THE POTENTIAL OF ARTIFICIAL RECOGNITION FOR URBAN MORPHOLOGICAL CLASSIFICATION BASED ON URBAN OPEN-SOURCE DATA

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ABSTRACT

With the global data explosion, urban opening-source data has become a new data collection method for studying urban morphology. But most people only pay attention to the availability of machine learning and ignore the accuracy and availability of artificial attribute classification of urban opening-source data. Local Climate Zones（LCZs）provides a method for characterizing urban morphology accurately. Therefore, we take the downtown area of Chengdu as the research scope, convene students with sensitive morphological cognition and design background, and use the urban opening-source data to recognize the LCZ types artificially. We conclude that artificial recognition and urban opening-source data have certain potential and value in urban morphology classification, and it is worthy of our in-depth exploration.

INTRODUCTION

The advantages of urban opening-source data are the key reason for being used widely in urban morphology. Local Climate Zone (Stewart and Oke, 2012) (Table 1) can be based on building height and density, vegetation condition, and other underlying surface-cover types. which can accurately characterize the urban morphology.

Throughout the study of urban morphological classification, machine learning is the mainstream research method. Therefore, as the accuracy requirements of machine learning results become higher and higher, the artificial selection of early samples and the verification of later consequences also need to achieve satisfactory accuracy. Most scholars are only concerned about the feasibility of machine learning, while few development potential and feasibility of the artificial recognition have been studied.

Therefore, this paper takes the downtown area of Chengdu as the research scope, and explores the accuracy, availability, and development potential of artificial recognition for urban opening-source data. First, analyze the types and proportions of various LCZ types that are easily confused, and analyze the possible causes; then discuss the potential of artificial recognition and urban opening-source data in urban planning and prospects.

BACKGROUND

In recent years, urban opening-source data has been born with the explosive growth of global data and the development of artificial intelligence. There are significant advantages, including wide coverage, large data volume, high resolution, and low cost. Therefore, they are widely used to study classification on urban morphology, such as the classification of New York City streets（Li X et al.,2017）, and the classification of the built environment related to walkability（White, J .T.，2013）. Local climate zones (Stewart and Oke, 2012) (Table 1) can accurately characterize the

urban morphology, which is based on surface cover, structure, material, and human activity. Therefore, in recent years, LCZ maps have been drawn to classify urban morphology around the world. For example, World Urban Database and Access Portal Tools[i] have been used in Chengdu（Chen F. and Huang Y., 2018）, Guangzhou（Lelovics E. et al., 2014）, Lhasa（Huang Y. et al., 2018）, and western regions to call on global users to draw LCZ maps to collect Chinese urban morphology.

