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FEATURE-BASED CLASSIFICATION OF RESIDENTIAL LAND USE INTEGRATING REMOTE SENSING AND SETTLEMENT POINT CHARACTERISTICS

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ABSTRACT

In the context of the feature-based categorization of residential land use, this research investigates the mutually beneficial relationship between remote sensing technologies and the features of settlement points. Through the incorporation of geographical data and information that is centered on people, this method provides a holistic knowledge of the dynamics of urban environments. In this work, a technique is presented that makes use of an existing database of settlement points identifying buildings in order to differentiate between regular and irregular residential settlements. Nine data characteristics that describe the density, distance, angles, and spacing of the settlement points are computed at several spatial scales. These features pertain to the settlement points. For the purpose of classifying land use zones, these data are examined both alone and in conjunction with five standard remote sensing metrics on elevation, slope, vegetation, and nighttime lights. This is done using a supervised machine learning technique.

Keyword: - *Population; Land; Residential; Areas; Urban.*

INTRODUCTION

In the modern period, which is characterized by fast urbanization and population increase, it is very necessary to have an effective management system and a comprehensive knowledge of land use patterns in order to achieve sustainable urban development. With residential land use being such an important component of urban landscapes, it is necessary to use advanced approaches for the categorization and analysis of this material. The combination of remote sensing technologies with the features of settlement points appears as a potent strategy for feature-based categorization when viewed in this perspective. The extraction of significant information from both spatial and non-spatial data is made possible by this all-encompassing and synergistic technique. As a result, urban planners, politicians, and researchers are provided with a sophisticated knowledge of the dynamics of residential land use. When it comes to capturing the deep intricacies of spatial patterns and settlement dynamics, conventional techniques of land use categorization are proving to be inadequate as metropolitan areas

continue to develop. Because of its capacity to capture high-resolution pictures and data, remote sensing technology has emerged as a vital instrument in the area of land use analysis. LiDAR (Light Detection and Ranging) systems, satellite sensors, and aerial photography all provide a plethora of information that may be used to detect, map, and evaluate residential land use patterns. This information can be gained via the utilization of these technologies. The combination of various remote sensing methods makes it possible to conduct an in-depth investigation of the physical characteristics, land cover, and spatial linkages that exist inside urban areas. In the same vein, the features of settlement points, which include demographic data, infrastructure, and socio-economic indicators, provide a more in-depth comprehension of the human component that is present inside residential areas. The categorization process is improved by the incorporation of human-centric elements into the study, which is accomplished via the combination of data from settlement points with information obtained from remote sensing. Taking a holistic approach not only detects physical elements, but it also provides light on the social and economic factors that drive the dynamics of land use. A depiction of residential land use that is more accurate and nuanced is produced by the feature-based classification technique. This is accomplished by bridging the gap between physical characteristics and human activities during the classification process.

The capability of feature-based categorization to adjust to the ever-changing characteristics of urban environments is one of the most significant benefits of this method. When it comes to quickly keeping up with the fast changes that are taking place in metropolitan settings, traditional techniques of land use categorization sometimes fail. This method, on the other hand, provides a strong framework that can adapt to changing patterns of land use since it takes advantage of the flexibility that distant sensing and settlement point characteristics afford. The approach of feature-based categorization offers a dynamic instrument for monitoring and assessing these changes in real-time. This is because cities are undergoing transformations that are driven by variables such as population increase, economic development, and urban planning regulations. Furthermore, the combination of remote sensing and settlement point characteristics helps the discovery of spatial correlations and trends within residential land use.

The definition of residential zones, the identification of informal settlements, and the evaluation of changes in land cover over time are all included in this. By this strategy, urban planners can get spatial insights that enable them to make well-informed choices about the development of infrastructure, the distribution of resources, and the preservation of the environment. Cities can optimize their spatial organization, improve infrastructure planning, and promote sustainable urban growth when they have a thorough grasp of the spatial dynamics of residential land use. The fact that feature-based categorization may be used for the problem of urban sprawl and land management is yet another important facet of this classification method. Because of the growth of metropolitan areas, there is a growing need for effective land management to forestall the deterioration of the environment and to guarantee the health and happiness of the people who live there. There is a correlation between the integration of remote sensing and settlement point characteristics and the monitoring of urban sprawl, the

identification of areas that are in danger, and the implementation of appropriate land management methods. This proactive strategy helps to contribute to the establishment of urban landscapes that are resilient and sustainable, and that strike a balance between the requirements of the people and other aspects of the ecosystem.

