Advanced Building Management Framework Based on AI Analytics

Jaemin PARK, Republic of Korea

Key words: drone imagery, AI analysis, illegal construction, spatial data, urban management

SUMMARY

Rapid urban expansion and the relaxation of development restriction zones in Korea since t
he 2000s have accelerated construction activities in both urban and suburban areas. However,
these changes have also led to a significant increase in unauthorized and illegal buildings, crea
ting challenges in urban management, spatial planning, and public safety. Conventional monit
oring approaches such as field inspections, citizen reports, and satellite imagery are limited in
spatial coverage, temporal frequency, and cost-efficiency, making it difficult for local govern
ments to maintain accurate and up-to-date building information.

This study proposes an AI-driven framework for advanced building management based on
drone imagery and spatial data integration. The approach leverages deep learning-based imag
e analysis to detect unauthorized constructions, illegal extensions, and deteriorated structures
by comparing aerial observations with existing building registry and cadastral information. A
utomated feature extraction and change detection techniques enable efficient identification of
discrepancies between registered and actual building conditions.

The proposed method strengthens administrative capabilities by enabling real-time monitori
ng, reducing human dependency, and improving spatial data accuracy. Furthermore, it provide
s a scalable solution for local governments to enhance regulatory compliance and optimize ma
intenance planning. This research contributes to the development of an intelligent, data-driven
building management system that supports sustainable urban governance and efficient spatial
information utilization.

Advanced Building Management Framework Based on AI Analytics

Jaemin PARK, Republic of Korea

1. INTRODUCTION

Since the 2000s, as regulations on development restriction zones have been gradually relaxed, the number of buildings has steadily increased not only in urban areas but also in suburban regions. In proportion to this trend, the number of unauthorized and illegal buildings has also increased, causing various social problems. Aging buildings constructed without proper authorization pose a high risk of collapse, fire, and other safety accidents. Therefore, it is critically important to continuously identify and manage their current conditions. In particular, many small-scale aging houses are occupied by economically disadvantaged elderly individuals or socially vulnerable groups. As a result, safety accidents related to such buildings are highly likely to lead to human casualties.

Currently, unauthorized aging houses and illegal buildings are monitored through field inspections, citizen reports, and satellite imagery. However, considering the extensive spatial coverage and the large number of targets, these methods face clear limitations due to restricted manpower and budget constraints. In the case of Gwangju Metropolitan City, there are approximately 1,100 unauthorized houses, while only about 15 administrative officers are responsible for building management. This indicates a serious shortage of manpower and highlights the need to improve the existing visual inspection–based process. Similarly, in Jeju City, approximately 3,300 illegal buildings constructed since 2010 remain virtually unpunished. Although a policy was announced in January 2024 to prosecute unauthorized changes of use only for buildings that had received official approval, the absence of countermeasures for illegal buildings led to public criticism, labeling the policy as "reverse administration."

	
"Uncontrolled Increase of Unauthorized Houses" (February 15, 2024)	**"Backward Illegal Building Administration" (January 15, 2024)**

Figure 1. Broadcast news report

Less than two years have passed since the Itaewon disaster in 2022, in which illegal building extensions and the resulting obstruction of pedestrian flow were identified as the primary causes. Nevertheless, cases of illegal buildings continue to be detected nationwide. According to statistics, as of 2023, a total of approximately 241,185 buildings were identified nationwide as violations of the Building Act. Among them, approximately 114,117 cases involved residential buildings, while 126,068 cases involved non-residential buildings. The most common type of violation of the Building Act was the failure to obtain a building permit or submit a building notification, accounting for approximately 208,918 cases. Buildings constructed without obtaining a building permit, submitting a building notification, or receiving approval for use under the Building Act are structurally vulnerable and may face restrictions in being used for their intended purposes. In particular, among residential buildings, approximately 101,142 buildings were identified as unauthorized or unreported constructions. Residents of such buildings are effectively left unprotected against safety accidents such as collapse, subsidence, and fire. If corrective orders are not implemented within the designated compliance period, the permitting authority imposes enforcement fines on the owners of these illegal buildings.

