Acta Technica 62 (2017), No. 6B, 177–188 © 2017 Institute of Thermomechanics CAS, v.v.i.

Urban landscape design with low carbon energy saving and environmental protection for micro climate improvement

Yuan Li[2]

Abstract. To enhance reasonableness of low-carbon, energy-saving and environment-friendly urban landscape design, a design method for low-carbon, energy-saving and environment-friendly urban landscape, based on gray scale support vector machine algorithm, is presented. Firstly, by aiming at regional culture characteristics of Wuqi, urban landscape greening method is discussed and its impact index system is given. Secondly, grayscale support vector machine model algorithm is presented; GM(1,1) model and support vector machine model algorithm are used to optimize index optimization system; and design accuracy is enhanced. Finally, effectiveness of the proposed method is verified in application of regional cultural design for Wuqi.

Key words. Grayscale model, Support vector machine, Low carbon and energy saving, Urban landscape.

1. Introduction

Application of low carbon idea to urban landscape plant design is not only a specific policy for us to build low-carbon city under the general background of building a splendid China, but also an important carrier for urban landscape specialty to reach low carbon goal in development and construction of urban modern green infrastructure. The reason why we advocate application of low carbon idea to plant landscape design is that, in comparison with previous design, plant landscape design with low carbon idea is able to fulfill low pollution, low emission, low energy consumption and high carbon sink and enhance recyclable rate, apart from meeting aesthetic and practical functional requirements for landscape. On the other hand,

[1]Department of Architectural and Environmental Art Design, Xi'an Academy of Fine Arts, Xi'an Shaanxi, China, 710065

urban land resource is relatively short, which can be said “an inch of land, an inch of gold”. However, city is with the most intensive carbon emission and the weakest carbon sinking. Application of urban landscape plant gives full play to carbon sinking of green plant in relatively narrow space inside city and requires, under guidance of low carbon idea, scientific and reasonable utilization of plant resources, meticulous selection, proper arrangement, space level enrichment and carbon sinking function improvement.

At present, while overseas study about low carbon economy and low carbon economy is more than domestic one, study about low-carbon urban landscape is less and remains to be further improved and perfected theoretically. Present study about low-carbon urban landscape mainly focuses on demonstration about implication and necessity of low carbon, possibility solution for technical innovation and idea transformation, as well as theoretical analysis and demonstration about improvement of greenhouse gases emission level system and other aspects. In 2016, international organization, academic circle and governments had paid attention to “low-carbon city”. Some scholars presented some methods for scientific calculation and measurement for low-carbon city construction. For example, literature [5] presents regional carbon balance calculation method and literature [6] presents urban carbon emission and calculation technology system. During recent years, with increasing attention, overseas scholars have given a relatively full account of theory about low-carbon city, analyzed economic effects produced by low carbon, explored the relation between urban structure and carbon emission in traffic and obtained many valuable theories, which deserve to be learned and used by use for reference.

Low-carbon urban landscape design, a new word coming out freshly during recent years, is still in the stage of exploration and continuous trial. Presently, domestic study about this aspect remains to be further perfected and intensified. Only some basic conceptions are presented on the basis of two ideas, low-carbon city and low-carbon life. In China, theoretical books and papers about low-carbon urban landscape are relatively less and most come out during recent years; this is impacted by a late start of this themed study in China; and practical construction project about low-carbon urban landscape is not common. Introduction of low carbon idea brings new idea and method for landscape design of scenic city undoubtedly; thus, study and construction for low-carbon urban landscape becomes one of main direction of present urban landscape circle. Study about low-carbon urban landscape research and theory, theories or ideas presented by domestic scholars related to this field are mainly devoted to the following points: aiming at an increasingly further understanding of landscape design in present urban construction, green, ecological and low-carbon-oriented urban development idea has been gradually definite; ecological low-carbon landscape design will be an irresistible trend; low-carbon landscape design will become an important link of green and environment-friendly design of urban landscape; thus, each landscape designer shall seize the opportunity to master each link of design and construction and strive for environmental protection.

