Design of an Interactive Living Space: Anticipations of Spatial Articulation in Computer-Mediated Human-Space Interaction

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Abstract. Recent advances in embedded computing technology of microchips and sensors have given rise to computer-mediated, human-centered interactions and emergent mobile lifestyles. One of the main criticisms of the current trend of habitable interactive architecture is its disregard towards spatial thinking of traditional architecture. The potential of interactive technology in actualizing spatial responses to emerging needs is also largely unexplored. This paper proposes design possibilities of an interactively modifiable living space that aims to accommodate evolving lifestyle of highly mobile, information age professionals, also referred to as neo-nomads. Proposed design opens up discussions on the creative, adaptive spatial responses of interactive space designed to orchestrate possible future actions and interactions of target users on the basis of formed anticipations.

Keywords: Anticipation · Interaction · Interactive Architecture · Embedded Computing · Spatial Articulation · Neo-Nomad · Mobility.

1 Introduction

Architecture is inherently anticipatory. Anticipation allows design to take decisions at current condition by looking into prior and possible future conditions [1]. Architectural design concepts and model scenarios are generated as representations of future conditions aiming to support possible actions and interactions that have not been realized yet [2]. By means of formal, spatial and technical adaptations and transformations, architecture provides allowances for emergent needs and lifestyles, desired human interactions, psychosocial changes and new forms of identity.

Many researchers and practitioners predict human-centered, embedded computing technology to play a crucial role in our interaction with surrounding built environment in the coming years [3]. Embedded computing has increased mobility and given rise to a new breed of highly mobile, technology-dependent, wireless professionals or “neo-nomads” who can work and communicate remotely [4]. The phenomenon of transitional living of rapidly growing information age professionals has prompted researchers to seek new design vocabularies for computer-mediated spatial adaptations [5]. However, current design trends of habitable interactive spaces are criticized by many for insensitivity towards traditional "architectural thinking" of spatiality and its conceptual, aesthetic and functional aspects [6, p.134]. These researchers urge designers to explore interactive technology as a creative design mean in architectural space-making to meet emerging needs and lifestyles [3].

This paper proposes design possibilities of an interactively modifiable space intended to support the lifestyle of neo-nomads. The design combines embedded computing technology with traditional architectural space-making techniques. It constitutes of a single interactive space that constantly articulates itself to produce a variety of aesthetic and emotive spatial qualities. Here, "spatial articulation" refers to modification of overall visual quality of space, i.e. character, feel and appearance, by manipulating the variables of visual space perception. These variables include but are not limited to light, material, color and texture [7]. In a real-time, sensor-driven interaction with the occupant, the dynamically changing spatial qualities aim to support occupant's evolving psychological and physiological requirements associated with daily activities. The paper analyzes the anticipatory capacity of proposed interactive architectural space to prepare for possible future needs, expectations, actions and interactions of target users by reflecting perceptions of these possibilities in its present state.

2 Background

This section discusses traditional architectural space-making and its influence on human action, mood and behavior. It further discusses the notion of interaction in architecture, current trends and criticisms of interactive architecture, as well as the phenomenon of neo-nomads.

2.1 Architectural Space-Making

Visual perception of the overall quality of a space is dependent on the visual properties of architectural elements that construct it and their interrelationships [8]. These properties include color, material, texture, size and shape. Architecture is essentially a spatial entity with distinct spatial functions. Space-making is anticipatory both as a product and a process. During design process, each space-making element, e.g. wall, ceiling or column, brings with it anticipated intentions of possible actions and spaces that may form around it. Spatial context guides human actions. Space creation techniques of traditional architecture carry underlying psychological, physiological and phenomenological implications that intends to shape human activities, experience and behavior [9].

