ON THE INFORMATION SCAPE OF SPACES

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Abstract. This research introduces a new paradigm of "information scape" reshaping our understanding of how people interact within spaces. As individuals navigate through spaces, they consistently encounter making decisions regarding their potential positioning and the direction of their attention. These decisions are influenced by the limited availability of information, prompting individuals to gather surrounding information, make decisions for further interactions, and enhance their prospects for survival. A crucial aspect of spatial decision-making process involves the trade-off between acquiring valuable information from a chosen perspective and potentially sacrificing information from other directions. This trade-off emerges as one of the key determinants of user experiences within a given space. To address this issue, measurables for information trade-off are conceptualized with the assistance of isovist tool. The identification of each individual's specific direction is achieved through the adoption and extension of directed partial isovists, incorporating a set of isovist metrics such as the proportion of partial isovist areas and radial lengths. An observation is conducted to reveal the correlation between individual spatial preference and information scape measurables. The research endeavours to conceptualize a novel perspective of information scape in the context of human spatial behavior, elucidate methods for quantifying its measurables, and discuss scenarios involving information trade-offs between individual directional choices and spatial configurations.

Keywords. Information Scape, Information Trade-off, Isovist, Environmental Preferences, Spatial Preference, Spatial Behaviour

1. Introduction

The perception of space is genetically inherited from our ancestors, who were adept at

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sensing danger and opportunities for food and other benefits from the environment (Appleton, 1975). An information scape can be conceptualized a scape of information that an observer or person can attain and process from one's specific location within a given spatial context (Aung & Shih, 2023). It influences human navigation and wayfinding in the environment, perception, and adaption to leverage their natural senses (Kaplan & Kaplan, 1989). Information acquisition is intricately tied to both the nature of the information being conveyed and the specific context in which it is presented in the environment. The observer's perception and understanding of information are influenced by various factors, including the type of information, its relevance to the observer's goals or interests, and the overall context or situation in which the information is encountered. Different locations have different prevalent information which may not be uniformly disseminated in the environment. It may hypothetically depend on factors such as geographical and topological location, the purpose, context, and sense of the space, etc.

As individuals navigate through spaces, they continually make decisions about where to position themselves and where to direct their attention in accordance with specific information availability. This decision-making process involves acquiring surrounding information and making decisions for further interactions, such as seeking opportunities or secure locations for survival, as seen in activities like hunting or foraging for food. Likewise, individuals themselves serve as information sources to others within the same contextual space or neighbouring area, creating a reciprocal exchange of information. In the presence of limited information availability, individuals exhibit diverse behaviours, resulting in arising emergent behavioral patterns through their interactions.

Within the framework of the information scape theory, a hypothesis postulates that humans strategically position themselves to maximize the acquisition of information in their frontal spaces while minimizing inaccessible information situated behind them. Essentially, individuals optimize the visual information in their immediate frontage, reducing the cost associated with obtaining information from the rear. Consequently, individuals express a preference for positioning themselves in areas where the balance of visual information between the front and rear is deemed more valuable, with a prioritization of information from the frontage over that from the rear.

In this case, the key aspect of spatial decision-making of positioning process is the information trade-off between acquiring valuable information from their chosen perspective and potentially sacrificed information from other directions. This trade-off appears one of the key determinants of user experiences within the space. The question raises: how could potentially it be measurable? To address this issue, the concept of information trade-off as a measurable is conceptualized with partial isovists. Isovist, introduced by Benedikt in 1970s, provides a promising geometrical notion on the study of spatio-visual experience in the space (Benedikt, 1979; Ostwald & Dawes, 2018a). It has made a significant contribution to the field of behavioral studies and theories across diverse disciplines from architecture and urbanism to environmental psychology, through its quantifiable measures and metrics, which encompass, for instance, isovist boundary, line of sight (LoS) or radial lines (Stamps, 2005). In this study, directed partial isovists are adopted to identify an individual specific direction of each person. Then, the measurable of information trade-off is conceptualized and extended with a set of isovist metrics: proportion of two partial isovist areas (120-degree frontage and 240-degree rear partial isovists) mean and minimum radial lengths.

Following this, the observations of occupancy patterns are conducted to comprehend human environmental preferences in the specific location and evaluate the emergent relationship between spatial patterns and information scape measurables. This exploration seeks to understand how individuals, whether consciously or unconsciously, navigate and engage with their surroundings within a given spatial context in the perspective of information scape theory.

