# Isovist and Psycho-Physiological Stress at the Pedestrian Level: A Real-Time Measurement Case Study in a High-Density City

*Luyao Xiang, Georgios Papastefanou*

(PhD Candidate Luyao Xiang, School of Architecture, The Chinese University of Hong Kong, New Territories, Hong Kong, xiang.luyao@link.cuhk.edu.hk)
(Dr. Georgios Papastefanou, GESIS Leibniz Institute for the Social Sciences, B2,1 Mannheim, Germany,georgios.papastefanou@gesis.org)

## 1 ABSTRACT

Modern city living can be burdensome to mental health. Statistics from the World Health Organisation indicate that depression will be the second leading cause of disability worldwide by 2020. Emotion is an important part of mental health. Prospect refuge theory is the most famous theory that explains environmental emotional influence in terms of urban planning and architecture. Calculating isovist indicators is a means to quantify the physical environment, and it exhibits a close relationship with the factors proposed by the theory. This study was conducted for the first time in Hong Kong. In April, 30 subjects were asked to walk a predefined route for an average of 1.3 h. The subjects wore a portable smart band to record their psycho–physiological stress 10 times/s. After data collection, a logistic regression model was applied to explore the relationships between isovist indicator level and emotional response. Results demonstrate the following. (1) An open space with a visual target at a distance is the dominant factor that creates positive emotions in Hong Kong. (2) Refuge is not a positive factor for happiness, which differs from the findings in Europe. (3) Prospect refuge theory restricts the interpretation of complexity. (4) A visual field of 120° is suitable for further analysis.

Keywords: prospect refuge theory, real-time measurement, skin conductance response, isovist, high-density city

## 2 INTRODUCTION

The effects of city environment on mental health have attracted the attention of many researchers. An increasing number of evidence indicates that city living is more likely to damage mental health at present (Schroeder (1942), Weich (2002), Sullivan and Chang (2011), Daniel P. Kennedy and Ralph Adolphs (2011), (Lederbogen et al., 2011, Tost, 2011). Statistics from the World Health Organisation (WHO) indicate that depression will become the second leading cause of overall disability worldwide by 2020 and the largest contributor to disease burden by 2030.

Urbanisation is an inevitable tendency in the future; hence, other cities can learn from experience in high-density cities. Numerous studies (Bratman et al., 2015, Roe and Aspinall, 2011, Chen et al., 2016, Lee et al., 2009, Pretty et al., 2005) have indicated that a natural landscape positively affects psychological well-being and can relieve stress from many aspects. As urban planners and architects, we aim to obtain detailed information about urban areas to design them and then propose the corresponding improvement strategies to achieve a psychological friendly city environment.

The most authoritative theory for interpreting environmental emotional response and stress in the disciplines of architectural, interior and urban design is prospect refuge theory. It argues that the instinct of human beings is to feel safe and pleased in a habitat that can offer views and a sense of enclosure. Prospect refuge theory emphasises the visual impact of the environment on emotional response. Isovist analysis is an effective method for quantifying the physical environment. Knöll et al. (2017) found that isovist is the second best predictor for perceived urban stress. Dosen and Ostwald (2016) performed an examination to determine whether human perception of a simple space is directly correlated with isovist measures. Gerald Franz and Jan M Wiener (2008) used isovist indicators to quantify environmental configurations and to test theories on behavioural and emotional responses to environments. In Yu et al. (2016)'s study of the Yuyuan Garden, isovist was used to quantify the transparency and mystery aspects of the garden. Tobias Meilinger et al. (2012) addressed the interactions among human wayfinding performance, the mental representation of routes and the isovist characteristics of path intersections.

Psycho–physiological stress indicators typically include electroencephalogram (EEG), electromyogram (EMG) and SCR. Devices measuring EEG and EMG are too large to ignore even if they are portable, thereby causing discomfort and a sense of being strike whilst walking, which influences the experimental results.

SCR directly shows the activity degree of sweat glands on the palms. Hence, a portable SCR device is similar to a smart watch. When the subjects wear this device, they can act as normal pedestrians. To date, only three studies have used a portable device to measure SCR whilst walking in city streets. Li et al. (2016) made the first attempt to correlate isovist indicators with skin conductance response (SCR). Their study concluded that pedestrian activities were not simply restricted to any single isovist indicator, but comparatively dominated by compactness, occlusivity and maximum visibility. Li's study provided new insights into urban qualities.