The spatial, architectural imageries and sensations of past lived spaces of domestic habitat evoke a variety of emotions in us [10]. Feelings of safety, solitude, contemplation, intimacy, comfort, creativity, danger or impermanence may emanate from the openness, enclosure, warmth, crowdedness, a specific light or shadows of the lived domestic space – its attic, hearth or corridor [11]. Architects explore these aesthetic and emotional spaces by examining the metaphysical, psychological and metaphorical implications of light and material as sensory stimuli. Renowned architect Louis I. Kahn believed that a room's size, surfaces, openings and lighting combined has an influence on occupant's mood and action in that space [10]. Aesthetics of space rely on the meaningful emotions that emerge from the cultural and temporal meanings and essences of light and material [12]. Some spaces have aesthetic dimensions that seek to convey a higher level of consciousness. The large central space of Kahn's Exeter Library had no other programmatic function but to provide sheer inspiration [13].

2.2 Human-Space Interactions and Interactive Spaces

In this paper, "interaction" is defined as a simple input-output mechanism that is similar to McCullough's [14, p.20] definition of a "deliberative" two-way exchange between man and machine. An action or input must be reciprocated with a deliberate response or output in order to complete an interaction. In the realm of habitable architecture, human-space interaction occurs when physical space changes shape or appearance in response to an input or action from user. For example, an occupant interacts with space by adjusting apertures to modify spatial quality of a room. As an active participant in this interaction, occupant personalizes and customizes living space by formulating physical, emotional, aesthetic and social meanings [15].

In recent years, human-centered information technology has moved towards socio-cultural, artistic, mobile and embodied human interactions [14]. Technological innovations have facilitated new forms of human-space interaction [9]. In interactive architecture, interaction between human and built environment is enabled by integrated or embedded computing technology in the form of microchips and sensors. The "interactive essence" of computing technology can enable buildings or spaces to embody interconnectedness of information technology, respond to human and environmental input and acquire sensitivity to behavior [16, p.25]. These include the potential for constant formal and visual change, reconfiguration and personalization. Sensors receive signals from users and reciprocates automatically [17].

Embedded computing has also triggered "embodied" interaction with physical world in real time against physical and social settings [18, p.102]. An upsurge of innovation in interactive materials has inspired development of a variety of spatial art installations of urban scale with both embedded and embodied computing. Materials, especially textiles, with embedded sensors change color, luminance, move, shrink or expand in response to human touch and sound [19]. These spatial studies explore bodily and sensory engagements with space and challenge traditional ways of perception, navigation and interaction with space [15].

2.3 Current Trends of Interactive Architecture

In the emerging field of interactive architecture, buildings embody wireless interconnectedness, use kinetic elements and sensor-based controls for space and energy optimization, and respond to human and environmental input through modifications of programmable digital surfaces [20]. Some researchers predict embedded computing technology to change human relationship with built spaces in the coming years and stress on the urgency of research on computer-mediated spatial adaptation for contemporary "information-able" architecture [16, p.25]. However, a growing number of researchers and practitioners criticize current practices of habitable interactive architecture for their market-driven goals and surface-deep focus on gadget and media design [5]. Others criticize the preference of digital displays of interactive systems over the aesthetics and functional roles of physical, material spatiality of the building [6]. These researchers urge designers to understand traditional architectural space-making in their exploration of computer-mediated interactive living spaces.

2.4 Neo Nomads

Neo-nomads are a new breed of highly mobile, information age professionals, popularly known as Silicon Valley workers. Portable computing, mobile technology, digital and social media and continuous online presence allow these minimalists to work and communicate remotely [4]. Highly adaptive to new, dynamic settings with no fixed sense of belonging, they are able to move from café to café to work, correspond and socialize [21]. The Silicon Valley workers are currently facing severe housing crisis due to space shortage, higher rent and job growth [22].

3 Proposal: An Anticipatory Interactive Space

This paper proposes design possibilities of an interactively modifiable living space for the neo-nomads. It constitutes of a single space enclosed by programmable, interactive planar surfaces (walls, floor and ceiling) with embedded computing technology. In a computer-mediated interaction, embedded sensors will track human input, gestures and movement within space and articulate spatial quality in real-time. Spatial articulation will occur through modulation of variables of space perception, such as, light, color, material and texture. The design will create a series of strong spatial experiences for psychological, physiological or phenomenological impact intended to support a range of human mood and emotions associated with daily living. These include feelings of intimacy, security, contemplation, creativity and spirituality.

