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Dataset of Land Use Classification of Rural Courtyards by UAV Image Fusion Deep Learning: Take Ciyutuo Village as an Example

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Abstract: The courtyard structure dataset plays a key role in refining the identification of rural spatial structures and promoting comprehensive rural revitalization. Here, we take Ciyutuo Village in Shenyang City, Liaoning Province as the experimental area, and use the UAV field aerial data in September 2022 to address these efforts. Based on the QGIS and Geoscene Pro platform, deep learning and artificial visual interpretation methods are used to produce the experimental dataset of land use classification in Ciyutuo Village. The dataset includes (1) courtyard distribution data generated by deep learning of UAV images, including residential courtyards, industrial-collective courtyards, and abandoned courtyards; (2) Building distribution data, including farm buildings, industrial-collective buildings, and abandoned buildings; (3) Vector data of roads and farmland in residential areas; (4) Typical courtyard structure classification diagram. The dataset is archived in .shp and .tif formats, consisting of 65 data files, with a data size of 8.97 MB (compressed to 1 file, 6.84 MB).

Keywords: village; courtyard structure; UAV imagery; Ciyutuo Village; deep learning

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The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2024.06.10.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2024.06.10.V1.

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[2] Xu, Y. T., Li, J. Z., Xu, X. P., *et al*. UAV imagery with deep learning based land use classification dataset in Ciyutuo Village practice [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2024. https://doi.org/10.3974/geodb.2024.06.10.V1. https://cstr.escience.org.cn/CSTR:20146.11.2024.06.10.V1.

1 Introduction

Villages, as the fundamental carriers for rural revitalization and the basic units for coordinated regional spatial governance and the integration of human and natural ecosystems, encompass numerous critical issues, including the harmonious development of people and nature[1,2]. Addressing micro-level challenges within the framework of family courtyards in these villages is essential for stabilizing rural ecosystems and advancing overall rural revitalization. Since the 19th National Congress of the Communist Party of China, the CPC Central Committee has repeatedly emphasized the importance of rural revitalization, highlighting the need for the rational protection, utilization, optimization, and renewal of rural resources to promote sustainable, ecologically livable rural environments[3–5]. In recent years, numerous scholars studying villages have approached their research from various disciplinary perspectives, resulting in a wealth of valuable findings. Urban and rural planning mainly focuses on the construction of rural living space architectural style[6], spatial form optimization[7] and functional area planning[8]. Architecture focuses on the architectural style of rural residential buildings and the improvement technology of living space performance[9]. Geographers focus on the evolution of spatial and temporal patterns of rural transformation [10], food security[11], and rural sustainable development evaluation[12], while ecologists focus on the quality assessment of human settlements[13], rural ecosystem services[14] and rural resource metabolism activities[4]. At present, the existing building spatial datasets are mainly concentrated in urban areas, such as functional area division[15], solid building surface extraction[16], and the scale is generally macro, lacking fine expression on the micro scale. Therefore, to build the datasets on the scale of rural courtyards has remarkable theoretical significance and practical value towards promoting the global integration and diversified value-added of rural resources.

2 Metadata of the Dataset

The metadata of the UAV imagery with deep learning based land use classification dataset in Ciyutuo Village practice[17] is summarized in Table 1. It includes the dataset full name, abbreviations, authors, geographic zone, year of the dataset, spatial resolution, data format, data size, data files, data publisher, and data sharing policy, etc.

3 Methods

3.1 Study Area

The demonstrated research area is part of Ciyutuo Village, Shenbei New District, Shenyang City (Figure 1). Ciyutuo Village is situated in the central part of the Liaohe River Plain, characterized by a flat and open terrain. The village experiences a temperate continental monsoon climate, with cold and dry winters, warm and rainy summers, and windy conditions in both spring and winter. In recent years, the local government has made significant strides in infrastructure development, actively promoting green production and sustainable lifestyles, giving the village a refreshed appearance. Additionally, efforts have been made to foster new rural business ventures in agriculture, courtyard economies, tourism, and other related industries, which show promising potential. However, challenges remain, such as the outmigration of young and middle-aged labor, the abandonment of courtyards, and inadequate management and maintenance of the “toilet revolution”. This region faces the practical problems and needs of stock revitalization[19], supply and demand docking, planning guidance, fund raising, follow-up operation and maintenance, and effectiveness evaluation.

