Application of Style Transfer in the Vectorization Process of Floorplans

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Abstract

As the market for indoor spatial information burgeons, the construction of indoor spatial databases consequently gain attention. Since floorplans are portable records of buildings, they are an indispensable source for the efficient construction of indoor environments. However, as previous research on floorplan information retrieval usually targeted specific formats, a system for constructing spatial information must include heuristic refinement steps. This study aims to convert diverse floorplans into an integrated format using the style transfer by deep networks. Our deep networks mimic a robust perception of human that recognize the cell structure of floorplans under various formats. The integrated format ensures that unified post-processing steps are required to the vectorization of floorplans. Through this process, indoor spatial information is constructed in a pragmatic way, using a plethora of architectural floorplans.

2012 ACM Subject Classification Applied computing → Graphics recognition and interpretation, Computing methodologies → Scene understanding

Keywords and phrases Floorplan, Vectorising, Style Transfer, Generative Adversarial Networks

Digital Object Identifier 10.4230/LIPIcs.GIScience.2018.39

Category Short Paper

Funding This research was supported by a grant (18NSIP-B135746-02) from the National Spatial Information Research Program (NSIP) funded by the Ministry of Land, Infrastructure and Transport of Korean government

1 Introduction

Recently, the development of information technology has made it possible to expand location-based services such as position tracking and indoor navigation. Consequently, the indoor spatial information market has burgeoned and various studies on indoor spaces are being conducted. The accomplishment of several services and research on indoor spaces requires a database that contains information of the geometry, topology, and semantics of indoor

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10th International Conference on Geographic Information Science (GIScience 2018).
Editors: Stephan Winter, Amy Griffin, and Monika Sester; Article No. 39; pp. 39:1–39:6
Leibniz International Proceedings in Informatics
Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

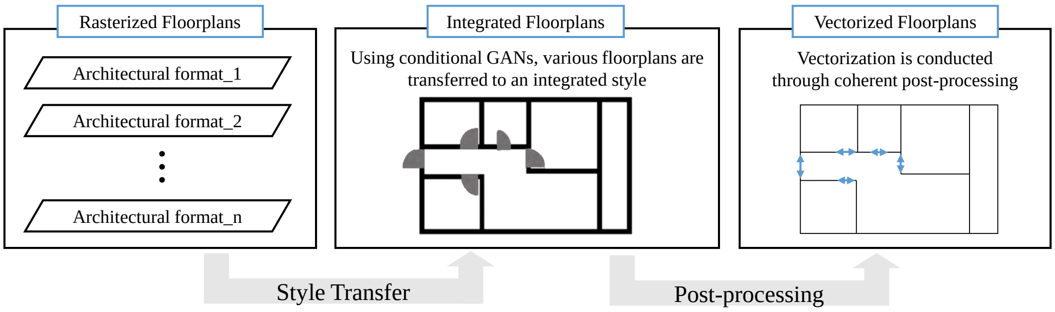

Figure 1 Study flow chart.

cells. The construction of indoor spatial information has been based on aerial photographs, 3D laser scanning, 2D floorplans, and CAD plans [7]. Among these, the 2D floorplan is pragmatically focused on because it is obviously present in existing buildings, being usually open source and simply and effectively available compared to other methods. With such features, OpenStreetMap and Google Maps provide a plug-in that allows users to build their own indoor maps using floorplans. In addition to these tools, several systems are used in the construction of indoor spatial information from floorplans, such as open sources like QGAR [13] and commercial vectorization software. These systems, however, have some limitations: the accuracy of outputs depends on the level of information represented by the floorplans, such as grid lines, layouts, symbols, and electric wiring, thus requiring heuristic revisions.

This paper proposes a method of refining various types of floorplans and levels of information in a consistent form. Even with the dramatic advances in computer vision, retrieving information on floorplans is a challenge due to the number of rooms in different houses, different formats of symbols and walls, and different levels of information. Despite all these difficulties, humans can still recognize the structures of houses from floorplans. The goal of this paper is to materialize this "perception" through deep networks by learning many types of floorplans.

2 Related work

Retrieving leaking information from raster floorplans follows sequential steps [4, 7, 8]. First, textual and graphical data are separated in a preprocessing step [14]. Then, lines in vector are extracted from the graphical data [1]. The next step is a pattern recognition that assigns semantic information, such as walls and openings, to the extracted lines [3, 6, 8]. Finally, room space is detected through the use of geometry and semantic information, including textual data [3, 12]. The studies of construction of indoor information from floorplans are, in a broad view, all or parts of these steps. Although the issue of these research is automation, they work partially or conditionally for practical datasets, demanding additional manual processes.

