Automatic Wall Detection and Building Topology and Property of 2D Floor Plan

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Abstract

Recently, indoor space construction information has been actively carried out primarily in large buildings and in underground facilities. However, the building of this data was done by only a handful of people, and it was a time- and money-intensive task. Therefore, the technology of automatically extracting a wall and constructing a 3D model from architectural floor plans was developed. Complete automation is still limited by accuracy issues, and only a few sets of floor plan data to which the technology can be applied exist. In addition, it is difficult to extract complicated walls and their thickness to build the wall-junction structure of indoor spatial information, which requires significant topological information in the automation process. In this paper, we propose an automatic method of extracting the wall from an architectural floor plan suitable for the restoration of the indoor spatial information according to the indoor spatial information standard.

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1 Introduction

Currently, indoor spatial information is constructed for large facilities such as subways and shopping malls. However, according to [10], indoor space construction work uses a mixture of manual and automatic methods, and requires adequate financial resources and time. It is difficult to construct indoor spatial information for general buildings and facilities. To

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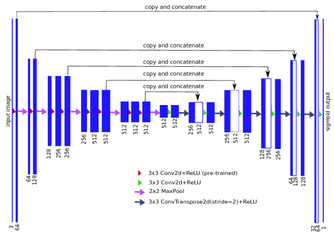

Figure 1 U-net.

overcome this, many studies automatically vectorize walls using 2D scanned floor plan images. In these studies, CAD files in DWG format, which are printed on paper, lose some of their attributes, and topological data are used. To express and restore these data from floor plans, studies have developed a standard format of indoor spatial data. OGC has introduced CityGML and IndoorGML, which are indoor spatial information presentation standards. Among them, CityGML has been developed for 3-dimensional modeling of urban space, while IndoorGML was proposed for indoor spatial information representation. According to [6], IndoorGML supports modeling of various viewpoints of indoor space using multi-layer and space division concepts, and it is essential to construct the node-link structure of space in order to compensate for the limitations of CityGML [5]. Therefore, the authors extracted the topological information of the wall and its thickness according to the indoor spatial information standard in this study. Lastly, the data used was provided by Korea 's building information integration system.

2 Related Work

Wall detection studies are based on image processing and consist of four steps. First, preprocessing is performed, where the noise of the drawing is removed. Noise, which is an auxiliary part of the data, includes numerical lines, titles, legends, etc. In the past, various filters were used to remove noise by [2], and simple neural networks have also been tested. Second, OCR is also a very important part of pre-processing, recognizing characters and replenishing the information contained in the floor plan or removing characters that may interfere with wall detection. The third step is the vectorizing process. Most algorithms deal with only straight or arc-shaped walls. Typically, [7] constructed attribute and topological information using nodes and semantic data, and only nodal points of a right angle were considered. [8] automatically generated vector drawings by applying various filters using the vertical and horizontal characteristics of the wall. [9] assumed that all the walls are straight and divided the space into rectangles of various sizes and shapes, and combined them to represent the walls, thus all the walls are represented by straight lines. The fourth is symbol recognition and is excluded from the scope of this study. At this time, it is more difficult to detect free-form walls than straight-line walls. In addition, the wall detection study shows a significant difference in performance, depending on which data are used in [1]

3 Method & Result

3.1 preprocessing with image segmentation

This study is divided into preprocessing, segmentation, and vectorization steps of the drawing, and preprocessing is accomplished using a deep neural network. The network used is U-net,

Figure 2 Drawing and label.

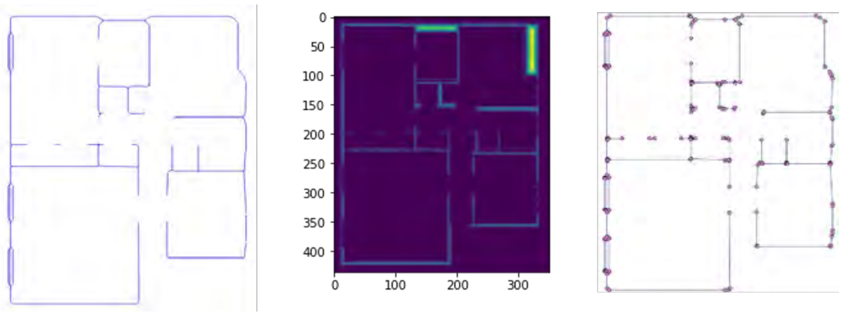

Figure 3 Skeleton, width of wall and node.