Table 1 Metadata summary of the dataset

Items	Description
Dataset full name	UAV Imagery with deep learning based land use classification dataset in Ciyutuo Village practice
Dataset short name	VillageCiyutuo_2022
Authors	Xu, Y. T., Institute of Applied Ecology, Chinese Academy of Sciences, xuyaotian22@163.com Li, J. Z., Xuchang University, zhong_lij@163.com Ren, W. X., Institute of Applied Ecology, Chinese Academy of Sciences, renwanxia@iae.ac.cn Xu, Y. P., Institute of Applied Ecology, Chinese Academy of Sciences, 17839964283@163.com Li, H. Q., Technical University of Berlin, lihongq@163.com Xue, B., Institute of Applied Ecology, Chinese Academy of Sciences, xuebing@iae.ac.cn
Geographical region	Ciyutuo Village, Shenbei New District, Shenyang City
Year	2022 Spatial resolution 5 cm
Data format	.shp, .tif
Data size	8.97 MB (compressed into one file with 6.84 MB)
Data files	courtyard.rar, building.rar, road&farmland.rar, typical courtyard structure classification atlas.tif
Foundations	Chinese Academy of Sciences (XDA28060302, XDA28090300); National Natural Science Foundation of China (41971166)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	(1) *Data* are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use *Data* subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute *Data* subject to written permission from the GCdataPR Editorial Office and the issuance of a *Data* redistribution license; and (4) If *Data* are used to compile new datasets, the 'ten per cent principal' should be followed such that *Data* records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[18]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS, GEOSS, PubScholar, CKRSC

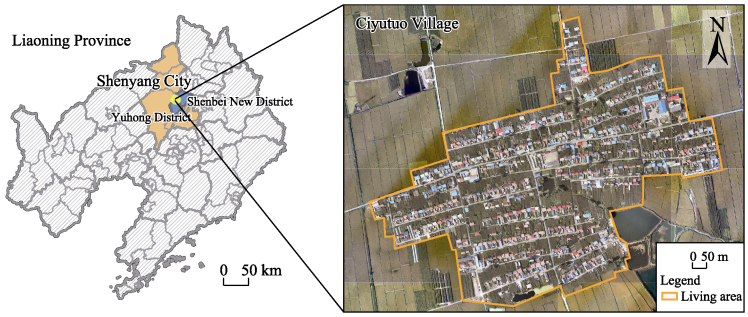

Figure 1 Locationg and overview of the study area

3.2 Data Sources and Processing

The original UAV aerial remote sensing image data of this dataset was taken by authors' team in the Ciyutuo Village in September 2022, with a spatial resolution of 5 cm. The specific data processing method flow is as follows:

(1) Establish a basic framework for interpreting the metabolic activities of natural village courtyard resources

This study initially constructed a basic framework for interpreting resource metabolic activities at the family courtyard scale based on natural villages in Northeast China (Figure 2), which mainly includes three levels: method level, element level, and expression level. In the method level, the expansion design is carried out by combining UAV interpretation with field research. In the element level, through the super-fine interpretation of the 5-cm resolution image, three elements are obtained: courtyard structure, single building roof characteristics, and surface hardening condition. To solve the problem of occlusion caused

by UAV aerial photography on the characteristics of ground objects, the study is based on field research to test the interpretation and sample the basic family situation of villagers. And the expression level contains a variety of more detailed indicator elements, which is the fundamental basis for the optimal allocation of ultra-refined village resource elements.