Through the integration of remote sensing and settlement point characteristics, the feature-based categorization of residential land use is a cutting-edge approach that has enormous promise for the planning and development of urban areas. This method offers a comprehensive comprehension of the intricate dynamics that are responsible for the formation of residential places. It does this by using the power of cutting-edge technology and combining bodily characteristics with data that is centered on people. The versatility, real-time monitoring capabilities, and geographical insights that feature-based categorization provides make it a powerful tool for solving the difficulties that are brought about by expanding urbanization. As cities continue to develop, it is becoming more important to adopt new strategies such as this one to create urban landscapes that are both resilient and sustainable, and that also meet the varied requirements of the people who live there.

REVIEW OF LITERATURE

Yao, Yao et al., (2022) It is vital to the logical optimization of urban structure to have an accurate characterization of the patterns of land use in urban areas. It is possible to improve the classification of land use by integrating the socioeconomic features revealed by social sensing data with the outward physical qualities of city parcels that are collected from remote sensing photos. Most of the the social sensing data that is currently available, on the other hand, suffers from location bias and lacks temporal resolution. As a result, these data are unable to effectively represent the socioeconomic information of land use, which in turn leads to poor classification accuracy. This study investigates the deep semantic information of high-spatial and temporal resolution time-series electricity data to investigate its relationship with socioeconomic characteristics and to construct a neural network (TR-CNN) that is capable of fusing time-series electricity data and remote sensing images to identify urban land-use types. The study is based on the problems that have been discussed above. To conduct a demonstration study, we chose Anyuan District in Pingxiang City, Jiangxi Province. The findings indicate that the proposed model has an accuracy of 0.934, which is 4.3% and 6.7% higher than the accuracy of the ResNet18 model, which relies solely on remotely sensed images, and the LSTM-FCN model, which relies solely on time-series electricity data. In addition, the findings demonstrate that the use of time-series electrical data is capable of efficiently identifying residential and commercial locations; but, when compared with remote sensing photos, it is more challenging to identify public service facilities. By linking remote sensing photos and electricity data, this research shows for the first time that the semantic features of electricity data can properly detect urban land-use patterns from both "top-down" and "bottom-up" recognition patterns. Additionally, this study demonstrates that the semantic features of electricity data may represent socioeconomic characteristics.

Yin, Jiadi et al., (2021) The use of remote sensing (RS) in urban mapping has been around for quite some time; yet, it is challenging to represent the richness and variety of urban functional patterns using RS alone. Emerging Geospatial Big Data (GBD) are regarded to be a complement to Remote Sensing (RS) data. These data serve to add to our knowledge of urban lands, ranging from the physical aspects (such as urban land cover) to the socioeconomic aspects (such as urban land usage). The integration of RS and GBD has the potential to be an efficient method for combining socioeconomic and physical factors, which has a significant potential for producing a high-quality urban land use categorization system. For this investigation, we conducted a literature analysis and concentrated on the current state of the art and different perspectives about the categorization of urban land use by combining RS and GBD. In particular, the RS characteristics that are often used (such as spectral, textural, temporal, and geographic data) and the GBD features (such as spatial, temporal, semantic, and sequence aspects) were discovered and examined in the context of urban land use categorization. The integration solutions for RS and GBD features were separated into two categories: feature-level integration (FI) and decision-level integration (DI). More specifically, the FI technique integrates the RS and GBD characteristics and classifies urban land use types by making use of the integrated feature sets. On the other hand, the DI method analyzes RS and GBD individually and then combines the classification findings based on decision criteria. In addition, we spoke about other important topics, such as the establishment of analytical units, the segmentation of parcels, the labeling of parcels according to the forms of land use, and the integration of data. Our findings offer a retrospective study of various characteristics of RS and GBD, as well as strategies for integrating RS and GBD, as well as the advantages and disadvantages of each. This study has the potential to contribute to the definition of the framework for future urban land use mapping, as well as to provide improved assistance for urban planning, urban environment assessment, urban disaster monitoring, and urban traffic analysis.

Dong, Jinwei et al., (2021). When it comes to urban planning and sustainable development, having information regarding how land is used in urban areas is essential. The growth of geospatial big data (GBD) has led to a rise in the availability of remotely sensed (RS) data as well as the creation of new techniques for the integration of data, which has resulted in the acquisition of new chances for mapping different forms of urban land use. The methodologies of RS and GBD integration, on the other hand, are varied owing to the variances in data, research regions, classifiers, and other factors. The purpose of this research is to provide a concise summary of the primary approaches to data integration and to assess those approaches via the lens of a case study of urban land use mapping in Hangzhou, China. First, we divided the RS and GBD integration approaches into two categories: decision-level integration (DI) and feature-level integration (FI). Then, we examined the primary distinctions between these two types of integration by evaluating the current body of research. After that, the two approaches were used to map urban land use types in the city of Hangzhou. This was accomplished by using urban parcels that were produced from the Open Street Map (OSM) road network, 10 m Sentinel-2A pictures, and points of interest (POI). Both quantitative and

qualitative validations were performed on the related categorization findings, and both were performed using the same testing dataset. As a final step, we used bibliographic evidence and quantitative analysis to highlight the benefits and drawbacks associated with both techniques. The findings demonstrated that: (1) the visual comparison reveals that DI-based classification delivers a generally superior performance compared to FI-based classification; (2) DI-based urban land use mapping is simple to implement, whereas FI-based land use mapping allows for the combination of features; (3) DI-based and FI-based methods can be used together to improve urban land use mapping, even though they have different performances when classifying different types of land use. The results of this research contribute to a better understanding of urban land use mapping about the integration strategy of RS and GBD.