In this paper, a design method for low-carbon urban landscape, based on support vector machine algorithm, is presented to meet the fact that urban landscape ecology planning from a perspective of low carbon is a trend of subsequent development in the world. And implementation and fulfillment of low carbon idea is also an inevitable path for China to fulfill low-carbon city design. Thus, in urban landscape planning and design, close attention shall be paid to various problems for positive discussion and solution; overseas practical experience shall be used properly for reference so as to promote urban landscape planning, design and development under low carbon idea in accordance with practical characteristics of urban development in China.

2. Description of study area

2.1. Regional cultural characteristics of Wuqi

A city of mountains and waters: There are two major drainage basins, Wuding River and Beiluo River, within Wuqi; main terrain structure can be summarized as "eight rivers, two gullies and two major mountainous areas." Urban area is built near mountain and water; there is a unique natural ecological environment in mountainous area, with "mountain, water, clearness and delicateness".

A city of heroes: Many people with lofty ideals appeared in Wuqi County; especially, Wuqi, during early Warring States Period, stationed troops for garrisoning frontiers and made great achievements. Wuqi County was named by this man, an outstanding strategist, politician, reformer and representative of military strategists, who wrote Wuzi playing an important role in Chinese ancient military books. Fan Zhongyan, during Northern Song Dynasty, recovered the city occupied by the Western Xia regime within Wuqi. Those deeds and spirits of hero encourage Wuqi people from generation to generation. Sites of numerous ancient battlefields, renowned cities and ancient castles are kept within this County.

A red city: In 1934, Liu Zhidan led the Red Army of North Shaanxi to start a Soviet area in Wuqi; on October 19, 1935, Mao Zedong led the central Red Army to join forces with the Red Army of North Shaanxi in Wuqi County, guided the "Qieweiba" battle, a last stop of Long March in Shengli Mountain and ended the Long March of 25000 Liwell known to the world. Wuqi became an ending point where the Long March was ended and a starting point where Chinese revolution marched to victory; thus, it shines throughout the history and gains much attention as a base of revolution tradition education and hot issue for red tourism.

A golden city: There are abundant petroleum resources in Wuqi County; over 10 years of development and construction makes Wuqi a petroleum production base integrated with petroleum exploration development, gathering, transportation and purification, storage and sale. Petroleum, a significant natural resource in Wuqi, leads Wuqi to get rid of poverty and go on a path of affluence in characteristic era industry and makes Wuqi listed in "top one hundred counties in Western China" for four times and ranked consecutively "top ten counties in Shaanxi" for five times. Studied and designed areas for regional cultural characteristics of Wuqi are shown in Figure 1.

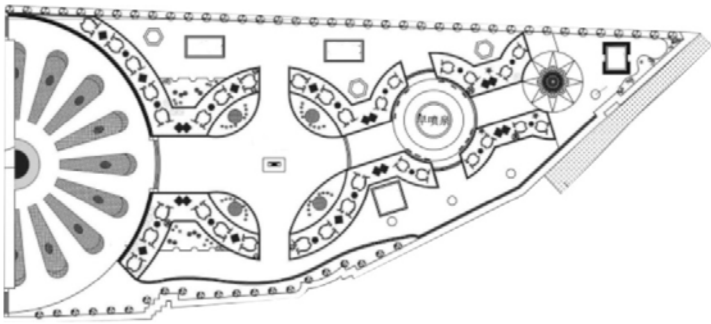

Fig. 1. Studied and designed areas for regional cultural characteristics of wuqi

2.2. Design method for urban landscape greening

At present, there are numerous factors impacting greening and carbon sinking of urban landscape, as shown in Figure 2. About plant landscape design:

1) Keep vegetation; intensify protection and management for superior urban vegetation; assure carbon storage capacity of urban landscape greening system is kept in plant for a long term; reduce atmospheric carbon source; keep original plant resource in accordance with ecological design principle, in terms of plant arrangement design.

2) Optimize varieties of trees in accordance with corresponding carbon sinking capacity of various greening trees; analyze characteristics of urban landscape; reasonably select trees of high carbon sinking capacity and good greening effects; fulfill effective integration between greening and environmental protection. Besides, by giving full consideration to regional and climatic characteristics, in accordance with carbon sequestration capacity of plant, perform practical investigation, analysis and comparison for growth of all varieties of trees; select varieties of trees equipped with functions of carbon sequestration, energy saving and air purification; then plant them in a scientific way so as to provide reliable basis for urban landscape ecology design.