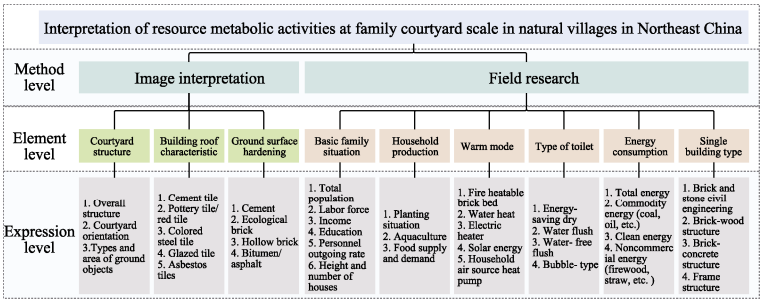

Figure 2 Basic framework for interpreting resource metabolic activities at the family courtyard scale based on natural villages in Northeast China

(2) Feature vectorization and recognition

Based on the Mapflow plug-in built in the QGIS platform, the deep learning feature boundary recognition of the houses is carried out, and the boundary surface layer of the houses in Ciyutuo Village is extracted. After manual verification and correction, the accuracy is 99 %. Based on the Geoscene Pro platform, artificial visual recognition interpretation and vectorization operation of UAV remote sensing images are carried out, and the boundary layer of the courtyard, the road layer, and the farmland layer of the village group are obtained. Among them, the house layer is divided into three types: family-use houses, family abandoned houses, and industrial-collective land houses (generally referring to land for the integrated development of primary, secondary, and tertiary industries in rural areas, used for the construction of privately or collectively operated industrial sites for agricultural product processing and distribution, rural leisure and tourism, e-commerce, and so on). Each layer contains four attribute fields: perimeter, area, building structure, and number of floors. The courtyard layer is categorized into three types: courtyards in use by families, abandoned family courtyards, and industrial-collective land courtyards. These types also have four attribute fields: perimeter, area, courtyard orientation, and road type. The road layer includes all main roads within the village group, while the farmland layer encompasses large tracts of land belonging to the village group as well as cultivated land within courtyards.

(3) Field survey and examination

The fieldwork was organized into three key areas: household livelihoods, resource metabolism patterns, and house courtyard characteristics. The analysis of household livelihoods focused on factors such as family size, income sources, production means (including cultivated land area, livestock numbers, crop yields and market prices, and the use of agricultural machinery), the average age of the labor force, total village population, migration rates, and agricultural support policies. Resource metabolism patterns were assessed through data on toilet types, solar equipment installations, heating methods, and overall energy consumption. The characteristics of house courtyards were examined in three aspects: surface hardening types, building types, and roof characteristics.

4 Data Results

4.1 Data Composition

The dataset consists of four files:

(1) Courtyard distribution data generated by deep learning of UAV images;
(2) Building distribution data;
(3) Vector data of roads and farmland in residential areas;
(4) Typical courtyard structure classification diagram.

4.2 Data Results

4.2.1 The Macro Overall Layout of the Village Courtyard

The total area of the residents' living area in the village (Figure 3) is about 5.6×10^5 m^2, of which the total area of cultivated land is about 4.1×10^5 m^2. The area primarily consists of one-year rice crops cultivated by individuals or collectives. In some courtyards, only cornfields or vegetable gardens are grown, while a few engage in livestock and poultry farming, raising pigeons, sheep, cattle, and horses. Most village collectives focus on large-scale greenhouse farming, livestock breeding, and the processing of agricultural and sideline products. They also manage centralized resource facilities, such as unified recycling and waste treatment plants. Additionally, some villagers, leveraging national rural revitalization and energy development strategies, engage in specialty farming, livestock breeding, and the installation of distributed photovoltaic systems in courtyards or on unused land. Based on image analysis and field research, the region contains a total of 406 courtyards. Among them, there are 393 households with long-term or seasonal residence, accounting for 96.8 % of the total dynamic classification of courtyard use; 10 abandoned courtyards, accounting for about 2.5 % of the total; and 3 industrial-collective land courtyards, accounting for about 0.7 % of the total. The rural courtyards are mainly planted with rice, and the cultivated land area accounts for a large proportion. Individual courtyards are distributed with pigeon sheds, sheep pens, and other self-employed breeding.