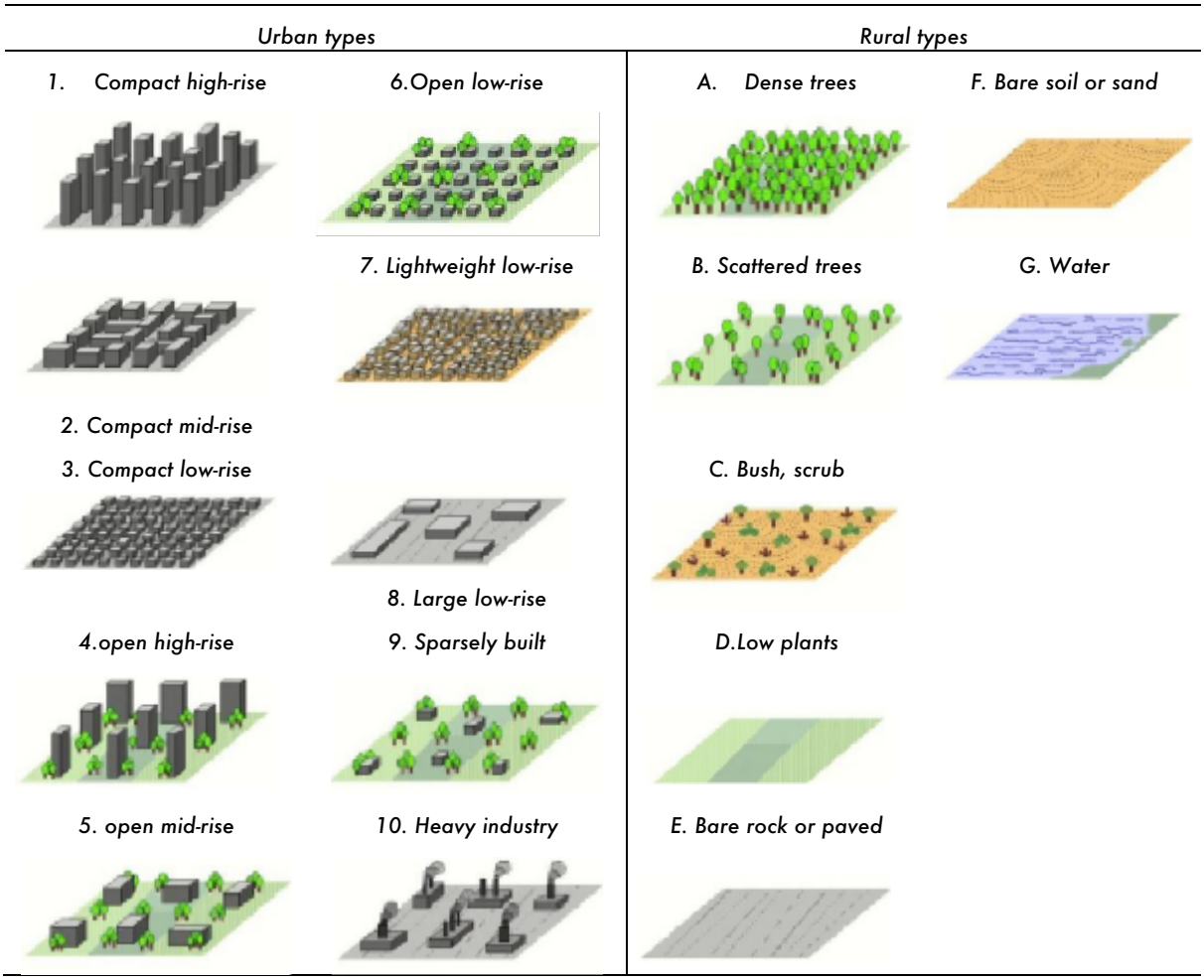

Table 1. 17 types of local climate zones (Stewart and Oke, 2012).

METHODOLOGY

120 students were convened to complete this experiment, who are sensitive to urban morphological and have been trained for several years in the context of urban morphology. In order to collect data efficiently and standardly, the method is based on displaying sample pictures of urban opening-source data, referring to artificial classification guide and values of geometric and surface cover properties (Stewart and Oke, 2012), and filling out online questionnaires. In addition, one LCZ sample corresponds to a set of questionnaires[ii]. The experimental steps are as follows:

1. The design of artificial recognition.

(1) Acquisition plan of urban opening-source data:① Aerial satellite maps are from Tencent Maps and Gaode Map platforms[iii], and the boundary radius is 200~400m; Use Tencent Maps API[iv] to

pick up street view maps, the pixels of which are 640*480, and 2 recognition points are selected according to the actual situation; ③ The ratio between the two is 1:2. ④ The order of resource acquisition : first calculate the building surface fraction of the satellite map, and then pick up the readable street view images within the corresponding plane range. Figure 1 is an example data[v].