3) Implement vertical greening and roof greening. Urban environment is relatively intensive while advancement of roof planting and servicing technology makes some arbors able to be grown in thin soil and provides the possibility of fulfilling ecological design of building roof city. In ecological design of Japanese city, building roof greening project is very successful. For example, in design of roof garden in Osaka, Japan, more than one variety of plant is arranged scientifically; designing roof in the form of building step into roof garden not only increases roof greening capacity, but also makes environmental protection and economic development win-win, as shown in Figure 2. In accordance with low carbon idea, comprehensively analyze present conditions of urban landscape; expand greening area and present a good urban ecological landscape by plant landscape design, vertical greening, roof greening and etc.

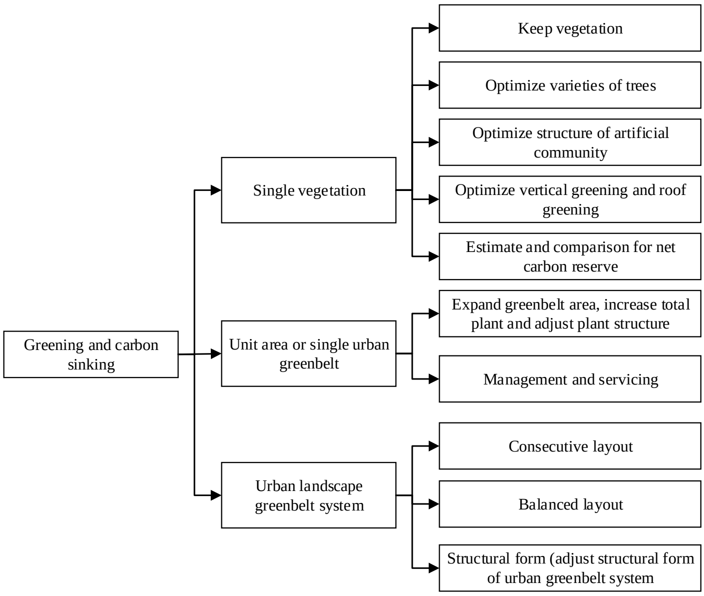

Fig. 2. Design method for urban landscape greening

3. Grayscale support vector machine model

3.1. GM(1,1) model

GM(1,1) is the commonest and simplest model among gray models and an exception of GM(1,N)[6]. Assume original data time sequence is GM(1,1) modeling sequence $x^{(0)}$, then

$$x^{(0)} = (x^{(0)}(1), x^{(0)}(2), ..., x^{(0)}(n)) \,. \tag{1}$$

Assume 1-AGO sequence $x^{(1)}$ is produced from $x^{(0)}$ with one accumulation, then

$$x^{(1)} = (x^{(1)}(1), x^{(1)}(2), ..., x^{(1)}(n)) \,. \tag{2}$$

Where, $x^{(1)}(1) = x^{(0)}(1)$; $x^{(1)}(k) = \sum\limits_{m=1}^{k} x^{(0)}(m)$.

Assume $z^{(1)}$ is mean sequence of $x^{(1)}$, it can be deduced that $z^{(1)}$ is

$$z^{(1)}(k) = 0.5x^{(1)}(k) + 0.5x^{(1)}(k-1) \,. \tag{3}$$

Thus, grey differential equation of GM(1,1) is as follows

$$x^{(0)}(k) + az^{(1)}(k) = b \,. \tag{4}$$

Put $k = 2, 3, ..., n$ in formula (4); then

$$\begin{cases} x^{(0)}(2) + az^{(1)}(2) = b \\ x^{(0)}(3) + az^{(1)}(2) = b \\ \vdots \quad \vdots \quad \vdots \quad \vdots \\ x^{(0)}(4) + az^{(1)}(2) = b \end{cases} . \tag{5}$$

