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# A Method to Extract the Structural Strata and Elements of Landscape using GIS

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**Abstract:** Analyzing the landscape with using large three-dimensional database is well noted as the new method. In applying the method, the measure to divide the database into several densities of data to adjust many places and to analyze in mainframe computer is in need. The purpose of this study is to clarify the method of dividing spaces into structural layer, which can be measured in its quantity.

The theoretical method to extract the landscape elements by the distance from the viewpoint has been recognized by the previous studies, which based on the human phenomenon philosophy. However, the quantity of distance, which defines the space as a whole environment around viewpoint, is not yet applicable for practical design. Because, the quantities have not been clearly found to apply to the real space since, feelings of distance varies by personal image. The cause of differences is due to some factors such as physical factors including the topography, the vegetation, and the building surroundings. Furthermore, there are other factors for example, psychological and social.

In this study, the physically caused distance definition is to be cleared through the method to extract the structural strata and the elements of landscape.

As an initial analysis, the angle of gaze from viewpoint, based on human engineering, the heights of the layers were examined and clearly found. The relationship between the eyesight and the angle of gaze are analyzed. Secondly, the continuity of figure from viewpoint is measured. It applied the fifty meters mesh digital map, the topographic vector data, the aerial photograph, and the building form vector data, to the Geographic Information System; the SIS and the ArcGIS. It proved that three scale of view; the close, the distance, and the background divides the real landscape. With this result, the method to extract the structural strata is found.

Preliminary, the methods' application was tried to real spaces for further analysis. The results encouraged the analysis of physical quantity related with the human image including the time-space, and the relationship between the view and the other sense, which are under processes.

**Keywords:** three-dimensional data, GIS, time-space, structural strata, Fukuoka City

## 1. Introduction

In the series of the studies regarding the spatial characters influenced by the quantity and by the types of change, named the 'Nature of Time', the relationship between the change of space and the image of residents has been clearly found<sup>1</sup>. The characteristics by the spatial changes, which has been dealt with in these studies, are totally different from in the previous studies on the image of space, considering is as an steady object. The verifications are under process with real urban spaces' analysis. The Geographic Information Systems (GIS) is used for the analysis and the result is expected to deliberate the new nature.

Various phenomenon are available to be analyzed in our surroundings. This includes not only the length of time but also the type of change. This complexity makes difficult to apply the GIS analysis since, the unit of the space has vast amount of data. The computer simply cannot afford the huge data of large urban space.

Analyzing the landscape with using large three-dimensional database is well noted as the new method. In applying the method, the high-speck computer can calculate the huge data. There is even a possibility of developing the new system in the widely used computer in the future. However, still the measure to divide the database into several portions/segments of data and adjust into appropriate scale for analysis is in need.

The purpose of this study is to clarify the method of dividing spaces into structural layer, which can be measured in its quantity for further analysis.

Over the theory of the 'Nature of Time', the authors verified the relationship between the length of change and the expanse of the perceptual space. It is believed that through confirming the theory by the division of the psychological space and of the length of the time, the study will make significant progress.

## 2. Space for Human

The theoretical method to extract the landscape elements by the distance from the viewpoint has been recognized by the previous studies, which based on the human phenomenon philosophy. This theory is based on 'Space for Human' by O. F. Bornow<sup>2</sup>.

The theory based the existence of human being. The perceptual space is defined based on the functions of sensory organ as well as psychological factors. An idea of the Time-Landscape is almost the same. In this study, the distance by the physical orientation of human existence would be analyzed from the point of view as the 'landscape'. Although the movement of human in real space must be included when the spaces are analyzed, this factor will not be included at this stage of the study.

There are some studies analyzed the spatial distance based on the perception. The studies on the sense of spatial distance by E. Hall (1966)<sup>3</sup>, and by Takahashi (1996)<sup>4</sup> are the exponents. On the analysis on the relationship between the sense of vision and the real spaces, by Matsumoto et al. (1996)<sup>5</sup>, the numeric value of distance was apparent.

