International Journal of Information Technologies and Systems Approach
Volume 17 • Issue 1

Integrated Design of Building Environment Based on Image Segmentation and Retrieval Technology

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ABSTRACT

Existing models still exhibit a deficiency in capturing more detailed contextual information when processing architectural images. This paper introduces a model for architectural image segmentation and retrieval based on an image segmentation network. Primarily, spatial attention is incorporated into the U-Net segmentation network to enhance the extraction of image features. Subsequently, a dual-path attention mechanism is integrated into the U-Net backbone network, facilitating the seamless integration of information across different spaces and scales. Experimental results showcase the superior performance of the proposed model on the test set, with average dice coefficient, accuracy, and recall reaching 94.67%, 95.61%, and 97.88%, respectively, outperforming comparative models. The proposed model can enhance the U-Net network's capability to identify targets within feature maps. The amalgamation of image segmentation networks and attention mechanisms in artificial intelligence technology enables precise segmentation and retrieval of architectural images.

KEYWORDS

Architectural Environment Integration Design, Artificial Intelligence, Attention Mechanism, Image Segmentation, U-Net

Image-segmentation techniques are extensively employed in architectural design due to the rapid advancement of artificial-intelligence technology. Researchers commonly segment image regions through manual or machine-learning methods. The threshold-based segmentation method (Du et al., 2023; Wang et al., 2023) delineates the image's grayscale histogram by selecting various grayscale thresholds. Pixels within the same grayscale range are considered part of the same class, sharing inherent similarities. The edge-based segmentation method (Li et al., 2010; Khan et al., 2023; Maican et al., 2023) necessitates the identification of the edge starting point, followed by a search for and connection of surrounding edge points from the starting point based on a similarity criterion. The region-based segmentation method (Liu et al., 2020; Xu et al., 2022; Li et al., 2023) relies on the spatial information of the image, constructing the segmentation region based on the similarity features of pixels. The graph partitioning approach in the graph theory-based segmentation method (Pei et al., 2020; Mamatha et al., 2022) completes the segmentation process by determining the optimal

DOI: 10.4018/IJITSA.340774
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solution to the goal function. Thus, the application of image-segmentation techniques in architectural design facilitates a more intuitive understanding of architectural construction and design methods for relevant practitioners.

The evolution of cities is contingent upon the interplay between the architecture people inhabit and their environment. As population density escalates, the development and layout of cities become increasingly intricate. Modern cities resemble networks, encompassing elements such as population, transportation, architecture, nature, industry, land, and water. Consequently, in urban planning and architectural design, designers must not only contemplate architectural design but also address and enhance the natural environment upon which we rely. The integration of the concept of environmental protection with architectural design is imperative. Architectural images harbor comprehensive information about architecture and environments, underscoring the necessity of employing image segmentation technology to precisely delineate architectural styles and environmental elements. This ensures the provision of more-nuanced image information and design concepts for architectural designers (Yin et al., 2022; Wang et al., 2022; Lüddecke & Ecker, 2022).

This paper introduces a model for architectural image segmentation and retrieval based on an image-segmentation network, specifically tailored for multi-perspective scenarios. The primary contributions include:

(1) Integration of spatial attention and dual-path contextual attention into the U-Net segmentation network to extract additional contextual architectural image features, thereby enhancing the network's ability to identify targets within feature maps
(2) Training the improved U-Net segmentation network on a self-constructed dataset of architectural images in this study, leading to the optimization of network parameters

The proposed approach proves effective in achieving accurate segmentation and retrieval of architectural images. This capability holds promise in assisting architectural designers in crafting superior urban architectural environment integration design solutions.

RELATED WORK

Prior to the integration of image-segmentation and retrieval technology into the realms of architectural design and urban development, architects seeking a comprehensive understanding of the overall design schemes and aesthetic styles of integrated architectural environments typically engaged in discussions with peers and consulted relevant literature. However, these conventional methods proved inadequate in meeting the sensory requirements of urban design concerning architectural style and green environments. With the introduction and application of image-segmentation and -retrieval technology, a novel solution has emerged for this challenging issue. For architects, the segmentation and retrieval of architectural images offer a superior means of acquiring relevant knowledge about integrated architectural environment design, thereby propelling the development of green cities. Consequently, the key focus shifts to the construction of an intelligent and efficient architectural image-segmentation and -retrieval model.

In recent years, the application of deep learning–based semantic image segmentation has become widespread across various domains. This approach is employed primarily to address issues such as fuzzy boundaries, low precision, and low resolution in images. When image-segmentation techniques are applied to architectural images, the model is expected not only to accurately delineate specific architectural features and refine architectural categories but also to assist designers in obtaining more-precise design solutions.

Deep learning–based semantic segmentation of images (Ulku and Akagündüz, 2022; Hemamalini et al., 2022) has witnessed widespread adoption across various domains, effectively addressing issues

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