The main reason for handwork is that a model does not handle a wide spectrum of architectural floorplans. Previous research focus mainly on a consistent form of floorplan datasets [5] or, after classifying floorplans by wall and symbol formats, apply tuned algorithms respectively [3]. In order to ensure versatility for previous models of retrieved floorplans, the goal of this study is to convert several floorplans into an integrated and unified form. Figure 1 shows the whole workflow. Various rasterized floorplans are converted to an integrated format, and being vectorized by a coherent post-processing.

(a) (b) (c) (d)

Figure 2 Different floorplan formats: (a) format with simplified walls, (b) format with bearing walls, pillars and the interior symbols, (c) format with the electronic wiring, (d) format with different representative of walls.

We approached the problem by integrating diverse formats of floorplans with a style transfer that converts domains of data while maintaining their features. Recently, image style transfer has improved remarkably with the development of generative network models. Based on Generative Adversarial Networks (GANs), deep networks, such as Conditional GANs [9] , CycleGANs [15], and DiscoGANs [10], have gained great reputation on style transfers. Conditional GANs and CycleGANs transfer images into different styles with preserving the underlying structure, while DiscoGANs focuses primarily on the texture of them. Conditional GANs works in condition that labeled pairs exist, while Cycle GANs and DiscoGANs aims to convert domains even when images in each domain are not paired. We propose an integrated format with a strength in vectorization and convert floorplans to this format. Given the characteristics of each networks, we use Conditional GANs because we prepare pairs of floorplans in the integrated format and underlying structure of floorplans that conveys geometry information is important on our goal.

3 Style for integrated floorplans

In order to integrate different floorplan formats into a unified format, the following should be considered: 1) the represented information shared in diverse floorplans, 2) the meaningfulness of the level of information extracted as material for indoor spatial data. The architectural floorplan spectrum that can be used for the construction of indoor spatial data is variable (Figure 2). In Figure 2 (a), the wall structure is simplified and detailed information, such as equipment, is omitted. Figure 2 (b) represents the bearing walls and the pillars, as well as several interior symbols. Figure 2 (c) represents the electronic wiring on the topology of the walls. Figure 2 (d) represents walls with different formats and some noises is present. Floorplans of such varied purposes, however, preserve a structure of cells made of walls and openings. In the integrated format, the simplified walls and openings are targeted as representative of the floorplan. Homogeneous walls and openings containing original information represent the structure of cells. Figure 1 shows example of the integrated format. Research on indoor information, such as matching indoor position with photo, are based on the extrusion of simplified walls with openings [2, 11]. In other words, indoor research generally uses only the topology of walls and openings, which means that the integrated floorplan style can be used significantly.

A floorplan dataset was provided by the E-AIS (Electronic Architectural Administration Information System), which is an architectural floorplans management system maintained by Korea's Ministry of Land and Transport. Approximately 400 floorplans in various formats were used and manually annotated to the integrated format.

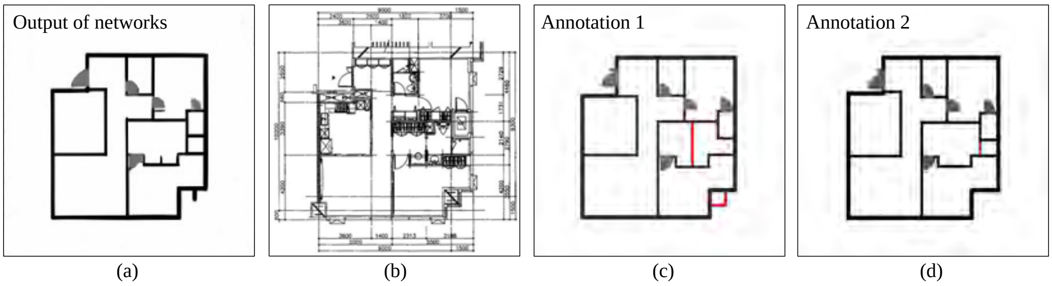

Figure 3 (a) output, (b) original floorplan, [(c) annotation 1 and (d) annotation 2] are annotations by different annotators. In relation to the original floorplan, annotation 1 represents the boundary column and the sliding door as a wall, while annotation 2 disregards this information.

4 Style transfer via conditional GANs

Conditional GANs proposed by Isola *et al.* [9] are practical and effective networks that transfer style preserving intrinsic features when data pairs are given. The generating networks are type U-net, which have the advantage of keeping the underlying structure, and the discriminating networks are type PatchGANs classifier, which discriminate generated images by summing up score of each patch implicitly. The integrated format and its correspondents were fed simultaneously, and both networks improve competitively. The network structure and the parameters were modified for the purpose of ours.

