TOWARDS THE PERCEPTIONAL WORLD: A MODELING FRAMEWORK FOR TRANSFORMING PHYSICAL ENVIRONMENTAL DIGITAL DATA INTO PERCEPTIONAL DIGIRAL DATA*

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Abstract:

For the needs of landcape and urban planning, two kinds of data are normally necessary: the objective data such as physical environmental data (topography, geology, ecology, land use, etc.) and the subjective data such as sensory or perceptional data about human living world (the sense and attitude to a place, the sense of landscape beauty, etc.). How to get such subjective data by transforming the objective data will be a great challenge to the professions of photogrammetry and remote sensing. Focusing attention on this issue an approach to transform the physical environmental digital data into perceptional data for the field landscape planning by photogrammetry and remote sensing methods is provided in this paper. The main work of this paper is to establish a modeling framework in which the field physical environmental information and the field of perceptional information can be transformed from each other. Its basic work is to make this modeling framework operable on practical field landscape planning through holistic study of field theory, photogrammetry and remote sensing methods, computer information system technique and some special software-making, in which the following issues are introduced and discussed in detail: 1) the theory study of the field from the viewpoint of landscape and urban planning profession; 2) the framework of time-space simulation of the field environmental information; 3) the transforming framework of field landscape perceptional information; 4) the mathematical models for some perceptional data transformation ; 5) creation of a field landscape information system.

Key Words: Data Transformation, Field Planning, Photogrammetry, Remote Sensing Application, Human Settlement, Perceptional Digital Data.

1. Introduction

To understand and manage the living world from a point of politic view of architectural sciences and arts, a new concept in the professions of architecture, urban-rural planning and landscape architecture termed "field" was provided by the author Liu Bin-yi in 1991. It is something similar to the term "field" in physics, meaning the existence of time-space in which Man and his living environment interact on each other. Its space ranges from the architectural environment, the urban-rural area to the landscape region with the time change from the past, the present to the future. The environmental construction of the living world and its outward appearance are mountaions, rivers, farmlands, cities, sceneries and gardens, etc.---the landscapes which people are familiar with in their daily life. Its inward, based on the philosophy of living world and environment cognition theory, are various kinds of information ranging from the physical to the perceptional ones which exist in a form of combination of the objective and the subjective (Figure 1). The modern politic approach of architecture design, urban-rural planning and landspace planning and design is called field plannig. According to the professional needs, the basic process of field landscape planning involves (1) field landscape information collection by photogrammetry and remote sensing; (2) field landscape information analysis (inventory, assessment and evaluation) obtained by computer information system; (3) proposal or decision-making by both hand and computer-aided mapping. So far, photogrammetry and remote sensing have been successfully applied to the information collection and analysis of field landscape planning with measurable variables such as land use, physical resources inventory, environmental pollution, urban spatial structure and population distribution, etc.. But all that is limited to the objective information. It needs to be identified whether photogrammetry and remote sensing can be used in the perceptional information collection of field which involves a lot of "unmeasurable" variables. In the studies of "time-space translation and psychological calculation of landscape information", "the systemtics of landscape engineering and method of landscape resources investigation" and "field regulation study" three research projects are supported by National Natural Science Foundation of China. The existence of this capability was demonstrated and an approach to perform these projects implemented (Liu Bin-yi, 1989, 1990, 1991a, 1991b). This paper work is an extension of these researches. Generally, the subjective variables can be expressed approximately by the objective variables. We can collect those "unmeasurable" field perceptional information from the field objective information by finding the relationships bewteen them according to the theory study of field. Therefore, we can transform the environmental digital data into the perceptional digital data by modern photogrammetry and remote sensing methods. It would be very usefull for the professions of architectural and environmental sciences.

The study began with development of the field theory in terms of architectural and environmental sciences and with development of a three-dimensional mathematical framework for modeling the characteristics of the field. Computer-based data files were then prepared by digitizing the X,Y,Z coordinates of aerial photographs and interpreting Landsat 5 TM CCT image data. The DTM established on the study area covered 53 sq.km with grids of 10m x 10m and 30m x 30m. The TM CCT image data is 1800 x 1700 pixel. The

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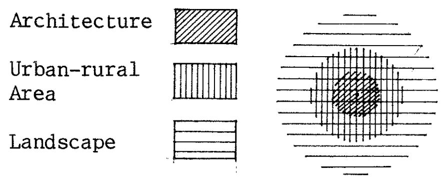


Fig 1. construction of the field of the living world

data files were then analyzed and calculated according to the mathematical model of the lield landscape elements to createa series of field landscape information files. The perceptional data of field were then analyzed and evaluated to create a series of the output drawings similar to those frequently generated from data files created by digitizing the topographic and other natural resources data sources. As a part of this study, the author generated a software, which creates the desired three-dimensional modeling framework, conducts necessary analysis and produces graphic output. One of the final results of this study was creation of a field landscape information system.