The research attempts to conceptualize a novel perspective of information scape on human spatial behaviour, quantify its measurables, and discuss the scenario of information trade-off between the choices of individuals directions and spatial configurations. Overall, the research provides a foundation for understanding complex relationship between human and spaces in architectural and urban environments by introducing the concept of information scape and measuring its dynamics.

2. Theories of Environmental Preference and Information Scape

In the mid-1970s, scholars in the disciplines of architecture and spatial psychology began exploring human preferences for certain features or spaces within the built environment. Appleton, in his book "The Experience of Landscape" (Appleton, 1975), raised questions about individual preferences for landscapes and introduced two theories: habitat theory and prospect-refuge theory (Appleton, 1975). Habitat theory proposes that our ability to assess an environment is an innate skill to embrace our primary natural survival. The Prospect-Refuge theory suggests that these innate tendencies prompt individuals to explore environments conducive to pleasurable experiences, emphasizing our primary senses of security and prospect (Dosen & Ostwald, 2013).

Likewise, Stephen Kaplan and Rachel Kaplan contributed to the understanding of environmental preferences with their theories of information processing and environmental preference matrix, as presented in "The experience of Nature: A Psychological perspective"(Kaplan & Kaplan, 1989; Ostwald & Dawes, 2018c). These theories characterize the environment based on complexity, mystery, legibility, and coherence. On the contrary, information scape theory introduces a conceptual framework of information scape on individual and their cognitive states establishing a reciprocal relationship, in the built environment.

The quantitative assessment of human perception and preferences regarding the physical environment often employs theoretical frameworks such as the prospect-refuge theory and related environmental preference theories, facilitated by the use of isovists, a geometrically constructed computational tool. For example, concerning the Hildebrand's theoretical exploration of prospect-refuge theory assessing spatial pattern of the Wright's spaces (Hildebrand, 1991), Dawes and Ostwald conducted quantitative analysis, scrutinising the spatio-visual evidence of Wright's houses through the use of isovist (Dawes & Ostwald, 2014b, 2014a; Ostwald & Dawes, 2020). Following this, Huangfu and Chung proposed a computational approach measuring prospect-refuge values: visual integrity and visual continuity in the built space (Huangfu & Chung, 2019).

Recent studies have utilized environmental preference theories to investigate the relationship between spatial patterns and preferences. Sailer and Psathiti (2017) explored seating selection of lounge spaces, considering factors such as category, orientation of seats, spatial configuration, and nearby facilities, utilizing isovist and space syntax approaches (Sailer & Psathiti, 2017), while Keszei et al. (2019) investigated seat preferences of lounge area in various social scenarios with 3D virtual environments and space syntax measurables (Keszei et al., 2019). Chun et al. (2019) implemented agent-based simulation model for seating choices of café-style seating configuration, incorporating prospect-refuge metrics derived from isovist measures and other physical environment impact factors (Chun et al., 2019).

Despite the widespread use of isovist and space syntax measurables in recent studies on environmental preference theories, there is still a knowledge gap in understanding the impact of seat preferences on information trade-off situations, particularly regarding the application of partial isovists and their proportional variables.

3. Methodology

The research methodology is comprised of three distinct components: computational isovist analysis, empirical observation of occupancy patterns, and correlational analysis between information scape variables and occupancy patterns to reveal the relationship between information scape variables and behavioural configuration in the built environment.

The computational isovist analysis is implemented using the grasshopper, a visual programming tool embedded in the Rhino 3D computer-aid design software. 42 isovists are established to align with the seats' configurations and directions. Once the isovist locations are identified, radial nodes are arranged in a polar array spanning 360 degrees, with intervals set at 5 degrees with maximum radial length of 80 metres as visual boundary. This arrangement results in 72 radial lines extending from the central location point within each isovist.

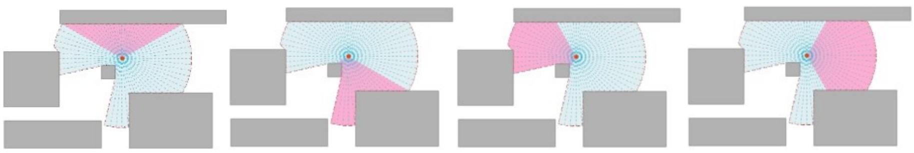

Figure 1. 120-degree and 240-degree partial isovists, and their four-cardinal orientation, visible boundary, and radial length