However, the quantity of distance, which defines the space as a whole environment viewpoint, is

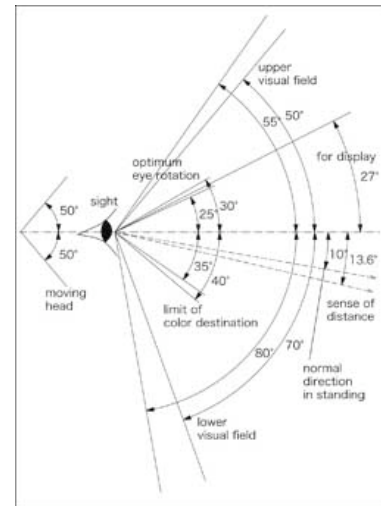
not yet applicable for practical design. The quantities have not been clearly found to apply to the real space since, feelings of distance depends on personal image. The causes of differences are due to some factors such as physical factors including the topography, the vegetation, and the building surroundings. Furthermore, there are other factors for example, psychological and social.

In this study, the physically caused distance definition is to be cleared through the method to extract the structural strata and the elements of landscape.

### 3. Optic Angle and Distance of Consciousness

As an initial analysis, the angle of gaze from viewpoint, based on human engineering, the heights of the layers will be examined. In the analysis, not only the ‘sense’ based the single sensory organ, but also the process from ‘perception’ onwards ‘recognition’ will be dealt with.

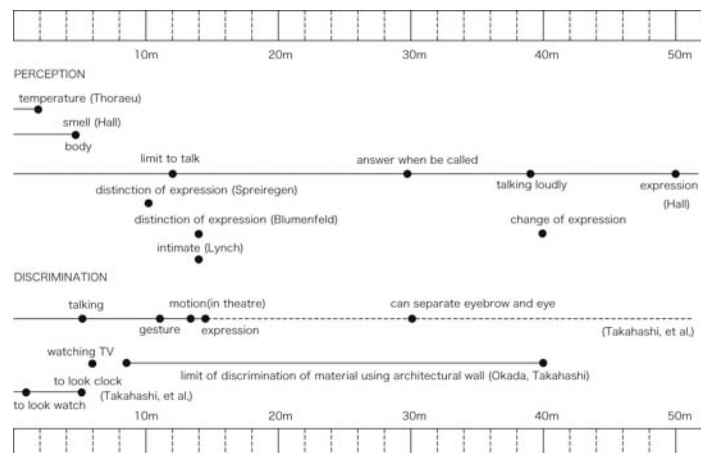
Firstly, the theories about the system of an angle of view are gathered based on previous studies. The relationship between the eyesight and the angle of view are examined. Specially, the angles defined by the experiment in the previous studies are sorted in the Fig.1. The general sight, called the white sight is between fifty to sixty degrees in upper visual field, between seventy to eighty degrees in lower, and between one hundred to one hundred twenty-four degrees in horizontal. Meanwhile, as a perceptual field, an angle of elevation as either twenty-seven or thirty degrees, an angle of depression as either forty or thirty-five degrees, and an angle of horizon as either ten to thirty or sixty degrees. These results are based on the various experiments as well as theories established by the predecessors theories rested on the experiment<sup>6</sup>. As the results do show little difference in number, this study will hypothetically employ the thirty degrees for an angle of elevation.



**Fig. 1**  
**Visual Field and Angles**

Secondly, the perceptual distances of recognition mentioned in the previous studies are summarized in Fig 2. The distances showed in

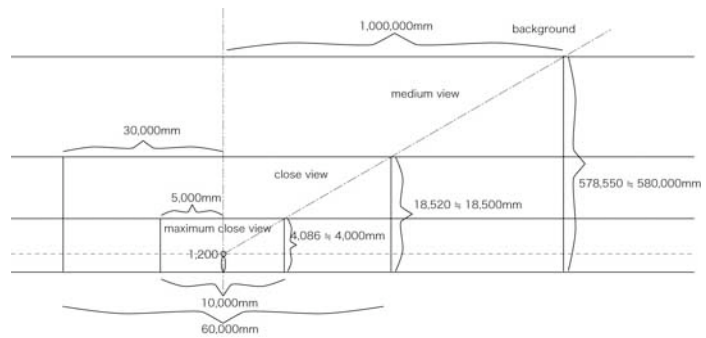
the table were the results of experiments done in the previous studies. Not only the visual organ but also other senses such as auditory and smell are examined to define the perceptual distance. they are also showed in the table Furthermore, psychological factor over the perceptual distances is regarded that this shall be taken into consideration when carrying out the further analysis. Some significant numbers in the table are approximately five meters for