The present project is conducted for the first time in Hong Kong, a typical high-density city. The literature review indicates that isovist indicators exhibit a clear correlation with prospect refuge theory and can quantify the psychological aspects of the physical environment. Thus, this study focuses on analysing isovist indicators and SCR. The subjects (n=30) are asked to walk on a predefined path in the city centre of Hong Kong. Meanwhile, skin conductance response and Global Positioning System (GPS) data are continuously recorded. The entire field trip lasts for 1 month. After data collection, a regression model is applied to explore the relationship between geometric environmental property and emotional response.

This study addresses the following questions:

(1) Isovist parameters have been found to exhibit high correlation with prospect refuge theory in previous studies. However, which isovist parameters considerably affect (negative/positive) physiological arousal in a high-density city?

(2) Will the result of the experiment in a high-density city differ from those of previous studies conducted in Europe?

(3) Only (Li et al. (2016), Hijazi et al. (2016))  tested different angles of view in isovist analysis (60° and 360°). The 90°/120°/180° vision angles are added in the present study, thereby making the experiment closer to reality, to determine which vision angle exhibits the best correlation with arousal.

## 3  THEORETICAL BACKGROUND AND RESEARCH HYPOTHESES

### 3.1 Emotional responses and physiological reactions

The background of biopsychological framework of emotion indicates that physiological responses are regarded as a central dimension in the manifestation of the neuro-affective appraisal of stimuli. (Kreibig (2014), Kreibig (2010)) reviewed numerous studies that verified the relationship between specific emotional states and specific physiological arousal reflected in peripheral parameters, such as skin conductivity, skin temperature, heart rate variability and endocrinological changes for positive and negative emotions. Rainville et al. (2006) and Levenson et al. (1991) demonstrated that basic emotions, such as anger, fear, happiness and sadness, are associated with the distinct patterns of physiological changes.

These studies state that electrodermal activity (EDA), which is also known as galvanic skin response (GSR) or skin conductivity, is the simplest and most effective indicator of emotional arousal. EDA directly reflects sweat gland activities, which are directly enervated by the neural signals of sympathicus nervous systems, whereas sympathicus nervous excitation is closely related to the brain structures of neuro-affective negative (avoidance) or positive (approach) appraisal (Boucsein, 1995, Boucsein and Backs, 2009). Setz et al. (2010) and G. Papastefanou (2013) experimentally verified that as a single parameter, EDA enables the identification of stress reactions. However, G. Papastefanou (2016) also showed that EDA changes that have been cleaned of artefacts and noise can function as an effective tool for identifying emotional responses to aversive and appetitive stimuli.

### 3.2 Responding to environmental properties: Theoretical approaches

#### 3.2.1  Prospect-refuge theory

The theory was first developed by Appleton (1975) whilst conducting research on landscape preferences. It argues that humans naturally feel safe and pleased in a habitat that can offer views and a sense of enclosure. This theory acquires inspiration from the basic biological knowledge of humans. An environment can be considered conducive to living, where a positive emotional response is received. Conversely, if an environment is perceived less suitable, then an anxious or restless reaction is received. From the perspective of evolution theory, only those who are sensitive to positive factors can live long to procreate and pass the

preference to the next generations. In addition, the application of this theory to design actually combines Berlyne's arousal theory (1951), where increased pleasure is experienced at the moment of seeing a space or scene with a certain degree of uncertainty or novelty. Nevertheless, an anxious sense will appear. The first and best-cited architectural application of prospect refuge theory was presented by Hildebrand (1993). He proposed that the emotional response to Frank Lloyd Wright's architecture elements forms the symbols of prospect and refuge.

### 3.2.2 Components of the environment based on prospect-refuge theory

After Hildebrand's work, numerous studies have applied this expanded definition of prospect refuge theory to analyse emotional response to the physical environment. The model generally has four components.

Prospect is a key aspect of the theory that indicates a clear field of vision. An individual with a large field of vision can detect possible enemies better than an individual with a limited field of vision. Prospect is related to depth of view, perceptual features of outlook, spaciousness, openness, geometric features of the isovist area and maximum radial line length.

Refuge is another key aspect of the theory. It presents a space, which must be partially enclosed and functions as a safe hiding place in a dangerous situation. Refuge is related to the perceptual features of enclosure and safety, and the spatial visual geometric features of occlusion and minimum radial length.