Then, each 360-degree isovist is partitioned into two components: a 120-degree view specific partial isovist or directed view cone, reflecting an area of relatively accessible visual frontage information of the observer and 240-degree partial isovist, signifying an area of which information unlikely to be available without any rotation or changing direction of original observed viewpoint, thereby incurring additional costs. Therefore, it is assumed that 120-degree isovist is associated with the direction of the observer and seating configuration. The information trade-off index can be computed by the proportion of two isovist area of partial isovists as follow:

$$IR = A(t)/A(t') \quad (1)$$

Where *IR* is the information trade-off index of *i-th* location, *A(t)* is the area of directed view cone or 120-degree partial isovist, and *A(t')* is the area of 240-degree partial isovist. The index, having the equilibrium state between front and rear isovists is at approximately 0.5 (scale free), varies in an accordance with the direction and location of an observer. The location where frontage 120-degree partial isovist outcompetes the rear one would have an index higher than 0.5, whereas the place with a smaller area of 120-degree partial isovist than the rear area will have an index less than 0.5.

In addition to the information trade-off index values, mean radial length, minimum radial length of both 120-degree and 240-degree partial isovists are computed to explore the relationship between occupancy patterns and information scape variables.

The observational segment was performed at a burger shop located at the National Taiwan University of Science and Technology (NTUST). Over a span of 10 days, a total of 464 individuals, predominantly students and employees of the campus, and 42 seats locations were randomly recorded through snapshots to investigate user occupancy patterns and reveal the individual's spatial preferences. The observations are examined along with the measurables attained from the computational analysis of information scape of the study area. A Pearson's correlational study is employed to elucidate the relationship between individual preferences in the choice of location and the hypothesized measurables related to information scape.

4. Result

4.1. COMPUTATIONAL ISOVIST ANALYSIS

Given the inherent nature of humans to strategically position themselves for advantageous information access, aiming to exploit opportunities for personal benefit, the orientation of an observer becomes crucial in the information scape theory. Consequently, while a wealth of information may have accessible in the line of the sight line, certain degree of information must be compromised in the peripheral, out-of-sight areas. The phenomenon of information trade-off emerges as a consequence of the delicate balance between acquiring information from a specific direction and the corresponding loss of information on the blind side. This trade-off underscores the significance of accounting for information dispersion within the physical environment.

Due to the directional advantages offered by isovist measures, information trade-off index can hypothetically evaluate using a half partial isovist (180 degree) and third partial isovist (120 degree) instead of the full 360-degree isovist (Ostwald & Dawes, 2018b). Nonetheless, the 120-degree isovist holds significance in the context of information scape theory, as it closely resembles the human binocular field of vision (Chun et al., 2019; Ruia & Tripathy, 2023). The each 120-degree isovist is aligned with the individual direction of seating orientation and the observer as portrayed in Figure 2.

The Figure 3 illustrates the distribution of information scape trade-off indices of observed configuration. According to the figures, a significant number of higher trade-off indices can be observed on the seat locations situated against the interior wall within the zone D, ranging from 1.53 to 2.76. On the contrary, the majority of lower indices are prevalent in the seats facing the interior wall, reaching as low as 0.02. The balanced proportion of front and rear partial isovist areas, approximately 0.5, are particularly perceived within the central seating areas. In result, these locations can be considered as an area exhibiting balanced information trade-off values.

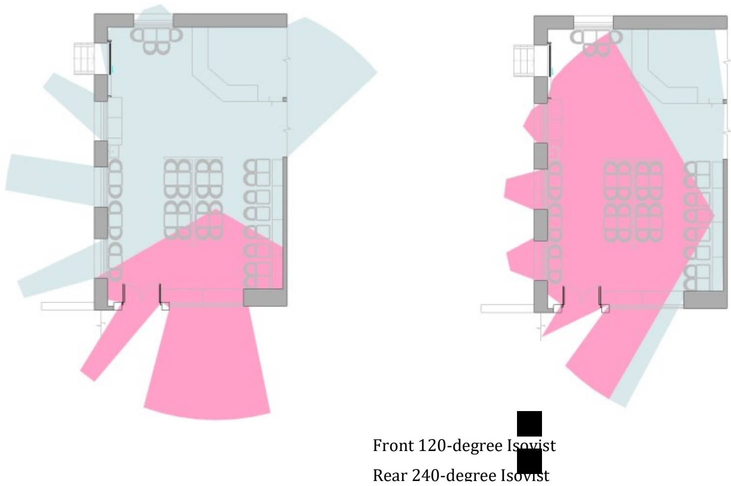

Figure 2. 120-degree and 240-degree partial isovists corresponding to their configurations and orientations of different seating settings