The continuous increase in illegal buildings is the result of multiple interrelated factors, including efforts to maximize rental income, shortages of specialized personnel among local government officials, and tenants' preference for low-cost housing. These issues related to manpower shortages and difficulties in administrative processing are not limited to specific regions but represent a nationwide challenge that requires systematic improvement. To address these problems, this study proposes the application of artificial intelligence (AI)–based analytical technologies and the utilization of drone imagery, which have recently emerged as major technological trends. Through the integration of these two technologies, building information can be managed more efficiently, and the building management process can be advanced. Ultimately, this approach is expected to reduce human, temporal, and administrative inefficiencies.

2. NECESSITY OF THE STUDY

2.1 SHORTAGE OF ADMINISTRATIVE MANPOWER

Building management is a field that requires a high level of professional expertise and practical experience. However, it is currently facing a chronic shortage of administrative manpower. The lack of specialized personnel can lead to a decline in the quality of building management and an increased risk of safety accidents.

In the case of Gwangju Metropolitan City, there are approximately 1,100 unauthorized houses, while each autonomous district is staffed with only about three officers, resulting in a total of approximately 15 personnel responsible for building management across the entire city. Consequently, each officer is responsible for managing approximately 80 buildings. In addition to comparing documents with individual buildings through visual inspection, officers are also required to carry out administrative tasks such as issuing corrective orders and imposing enforcement fines. Given the workload and complexity of these tasks, it is evident that systematic countermeasures are required. These issues are not limited to Gwangju Metropolitan City but represent a nationwide problem that necessitates comprehensive improvement.

2.2 INEFFICIENCY DUE TO LACK OF TIMELINESS AND ACCURACY

Existing building management systems often suffer from insufficient application of advanced technologies, resulting in reduced data accuracy and timeliness. Inaccurate data leads to inefficient management practices and increases the risk of safety-related incidents. Moreover, traditional building information management methods rely heavily on manual visual inspection conducted by a limited number of personnel. This approach requires a significant amount of time and is prone to human error, such as incorrect data entry, thereby reducing overall efficiency.

As a result of inaccurate building management and the provision of incorrect information, the likelihood of civil complaints increases. Furthermore, the additional time and costs required to process such complaints place a substantial administrative burden on local governments.

3. RESEARCH CONTENT

In this study, an approach to updating building status management through AI-based object detection analysis using drone imagery is examined. Drone imagery has become highly applicable in recent years, as it enables the observation of wide areas within a short period of time while providing high-resolution image quality.

However, managing building conditions solely based on raw imagery presents limitations, as the process still relies heavily on visual inspection by administrative personnel. This results in considerable time and cost expenditures. Therefore, this study aims to explore methods for automatically detecting building conditions by applying AI-based image analysis techniques to drone imagery, and to propose practical approaches for utilizing the results.

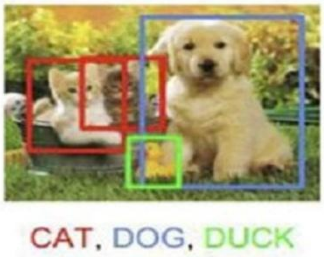
Classification	Classification+Localization	Instance Segmentation
		

Figure 2. Object Detection

3.1 OVERVIEW OF THE STUDY

Object detection, which is one of the core techniques in the field of deep learning, belongs t o the domain of computer vision. It is a technology that detects objects in images and identifie s their locations and sizes.

Unlike simple image classification, object detection focuses on identifying the locations of objects within an image. Therefore, it is common to represent detected objects by displaying b ounding boxes, which indicate the position and spatial extent of each object. In simple terms, o bject detection is a technique that analyzes images or videos to identify specific objects. For e xample, it can automatically recognize and locate objects such as people, vehicles, and animal s within an image. Object detection performs two primary tasks: object classification and obje ct localization.