The user will be offered a series of designed spatial qualities intended for aesthetic and emotive impact. User will be able to modify any or all surfaces and customize space to suit their own psychological needs. Interactive space possesses the capacity to receive input from external environment. With abstract representations of modulated light, color and shadow, interior space is able to reflect external weather conditions, diurnal and seasonal changes to perceptually situate user with the physical world (Fig. 1).

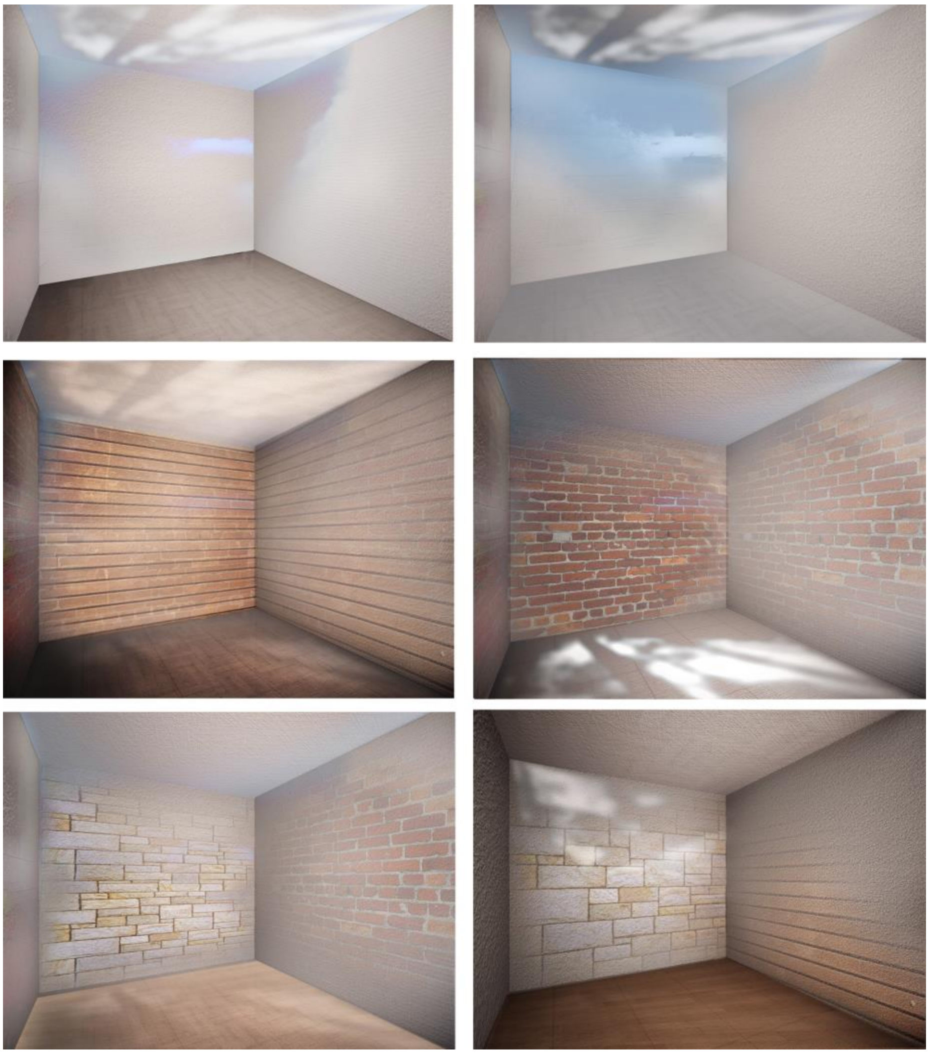

Fig. 1. Examples of possible spatial variations by modifying one or more surfaces (light, color and texture). Space articulates in response to user and environmental input.

