64 2,27
6. Willingness to follow the various cues from space: – robotic blossoms – light – sound	2,18 2,82 2,73
7. To what extent should the components of the prototype be changed to improve: – its' functionality – its' perception	2,02 2,45
8. the general effectiveness of the project	2,82
On an aggregate basis: – mean score – coefficient of variation of standard (mean-square) deviation, %	2,45 12,6

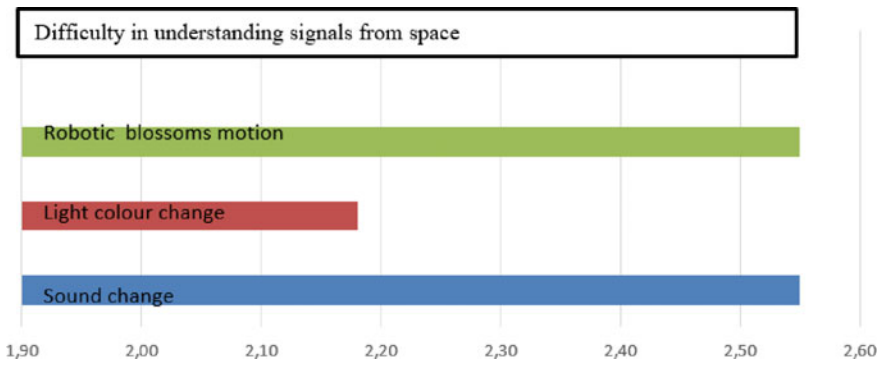

Fig. 4 Difficulty understanding signals from space chart

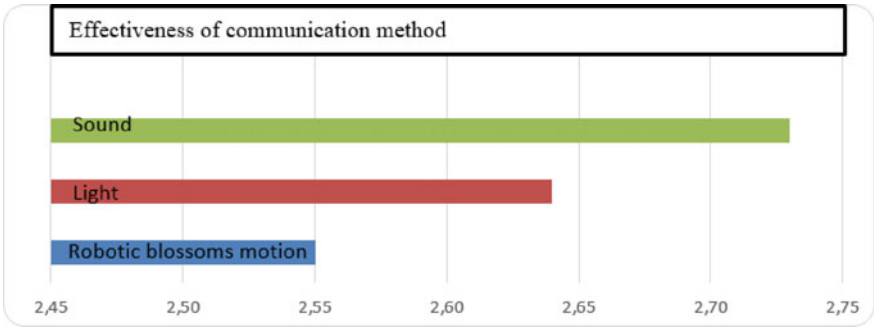

Fig. 5 Effectiveness of communication method chart

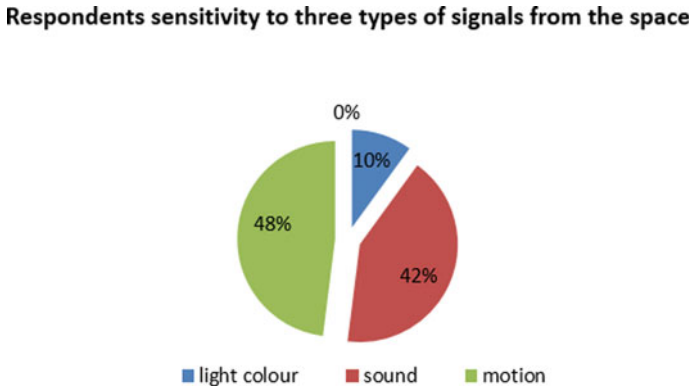

Fig. 6 Respondents' preference of different signal types responsiveness

solidity. Together with ethic, technical, cultural and artistic ties, the space contributes to social durability.

Interactive space can be considered as participant of social relationships through understanding of its communication with users, assessment of their assembling into groups and seeking participation of others, attribution of their actions meaning, evaluation of information exchange and willingness to be engaged in a dialogue with the space. The space can consider from two perspectives: either through its intrinsic materiality (or tangibility), or through its symbolic or aesthetic performance (defining it as social and subjective). ANT allows to shift from this modernist consideration, suggesting understanding space as a matter absorbed into meaning, making it both tangible and alive.

ANT allows to consider built context as a variable, that can move, change and evolve in real time, consisting of many dimensions itself, impacting performance of architecture and influencing its behaviour if it is interactive.

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