Convert formula (5) to obtain matrix equation below

$$y_N = BP = [x^{(0)}(2), x^{(0)}(3), ..., x^{(0)}(n)]^T . \tag{6}$$

Where B is time sequence data matrix, y_N data vector and P is parameter vector, there will be

$$\begin{cases} B = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \cdots & \cdots \\ -z^{(1)}(n) & 1 \end{bmatrix} \\ P = [a, b] \end{cases} . \tag{7}$$

solve by least square method and obtain the formula below:

$$P = (a, b)^T = (B^T B)^{-1} B^T y_N . \tag{8}$$

Then put obtained coefficient $P = [a, b]$ in formula (6); by solving its differential equation, obtain gray GM(1,1) expression as follows

$$\hat{x}^{(0)}(k) = u^{k-2} \cdot v , \tag{9}$$

Where $u = \frac{1-0.5a}{1+0.5a}$, $v = \frac{b-a \cdot x^{(0)}(1)}{1+0.5a}$
then check and assume $\varepsilon(k)$ is residual, then

$$\varepsilon(k) = \frac{x^{(0)}(k) - \hat{x}^{(0)}(k)}{x^{(0)}(k)} \times 100\% . \tag{10}$$

3.2. Support vector machine model

Assume there are n learning sample(s), which can be expressed as $\{x_i, y_i\}$, $i = 1, 2, \ldots, N$, where x_i is input sample and y_i is output expected value of prediction model. SVM describes estimate function by formula (11):

$$f(x) = w \cdot \varphi(x) + b . \tag{11}$$

Where w is weight vector and b is offset vector

Optimize target value with optimization function; then there will be

$$\min J = \frac{1}{2}\left\|w\right\|^2 + C\sum_{i=1}^{n}\left(\xi_i^* + \xi_i\right). \tag{12}$$

See formula (13) for constraint conditions met in formula (12)

$$\begin{cases} y_i - w\cdot\varphi(x) - b \le \varepsilon + \xi_i \\ w\cdot\varphi(x) + b - y_i \le \varepsilon + \xi_i^* \\ \xi_i, \xi_i^* \ge 0, i = 1, 2, \cdots, n \end{cases}. \tag{13}$$

Where ξ_i, ξ_i^* both are relaxing factor and C is penalty factor [10].

Introduce Lagrange multiplier; transform the said optimization issue to typical convex quadratic one; then obtain formula (14)

$$\begin{aligned} L(w,b,\xi,\xi^*,\alpha,\alpha^*,\gamma,\gamma^*) &= \frac{1}{2}\left\|w\right\| + C\sum_{i=1}^{n}\left(\xi_i + \xi_i^*\right) \\ -\sum_{i=1}^{n}\alpha_i(\xi_i + \varepsilon - y_i + f(x_i)) &- \sum_{i=1}^{n}\alpha_i^*(\xi_i^* + \varepsilon - y_i + f(x_i)) \\ -\sum_{i=1}^{n}\left(\xi_i\gamma_i - \xi_i^*\gamma_i^*\right). \end{aligned} \tag{14}$$

Where both α_i and α_i^* are Lagrange multipliers

During solving, to accelerate solving, transform formula (14) to dual form; then obtain

$$\begin{aligned} W(\alpha,\alpha^*) &= -\frac{1}{2}\sum_{i,j=1}^{n}(\alpha_i - \alpha_i^*)(\alpha_j - \alpha_j^*)(\varphi(x_i), \\ \varphi(x_j)) &+ \sum_{i=1}^{n}(\alpha_i - \alpha_i^*)y_i - \sum_{i=1}^{n}(\alpha_i - \alpha_i^*)\varepsilon. \end{aligned} \tag{15}$$

See formula (16) for constraint conditions

$$\begin{cases} w = \sum\limits_{i,j=1}^{n}(\alpha_i - \alpha_i^*)x_i\,, \\ \sum\limits_{i=1}^{n}(\alpha_i - \alpha_i^*) = 0\,, \\ 0 \le \alpha_i, \alpha_i^* \le C\,. \end{cases} \tag{16}$$