First, object classification determines what type of object is present in the image. For instan ce, if objects such as dogs, cats, or cars appear in the target imagery, the model identifies the c ategory to which each object belongs. Second, object localization identifies the bounding box of each object within the image. The process of defining bounding boxes is commonly referre d to as labeling, and these boxes are typically represented in rectangular form. The combinatio n of these two tasks produces the final output of object detection analysis. In this study, object detection techniques are applied to explore methods for detecting and managing building con ditions. The overall research workflow is presented below.

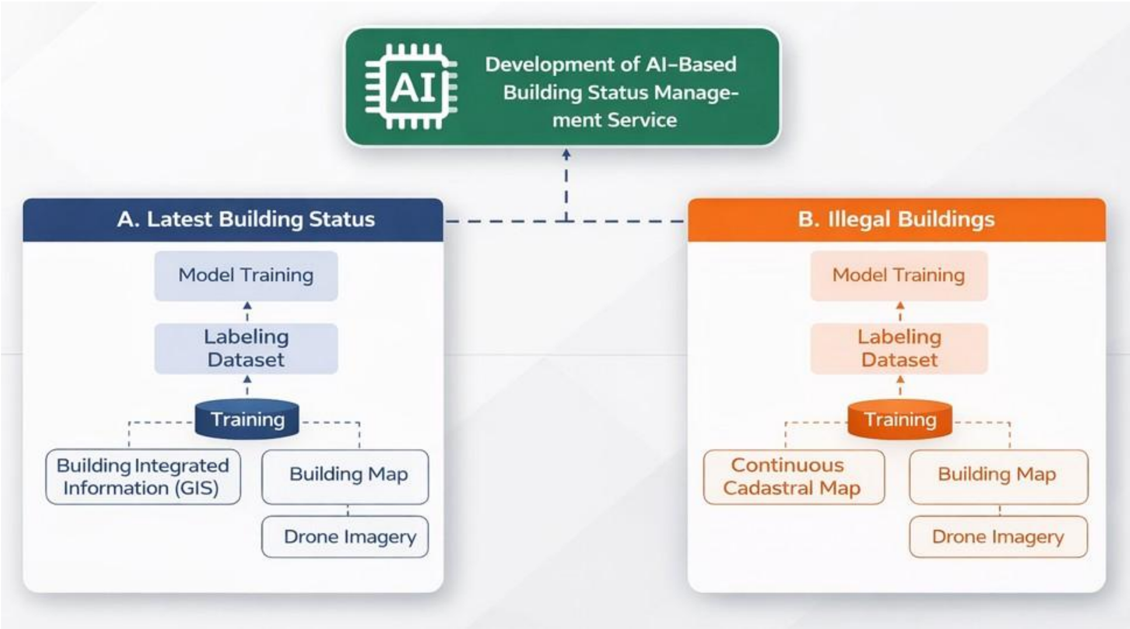


Figure 3. Research Workflow

First, data are collected to construct the training dataset. Drone imagery previously acquired by the authors is utilized, specifically imagery covering the Gyerim-dong area in Dong-gu, G wangju Metropolitan City, which was designated as a resurvey area. In addition, GIS-based B uilding Integrated Information and Continuous Cadastral Map datasets overlapping with the dr one imagery are downloaded and prepared.

The Building Integrated Information dataset is a spatial, land-based building information da taset constructed at the individual building level by integrating building spatial information de rived from continuous cadastral geometry with attribute information from the Building Regist er of the national architectural administration system, "Seumteo." This dataset has been establ ished nationwide and is collected and managed by the National Spatial Information Center of t he Ministry of Land, Infrastructure and Transport.