The goal of this study is to transfer floorplans to the integrated style. To maintain the underlying structure of floorplans, tuning is performed in a direction that emphasizes the sharp edges and the position accuracy of the simplified walls and openings. Regarding hyperparameters, 1) the L_1 error was increased by 1.5 times compared to that in the study on conditional GANs, and 2) the patch size of the discriminator was adjusted to 16×16. The lower the ratio of L_1 error to generative error, the sharper the extracted walls, although they tend to be cut off. The smaller the patch size, the neater the induced outputs without noise, even if computation becomes larger. The aforementioned parameters were mutually determined for the networks.

The advantage of using generative models rather than pixel-based classification models such as Convolutional Neural Networks(CNNs) is that the structure of cells and the shape of the homogeneous walls are “selected and generated” by networks. As seen in Figure 2, many architectural floorplans are neither neat nor homogeneous, which means that the outputs of the classification models require demanding post-processing steps.

5 Qualitative evaluation

Given that the purpose of this work is to transfer floorplans from various formats to the integrated one, this study inevitably aimed at ambiguous criterion. The annotating depends on individuals while prioritizing a representation of the cell structure, thus yielding multiple annotations match with one floorplan (Figure 3). Since the networks were trained with these pairs, we do not ensure their incorrectness even when the outputs do not match with the annotations. Figure 3 (a) shows this. An output (Of course, this pairs is only used in test set) does not match with both annotations but represent the cell structure quite well. Therefore, an evaluation should take account of preserving structure of cells, which was inappropriate for raster output images. For this reason, qualitative evaluation is performed for the style transfer.

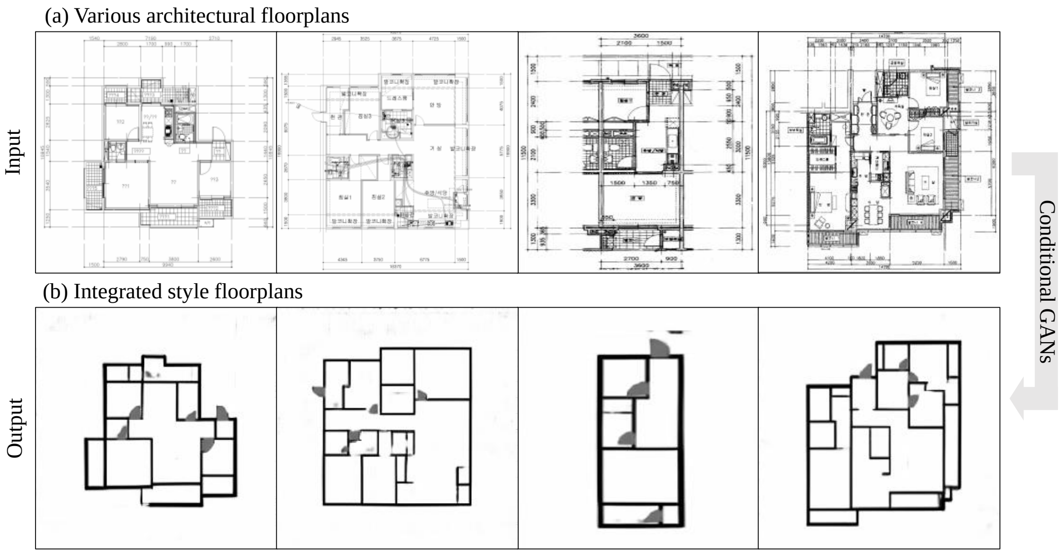

Figure 4 Results (a) Various architectural floorplans as inputs, (b) Transferred floorplans in the integrated format as outputs

Figure 4 shows the results of the style transfer. Figure 4 (a) represents various floorplan spectra used as inputs, while Figure 4 (b) represents the integrated style floorplans operated by deep networks. Despite the diverse formats and levels of representative information, the floorplans were transferred into the coherent, integrated form. The networks generate walls with uniform shape and clear boundaries even in conditions where the original walls were crooked, or edges were blurred. However, in the case of openings, the positions were extracted correctly, but the boundary was blurred. In particular, the networks perform well at points where the information was overlapping (e.g. doors on tile patterns, pillars in walls) which was identified as a difficulty in previous studies.

6 Conclusion

When applying style transfer via conditional GANs, diverse floorplans were transferred into the integrated format. The deep networks is suitable for this problem, we confirm that it works well. This ensures that single unified post-processing steps are required to the consummation of vectorizing floorplans. Through this process, it is possible to construct indoor spatial information in a pragmatic way, using a plethora of architectural floorplans.

For further study, we will perform additional evaluation. This paper covers suggestion of the style transfer in the vectorization of floorplan, thus only the qualitative evaluation is performed. In the field of retrieving information from floorplans, a match table is a common evaluation method for vector results, that is proper forms for representing cell structures. Thus, after whole vectorization that is specific to the integrated format, we will perform the matching-based assessment as a quantitative evaluation.

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