Complexity refers to the amount of information contained in a space, along with the number of occluding edges (or vertices) and the jaggedness of its geometry.

Mystery sense is associated with the lack of available information about a place and the intelligibility of this information. Mystery is about drifting between spaces, changing luminosity and occlusivity degree.

Apart from the four main components, other studies have expanded the definition of the theory and summarised several subcomponents, such as (1) light, which is helpful when observing during a possible danger; and (2) visual pull, which refers to the visual attractiveness of a place.

## 3.3 Quantification of geometric visual perception: Isovist

### 3.3.1 Isovist indicators

Isovist analysis is one of the most extensively adopted approaches for transforming space in space syntax. In general, isovist is defined as 'the set of all points visible from a given vantage point in space (Larry S. Davis and L.Benedikt, 1979). Benedikt's method identifies six geometric measures: area, perimeter, occlusivity, compactness, jaggedness and variance and skewness of the radial distances of each observation point.

Isovist area determines the area of the polygon.

Isovist perimeter is the total length of the boundary.

Occlusivity refers to the total length of all occluded edges. Occluded edges are the undefined parts of building surfaces, i.e. the unclear or ill-defined parts.

$$Occlusivity = P - P_f$$

(P = isovist perimeter, $P_f$ = overall lengths of solid boundaries within the isovist area)

Compactness describes the compact and simple degree of the visual area.

$$Compactness = 1 - \frac{2\sqrt{\pi S}}{P} \quad (S = \text{isovist area})$$

Jaggedness describes the complexity of the polygon with the amount of vertice and the vertex density.

$$Jaggedness = \frac{P^2}{S}$$

The variance and skewness of radial distance are measured through the maximum/minimum radial line, where the length of the longest/shortest single radial line is used to generate the isovist. The length of radial lines represent the distance that a person can see (Dawes and Ostwald, 2014).

Drift magnitude is the distance between the observation point and the mass centre of an isovist polygon.

Drift angle refers to the angle between the occupant facing the direction and the mass centre of an isovist polygon.

Isovist indicators have been introduced in the preceding paragraphs, and a large number of studies have demonstrated the strong relationship between the levels of these indicators and emotional response. To date, a change in isovist during the experience process has not yet been reported. A change in isovist is related to a person's memory of walking on a street, and over time, memories that arouse a stimulus level will either remain the same or increase (LaBar and Phelps, 1998, Baddeley, 1982, Kleinsmith and Kaplan, 1963). Therefore, considering the time difference in isovist (D1) within several seconds will bring new insights into this topic.

### 3.3.2   Space syntax and Depthmap

Space syntax offers various quantitative indices to present the properties of places from several aspects, which are potentially associated with different psychological responses, including behavioural affordances, orientation and disorientation, spatial knowledge acquisition, perceived spaciousness, privacy and social interaction, stress and fear (Montello, 2007).

Depthmap is an efficient computational method for calculating isovist indicators. It applies the same isovist definition and calculation formula as those of Benedikt's. Depthmap provides two types of visibility analysis: isovist analysis and visibility graph analysis (VGA). In isovist analysis, the spatial properties of the visibility field can be attributed to a specific observation point and then a graph can be generated by linking this point with other points. Isovists can also display the visibility field of a specific area. A group of isovists is generated from a designed path with regular intervals to present the situation of walking in space (Kinda Al_Sayed et al., 2013).

## 4   OVERVIEW AND HYPOTHESES

Evidence shows that a city environment can be burdensome to a person's mental health. Prospect refuge theory is one of the theories that interprets environmental psychological impact. To quantify the environment, some researchers have used isovist indicators as intermedium to connect the environment with the prospect refuge theory. On the basis of previous studies and theories, isovist area, maximum radial line and occlusivity will have a negative impact on the possibility of generating negative emotions, whereas the other measures will have a positive impact.

| Spatio-cognitive components | Perceptual property | Corresponding isovist indicators | Negative emotional response possibility |
|---|---|---|---|
| Prospect | Spaciousness, openness | Isovist area | \ |
| | | Isovist maximum radial line length | \ |
| Refuge | Enclosure, safety | Occlusivity | \ |
| Mystery | Intelligibility of information, luminosity, drift between space | Occlusivity | \ |
| | | Difference of isovist (D1) | / |
| Complexity | Volume of information | Number of including edges, | / |
| | | Jaggedness | / |
| | | 1/Compactness | / |

Table 1 Prospect refuge components & isovist indicators

The present project is performed for the first time in Hong Kong, a typical high-density city. The subjects are asked to walk on a predefined path in Hong Kong's city centre, whilst SCR and GPS data are continuously recorded. In the following logistic regression analysis, isovist indicator level is used as independent variable, whereas the change situation of emotional response is regarded as a dependent variable.