Next, building conditions that can be visually verified from the drone imagery are identified , and a building map is manually created. The completed building map is then overlaid with bo th the Building Integrated Information dataset and the Continuous Cadastral Map, after which labeling is performed. Based on the analyzed results, potential approaches for a building status management service are subsequently reviewed and evaluated.

3.2 IMAGE ANALYSIS

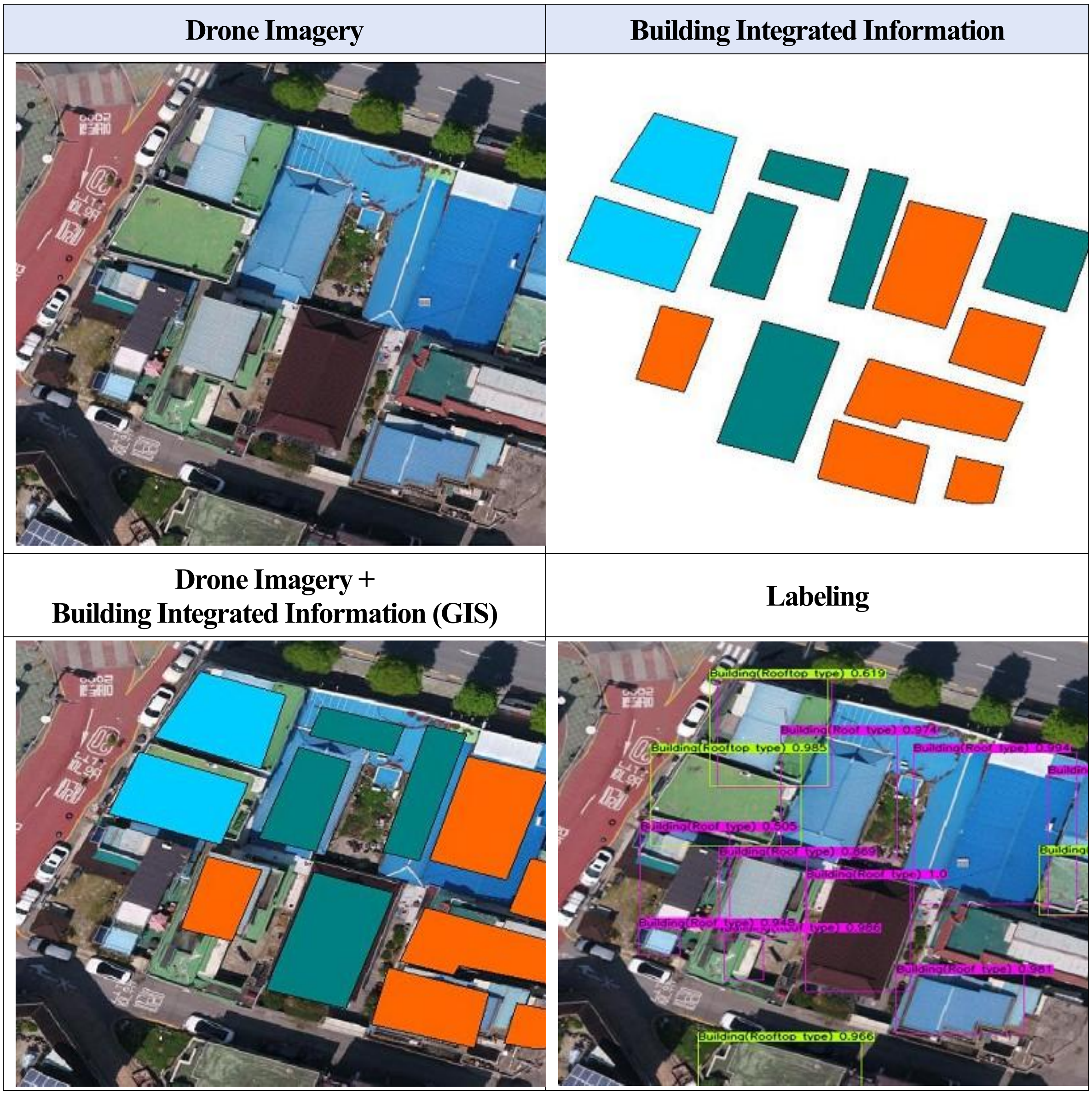


Figure 4. Construction of a Labeling Dataset Using Drone Imagery
and Building Integrated Information

First, this section describes the overlay of Building Integrated Information and drone imagery within a GIS environment. One of the methods for obtaining building register attribute information from the architectural administration system, Seumteo, is through the Building Integrated Information dataset provided by V-World GIS.