**Fig. 2 Perceptual Distances of Recognition**

sensing smells, between ten to fifteen meters for regular conversation including expression notice, and watching images such as TV and clock, and over thirty meters for shouting.

In this study, the hypothesis is set as in the Fig.3 based on the visual, the auditory and the smell as main organs. This tries to divide space into four layers considering both the three senses and background of human being. The first layer called ‘maximum close view’ with a height of four meters defined by the radius of five meters of perceptual distance circle with thirty degrees of an angle of elevation from where human stands. The same procedure applied to define the second layer called ‘close view’, which has the height eighteen point five meters within the radius of thirty meters. The thousand meters is used to divide ‘medium view’ and ‘background’ since, the thousand meters is considered as the limit to recognize human existence by eye<sup>3</sup>. The height is set as the five hundred and eighty meters for the ‘medium view’. The last layer named ‘background’, which covers beyond the ‘medium view’. Based on the above-mentioned four hypothetical layers, the analysis will be undertaken as an example to extract the structural strata.



**Fig. 3 Hypothesis of Perception in Urban Area**

#### 4. An Analysis of Fukuoka City

In this chapter, the continuity of figure from viewpoint is measured based on the eyesight and four layers. The analyzed area is the Fukuoka City, Japan.

Fukuoka Plain spreads in Fukuoka City has topography surrounded by the mountains; on its east, the Nishiyama and Inunariyama which has about five hundred meters heights, on its south east, the Migorisanchi about nine hundred meters heights, and on its south west, the Sefurisanchi about from six hundred to thousand meters heights. Within the circle of these mountains, there are some small singer mountains as semicircle, some hills besides as Fig.4. Fukuoka City covers all the plain area of 37km



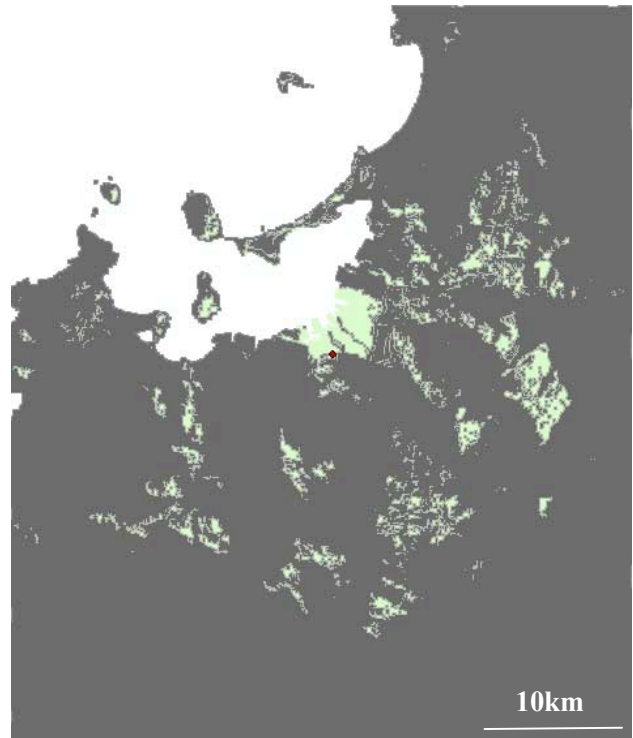
**Fig. 4 Fukuoka City**

with approximately two million population. The city serves as a center of Kyusyu island region in both economy and culture.

The fifty meters mesh digital map was firstly used for the analysis. The angles of mountains constitute background are calculated. In this analysis, the measured points are the center of the mesh. Although this method can not be precise, it is still enough for analyzing the background. The GIS applications used are the SIS and the ArcGIS.