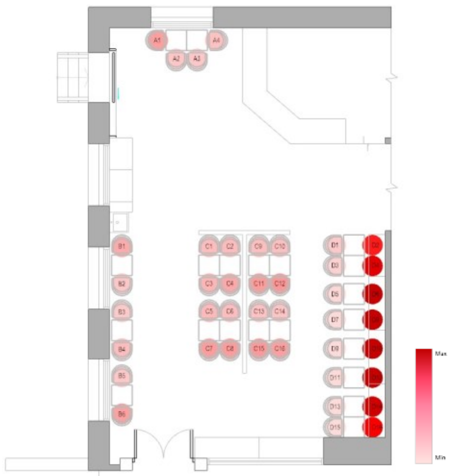

Figure 3. Information scape trade-off indices corresponding to seat configurations

In addition to the trade-off indices, several isovist radial length measures: mean and minimum radial lengths of 360-degree isovist as well as mean and minimum radial lengths of 120-degree and 240-degree partial isovists, are computed to examine the association between human preference and variables. Examining the data reveals a noteworthy pattern, notable findings indicate significantly longer mean, and minimum radial lengths of partial isovists in seats positioned at the centre and those against the wall, facing the shop and window. Conversely, longer mean, and minimum radial lengths of 360-degree isovists are evident exclusively at the shop central area. The shorter minimum radial lengths of all isovists are consistently observed at window seats.

4.2. SPATIAL PREFERENCE OBSERVATION

To validate the hypothesis of information scape trade-off situation, the case study was conducted at the burger shop situated at the National Taiwan University of Science and Technology (NTUST). The seating floor plan of the establishment is divided into four zones. Zone A and B, positioned adjacent to the cashier counter and against the window, respectively, are designated as window seats, providing a visual balance between the exterior and interior. These zones comprise a total of 10 seats, accounting for 23.8 percent of the overall seating. Following this, Zone C, located at the centre of the shop, and Zone D, positioned near the interior wall, collectively accommodates 16 chairs each, contributing to 76.2 percent of the entire seating arrangement. It is noticeable that Zone D encompasses seating arrangements facing the wall and positioned against the wall, resulting in significant variations in information scape measurables. For instance, the information scape trade-off index for seating D8, positioned against the wall, is higher (2.63) compared to D7, which is facing the interior wall has a value of 0.03. The occupancy distribution of seating plan can be depicted using gradient map in Figure 4 (b).

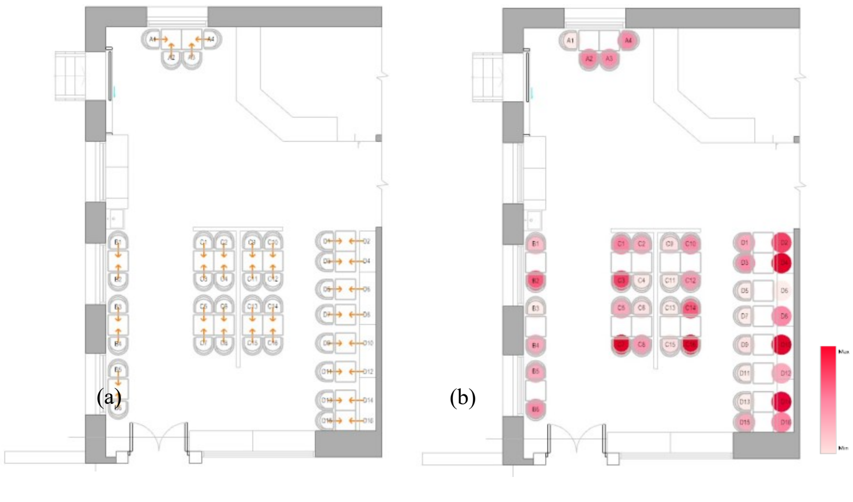

Figure 4. Floor layout Plan of the burger shop (a) Direction of the individual seating (b) Occupancy distribution of seating configuration

After analysing the observations of the shop, it becomes evident that the configurations and locations of seats significantly associate with individual preferences in choosing their locations. As described in Figure 4(b), among 45 number of observations, the most frequently occupied seats, namely C7 and C16 located in zone C, exhibit frequencies of 23 and 24, respectively. These seats demonstrate a balanced information trade-off, contributing 0.78 and 0.76 respectively. Following this, the secondly most popular seats: D2, D4, D8, D10, D14 and D16, situated against the interior wall and facing the windows, account for frequencies ranging from 13 to 21, featuring the highest information trade-off indices among others. On the contrary, the least occupied seats are those facing the interior wall characterized by the lowest information trade-off values, amounting to the frequency as low as 4.