which is efficient for data augmentation; it uses context information efficiently and exhibits very accurate localization performance. U-net was selected due to its advantage of high speed and very high performance with very little data according to [3]. Since annotating floor plan data is time-consuming, few data were used. U-net was determined to be suitable for this study, and its structure is described in figure 1. To train U-net, labels 0-2 were applied to the floor plan as shown in 2. (0: wall, 1: node, 2: background)

3.2 recovering topological information

The thickness of the walls was obtained by the method of [4], and thinning was performed using the Zhang-Suen algorithm with the same data. In [11], the Zhang-Suen algorithm preserves the topological information of the wall because it provides information on the connectivity clearly, and each node of the skeleton obtained through thinning can be used as a candidate for real nodes existing on the wall. Results are described in 3.

3.3 building adjacency matrix

However, the number of extracted nodes from the skeleton tends to be overestimated compared to the actual intersections of the wall entities. Therefore, the nodes nearest to each junction were extracted separately from preprocessing as the positions of actual junctions. An adjacency matrix was constructed between junction and link, and a depth-first search was performed to simplify the graph in 4. Finally, the wall thickness value assigned to the pixels facing the detected wall was input to construct the vector data.

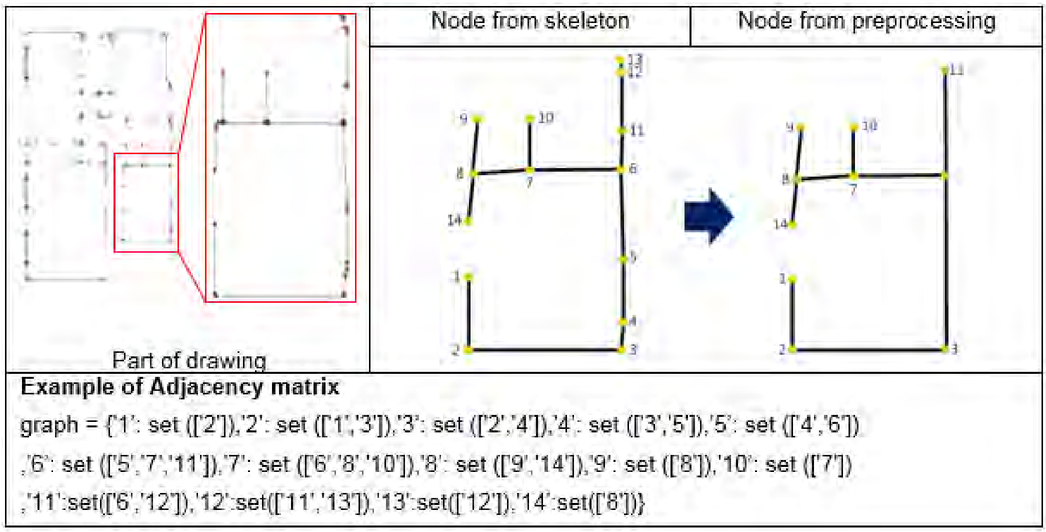

Figure 4 Node-link simplification.

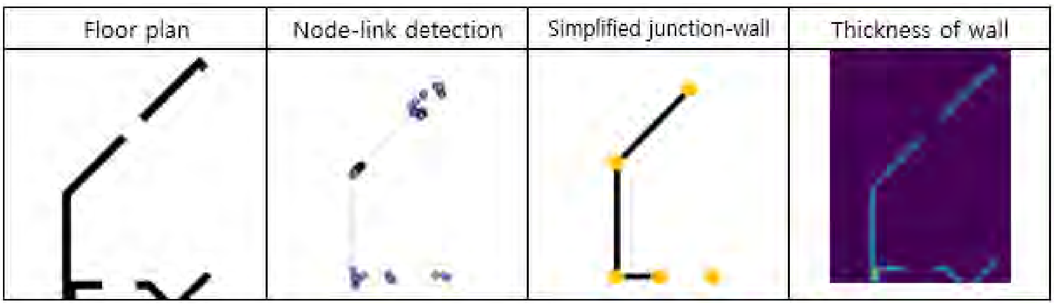

Figure 5 Whole process.