Fig.5 expresses the visible area targeting the background from the point in central Fukuoka. The height of viewpoint is one point two meters from the ground level not taking into consideration of buildings, bridges, and trees. The figure shows the characteristic of plane surrounded by mountains. Fig.6 describes the possible view area from the hill in the city. This relatively show the background clear compare to the Fig.5.

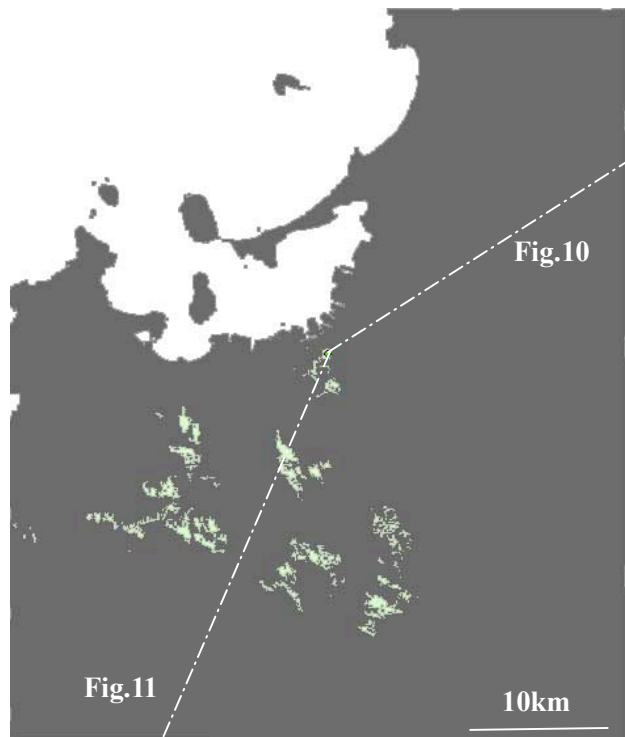
The results of visible area is in Fig.7,



**Fig. 5**  
**Visible Area from City Central**  
**without the Influence of Buildings and Trees**



**Fig. 6 Visible Area from the Hill in Central**

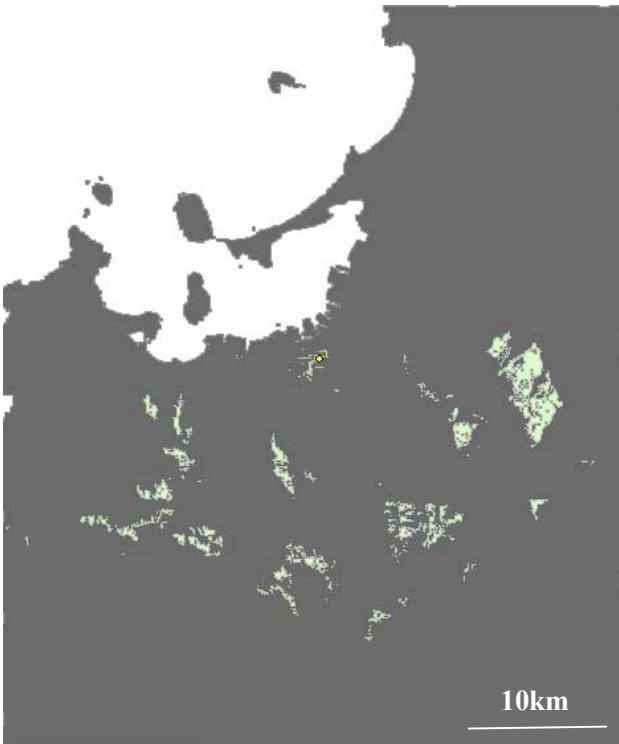


**Fig. 7 Visible Area from City Central**

which used the data on the layer of ‘nearest close view’ and of ‘close view’ with an angle of thirty degrees elevation. The point of view is the same as in the Fig.5, but outcome is smaller in area due to the buildings and other structures. However, the analysis ignores the additional or temporary obstacles for visibility such as trees, car, bicycles, signs, and lights.