(2) The design of the questionnaire: ① Investigate the regional background of the testees; ② The testees have been asked to recognize the index quantitatively and attribute classification qualitatively, and this questions are set in order from simple to complex;③In order to guarantee the publicity and effectiveness, each set of questionnaires must be completed within 1 minute;

(3) The logical design of the artificial classification guide: the overall classification is based on 3 aspects of morphological characteristics[vi]. ① First, the built-up building is divided into conventional and unconventional types, unconventional types include lightweight low-rise (LCZ7) characterized by light-weight building materials, large low-rise (LCZ8) characterized by large-scale volumes, and sparsely built (LCZ9) characterized by rural forms.②Then the building surface fraction is divided into compact, open, and sparse ③Finally, the building height is divided into high-rise (>25m), middle-level (10~25m), low-level (<10m) ; ④Through the superposition of the 3 aspects of morphological characteristics to achieve the attribute classification of LCZ types.

2. Selection of samples

(1) Proportion of samples: according to the types and composition ratio in downtown Chengdu (Chen F. and Huang Y., 2018); (2) Calculation of indicators: building surface fraction is calculated in the satellite image and the aspect ratio is calculated in the street view.

Based on the above principles and methods, 8 types and a total of 20 built-up LCZ samples were selected (Table 2).

3. Data processing scheme

(1) Compare the LCZ types guessed by the test participants with the actual LCZ types, and analyze and summarize the two types of data by a confusion matrix; (2) Analyze the possible reasons.

Figure 1. Example images for urban resource data.

 LCZ1	 LCZ2	 LCZ2	 LCZ2
 LCZ3	 LCZ3	 LCZ4	 LCZ4
 LCZ4	 LCZ5	 LCZ5	 LCZ5

			
LCZ5	LCZ5	LCZ5	LCZ5
			
LCZ6	LCZ6	LCZ8	LCZ9

Table 2. Samples of Local Climate Zones based on Gaode map and Tencent map.

FINDINGS

From the result of the confusion matrix[vii] of the test (Figure 2), it is found that the testees' ability to capture the urban morphology through the urban opening-source data is uneven in various LCZ types. The recognition accuracy of the open built zones（e.g., LCZs 4 – 6）is lower, however, the recognition accuracy of the compact built zones（e.g., LCZs 1 – 3） is higher. In addition, the types and proportions that are particularly confusing are concluded in Table 3, and analyze possible causes.

1. The most confused LCZ types

It can be seen from Figure 3 that the most confusing LCZ pair types are open midrise (LCZ5) and compact midrise (LCZ2), with an average confusion rate of up to 58.72%; followed by open high-rise (LCZ4) and compact high-rise (LCZ1) have a confusion rate of 41.04%. These two pairs of LCZ types are one-way confusion type, that is, the open types is easier to be recognized as the open types, and the reverse is not easy. However, there is a two-way confusion between the open low-rise (LCZ6) and the compact low-rise (LCZ3), The average confusion rate is 25.4%, which may have a lower visual grasp of the low-rise building scale than the middle and high-rise buildings, so it is not easy to distinguish.

2. Reasons for possible confusion

(1) In the aerial satellite image, the proportion of building surface fraction would be increased because of the building facade can easily be recognized as the building roof. The aspect ratio of the high-rise and middle-level samples visually will be much larger than the actual and theoretical LCZs.

(2) Within the limits of the central urban area of Chengdu, the small number of compact built zones（e.g., LCZs 1 – 3）leads to the testees not knowing much about it and unable to make correct decisions.

			guessed types (LCZ)								Confusion rate (%)	recall (%)
			1	2	3	4	5	6	8	9		
Actual types (LCZ)	1	1	84	18	0	4	1	0	0	0	16.07	75
	2	2-1	3	89	12	0	5	2	0	0	8.93	79
		2-2	3	97	4	0	6	1	0	0	5.36	87
		2-3	4	103	2	0	2	0	0	0	3.57	92
	3	3-1	0	0	86	0	3	22	0	0	19.64	76.79
		3-2	0	8	99	0	1	4	0	0	7.14	88.39
	4	4-1	50	1	0	59	0	0	0	0	44.64	52.68
		4-2	42	0	0	69	0	1	0	0	37.50	61.61
		4-3	46	0	0	63	1	0	0	0	41.07	56.25
	5	5-1	2	38	2	3	59	7	0	0	33.93	52.68
		5-2	0	61	1	1	44	3	0	0	54.46	39.29
		5-3	1	93	3	0	13	1	0	0	83.04	11.61
		5-4	2	88	5	0	16	0	0	0	78.57	14.29
		5-5	11	58	2	1	35	3	0	0	51.79	31.25
		5-6	0	22	4	0	78	4	0	1	19.64	69.64
		5-7	0	96	5	0	10	0	0	0	86	8.93
	6	6-1	0	1	8	0	8	84	0	10	8.93	75.00
		6-2	0	0	35	0	1	74	0	1	31.25	66.07
	8	8	6	6	25	0	0	5	67	0	22.32	59.80
	9	9	0	0	0	0	0	4	3	105	3.57	93.80