2. The Synthetical Framework of Theoretical Analysis of the Field Landscape World

2.1 The construction of the framework

As shown in the Figure 2, the framework, with the combination of subject and object as its foundation, has revealed us the layers of field landscape subjective and objective information. The primary elements of the field landscape concepts have formed a basic structure of this framework. The field landscape finds its time-space existence in terms of the four basic elements in the framework: view, viewfield, viewplace, and vieworder, each of which is made up of its interacting elements of subject and object contained. According to the order of view-viewfield-viewplace-vieworder, the time-space interval for field landscape existence is narrowing, the information density is increasing down the levels and the time-space limitation is intensifying. The view is time-space existence of interacting elements of scenic and scenery of the field. Its time-space scope ranges from the galaxies millions of light-years beyond to a blooming flower nearby. It is formed mainly through the perception of transculture and the two-dimentional form, shade and color. The viewfield is a time-space existence of interacting elements of sight and prospect of the field. its time-space is confined, at the object axle, by the differences of regional culture and the development of historical tradition. The viewplace is a time-space existence of the interacting elements of nature environment and image situation of the field. Its time-space scope is confined, at the object axle, by the field land-scape variation such as the alternation of seasons, range of terrain and depth of range, and at the subject axle, by the local history, popular legends and deep-going experience. The vieworder is a time-space existence of the interacting elements of man-made environment and yi-jing. Its time-space scope is confined by the following elements: at the object axle, there are space-limitation, time-change, space-depth and time-sequence; at the subject axle, the literary meanings, ideology and myth are implied in a man-made environment gardens and scenic spots, latent experience and time-space aesthetics. The four layers from view to vieworder emphasize the field engineering of the following four respects: visual environment quality analysis and control of the field; field landscape resources assessment and investigation; field landscape perception evaluation (landscape kuang-ao ranking) and landscape area and urban space planning; field landscape time-space perception arrangement.

2.2 The relationship between the subjecive elements and the objective elements

At the level of "view", what the subjective perception mainly concerns is the evaluation of the field landscape, that is transculture, temperary and deviate to the satisfaction of the visual which is devided into the perception about shade (S') such as complexity or unity and the psychological perception about color (C') such as quiet or vivid, cold or warm. So the perceptional information S' and C' can be collected through the transformation of the objective information of shade (S) and color (C) according to the functions established: $S'=f(S)$ and $C'=f(C)$.

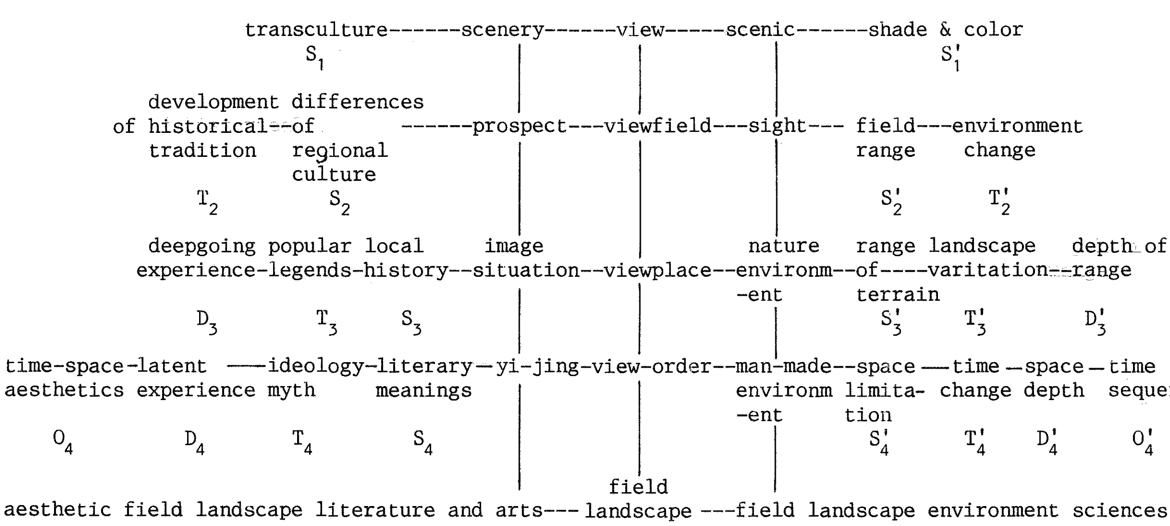


Fig.2 The synthetical framework of theoretical analysis and evaluation of field landscape

At the level of "viewfield" what the subjective perception considers is not only the temporary and the transculture elements, but also the permanent and regional culture effect. It is actually emphasizing the assessment and investigation of regional perception of the field landscape. The subjective information of resional perception of the field landscape is divided into the sense of landscape characteristcs such as magnificent uniqueness peril and beauty, the sense of the field naturalness, and the sense of landscape beauty (scenic beauty estimation, SBE). All the perceptional information also can be collected through the transformation of the objective information of the field space, surface and its physical environmental change according to the functions established by Liu Bin-yi in 1990.

At the level of "viewplace", the evaluation of subjective perception includes, in addition to the subjective elements similar to those mentioned above, cultural tradition, personal acquaintance and deep-going experience developed from long-term sediment, i.e. the ingredients of intention. It is the evaluation of field landscape perception focus upon the sense of situation. The subjective information of viewplace can be divided into the sense of sixteen factors in terms of the Chinese expression named kuang-ao. "Kuang" means wide, vast, extensive, spaciouseness, open-outward oriented or extroverted and is identified with peaks, ridges and relative high point in the field. "Ao", on the other hand, means narrow, small, enclosure, restricted, directional-inward oriented or introverted-and is usually identified with valleys, sides of streams in the field. However, all these perceptional information can be collected through the transformation of the three - dimensional nature environment and change of seasons of the field according to the functions established (Liu Bin-yi 1990).