The experimental results in Hong Kong would be distinct from those of previous studies conducted in Europe because of social and cultural differences (Li et al., 2016, Hijazi et al., 2016, Griego et al., 2017). People in Hong Kong may be more sensitive to the physical environment given that density is considerably higher in Hong Kong. In addition, given that prospect refuge theory regards prospect and refuge as its main

components, the indicators isovist area, maximum radial line and occlusivity would exert dominant effects on arousal.

## 5 MATERIALS AND METHOD

### 5.1 Participants

The subjects (n = 30, mean age = 24.77 years, age SD = 0.718) are Chinese people studying and living in Hong Kong for less than 3 years. These people are relatively familiar with Hong Kong's living surroundings but are still curios about its environment. In addition, the subjects do not have a history of heavy mental illness, have no symptom of systemic sweating (secondary) and have not suffered from accident in the previous months.

### 5.2 Walking path and experiment design

The predefined walking path is located in Tsim Sha Tsui. Tsim Sha Tsui is a famous commercial centre in Hong Kong. Apart from large shopping malls, it has many retail stores, restaurants and exhibition areas. Tsim Sha Tsui has a huge daily pedestrian volume. The walking path consists of four roads: Nathan, Peking, Hankow and Haiphong Roads. The four roads have distinctive features. Nathan Road is a main city road with four lanes separated by a central isolation greening zone. Peking Road has two lanes in the same direction, without greening on any sides. There is a shopping mall entrance on this road. The width of Hankow Road is equal to two lanes, but one of the lanes is designated for parking, whereas the other side is planted with street trees. Haiphong Road is located between the city and a man-made park.

The experiment was conducted during the entire month of April. On each experimental day, two to four subjects were individually asked to walk on the predefined city path at around mid-noon. The subjects were told to observe the surrounding carefully during the walking, and at the end, to give some reconstruction suggestions. The city path has four corners where the subjects are required to stop walking to experience the streetscape for 10s. Although stopping at the end of each street will result in a longer walking period, establishing an initial impression of the streetscape before experiencing it can prevent numbness from walking and force the subjects to immerse themselves in their surroundings.

### 5.3 Introduction of equipment

The smart band comes from BodyMonitor company, which was developed by GESIS–Leibniz Institute for the Social Sciences. Its validity was confirmed by an experimental research (Papastefanou 2013) and several field studies (Hogertz 2010, Bergner et al, 2011, Bergner et al 2013, Hijazi et al. 2016, Steinitz et al. 2014). The band sensor captures skin conductivity and skin temperature at a rate of 10 Hz. In addition, skin contact quality and ambient temperature are measured simultaneously, thereby allowing the detection of crucial artefacts in skin conductivity and skin temperature caused by the changing contact quality between the skin and the transducers.

The measurement method of the equipment follows the theoretical approach of basic emotion theorists (Ekman, 1992, Levenson, 2003), who underlined a specific physiological arousal for specific emotional responses. The outcome includes binary data, i.e. 0: no response and 1: response for every moment during measurement. The BodyMonitor's algorithm provides a function for sorting emotions: positive, negative, balance and retraction. This study only involves positive and negative emotion responses for analysis.

### 5.4 Preparation for georeferenced analysis

Step 1: Define a norm path.

This type of walking path can be represented by a kml format file using Google Earth.

Step 2: Divide the path into equally distanced georeferenced path segments.

A segment is defined as the space between two lines, which indicates that only the upper, lower, left and right bounds are defined as the boundary of a segment. Through this procedure, segments are actually conceived as a type of open-ended strips. A segment length of 2.5 m was selected in this study. Then, according to this segment length, the line borders of each 2.5m segment were determined by calculating the pair of points on each border line. This procedure is repeated for each part of the designed path.

Step 3: Assign the georeferenced sensor signals to georeferenced and fix errors.

Each time moment of the sensor signal is assigned to its corresponding segment by calculating the relative position of the point coordinates of the time moment and the point coordinates of the segment lines. This procedure erroneously assigns waypoints because the segments are geometrically defined as open segment strips. Therefore, a final correction is required to assign the time points and segments by using manually read time moments of the start and end of each path part.