The Building Integrated Information dataset includes multiple layers representing building conditions. However, because its update cycle is fixed and its accuracy is relatively limited, it cannot be regarded as fully reliable data. Therefore, in this study, the dataset is overlaid with r ecent drone imagery and analyzed in order to improve accuracy and secure data timeliness. In addition, to enhance labeling accuracy, building conditions visible in the drone imagery are m anually delineated to create a building map. Since buildings appear in various forms within im agery, such variations may cause confusion during machine learning–based image analysis. A ccordingly, by delineating building condition boundaries, the data are standardized and structu red prior to training. Second, the overlay of the Continuous Cadastral Map and drone imagery is conducted. As in the previous step, the building map derived from drone imagery is overlaid with the Continuous Cadastral Map.

When the Continuous Cadastral Map is overlaid with drone imagery, buildings that intersec t cadastral boundaries can be intuitively identified. Furthermore, since the attribute informatio n of the Continuous Cadastral Map includes land-use classifications, it becomes possible to id entify parcels with land categories where construction is legally prohibited. Labeling for the C ontinuous Cadastral Map and drone imagery focuses primarily on images in which cadastral b oundaries intersect building condition lines.

Images of cadastral boundaries intersecting building conditions

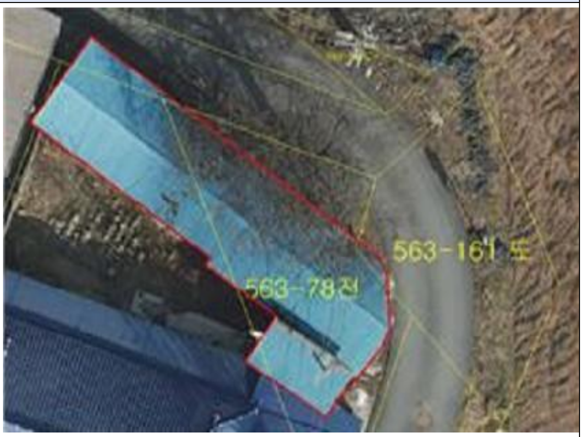


Figure 5. Construction of a Labeling Dataset Using the Continuous Cadastral Map and Drone Imagery

3.3 DERIVATION OF RESULTS

By training the AI model using the two types of datasets constructed in this study, the expec ted analytical results are as follows:
- Detection of building conditions that are not mutually reflected between the GIS-based Build

ing Integrated Information and drone imagery
- Detection of parcels containing buildings suspected of unauthorized occupation

No.	Location	Characteristics	Analysis Area	Detected Buildings	Undetected (Omitted) Buildings
1	Gyerim-dong area, Dong-gu, Gwangju Metropolitan City	Urban area	Approx. 2,100㎡	13	4
2	Hamyo-ri area, Unnam-myeon, Muan-gun, Jeollanam-do	Agricultural land	Approx. 500㎡	22	8

Table 1. Simulation Results of Image Analysis

As a result of training the labeled dataset generated by overlaying Building Integrated Information and drone imagery within a GIS environment, improved timeliness of building condition data can be expected. The Building Integrated Information dataset offers the advantage of enabling the identification of terrain and feature conditions across the entire national territory. However, its update cycle is fixed, and there are inherent limitations in the accuracy of the building condition information it contains.