At the level of "vieworder", the subjective perception evaluation in addition to the subjective elements similar to those at the level of "viewplace", and the aesthetic perception from the artificially evoked yi-jing (a Chinese artistic impression) arrangement, i.e., the time-space aesthetics, is emphasizing the evaluation and reconstruction of aesthetic field landscape perception from yi-jing. The subjective information of vieworder can be divided into several construction factors which have some relationships with the objective factors of vieworder. Some of the subjective information of vieworder can be collected through transforming the objective information into the subjective information of vieworder.

2.3 Supplementray explanation

All the perceptional information is primarily emphasis on the public sense but individual sense. It depends on the characteristic of field planning for the public. Because this planning is usually made for a community, a city or a regional area with the service object--the public. Therefore, the perceptional information considered here is based on the public in common. For example, it's the sense of the public that landscape of Versailles is sublime and beauty. However, some individual my do not think so.

3. Framework of Time-space Simulation of Field Landscape Information

3.1 Framework of Time-space Simulation of Field Environmental Information

Field environment can be divided into three parts according to its scale: national territory, landscape scenery area and city, as well as scenery spot, street and group of buildings. Field landscape environment information has the characteristic of spatial distribution with the time order, that is F-q. Assume the field landscape environment information source S_v in sequence of time is divided by a definite spatial system, this spatial system including the sequence of time is the framework F representing time-space distribution of field landscape environment information. F is physical simulation and mathematical description of T-q (Fig.3-1). The dimension, density of division and period of time of F can be different according to different scales of field environment. Generally, on the scale of national territory and region, F can be a plane of two dimensions with division densities of 80m x 80m - 30m x 30m and a period of one season; on the scale of landscape scenery area and city, F can be a space of three dimensions with division densities of 30m x 30m x 1m - 10m x 10m x 0.3m and a period of one month; on the scale of scenery spot, street and group of buildings, F can be a space of three dimensions with high division densities and short period of time. In the system of field landscape information, F is changed into a collection S of points with coordinates of three dimensions and color and gray of spatial

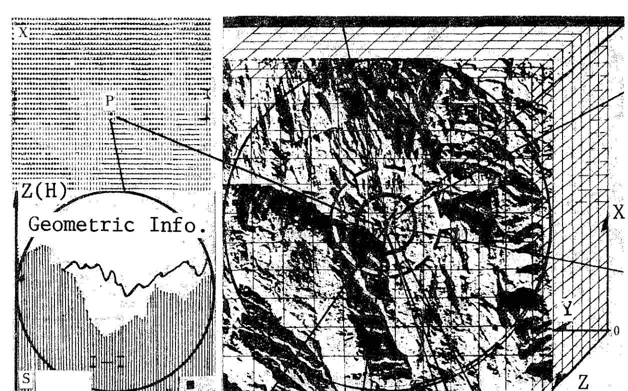


Fig.3-2 VIEW Fig.3-1 Framework of time-space simulation of field environmental information (FL DTM + FL DSM)

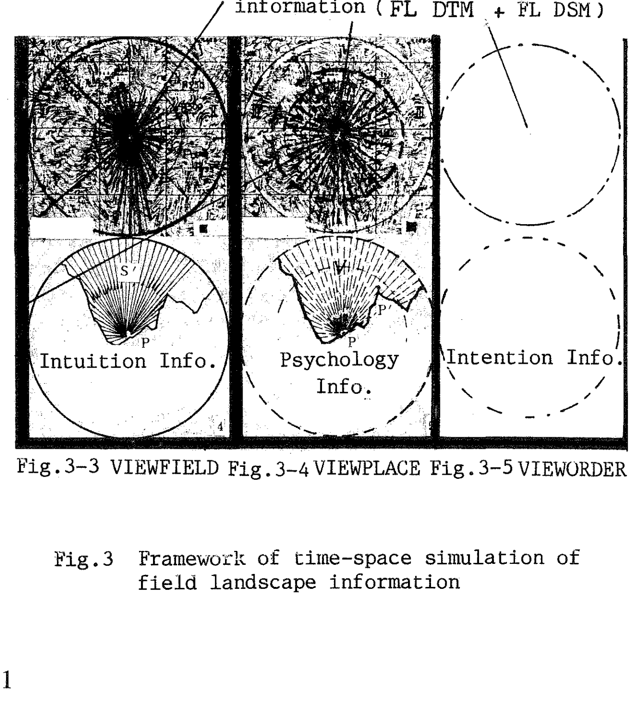


Fig.3-3 VIEWFIELD Fig.3-4 VIEWPLACE Fig.3-5 VIEWORDER

Fig.3 Framework of time-space simulation of field landscape information surface. S is the digtial space model of field landscape environment this research work established. S is composed of a digital terrain model of field landscape (FL DTM) and a digital surface model of lield landscape(FL DSM)(Fig.3-1).

3.2 Simulation Framework of Perceptional Information of Field Landscape

According to the author's theory study on landscape visual analysis (Liu Bin-yi, 1988, 1989d), the perceptions of field landscape can be divided into three levels: (1) on the biological level, people sense the field landscape by intuition; (2) on the psychological level, people cognize the field landscape by cognition; (3) on the cultural and social level, people reconstruct the field landscaspe by intention and habit. The perceptional information of field landscape also has the characteristic of time-space distribution. However, the time-space distribution is not so accurate as the distribution of field landscape environment information does. The simulation framework of perceptional information of field landscape is composed of four subframeworks which are connected with the framework F: (1) the framework of visual information distribution of field landscape (Fig.3-2); (2) the framework of intuition information disribution of field landscape (Fig.3-3); (3) the framework of cognition information distribution of field landscape (Fig.3-4); (4) the framework of intention information distribution of field landscape (Fig.3-5). In our system of field landscape information, these four subframeworks are changed into a series of evaluation model with FL DTM and FL DSM as their functions (Liu Bin-yi, 1988, 1989b). In other words, the simulation of perceptional information of field landscape is performed by the synthesis of FL DTM and FL DSM and a series of evaluation dimensions.