Figure 2. Confusion matrix of LCZ actual type (vertical) and participant guess type (horizontal).

CONCLUSIONS

The results preliminarily prove that urban opening-source data has the potential to provide useful information for urban morphology classification, and also prove that artificial recognition is a method of obtaining information worth digging.In the future, how to efficiently classify attributes of the urban opening-source data to explore the urban morphology? The key conclusions and recommendations are shown as follows:

(1) Increase the amount of data in open built zones (e.g., LCZs 4–6): open built zones (e.g., LCZs 4–6) are easily recognized as compact built zones (e.g., LCZs 1–3). Therefore, we can appropriately increase the number of urban opening-source data of open built zones (e.g., LCZs 4–6) when selecting samples artificially;
(2) Eliminating the problems caused by the internal factors: collect the geographical background information of the testees in the early stage of the experiment, and determine the most suitable sample ratio according to the geographical background ratio; or conduct targeted and simple geographical cognitive training for the participants;

(3) Adjusting decision-making indicators: The building surface fraction and aspect ratio are important indicators that affect artificial classification. Therefore, they can be used as the main decision-making indicators for judging LCZ types.

This study explores the potential of artificial classification and recognition through the attribute classification of urban opening-source data, and provides a basis and reference for future urban morphological classification based on the LCZ scheme.

actual types (LCZ)	Confusion rate (%)	guessed types (LCZ)	Photograph (actual)	Photograph (guessed)	Possible causes of confusion	
					Physical factor	internal factors
LCZ5 open midrise	58.27	LCZ2 compact midrise			Building surface Fraction & aspect ratio	The wrong type is less in Chengdu
LCZ4 open high-rise	41.04	LCZ1 Compact high-rise			Building surface Fraction & aspect ratio	The wrong type is less in Chengdu
LCZ6 open low-rise	31.25	LCZ3 compact low-rise			Building surface Fraction & aspect ratio	The wrong type is less in Chengdu
LCZ3 compact low-rise	19.64	LCZ6 open low-rise			Building surface Fraction & aspect ratio	—
LCZ8 Large low-rise	22.32	LCZ3 compact low-rise			Building surface Fraction & aspect ratio	–

Figure 3. Selection of actual and guess classes with high error rate in the LCZ recognition test.

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[i] Referred to as WUDAPT;
[ii] Based on the "Introduction to Green Architecture" and "Sustainable Environment and Design" interdisciplinary course support, students will complete the online quiz of "Urban Spatial Form Mining Quiz";
[iii] Since not all open platform remote sensing satellite images have good visual effects, two platforms are selected to complement;
[iv] Set the yaw angle (heading) according to the specific situation: the angle with the north direction; set the unified pitch angle (pitch): the heading angle is -5 degrees;
[v] According to the actual situation, there is no street view map available for the scattered low-level (LCZ9);
[vi] Classified according to permutation and combination, and excluding types that are not logically established and rare in Chengdu;
[vii] The diagonal part of the matrix (dark gray) indicates the LCZ classes that the participant correctly guessed, and the non-diagonal components (white and light gray) indicate the incorrect guessed LCZ classes, where the light gray part is the confusion mentioned above rates focus on the same incorrect type of guess LCZ classes;