In contrast, although the operation of drones incurs economic costs, drone imagery can be acquired as needed and provides high-resolution, highly reliable image data. By overlaying these datasets and training the AI model accordingly, it is anticipated that building conditions omitted from the Building Integrated Information dataset and those difficult to identify solely through drone imagery can mutually complement each other. As a result, more accurate and comprehensive building condition data can be obtained.

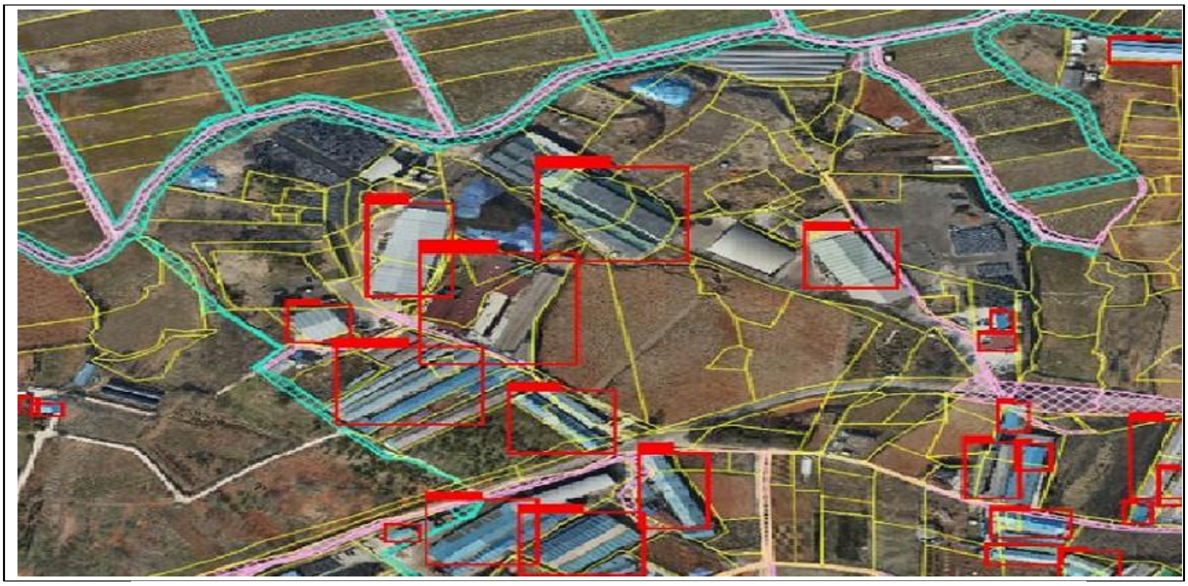


Figure 6. Object Detection of Roads, Waterways, and Building Conditions

Second, when the Continuous Cadastral Map is overlaid with drone imagery, there is a clear advantage in that building conditions intersecting cadastral boundaries can be identified intuitively. However, verifying such cases solely through visual inspection involves significant limitations in terms of time and cost. Accordingly, this study applies AI-based image analysis techniques to detect parcels containing buildings that intersect cadastral boundaries. Subsequently, a color table is applied on a parcel-by-parcel basis to land parcels with land-use classifications where construction is legally prohibited.

Through these two processes, the locations of parcels containing buildings intersecting cadastral boundaries can be identified using object detection, and the status of parcels suspected of unauthorized occupation can be visually confirmed through the application of color tables. It should be noted that it is not possible to definitively determine whether a building is illegal based solely on the imagery analyzed in this study. However, the significance of this approach lies in its ability to enable large-scale monitoring that can identify as many candidates of potentially illegal buildings as possible, without requiring exhaustive field surveys or on-site inspections.