Where, in terms of linear regression, SVM function is seen in formula below

$$f(x) = \sum_{i=1}^{n} (\alpha_i - \alpha_i^*)(\varphi(x_i), \varphi(x)) + b\,. \tag{17}$$

For nonlinear prediction issue, kernel function $k(x_i, x)$ may be used to operate instead of $(\varphi(x_i), \varphi(x))$, as shown in formula (18), so as to avoid curse of dimensionality:

$$f(x) = \sum_{i=1}^{n} (\alpha_i - \alpha_i^*)k(x_i, x) + b \tag{18}$$

4. Test design

4.1. Designed accuracy comparison

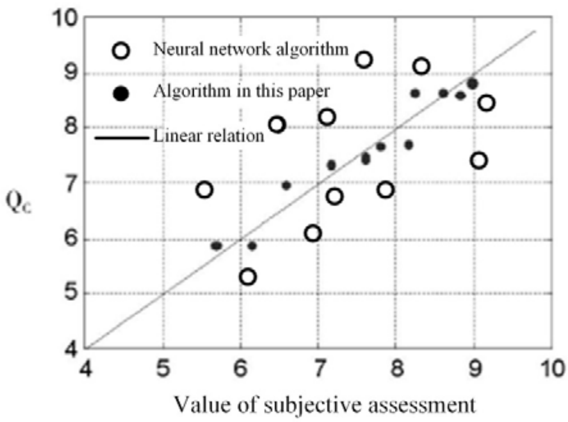

Fig. 3. Relation between values of predictive assessment and subjective assessment

To be able to reflect subjective assessment results of perceived sharpness by objective measured value, mathematical association between both is required to be established. It is found, by relevance analysis for subjective assessment value, contrast and other objectively measured values of 12 samples in test, that subjective assessment value is related to not only luminance contrast measurement value, but also luminance of its white background. Prediction results of low-carbon urban landscape assessment system are shown in Figure 3.

As shown in results of Figure 3, in accuracy of relation between values of predictive assessment and subject assessment, prediction accuracy of algorithm in this paper is superior to that of neural network algorithm, which presents an advantage in accuracy of algorithm.

Among samples tested, since technologies applied are not the same completely, white background of some products is relatively pure while some is with bluish green or yellowish green to a different degree. To explore impacts of color cast of white background on subjective visual comfort level for urban landscape, subjective assessment for color feeling comfort level is performed in the test simultaneously; assessment value varies from 0∼10, unacceptable to comfortable, marked as S. The higher S is, the less impacts there will be and more comfortable visual feeling is; 6 means a comfort level corresponding to basic satisfaction. Meanwhile, charoma C^*_{ab} of CIE LAB of background color is calculated; relevant comparison with comfort level S in subjective assessment is performed; test results based on algorithm in this paper are shown in Figure 4.

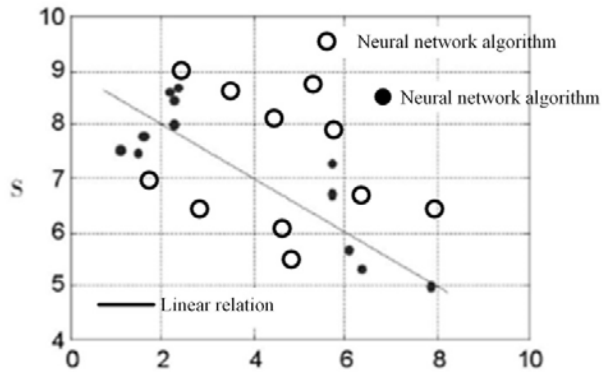

Fig. 4. Relation between visual comfort level and chroma of background color

As shown in Figure 4, from a perspective of overall trends, comfort level of visual feeling is related to color cast level of background color; the higher the level of deviation from white is, the lower the comfort level of visual feeling is. The reason may be that people have been used to white as main background color in visual feeling. It can also be seen in Figure 5 that, from a perspective of CIELAB chroma C^*_{ab} of background color, chroma less than 6 is fit for visual feeling of urban landscape; larger chroma will bring discomfort in visual feeling of urban landscape. In Figure 6, three samples, of which chroma is larger than 6, are close to prominent yellowish green; two samples, of which chroma is close to 6, are with prominent bluish green; other samples have a very samall chroma of background color and C^*_{ab} value close to 2 or lower, which is very close to paper white; all reach a level of good comfort (assessment value S is about 8).