Finally, the wall thickness value assigned to the pixels facing the detected wall is input to construct the vector data.

4 Conclusion

In this study, we designed an automation process that can extract information from printed architectural floor plans with missing geometric and topological information as vectors. For this purpose, image preprocessing using U-net was performed, and characters, various numerical lines, and other shapes were removed. Next, in addition to extraction of the wall thickness, skeletonization was performed to obtain connectivity information of walls and nodes as candidates of real junctions. Although the skeletonization result is composed of the skeleton link and nodes, it is difficult to identify them as the precise junction of the building. Therefore, the junctions extracted during preprocessing are considered as a guideline of the real edge of the drawing, and an adjacency matrix was created. Lastly, the thickness of the wall was added to the graph, and the link-node connectivity information of the floor plan was finally recovered. This process is described in 5. This study aimed to deal with walls placed at arbitrary angles that are not covered by existing research and is characterized by restoring wall thickness using image processing and an adjacency matrix.

5 Future Work

In this study, we constructed an adjacency matrix using links and nodes and utilized it to determine the direction of the walls and connectivity. However, the position of each node may be horizontally or vertically mispositioned. As a result, there is a disadvantage in that the rooms recovered by our method do not form rectangles (i.e., do not have four right angles). Therefore, in order to create a room in the graph with the same shape as in the actual building, it is necessary to locate each node at the correct position. In addition, in the process of inputting the thickness of the wall as an attribute of the link and the problem of changing the wall thickness while using the mode of the near pixels must be solved in future work.

References

1. Lluís-Pere de las Heras, Sheraz Ahmed, Marcus Liwicki, Ernest Valveny, and Gemma Sánchez. Statistical segmentation and structural recognition for floor plan interpretation. *International Journal on Document Analysis and Recognition (IJDAR)*, 17(3):221–237, 2014.
2. Samuel Dodge, Jiu Xu, and Björn Stenger. Parsing floor plan images. In *Machine Vision Applications (MVA), 2017 Fifteenth IAPR International Conference on*, pages 358–361. IEEE, 2017.
3. Hongyang Gao, Hao Yuan, Zhengyang Wang, and Shuiwang Ji. Pixel deconvolutional networks. *arXiv preprint arXiv:1705.06820*, 2017.
4. Ilsoo Jeon, Namsik Won, and Kidong Bu. A preprocessing scheme of thinning capable of lines' thickness recognition for the automated vectorizing of maps. *Journal of the Korean Association of Geographic Information Studies*, 2(2):1–8, 1999.
5. Ki-Joune Li, Tae-Hoon Kim, Hyung-Gyu Ryu, and Hae-Kyong Kang. Comparison of citygml and indoorgml-a use-case study on indoor spatial information construction at real sites. *Journal of Korea Spatial Information Society*, 23(4):91–101, 2015.
6. Ki Joune Li and Ji Yeong Lee. Basic concepts of indoor spatial information candidate standard indoorgml and its applications. *Journal of Korea Spatial Information Society*, 21(3):1–10, 2013.
7. Chen Liu, Jiajun Wu, Pushmeet Kohli, and Yasutaka Furukawa. Raster-to-vector: Revisiting floorplan transformation. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, pages 2195–2203, 2017.
8. Rui Tang, Yuhan Wang, Darren Cosker, and Wenbin Li. Automatic structural scene digitalization. *PloS one*, 12(11):e0187513, 2017.
9. Wenming Wu, Lubin Fan, Ligang Liu, and Peter Wonka. Miqp-based layout design for building interiors. *Computer Graphics Forum*, 2018.
10. Xuetao Yin, Peter Wonka, and Anshuman Razdan. Generating 3d building models from architectural drawings: A survey. *IEEE computer graphics and applications*, 29(1), 2009.
11. TY Zhang and Ching Y. Suen. A fast parallel algorithm for thinning digital patterns. *Communications of the ACM*, 27(3):236–239, 1984.