In summary, chairs against the wall in zone D and those at the centre of shop in zone C facing the cashier counter express the highest frequency of occupancy, whereas those facing the wall in zone D have the least popular seats among others. Window seats demonstrate moderate popularity in the seating configurations. It is evident that highly occupied seats often display higher information trade-off indices or, at times, exhibit balanced information trade-off indicators. Despite this, seats with lower frequencies of occupancy tend to have lower trade-off values. Further investigation involves correlational analysis between variables in the next section.

4.3. CORRELATIONAL ANALYSIS BETWEEN OCCUPANCY PATTERN AND INFORMATION SCAPE VARIABLES

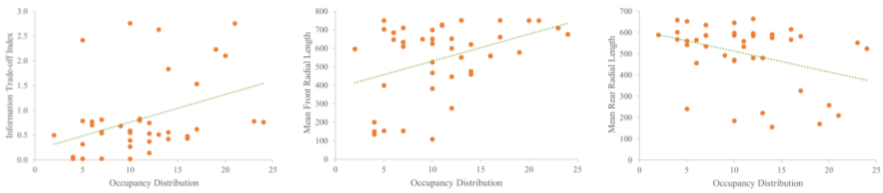

Figure 5. Correlational analysis between occupancy distribution and information trade-off, mean front, and rear radial lengths of partial isovists

After having investigated the trade-off indexes along with the mean and minimum radial lengths of 360-degree isovists as well as partial isovists, the correlational study between occupancy distribution of seats and above isovist variables are analysed.

The above scatter plots presented in Figure 5 illustrate the correlation results between occupancy pattern and information trade-off indices as well as mean front and rear radial lengths of partial isovists. It is evident that there are significant positive moderate correlations between occupancy pattern and information trade-off as well as mean front radial length of 120-degree isovist, with Pearson's correlation coefficient of 0.39 and 0.4 ($P < 0.05$ and $P < 0.01$), respectively. In terms of the statistical relationships of the indices and mean front radial length, individuals tend to locate themselves in places where they can enhance rich visual information in front of them. Conversely, a negative correlation is observed between occupancy frequency and mean rear radial length of 240-degree isovist with correlation coefficient of 0.36 ($P < 0.05$). This suggests that individuals are inclined to be concerned about the higher cost of information behind them and seek to address this situation by selecting spaces with lower rear radial lengths. These support the hypothesis that individuals likely enhance the visual data in their immediate surroundings while minimizing the expenses linked with acquiring information from behind them.

Noteworthily, statistically insignificant outcomes emerge in relation to occupancy variables when considering the mean and minimum radial length of full isovist as well as minimum radial length of partial isovists ($P > 0.05$). The maximum radial lengths of both isovists are considered neglectable, given that majority of isovists display maximum radial length in the context of observation. However, the limited sample size and the specificity of the observed environment are two significant limitations of this study that should be acknowledged. Future research could endeavour to collect a larger and more representative sample as well as the exploration of diverse case studies, to offer a comprehensive examination of the relationship between spatial preferences and representative measurables of information scape.

5. Discussion

This paper delves into the novel paradigm of environmental preference concept, namely information scape, highlighting the significance of the information landscape in the environment and its influence on individual preferences and behaviours in spatial decision-making. It lays the groundwork for a deeper understanding of complex interactions in both architectural and urban environments by introducing the concept of an information scape and measuring its dynamics. Additionally, it introduces the notion of an 'information trade-off situation' and posits hypotheses regarding human location preferences based on certain cognitive states. The quantitative assessment is conceptually employed using a set of geometric properties of partial isovists. Subsequently, observation is performed at a university campus burger store to validate the proposed computational measurables. Finally, a Pearson's correlational study is undertaken to investigate the relationship between individual preferences in choosing a location and the hypothesized information scape measurables. The study observes a positive association between the decision-making process of choosing a location and the ratio of partial isovist area, referred to as 'information trade-off indices,' and mean radial length of front 120-degree isovist, while, conversely, mean rear radial length reciprocally influences the choice of location preference.

Nevertheless, this research is not without its flaws. This study focuses primarily on two-dimensional geometry of space and other physical qualities such as texture, colour, and vertical height of the space, as well as local environmental influences, all of which can impact human preferences in real-world sittings were neglected. Additionally, the spatial preferences identified at the burger shop are most likely reflective behaviour personal stage of eating and different contexts of individual desire or stage may reveal diverse preferences in the environment. In future research, a larger representative sample size may yield more robust statistical results. Advanced behavioural simulations implemented with information scape variables, such as agent-based modelling, can contribute to a deeper understanding of the emergent behavioural patterns of individual preferences, assisting designers in implementation of design process, particularly evidence-based design.

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