As a result, the landscape view on the inside of city is established by the ‘nearest close view’ and the ‘close view’. Fig.8 and Fig.9 are the visible area from the other points in central area. The results are very similar. While, the background and medium view are perceived in five hundred and eighty meters heights. It proves that the layers hypothetically set before are appropriate to extract the nature of the city.

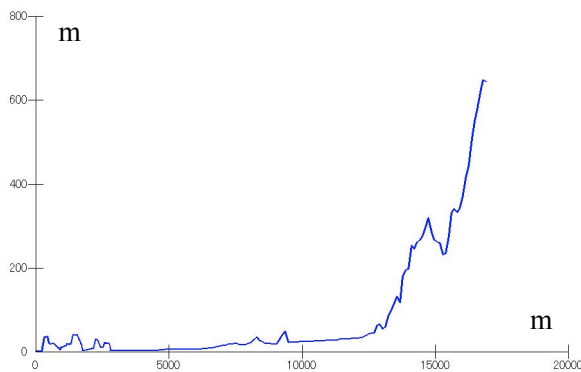
Fig.10 is the cross section of viewpoints from ‘maximum close view’ up to ‘background’ with one point extracted from Fig.7. It is apparent that the view area is widely covered by the maximum close view



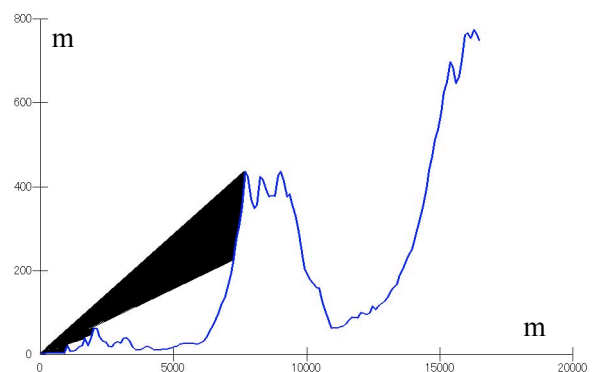
**Fig. 8 Visible Area from City Central (2)**