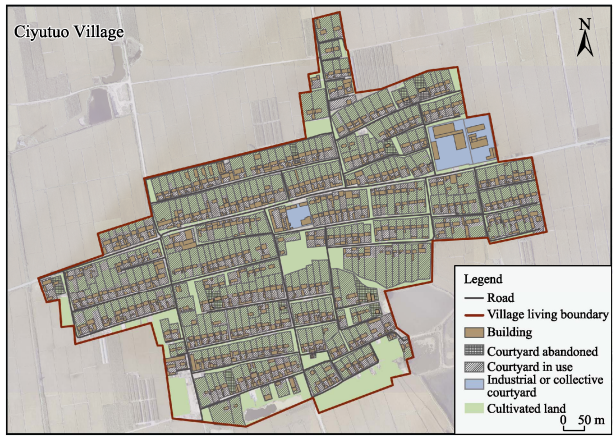

Figure 3 Land use distribution of rural courtyards in Ciyutuo Village

4.2.2 Multi-Feature Recognition and Classification of Typical Courtyard Structure

The space of rural courtyards mainly includes the spatial relationship of various material elements such as living space (residential living area), production space (planting and breeding), ecological space (resource treatment facilities) [20]. The overall distribution pattern of Ciyutuo Village has developed naturally over time. In later stages, it was optimized and adjusted to align with broader planning efforts. Each courtyard has been constructed and expanded over generations, with the village layout evolving in clusters near water sources. As a result, the village is surrounded by natural features such as farmland and lakes.

Combined with the spatial structure relationship schema between the spatial pattern of resource elements in Ciyutuo Village (mainly including ecological planting, livestock breeding, waste, and idle) and the spatial structure relationship schema of the living area of the residents' courtyard, the distribution pattern of resource elements in the four typical courtyards of ecological agriculture-aquaculture mixed type, ecological agriculture type, ecological breeding type, and waste type is generally presented (see data file for detailed atlas). According to the basic situation of the ground objects around the courtyard, the

characteristics of the images corresponding to different courtyard types are simplified, and the structure diagram of the courtyard is drawn. At the same time, the 1 m×1 m gridding and vector grid fusion refinement expression of the courtyard house is carried out to strengthen its attribute classification and recognition and resource metabolism calculation ability.

4.2.3 Courtyard Roof Characteristics and Types

In addition to the use of energy-efficient, easy-to-control heating and cooling equipment, the key to reducing building energy consumption is to strengthen the design and enclosure of the thermal insulation and heat insulation performance of the building structure and reduce the heat transfer coefficient of the roof structure. As one of the building envelopes, the roof is exposed to direct sunlight all year round, and the indoor and outdoor temperature difference heat transfer is carried out. The heat consumption caused by the roof is greater than that of any external wall or surface[21]. Due to long-standing economic and construction technology limitations in rural areas, the design of courtyard buildings often relies on natural materials without accounting for energy-saving requirements. Roofs are rarely insulated, resulting in a heat transfer coefficient significantly higher than that of urban buildings. Additionally, most houses in Ciyutuo Village are single-story structures built with brick-concrete, which increases the proportion of energy loss through the roof in relation to total building energy consumption. Therefore, based on the various roof types in Ciyutuo Village, this study analyzes the material and structural characteristics to establish roof-related energy consumption indicators. These include roof service life, thermal insulation performance, and waterproofing capabilities, though specific energy consumption values for these indicators require further investigation.