Huang, Huiping et al., (2019) Urban residential land has been experiencing fast changes and has received a great deal of attention all over the globe because of the deterioration of the environment and the acceleration of urbanization. While this is going on, it is vital to conduct a quantitative evaluation of the appropriateness of urban residential land to get a deeper and more powerful knowledge of urban residential land planning and improvement. To assess natural appropriateness, most urban land suitability studies depend primarily on remote sensing data and geographic information system (GIS) data. However, only a small number of research have focused on urban land suitability from a socioeconomic point of view. Consequently, this paper integrates remote sensing data (GaoFen-2 satellite image) and social sensing data (Tencent User Density data, Point-of-interest data, and Open Street Map data) to establish an evaluation framework for analyzing the suitability of urban residential land in the Haidian District, Beijing, China, in which, ecological comfortability, locational livability, and overall suitability were evaluated according to five attributes extracted from urban residential land via the factor analysis method. The assessment findings of this case study indicate that, in comparison to the suburban region in the northwest, the urban area tends to have lower ecological comfortability and greater locational livability. As one moves from southeast to northwest, the overall suitability improves, which is in line with the geographical distribution of ecological comfortability. The sustainable development of residential lands and the planning of urban land use are both areas that might benefit from the implementation of this approach.

Liu, Xiaoping et al., (2017) The administration of urban areas, the formulation of public policy, and the monitoring of population activities all benefit greatly from the provision of information about urban land use. The complexity of urban systems, on the other hand, makes it difficult to accurately classify the functional zones that exist inside metropolitan areas. Numerous research studies have focused on the categorization of urban land use by considering characteristics that are retrieved from either high spatial resolution (HSR) remote sensing pictures or data from social media. However, owing to the lack of models that are currently available, only a small number of studies have considered both aspects. By combining probabilistic topic models (PTMs) and support vector machines (SVM), we offer a unique scene classification framework in our research. This framework is intended to determine the predominant urban land use type at the level of traffic analysis zone (TAZ). Within the

framework, a land-use word dictionary was constructed by combining natural-physical aspects from high-speed rail (HSR) photographs with socioeconomic semantic information from many sources of social media data. We developed numerous experiments to assess the accuracy of our proposed model in terms of land use categorization using a variety of combinations of previously gathered semantic characteristics. In addition to comparing the results with data that was manually interpreted, we also performed these tests. Our technique, which combines characteristics collected from many sources of geographic data as semantic features to train the classification model, is successful, as seen by the classification results (overall accuracy = 0.865, kappa = 0.828). This technique may be used to assist urban planners in the analysis of fine urban structures and the monitoring of changes in urban land use. In the future, new data from a variety of sources will be included in this suggested framework.

Hu, Shougeng & Wang, Le. (2013). Information about the usage of urban land is an essential component in a broad range of planning and environmental management procedures. This research was conducted with the intention of the developing of an automated technique for the classification of detailed urban land-use classes using data obtained from remote sensing. Seven land-use parcel qualities, which were generated from pertinent remote-sensing data, were combined to identify four land-use classes. These classes were office, industrial, civic, and transportation, which were found to be the most difficult to categorize in prior research. An experiment was conducted at a research location in Austin, Texas, in the United States. Using a decision tree technique, we were able to attain an overall accuracy of 61.68% and a kappa value of 0.54. In comparison to all of the variables that were considered, it was determined that the most relevant elements were the building's height and its area. As an additional point of interest, the floor area ratio variable played the second most essential function out of the seven variables. This demonstrates that the horizontal and vertical qualities of buildings, as well as their related spatial characteristics, are significant in distinguishing between the four classes.