3.3 The Field Landscape Perceptional Information Elements

3.3.1 The Element of View As part of Visual Resources Management (VRM), the elements of view selected are primarily used to reflect the visual environment quality. It's related to the space and surface of physical environment. In the framework above, the variety of view was seleted as a basic element of view. This element can describe the quality and quantity of the view perception through digital calculation.

3.3.2 The Element of Viewfield As a part of landscape resources investigation, the elements of viewfield selected are primarily used to reflect the scenery value of landscape resources. It depends on the public perception to viewfield. This kind perception is related to both psychological and physical space and surface of viewfield. According to landscape analysis, a element, the variety of viewfield was provided by the author here as a basic element of viewfield.

3.3.3 The Elements of Viewplace: The Subjective Elements of Landscape Aesthetics The subjective elements of landscape aesthetics of landscape perception model from the essence of landscape aesthetics, in terms of the Chinese expression, named kuang-ao. On three levels of intuition, cognition and intention, there are sixteen landscape aesthetic elements derived to describe landscape kuang-ao:

(1) View distance;
(2) Mediums of landscape space;
(3) Relative height of viewer's position to the surroundings of the viewer;
(4) Sky area and boundary of viewshed;
(5) Ingredients of viewshed surface;
(6) Terrain variety of viewshed;
(7) Light and shade of viewshed space;
(8) Spatial limit of view-place;
(9) Surface variety of view-place;
(10) Variety of scenery or prospect;
(11) Viewplace slope;
(12) Viewplace aspect;
(13) Max. sight angle;
(14) View-place color;
(15) Character of intention space;
(16) Intensity of intention sense.

Anlysis and demonstration about these sixteen elements in detail made by the author Liu Bin-yi in 1986, 1990b).

4. Digitize the Landscape Elements

4.1 Digitize the Field Landscape Objective Elements

Based on the framework of spatial information distribution, the field landscape spatial elements such as landform can be digitized by Digital Terrain Model (DTM)(Fig.3-1).

Based on the framework of surface information distribution, the landscape surface elements such as vegetations, waters, cultivated field and residential area, etc., are digitized through the classification results of remote sensing digital image data (Fig.3-1).

4.2 Digitize the Field Landscape Perceptional Elements

The expression (1) expresses the landscape aesthetic information source on which the landscape aesthetic elements can be digitized:

$$S_v = \{S_z, S_x, S_y, S_d, S_c\} \tag{1}$$

in (1) $S_z=[Z_1,Z_2......,Z_n]$ expresses the collection of landscape form heights;
$S_x=[X_1,X_2......,X_n]$ expresses the collection of landscape form widths;
$S_y=[Y_1,Y_2......,Y_n]$ expresses the collection of landscape form lengths;
$S_d=[D_1,D_2......,D_n]$ expresses the collection of landscape light & shade (greys);
$S_c=[C_1,C_2......,C_n]$ expresses the collection of landscape colors.

4.2.1 The Variety of View: M1 For a definite view given, its variety can be obtained by calculating all the varieties of heights, widths, lengths, greys and colors, that is:

$$M1 = \sqrt{S_z^2 + S_x^2 + S_y^2 + S_d^2 + S_c^2} \tag{2}$$

$$S_z=\sqrt{\frac{\sum_1^N(Zi-Z)^2}{N-1}} \quad S_x=\sqrt{\frac{\sum_1^N(Xi-X)^2}{N-1}} \quad S_y=\sqrt{\frac{\sum_1^N(Yi-Y)^2}{N-1}}$$
$$S_d=\sqrt{\frac{\sum_1^N(Di-D)^2}{N-1}} \quad S_c=\sqrt{\frac{\sum_1^N(Ci-C)^2}{N-1}} \tag{3}$$

$$Z=\frac{\sum_{1}^{N} Z_i}{N} \quad X=\frac{\sum_{1}^{N} X_i}{N} \quad Y=\frac{\sum_{1}^{N} Y_i}{N}$$

$$D=\frac{\sum_{1}^{N} D_i}{N} \quad C=\frac{\sum_{1}^{N} C_i}{N} \tag{4}$$

4.2.2 <u>The Variety of Viewfield: M3'</u> For a definite viewfield given, its variety can be obtained through calculating the variety of visual lines and visual surface. M3, the variety of visual lines, can be calculated as follows:

Fig.4 shows a landscape visual model. On DTM, derive all height points Xi, Yi, Zi from the landscape visual model as shown in Fig.5 and Fig.6 (i=1,2,3,......,N).