3.1 Analysis of Anticipatory Dimensions

Every design initiates with a goal driven by anticipation. According to Nadin [23], design establishes known and perceived needs, desires and expectations to manifest possible future state that has an impact on the present state of users. During the anticipatory act of planning, the known needs, desires and expectations are identified, probabilities are predicted and possibilities are set to explore [23]. The goal of the proposed design is to support the neo-nomadic lifestyle. In the planning stage of the design, neo-nomadic profile is investigated in regards to their personal, socio-cultural, economic and technological aspects of domestic living. Their work and living pattern is observed and subjective personal experience is analysed. On the basis of this research, certain predictions and forecasts are made to identify "possible" future needs, desires, interactions and expectations of target users in their domestic environment.

The design anticipates that a "dynamically modifiable" living space can support the daily living of neo-nomads. Considering lack of space as one of the primary reasons for existing housing crisis in highly populated, urban areas, the design emphasizes on space optimization and proposes a single living space. This action-space is shaped by perceptions of "possible" needs, actions and interactions to occur. These needs range from day-to-day living environments to subjective aesthetic and emotive concerns. Space is enabled the adaptive capacity to modify in real-time and allow possible psychological scenarios to emerge in regards to neo-nomad's dynamic, transitional living and constant mental shift from living to work, personal to social or physical to digital etc.

Adaptability is an anticipatory response to possible future changes [1]. Specific attributes have been integrated in the design to grant it the adaptive capacity to achieve its goal. One design attribute is the application of traditional aesthetic and emotive space-making technique with light and material that intends to influence human mood and behavior. The other attribute is the interactive surface with embedded computing technology that can manipulate architectural surfaces in response to human input. The embedded computing based interactive surface, i.e. wall, floor and ceiling, has anticipatory capacity to generate and orchestrate a continuous human-space interaction. It also has the capacity to transform spatial quality in real time to provide a temporal, dematerialized context for target users. These attributes allow the living space its adaptability to articulate space in real time through human-space interaction.

For a space that is impermanent and evolving, the anticipation in architectural elements that construct it is challenged. The planar surfaces shift to the foreground as active participants in human-space interaction inviting user to make anticipatory creative input for possible spatial responses. Creative and aesthetic processes are driven by imagined ends with underlying anticipations of possible outcomes [1]. Each spatial experience of the occupant is informed by prior experience and interpretation of spatial feedback that again gives rise to new anticipation. In a constant dialogue with space through personalization and customization, occupant's anticipatory creative exploration of space-making has imagined goals, driven by possible physical, emotional and aesthetic meanings and interpretations. As suggested by Jakovich and Reinhardt [24], this aesthetic experience is also sought in the real-time interaction with architectural spatiality, as well as the temporality of materials.

3.2 Testing Method

Models can be created to test and verify if user's understanding of spatial functions, his interaction and response reflect the anticipation created by the designer in regards to how spatial modifications influence user's living [25]. CAVE technology, a four-sided, room-sized Virtual Environment can be used to simulate proposed interactive space at full scale (1:1). This technology can closely recreate the reality of authentic physical world experiences and allow user to move and view space with enhanced feeling of presence [26]. A small group of target occupants can experience and interact with simulated interactive space. User's subjective visual perceptions of space, aesthetic and emotive responses, as well as observation of their space usage can inform designer the extent to which designed anticipation has been realized. Testing process may inspire creative, playful exploration of space. It can thus challenge and redefine conventional expectations and interactions with domestic living spaces and give rise to new sets of design anticipations.

4 Conclusion

The design attempts to provide a platform for further research and experimentations in the realm of interactive architecture that is physical, tangible and essentially spatial in nature. This study attempts to investigate possible human interactions in and with emerging computer-mediated living spaces. It also explores the capacity of interactive technology to participate in the anticipatory design process of architecture. Test results of Virtual Environment simulation can potentially enrich future research in defining the field of interactive architecture. The paper also proposes a possible solution to the housing crisis of Silicon Valley workers and proposes a humane, aesthetic design approach that focuses on space optimization.

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