4. EXPECTED EFFECTS

1	Extraction of illegal buildings through analysis of road-name address and building data using recent drone imagery	+ AI
2	Extraction of illegal development activities through analysis of thematic maps of development restriction zones using recent drone imagery	

3	Extraction of parcels suspected of unauthorized occupation throu gh analysis of thematic maps of national and public land using re cent drone imagery	

Table 2. Potential Application Scenarios

At present, illegal buildings and various illegal activities within development restriction zon es have emerged as serious social issues, making enforcement and monitoring essential. Natio nwide, local governments invest substantial budgets each year to conduct aerial photograph in terpretation projects in order to detect such illegal activities.

However, in practice, aerial photographs are often interpreted manually by administrative o fficers, or illegal activities are identified through direct on-site inspections. As a result, the ove rall efficiency of enforcement operations remains extremely low. By applying object detection technologies based on AI analytics, as proposed in this study, the following expected effects c an be achieved.

Currently, object detection techniques applied to recent drone imagery tend to exhibit relati vely low accuracy. Nevertheless, if model training is repeatedly conducted using diverse datas ets and the accuracy of object detection classification can be secured at a level of 80% or high er, it is expected that 50–80% reductions in manpower and costs can be achieved compared to conventional enforcement methods based on field inspections. Furthermore, this approach can be extended to areas affected by disasters and emergencies to detect environmental changes, t hereby preventing illegal and disorderly development and reducing overall social costs.

In addition, by utilizing AI-based object detection technologies, the scope of application ca n be further expanded in the future to various fields. These include disaster and hazard manag ement areas such as landslide detection, building collapse, and road subsidence, as well as fore st and agricultural disaster monitoring, crop cultivation area–based yield prediction, and crop condition classification using soil and terrain data. As AI technologies continue to advance, th ey can be provided to the public in various content formats. Through such applications, AI-bas ed analytical results are expected to contribute not only to policy decision-making but also to t he enhancement of public services.

REFERENCES

1. Ahn, Y. G., et al., 2024, Drone-based construction safety inspection and AI web-based solut ion development, ScienceON Research Report, Daejeon, Korea.
2. Architectural Institute of Korea, 2023, Research trends in spatial information analysis using drone imagery, Proceedings of the Architectural Institute of Korea Conference, Seoul, Kor ea.
3. Graduate School of AI·SW, Sogang University, 2025, A study on change detection of build ings in domestic aerial imagery using deep learning, Master's Thesis, Seoul, Korea.
4. Kim, M. J., Park, H. W., 2024, AI-based detection of illegal buildings using high-resolution

drone imagery, Journal of the Korean Society of Civil Engineers, Seoul, Korea.
5. Korea Information Processing Society, 2024, Building feature extraction from UAV images using semantic segmentation, Proceedings of the Korea Information Processing Society Co nference, Seoul, Korea.
6. Lee, D. G., Cho, E. J., Lee, D. C., 2025, Evaluation of building detection in aerial images us ing region-based convolutional neural networks, Journal of the Korean Society of Surveyin g, Geodesy, Photogrammetry and Cartography, Seoul, Korea.
7. Son, H., Kim, D. H., 2025, Deep learning-based detection of unauthorized buildings using a erial images: A comparative study, Journal of Korean Society for Quality Management, Vol . 53, No. 3, pp. 315–328, Seoul, Korea.

BIOGRAPHICAL NOTES

Jaemin PARK has been working at the Korea Land and Geospatial Informatix Corporation (L X) since 2016. From 2016 to 2020, he was engaged in cadastral surveying operations, followe d by his involvement in cadastral resurvey projects from 2021 to 2023, focusing on the improv ement and modernization of cadastral data. Since 2024, he has been working in spatial inform ation projects, where he applies GIS-based analysis and spatial data management techniques a nd explores the integration of advanced technologies such as drone imagery and AI-based anal ytical methods for public-sector spatial information services.

CONTACTS

Jaemin PARK
LX
120, Giji-ro, Deokjin-gu
Jeonju-si, Jeollabuk-do
South Korea
Tel. +82-10-8619-1199
Email: b60106@lx.or.kr
Web site: www.lx.or.kr