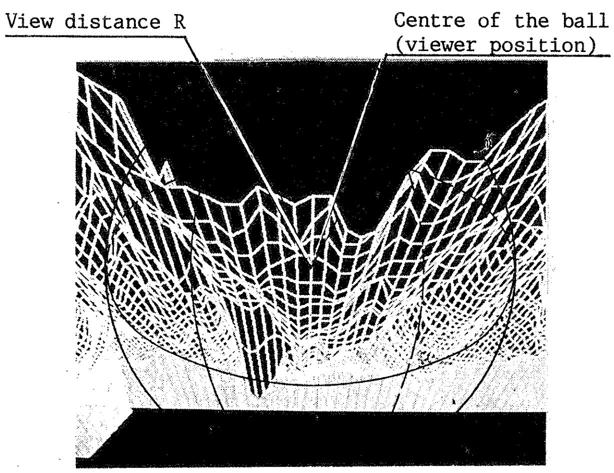


Fig.4 A landscape visual model (ball-like space

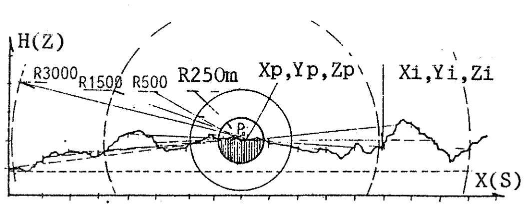
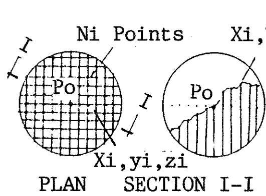


Fig.5 A landscape visual model (ball-like space of viewplace, point Po stands for viewer position)



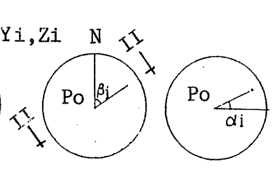


Fig.6 Calculation of the x,y,z coordinates of every point

Fig.7 Graphics of β and α

$$\gamma=\sin\frac{\beta}{2}\,\mathrm{Slop}=\sin\frac{\beta}{2}\,\frac{Z_2-Z_1}{\sqrt{(X_2-X_1)^2+(Y_2-Y_1)^2}} \tag{5}$$

Then, calculate γ of all the points within the ball, γ_i $(i=1,2,......,N_i)$, and make statistic analysis of it:

$$\gamma=\frac{\sum_{i=1}^{N}\gamma_i}{N_i} \tag{6}$$

$$M_3=\sqrt{\frac{\sum_{i=1}^{N_i}(\gamma_i-\gamma)^2}{N_i-1}} \tag{7}$$

The variety of viewfield:

$$M3'=k_1 M3+k_2 M1. \tag{8}$$

The k_1 and k_2 are coefficients of the weight.

4.2.3 <u>The Landscape Kuang-Ao Elements</u> As examples, the calculations of four Kuang-a elements will be introduced as follows:

1) Spatial Limit of Viewplace:Rh

$$Rh=Z_p-\frac{\sum_{1}^{N} Z_i}{Ni-1} \tag{9}$$

Z_p is the height of viewer's position; Z_i is the height of any point within the ball (Fig.8).

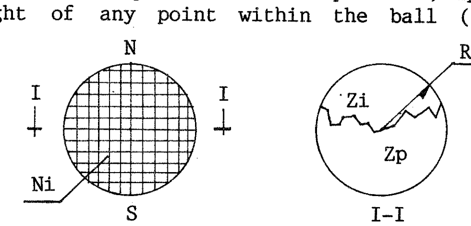


Fig.8 Graphic of the calculation of Rh

2) Viewplace Slope:SLM

$$SLM=\frac{Z_2-Z_1}{\Delta S} \tag{10}$$

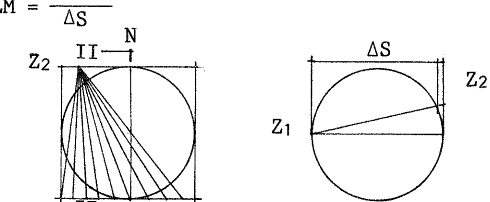


Fig.9 Graphic of the calculation of SLM

3) Viewplace Aspect:SLA

$$SLA=tg^{-1}\frac{\Delta Y}{\Delta X} \tag{11}$$

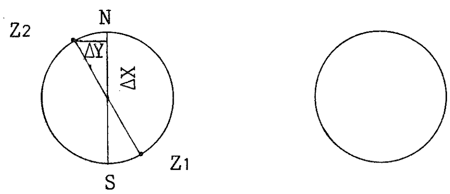


Fig.10 Graphic of the calculation of SLA

4) Spatial Kuang-ao of Viewplace:RH/Sar

$$RH = \left(\sum_{1}^{N}(H_p - H_i)\right)/(N-1) \tag{12}$$

H_p is the height of viewer's position,
H_i is the height of viewplace boundary,
N is the number of the height of viewplace boundary.
Sar is the area within viewplace boundary.

4.3 The Calculation Results

In the case study of assessment and planning of a national major scenic landscape area, the calculation results of the elements discussed above are shown in schedule 1 and schedule 2.