In general, the design requirements of the roof often include five aspects[22]: (1) waterproof and reliable, rapid drainage; (2) good thermal insulation performance; (3) the structure is safe and reliable; (4) beautiful appearance; (5) other functional requirements of solar equipment placement. Here, combined with the field situation, the roof is divided by material, which mainly includes reinforced concrete roof, tile roof, and metal roof (including color steel shed). Through the remote sensing image overlooking observation and on-the-spot investigation, according to the roof shape, it is summarized into two types: flat roof and slope roof (double slope roof and four slope roof); according to the location attributes and usage of the house, it is divided into five categories: flat roof main roof, double slope and four slope main roof, flat roof side roof, double slope side roof, and damaged roof (Figure 4). Among them, the flat roof is the most widely used roof form at present. Because it is easy to coordinate the relationship between building and structure, save materials, and fast construction progress, the roof surface is flat, and it can be used as a variety of utilization methods of living space, such as a crop drying platform or clothes drying platform. The slope roof has a long history in China and has been widely built in rural areas. The roof is steep and easy to drain rain and snow. It is generally composed of two parts: load-bearing structure and roof. According to

Figure 4 Summary of the characteristics and types of courtyard roofs in the? Ciyutuo Village

different needs, it also has insulation layer, heat insulation layer, and ceiling structure.

5 Discussion and Conclusion

From an interdisciplinary perspective, integrating the human-land system has increasingly become a crucial approach to alleviating pressure on rural ecological environments, realizing the diversified value-added potential of rural resources, and enhancing the vibrancy of rural living spaces. As the core region for economic development in Liaoning and a key area for modern urban agriculture, regional specialty agriculture, and rural tourism, this integration plays a vital role in advancing the scientific development and optimization of rural production, living, and ecological spaces, thereby supporting the growth of ecological economies. The creation of the first micro-spatial dataset for land use allocation within village courtyards in Shenyang sheds light on the spatial distribution patterns of rural human settlements amid recent urbanization. This dataset provides valuable data for understanding the vitality of rural settlements in Shenyang and assessing the potential for resource optimization.

As the smallest unit of administrative division, the village functions as a compact social ecosystem shaped by its natural environment, serving as a microcosm of broader society. The courtyard, being an even smaller unit, plays a crucial role in integrating agricultural production with living spaces, facilitating the transformation, circulation, and utilization of regional biomass resources. However, in the context of refined national social governance, the absence of detailed dataset at the courtyard scale remains a fundamental obstacle to optimizing village resource allocation. This issue manifests in three main ways: first, traditional aerial remote sensing images have low resolution, which hampers detailed spatial analysis at the village scale; second, official public data sources, such as statistical yearbooks, lack village-scale data statistics, and third, artificial field-work based sampling is often incomplete, with challenges related to high costs and time consumption.

This study introduces a method for interpreting family courtyard structures using ultra-high resolution UAV images with a 5-cm resolution. By employing the Mapflow plug-in within the QGIS platform and applying deep learning techniques, the study processes these images to extract the vector boundaries of houses in Ciyutuo Village. After manual classification, verification, and correction, the accuracy of this method reaches 99%. Using the Geoscene Pro platform, the UAV images are manually interpreted and vectorized to create boundary surface, road, and farmland vector layers for various types of courtyards in the village. This dataset, including four sets of vector data and a typical courtyard structure classification atlas, will aid in the further exploration of the spatial allocation characteristics of ultra-refined courtyard resources in Northeast China. Building on this, the study develops an ultra-refined model for interpreting family courtyard resource metabolism and establishes methodologies for constructing spatial dataset. Multi-layer modeling is conducted based on industrial, economic, environmental, and geographic spatial grids, with logical relationships between elements deduced to effectively represent element flows. This approach aims to accurately align the sustainable development model with village environmental, economic, and geographic units, enhancing the supply of ecological products and services at the courtyard level. The goal is to achieve synchronous upgrading, value-added, and benefits within the micro-level ecological-social-economic system, providing efficient scientific support for the global integration and diversified value-added of rural resources.

Author Contributions

Xu, Y. T., Li, J. Z., and Xue, B. conducted the overall design of the dataset development; Li, J. Z. and Ren, W. X. collected and processed the data of UAV Image; Xu, Y. T. vectorized and refined the data; Xu, Y. T., Ren, W. X., and Xu, Y. P. conducted field research and data

verification; Xu, Y. T. and Li, H. Q. wrote the data paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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