Rozenstein, Offer & Karnieli, Arnon. (2011). Significant shifts in land usage have taken place over the whole of Israel over the course of the last several decades. Areas that were once used for grazing have been reforested, converted to agriculture that is irrigated or rain-fed, transformed into natural reserves, often used as major military training locations, converted to rural and urban communities, or left unused. The maps of land use that are given by the Israeli government are less comprehensive for other land use classes than they are for agricultural and urban land use classifications. Even though rangelands continue to make up a significant portion of the northern Negev, the extent of their presence is not well characterized at present. As a result of ongoing changes in land use and the fact that existing land-use maps do not consider rangelands, there is a pressing need for the establishment of a dynamic land-use information database that can be employed by planners, scientists, and others responsible for making decisions. Data collected by remote sensing (RS) are a feasible source of information that might be used to construct and update land-use maps effectively. The goal of this effort is to investigate low-cost methods for merging data from the Israeli Geographic Information

System (GIS) with data from the present satellite remote sensing (RS) system to produce a land-use map for northern Negev that is generally accurate and up to date. Comparisons were made between several well-established approaches to land-use categorization based on RS data. Within the context of a geographic information system (GIS), auxiliary land-use data were used to update and enhance the accuracy of the RS categorization. It has been discovered that the use of a mix of supervised and unsupervised training courses results in a product that is more accurate than the utilization of either of these training classes on its own. In addition, it was discovered that using supplementary data and GIS methodologies to update this product may result in an improvement of up to ten percent in the product's accuracy. Eighty-one percent of the result was accurate overall. It has been proposed that the use of the approach that has been provided for additional RS pictures that have been collected at various periods may make the process of creating a database for changes in land use easier.

RESEARCH METHODOLOGY

The purpose of this study is to create a surface classification system that will categorize populated residential areas into regular or irregular settlement types on a grid with a spatial resolution of twenty meters. Large-scale urban planning is responsible for the formation of regular settlements, which are distinguished by formal planning as well as dwellings and roadways that are consistently spaced and structured. Alternately, irregular settlements are characterized by an unplanned layout that is characterized by the emergence of roads and dwellings that are thinner and more irregular. In most cases, irregular settlements are devoid of fundamental amenities and often occupy less attractive territory along the outskirts of metropolitan centers and in regions that are susceptible to risks. As will be seen in the next discussion, this categorization is determined from the training data that is currently available.

Following preliminary studies that were conducted using the settlement points, the resolution of the output was chosen. These analyses discovered that the average distance between the sites was roughly 20 meters. The supervised classification makes use of a random forest (RF) technique and is dependent on multiscale feature indices that are computed based on the distribution of settlement point locations.

RESULT AND DISCUSSION

Feature calculation

131 data layers were generated for each province as a result of feature computations. These data layers included 126 geometry-derived layers and 5 remote sensing measurements. On six processing nodes with sixteen cores each, the computations took a total of roughly 57 hours to complete utilizing 96 processors. To construct the training dataset, values were retrieved from these layers at the positions that were chosen at random.

Variable selection

In the first processing stage, which was based on ten runs of the RF, it was advised that the linearity in addition to both closest neighbor angle measurements at the 25 m scale be eliminated. The second phase consisted of entering the remaining 123 geometry-derived features into an RF model and comparing the relevance of the baseline variable that was generated to the importance of the variables that were generated from 500 random permutations.

Classification and accuracy assessment

In this report, we provide the cross-tabulation of pixel-level predicted vs SoACresidential kinds, as well as positive and negative predictive values, sensitivity, specificity, and overall accuracy scores for the predictions made in each province. The primary findings are summarized in Table 3, which can be seen here. The prevalence of each type in the validation data is shown in Panel A of the table. This prevalence is based on the individual pixel counts. In the validation datasets, the proportion of regular settlement areas varied greatly, ranging from 14% in Kunduz to 60% in Balkh, where Mazar-i-Sharif serves as the capital of the province. The cross-tabulation counts of a pixel-by-pixel comparison between the prediction data and the validation data are shown in Panel B. We utilize the terminology of "positive" and "negative" for our binary classifications, with normal settlements being referred to as positive. This is done for the sake of tradition. As a result, a true positive is a pixel that has been accurately projected to have a regular settlement, while a true negative is a pixel that has been correctly predicted to have an irregular settlement. The accuracy evaluations that were derived from the cross-tabulations are shown in Panel C. The terms "positive predictive value" (PPV) and "negative predictive value" (NPV) are used to describe the percentage of pixels with regular and irregular settlements that have been accurately anticipated. PPV and NPV are dependent on the predominance of each form of settlement, and the outcomes follow these patterns. It is important to keep this in mind. Both the sensitivity and the specificity of the model are unaffected by the prevalence, and the model demonstrates a sufficient capacity to accurately forecast the kind of settlement across all of the provinces.

CONCLUSION

When it comes to understanding residential land use, the incorporation of remote sensing and settlement point characteristics into feature-based categorization provides a dynamic and comprehensive approach. A nuanced view of urban dynamics may be obtained via the use of this technology, which combines geographical data with information that is centered on humans. It is a significant instrument for sustainable urban planning and development because of its flexibility in changing environments, its capacity for monitoring in real-time, and its capacity to handle difficulties such as urban sprawl. Cities need to embrace creative techniques as they continue to develop. This will ensure the establishment of urban landscapes that are robust and well-balanced, and that can meet the varied requirements of communities.

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