Schedule 1 The Calculation Results

No.	Rh	SLM	SLA	M1	M2	M3
(30 , 30)	+8.8	+61	59	0.73	1.00	0.45
(30 , 35)	-6.1	+85	348	0.73	0.96	0.34
(30 , 40)	-32.9	+77	59	0.69	0.74	0.34
(30 , 45)	-15.8	+90	68	0.68	0.72	0.26
(30 , 50)	-2.7	+103	90	0.70	0.85	0.43
(30 , 55)	+33.3	+45	59	0.66	0.62	0.28
(30 , 60)	+12.4	-39	0	0.69	0.74	0.27
(30 , 65)	-4.3	+7	338	0.69	0.52	0.22
(30 , 70)	-15.2	+54	0	0.68	0.44	0.13
(30 , 75)	+28.9	+47	329	0.69	0.66	0.31
(30 , 80)	+8.2	+35	314	0.70	0.79	0.29
(30 , 85)	-5.3	+62	30	0.69	0.51	0.22
(30 , 90)	+24.2	+95	59	0.68	1.03	0.45
(30 , 95)	+6.2	+81	314	0.68	0.89	0.37
(30 ,100)	+1.8	+45	338	0.72	0.81	0.37
(35 , 30)	-25.7	+55	0	0.69	0.72	0.28
(35 , 35)	+12.7	+75	0	0.67	0.55	0.17
(35 , 40)	-19.1	+109	30	0.70	0.92	0.37
(35 , 45)	-11.4	+103	59	0.71	1.15	0.67
(35 , 50)	-14.2	+89	0	0.68	0.99	0.46
(35 , 55)	-0.4	+225	101	0.73	0.92	0.43
(35 , 60)	-3.5	+36	348	0.67	0.39	0.20
(35 , 65)	+3.7	+67	11	0.71	0.77	0.27
(35 , 70)	+53.5	+75	11	0.65	0.73	0.56
⋮	⋮	⋮	⋮	⋮	⋮	⋮
(120, 90)	+7.0	+44	0	0.66	0.56	0.16
(120, 95)	-33.6	+58	0	0.65	0.44	0.18
(120,100)	-10.3	+60	78	0.71	0.70	0.25

Note: In the above schedule.
1. (I,J) stands for the NO. of studied point;
2. Rh stands for the relative height;
3. SLM of viewplace for the magnitude of Max. slope;
4. SLM of viewplace for the aspect of Max. slope;
5. M1,M2 & M3 stand for the density. In above study;
6. at each studied point search extension R=300m;
7. search point density: LD=50m² x lm;
8. this schedule is stored in file A:LV0150.0.50.

Schedule 2 Analysis for Kuang-Ao Units

No.	RH(M)	RH/L	Sarea (km^2)	Area (km^2)	Max. slop	RH/Sarea
(30 , 30)	-66.3	-1.33	0.968	0.900	+46.07	-68.46
(30 , 35)	-211.3	-2.11	1.266	1.099	+45.50	-166.91
(30 , 40)	-116.8	-2.34	0.114	0.113	+46.41	-1025.54
(30 , 45)	-116.8	-1.17	0.159	0.134	+49.43	-734.70
(30 , 50)	-97.4	-1.95	0.276	0.223	+40.33	-352.35
(30 , 55)	+18.4	+0.26	5.845	5.810	+14.17	+3.14
(30 , 60)	-59.3	-1.19	1.928	1.853	+29.15	-30.73
(30 , 65)	-130.0	-0.65	0.695	0.695	+41.21	-187.01
(30 , 70)	-124.5	-1.76	0.249	0.224	+37.05	-500.31
(30 , 75)	-161.3	-0.46	4.669	4.666	+23.40	-34.53
(30 , 80)	-133.4	-2.67	1.823	1.705	+36.30	-73.18
(30 , 85)	-261.9	-3.70	1.024	1.023	+39.21	-255.81
(30 , 90)	-99.4	-1.41	1.957	1.938	+40.47	-50.79
(30 , 95)	-71.8	-1.44	1.414	1.381	+38.07	-50.73
(30 ,100)	-211.3	-4.23	0.895	0.881	+45.00	-236.04
(35 , 30)	-89.5	-1.79	0.098	0.063	+52.26	-910.57
(35 , 35)	-89.0	-1.78	0.819	0.754	+36.51	-108.71
(35 , 40)	-61.6	-1.23	0.999	0.920	+54.35	-61.71
(35 , 45)	-1.1	-0.02	0.814	0.705	+67.12	-1.38
(35 , 50)	+11.8	+0.24	0.999	0.861	+55.35	+11.76
(35 , 55)	-125.0	-2.50	5.757	5.705	+48.14	-21.71
(35 , 60)	-131.3	-2.63	0.640	0.588	+42.35	-205.16
(35 , 65)	-56.8	-0.80	0.809	0.771	+38.18	-70.15
(35 , 70)	-30.9	-0.06	4.619	4.600	+14.34	-6.68
⋮	⋮	⋮	⋮	⋮	⋮	⋮
(120, 90)	-142.4	-2.85	0.683	0.668	+34.13	-208.51
(120, 95)	-91.8	-1.30	0.425	0.395	+51.13	-215.72
(120,100)	-80.5	-1.61	0.425	0.386	+49.34	-189.40

Note: In the above schedule,
1. RH stands for the defference between the hight of point (I,J) and the average hight of its boundary points. (unit:m)
2. RH/L stands for RH divided by the minimun distance between point (I,J) to its boundary points.
3. Area stands for the area of elevation formed by boundary points. (unit:km²).
4. Sarea stands for the area of the plane appoached by boundary points. (unit:km²).
5. Max. slope stande for the maximun angle from point (I,J) to its boundary points. (unit: deg,min).