4.2. Application of design with low carbon idea

Roof greening plays an important role in increasing urban greenbelt area, improving life environment, life quality, urban heat island effect, sand storm and other issues; and it is of extremely important significances to expand human greening space, build garden city, improve living condition, beautify city and improve ecological effects. Roof greening is able to play a role of heat insulation (Figure 5) for building. As shown in scientific research, room temperature of greened roof in summer is 1.3°-1.9° lower than that without roof greening on average and 1.0°-1.1°

higher in winter so as to relative reduce usage of air conditioner and carbon emission. Flat roof of buildings existing presently in Beijing downtown is 7000ha; assume both heat increased during summer and emitted during winter in roof panel are balanced by air conditioner, the total energy consumption will be about 50 million Yuan/day through calculation; however, if 30% of total energy consumption is used for roof greening, energy consumption of about 15 million Yuan/day will be saved.

Fig. 5. Roof greening landscape effect with low carbon idea

5. Conclusion

This paper presents a design method for low-carbon, energy-saving and environment-friendly urban landscape, based on gray scale support vector machine algorithm, and gives urban landscape greening design index system, fulfills optimization of landscape design index by designed gray scale support vector machine model algorithm, and verifies effectiveness of the proposed method by application to regional cultural design of Wuqi. The next research focus will be application system development of algorithm.

References

[1] Lavorel S, Grigulis K, Lamarque P, et al. (2011) *Using plant functional traits to understand the landscape distribution of multiple ecosystem services*[J]. Journal of Ecology, 99(1):135-147.

[2] Capozzi F, Piro G, Grieco L A, et al. (2013) *Downlink Packet Scheduling in LTE Cellular Networks: Key Design Issues and a Survey*[J]. IEEE Communications Surveys & Tutorials, 15(2):678-700.

[3] Vermeulen S J, Campbell B M, Ingram J S I (2012) *Climate Change and Food Systems*[J]. Social Science Electronic Publishing, 37(37):195-222.

[4] Singh A, Olsen S I (2011) *A critical review of biochemical conversion, sustainability and life cycle assessment of algal biofuels*[J]. Applied Energy, 88(10):3548-3555.

[5] Buckley R (2012) *Sustainable tourism: Research and reality*[J]. Annals of Tourism Research, 39(2):528-546.

[6] Rounsevell A, Pedroli G B M, Erb K H, et al. (2012) *Challenges for land system science*[J]. Land Use Policy, 29(4):899-910.

[7] Zacharias S, Bogena H, Samaniego L, et al. (2011) *A Network of Terrestrial Environmental Observatories in Germany*[J]. Vadose Zone Journal, 10(2011):955-973.

[8] Pan Y, Chen J M, Birdsey R, et al. (2011) *Age structure and disturbance legacy of North American forests*[J]. Biogeosciences, 8(3):715-732.

[9] Dobbs C, Escobedo F J, Zipperer W C (2011) *A framework for developing urban forest ecosystem services and goods indicators*[J]. Landscape & Urban Planning, 99(3–4):196-206.

[10] Hutley L B, Evans B J, Beringer J, et al. (2013) *Impacts of an extreme cyclone event on landscape-scale savanna fire, productivity and greenhouse gas emissions*[J]. Environmental Research Letters, 8(45023):575-591.

[11] Muller M (2017) *Adapting to climate change: Water management for urban resilience.*[J]. Environment & Urbanization, 19(1):99-113.

[12] Barthel S, Isendahl C (2013) *Urban gardens, agriculture, and water management: Sources of resilience for long-term food security in cities*[J]. Ecological Economics, 86(2):224-234.

[13] Singh R P, Tyagi V V, Allen T, et al. (2011) *An overview for exploring the possibilities of energy generation from municipal solid waste (MSW) in Indian scenario*[J]. Renewable & Sustainable Energy Reviews, 15(9):4797-4808.

Received May 7, 2017