## 5.5 Calculating isovist indicators using Depthmap

This study uses UCL Depthmap 10.00 to conduct isovist calculation and mapping generation. The software provides two types of visibility analysis, namely, isovist analysis and VGA. Isovist analysis is appropriate for predefining observation points, whereas VGA is suitable for overviewing visibility distribution over the entire area. In addition, the isovist field of view affects the result. The software has the following options: 1) Quarter isovist, 2) Third isovist, 3) Half isovist and 4) Full isovist. Previous studies (Li et al., 2016, Hijazi et al., 2016) have explored this topic using isovist fields of view of 60° and 360°. The subjects in this research are required to walk the path in one direction. Their emotional response is influenced only by the scenes in front of them. Therefore, the 360° isovist field of view is not considered in the analysis. Three fields of view (90°, 120° and 180) are involved.

The norm path is imported into AutoCAD before calculating the isovist indicators in Depthmap. Then, observation points are created by splitting the polyline every 2.5 m. Subsequently, the file is imported into Depthmap and used as the isovist path. Finally, the values of each observation point can be easily calculated using Depthmap.

## 6   RESULTS

Emotions are sorted into positive and negative aspects based on the BodyMonitor's algorithm. They are set as dependent variables, whereas the isovist indicators are set as independent variables in the logistic regression.

odds ratio of isovist parameters on momentary negative EDA responses (separates logistic regression with cluster robust s.e. estimation)

| Normalized isovist-parameter | 90° | Wald chi square | 120° | Wald chi square | 180° | Wald chi square | N of observations | N of cases |
|---|---|---|---|---|---|---|---|---|
| isovist area | 0.945* | 2.59 | 0.948 | 2.24 | 0.962 | 1.11 | 232010 | 30 |
| isovist compactness | 1.045 | 2.98 | 1.04 | 1.38 | 1.039 | 1.18 | 232010 | 30 |
| isovist drift-angle | 0.946* | 2.88 | 0.948 | 2.58 | 0.976 | 0.41 | 232010 | 30 |
| isovist drift-magnitude | 0.919*** | 7.66 | 0.920** | 6.08 | 0.934** | 3.72 | 232010 | 30 |
| isovist max-radial | 0.923*** | 7.46 | 0.925** | 5.54 | 0.946 | 2.2 | 232010 | 30 |
| isovist occlusivity | 0.964 | 1.46 | 0.974 | 0.62 | 0.985 | 0.18 | 232010 | 30 |
| isovist perimeter | 0.934** | 5.25 | 0.942* | 3.54 | 0.963 | 1 | 232010 | 30 |
| isovist jaggedness | 1.085** | 5.84 | 1.089*** | 6.89 | 1.068** | 4.91 | 232010 | 30 |

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 2 Logistic regression: negative emotion & isovist indicators

Isovist indicators level do not significantly influence the occurrence of positive emotions in the city environment. By contrast, negative emotions are strongly related to isovist indicators (Table 2).

Among the three tested isovist fields of view, the isovist indicators exhibit the strongest relationship with negative emotional response when the field of view is 90°. An increase in isovist area, compactness, drift angle, drift magnitude, maximum radial line and perimeter reduces the probability of obtaining negative emotions. Among these indicators, drift magnitude and maximum radial line significantly affect negative responses. Simultaneously, pedestrians are more likely to develop negative emotions when physical isovist jaggedness is increased.

When isovist field of view is increased to 120°, drift magnitude, maximum radial line and occlusivity still negatively affect negative emotions, whereas jaggedness has a positive effect. Thus, 180° is the maximum isovist field of view used in this study. Only drift magnitude and jaggedness significantly affect the result, i. e. they exert negative and positive influences, respectively.

## 7 DISCUSSION

### 7.1 Property 1: Prospect and refuge

Isovist area and maximum radial line are the representative physical indicators for prospect, whereas occlusivity is for refuge. The results in Table 2 show that an increase in isovist area and maximum radial line indicators causes less negative emotional response, thereby indicating that when more a space exhibits prospect and refuge properties, the probability that negative emotions will be triggered is less. Isovist area can trigger pedestrians' ability to overview space, and thus, provides them with sense of security. Moreover, isovist maximum radial line length strengthens this sense of security and enables pedestrians to detect the space from afar. The mathematical definition of occlusivity is the difference between isovist perimeter (P) and the overall lengths of solid boundaries within the isovist area (Pf). The solid boundaries within the isovist area provide pedestrians with opportunities to hide to observe the surroundings.