2	4	4	5	7	8	7	5	6	5	4	6	6	6	5
3	4	4	6	7	7	7	6	6	4	4	6	6	7	6
2	4	4	5	7	8	8	6	5	4	3	5	7	7	7
1	4	3	6	7	8	7	7	6	4	3	3	6	7	7
2	4	3	4	7	9	8	8	7	7	4	3	5	7	9
2	2	2	3	5	6	7	7	8	7	5	3	4	7	7
1	2	2	3	5	7	7	8	7	8	6	4	4	6	7
2	2	2	3	4	6	8	7	8	9	7	6	4	6	6
2	2	2	2	3	4	5	6	8	8	7	6	5	6	5
3	3	3	3	3	3	4	6	7	7	6	5	6	5	5
4	5	4	3	3	4	4	6	6	6	6	4	5	5	5
4	6	5	4	3	3	3	4	5	5	5	5	6	5	A
5	6	8	3	2	2	2	3	4	6	7	6	7	6	5
7	7	4	3	3	2	2	2	3	4	7	5	7	5	5
6	A	6	3	3	3	2	2	3	3	5	5	7	4	4
6	6	7	7	4	3	2	2	3	3	3	4	6	5	6
4	5	5	6	5	3	3	2	5	3	3	3	6	5	4
4	4	5	5	6	4	3	4	3	4	3	3	6	6	4

Fig.11 Distribution of landscape variety (M3) on the study area

Note:

1. This is a lvpan-ranking drawing on FL DTM
2. Model name:3:11000.M3
3. Ranking condition:
   (.0974033,1,.1)   (.1,2,.13)
   (.13,3,.16)   (.16,4,.19)
   (.19,5,.21)   (.21,6,.24)
   (.24,7,.27)   ((.27,8,.29)
   (.29,9,.31)   (.31,A,.34)
4. Scale:
   250 M per printer step on direction x
   250 M per printer step on direction y
5. Initial co-ordinates: (3450,5150)

As one of the landscape assessment results of this case of study, Fig.11 shows the distribution of landscape variety (M3 or SBE) on the study area. The bigger the numerical value, the more the beauty of the landscape around this viewpoint. Fig.12 shows the distribution of RH on the stury area.