**Fig. 9 Visible Area from City Central (3)**



**Fig. 10 Cross Section**



**Fig. 11**

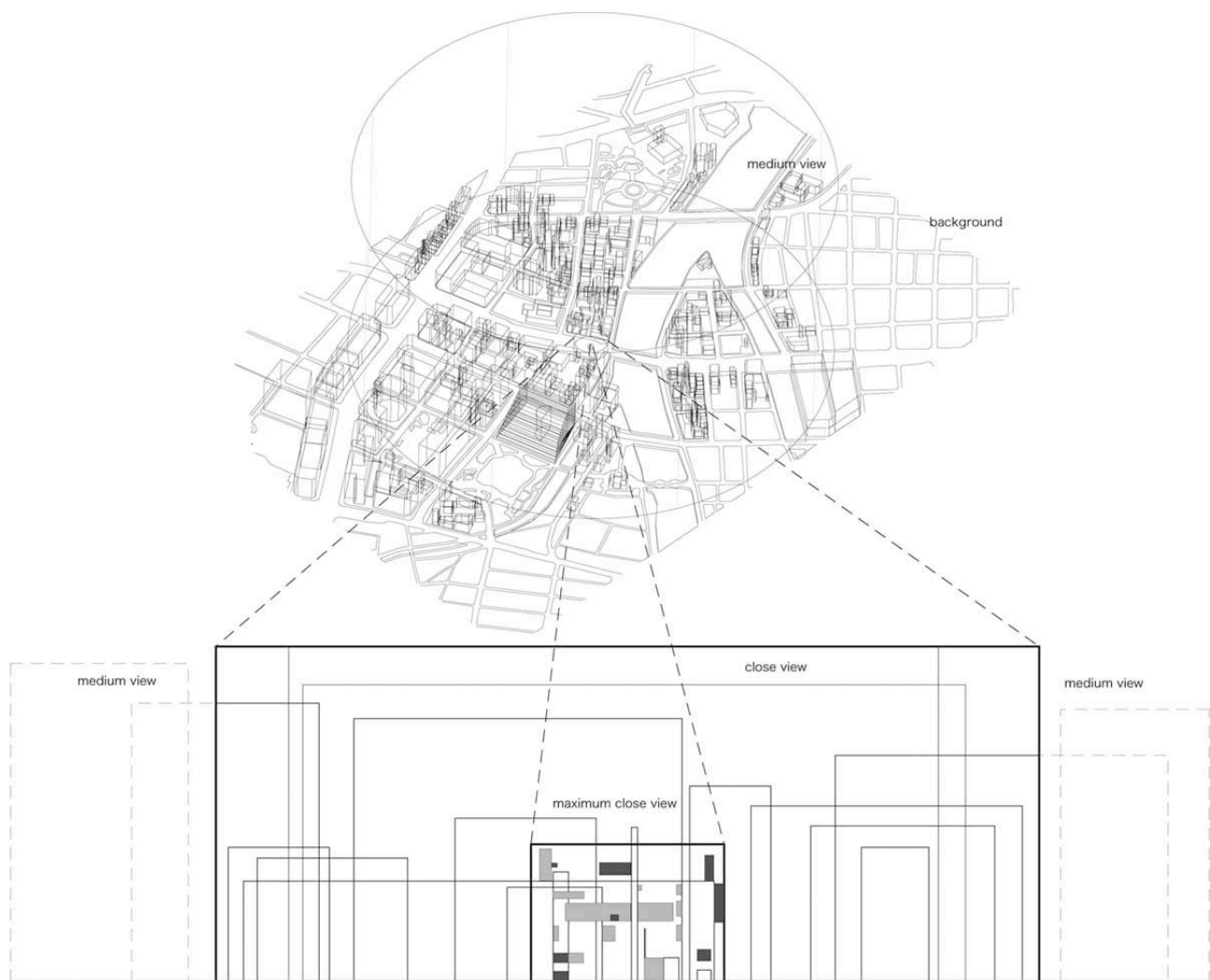
**Cross Section and Continuity of View**

layer and the close view layer. The continuity of figure from viewpoint is in Fig.11. It also clearly shows the domination of close view and medium view in the eyesight. This can suggest that the objects in these layers are influential when we perceive our surroundings. As far as what we observed from the Fukuoka city analysis, it can be said that four scale of view; the maximum close, close, the medium and the background divides the actual landscape. With this result, the method to extract the structural strata is proved.

## 5. Discussions on Application of Measure to Actual Space

Fig.12 is a hypothetical simulation, which expresses the model of a city with layers and the objects. The ‘maximum close view’ may include the information of smell and sound, the data of human activity, in the future. The ‘close view’ can compose the data of visual urban facilities and objects near the view point and it can also serve as a partition to analyze the boundary of eyesight including human activity. The ‘medium view’ is necessary to include the information and data on volume and outlines of constructions. The ‘background’ is affected mostly by the natural surrounding environment.

As the results of analysis, which our hypothetical theory applied to Fukuoka city, relevant



**Fig. 12 Image of the Hypothetical Simulation on Fukuoka City**



perspectives for the further study are found.

## 6. Conclusion

Based on the results of the study, it is apparent that the method of the analysis using huge data of GIS is confirmed. One of the future assignments is to show the credibility of the method in providing definite grounds figures through consolidated data analysis. Moreover, when applying the actual space, it requires showing the characters of area by special patterns.

The results of this study are as follows.

- (1) The hypothesis is set as the method of analyzing the huge spatial data into several segments.
- (2) Three layers and background are set in hypothesis based on the review of previous studies.
- (3) Through the analysis of Fukuoka City, the above hypothesis is verified.
- (4) The perspective of the study includes the analysis of height over the perception of distance since, the study only focused on the horizontal distance.
- (5) Another assignment of the study is to examine the time aspects of the time-space in the actual urban areas and find out the realistic tasks for the application of the method.

## 7. Acknowledgement

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