### 7.2 Property 2: Complexity and mystery

Table 2 shows that an increase in jaggedness is more likely to cause negative emotions. The implication is that the diversity and complexity of space are not beneficial for generating positive emotions. However, this concept is contrary to prospect refuge theory, which indicates that a degree of visual complexity enhances the sense of safety and exhibits a high positive relationship with preference for the site. This evidence mostly originates from interior space studies (Gerald Franz et al., 2004, Scott, 1993b, Scott, 1993a, Wiener et al., 2007, Dzebic, 2013), in which the number of vertices is positively correlated with interestingness and triggering pleasure. The current study is conducted outdoors, with a limitation of data. Therefore, only the geometric complexity of an isovist area is considered, which indicates that other information in the street is disregarded. The street environment is considerably more complicated than indoor space; thus, it includes various types of information, such as the elements on the façade of buildings, the arrangement of plants, the volumes of pedestrian and traffic, and the type of shops. Jaggedness and compactness contain only partial information of complexity. The result of the present study is consistent with that of Nasar (1984) , where only a linear positive relationship with preference is found and its weight value is the lowest among all factors that are relevant to preference, which differs from the curvilinear relationship posited by (Berlyne (1963), Wohlwill (1968)). Nasar attributed the reason to the imprecise and incomprehensive measurement of complexity.

### 7.3 Comparison with previous studies

To date, only two similar studies (Hijazi et al., 2016, Li et al., 2016) on isovist analysis, which were conducted in Zurich, Switzerland, are available. Although the present study uses different emotional data formats with the previous ones (the studies in Europe used arousal level, whereas this study uses arousal change in information), the comparability between the two is still meaningful because of the following: (1) the same device is used to record the psycho–physiological data, and (2) the information of arousal change is part of the message contained in the arousal level.

The results of previous studies showed that occlusivity is the dominant component among all the isovist indicators. Both studies found that occlusivity exhibits a significant relationship with negative emotion. Moreover, one study concluded that it correlates with positive emotions. Occlusivity is the enclosure degree of space, which can theoretically ensure a sense of security. By contrast, people's reliance on a sense of security in Hong Kong is not as strong as those in Zurich. An avenue with a high degree of enclosure makes them feel depressed if it is not designed masterly and conversely. Thus, people prefer open and interesting spaces. Accordingly, isovist area and maximum radial line play important roles in reducing negative emotions in Hong Kong.

In addition to occlusivity, compactness is advantageous in causing positive emotions in the Zurich's experiments. This tendency is similar to that in Hong Kong, where people are more likely to have positive

emotions when visible scenery becomes more compact. In summary, the demonstration of complexity in prospect refuge theory is restricted to indoor space.

## 8   CONCLUSION

The context of this study is set in Hong Kong. We investigated the correlative effects between the physical attributes of a city environment and pedestrians' emotional response using a combination of field trip method and computational aid to calculate isovist indicators. We concluded that:

(1) Prospect is the dominant attribute of the physical environment that affects people's emotion. Therefore, maintaining a high level of isovist area and maximum radial line is the key to avoid negative arousal. Designing an unobstructed visual focus at a distance is suggested when the surroundings are monotonous and boring in addition to creating an open vision.

(2) Prospect refuge theory is restricted to outdoor space in terms of complexity component. Geometric complexity induces people's negative emotion whilst walking along city streets. This finding is contrary to the idea proposed in the theory. The definition and measurement of complexity must be supplemented.

(3) Isovist transformation has a higher correlation with arousal than a stable isovist level because transformation brings a new message to people, which leads to a sense of mystery. Therefore, isovist difference over a time series can be a valuable parameter that is correlated with emotion.

(4) The city environment and social background of Hong Kong are distinct from those of Europe. Such difference is reflected in the refuge component. People in Hong Kong do not prefer an enclosed space, whereas people in Zurich are more likely to experience positive emotions when staying in a refuge environment due to the sense of security that it provides.

(5) Among all the isovist fields of view, 120° achieves the best correlation with arousal in Hong Kong. In further studies of this project, an in-depth analysis will be performed for the 120° field of view.

People's emotion are affected by many other factors, such as building façade details, crowds, traffic and weather conditions. In the future, this project will incorporate individual information, crowds, greening and weather conditions into the analysis to form a more comprehensive framework.

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