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------------------------------------------------------
|10.00122222210..011110000000..'.01221112581852000.....|
|10000112222210001122110000000..00112223356664311100....|
|.000000122332212233332222221110011123565310123331 0....|
|.00100001233333333332222222111111112467630 .134320..00|
|...0011111112333221110000001111111223444321223321 0.135|
|....01221000133321 0......00000111222222234443322100269|
|00001122211112221 1100..00122100000011223577754322223 56|
|22111222233221001122100024442 0.'    .023571=17533444433|
|33332221111111112233334444432 1. '.0011123578752125897 53|
|345542100.'.13454445791962 0.'  .135420..0111.  16:H:84|
|567754211 0.0235555668I=962.'   .145420 '.010'  07|#|84|
|89I187654433333445676654321100000011100013675 30.159=962|
|9=:=I97766554333467641000111111100.000025898521246764 2|
|58997532333321112232 10....001333333320001233455543333 4|
|157741' .01100..........  02456677631.'   .379841.036|
|345420.'.0110....00000...''0134454320.    .49::I87665|
|853111101110 00.0112211000..0012110......   06=H#@  H94|
|742111111111 00..0134555554322110001110 0..   16=HH#@@|72|
|1223222222111 0..03579=[H[:I8630 0367641000.026I:I864210|
|.13333332222100136 8I|@ @H:9741.04798520000125787 41' '.|
|01344566533233444334 69I97422345544432 0...000112345542 0|
|12345788653346764100 12320  .379852 0..''....   .481851|
|3212467765444443210011110..0245431 0....'...'   .245531|
|520024566654310001121111222 21.'.001100...' ...00...001|
|620.123344543322222221001245 42.  .0110....''..000....01|
|7310...012345787542110.0357641..00100...........011211 0|
|8420.   0124589864211 0.036764200000 0..'........0112100|
|864310..12444444322221122343333210...' .001100000000000|
|876531001344321111222333221234432 0...'..01211000..'.00|
|68I9630.0111100011224676532222222221111122321 00......0|
|4911840.'' '...0011369=I7532100123443333344310........|
|579852..023210..00024677531 10..001234555443310 0.......|
|841..  .3719620.....00000.......   036876432110000000.|
|62   .025819630....''       '....   .26876433222211000.|
|10.036898765321 00....0000000111110001334444456653 1000.|
|.'.159::964322210 0..0000000122332111111234556776420 00.|
|211235677776431100....00...023443221110123334444210000|
|443221124798631000......   .2455432210001122222110000 0|
|22211001245531002344210..  025765321100011122222111110|
|.000001000008..148=I6310...137875200000111122222332 10|
|.0000000.. '    159:=842100012465432221111111222233210|
|011100......   048=I853211000..136765322111112222221 10|
```

Fig.12 Distribution of RH on the stury area

Note:

1. This is a lskaan-ranking drawing on DTM
2. Model name: S:LS3000.SAR
3. Ranking Condition:
   (1.712989E-02,,.05)   (.05,,.1)
   (.1,.,.5)   (.5,0,1)
   (1,1,1.5)   (1.5,2,2)
   (2,3,2.5)   (2.5,4,3)
   (3,5,3.5)   (3.5,6,4)
   (4,7,4.5)   (4.5,8,5)
   (5,9,5.5)   (5.5,I,6)
   (6,=,6.5)   (6.5,:,7)
   (7,|,7.5)   (7.5,[,8)
   (8,H,8.5)   (8.5,#,9)
   (9,@,9.5)
4. Scale:
   109 M per printer step on direction x
   63 M per printer step on direction y

4.4 Testify about the Calculation Results

The testimony of the calculation results was taken through site investigation and the public test of the tourists.

5. Creation of a Field Landscape Information System

5.1 Field Landscape Information System

Based on the framework of time-space simulation field landscape information and the method of field landscape information collection, a computer simulation system of field landscape multi-layers information was created (See block diagram 1). This system is an extension of the Landscape Information System created by the author Liu Bin-yi in 1990b, 1991b. There are six function parts involved in this system: data collection, digital image output, simulation of field landscape environment information, simulation of field landscape perceptional information, information synthetic evaluation, applications of planning and design.

5.2 The Mathematical Models of Field Landscape Information

The mathematical models of field landscape information involve the models of field landscape environment information, field landscape perceptional information and the synthetic evaluation models of field landscape information. Among those models, some are well known, such as the slope, aspect or orientation, sunlight and shadow, etc., some are special according to some professional needs, such as the criteria of landscape and urban evaluation.

5.3 Computer Process Design and Software-making

This work involves two parts: (1) to find some software such as the Map Analysis Package and the PC ARC/INFO which can be used in the system directly; (2) to make some software such as the Landscape Analysis Package by one self (Liu Bin-yi in 1991).

6. Conclusion

the results of this study indicate the idea and method of how to collect the perceptional information for the needs of field evaluation and planning. Although the debate about quantitating sense has been lasted more than two thousand years, it is possible to quantitate field elements which indicate the perception of field environment by the method provided in this paper. Several benefits to the planning professions have been shown by the initial practice results: (1) to analyse and evaluate the living world of the field systematically and quantitively; (2) to realize a series of modern planning methods; (3) to develop a new application field for photogrammetry and remote sensing.

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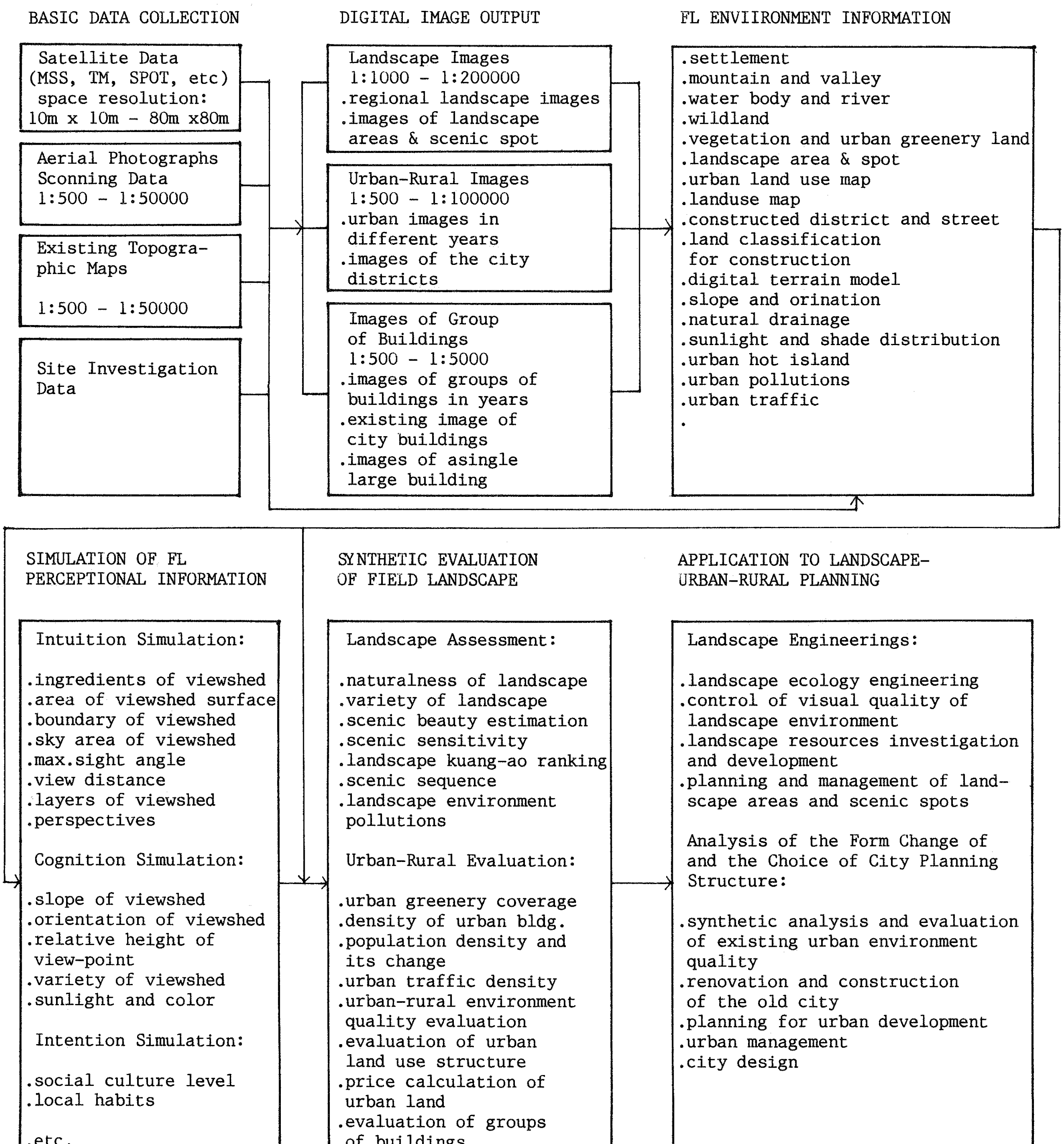

Block Dirgram 1. Simulation System of Field Landscape Multi-layers Information