Intelligent Archiving of Interior Design Images using Panorama Picture Sources

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Abstract –

This paper aims to propose an approach to establishing an intelligent interior design reference image database using 360-degree panorama picture sources. Building interior design reference images are usually taken by people in an ad-hoc way and stored/used for various purposes as non-standardized design communication resources. As several web/apps provide such resources, in this paper we suggest a certain organized way to build an interior design image resource that can improve design communication between architects and other stakeholders. Recent daily-life web/apps have collected architectural design images uploaded by users, but stored images hardly used for professional design purposes due to issues of sufficiency, quality, consistency, copyright, liability etc. In this paper we focus on the sufficiency and quality issues by using a deep learning enabled auto-classification of interior pictures extracted from a high-definition panorama picture source. The input image also can be generated by photo-realistic render software if it is a planned design. This paper describes an approach to simplify the process of establishing such an archive; 1) preparing panorama image, 2) auto-extracting entire interior reference images, 3) auto-classification and/or detection of the context represented in each picture to enrich pictures' dataset, and 4) archiving image data with generated information to be used for various design purposes. This paper also demonstrates an intelligent archiving of interior design reference images process implemented as a web/app software prototype.

Keywords –

360-dgree panorama picture; Data Archiving; Interior Design Reference Image; Auto-classification; Deep Learning

1 Introduction

Understanding the intention of architectural design is usually hard to people because of various reasons, including jargons and/or notations used by experts [1]. That is simply why architects and designers have used effective design visualization tools to make their communication easier for people. Design visualization is one of the key factors of decision-making in the architectural design process [2], and it is represented in diverse forms including standardized drawings, images, videos, and often with text [3]. As growing digital design techniques, such a design communication has been mainly involved with various visualization methods and media such as 3D models and live-action rendering techniques [4,5]. Especially in the perspective of interior design visualization, a high level of detail and realistic visualization that is very close to the as-built state of design is strongly necessary [6]. Our objective of this research is not on the intrinsic aspect of design, but on technical aspect of such visualization data. Thus in this paper we propose an intelligent approach to archiving interior design images using 360-degree panorama pictures of real spaces and photo-realistic renders of design models, and demonstrates an actual implementation of the process suggested.

In the case of the architecture domain especially in the construction phase and the facility maintenance phase, 360 panorama images are mainly studied and used in the Architecture domain, and utilization in the design phase has also been recently studied [7]. However, for 360 panorama images, it is difficult to verify images without distortion without specific devices such as HMD. In addition, these devices can cause users to experience discomfort such as motion sickness when worn. Therefore, rather than using the 360 panorama images circular image, this study converts the image post-processing process into a more easy-to-see and familiar form and enables it to be used as a reference image.

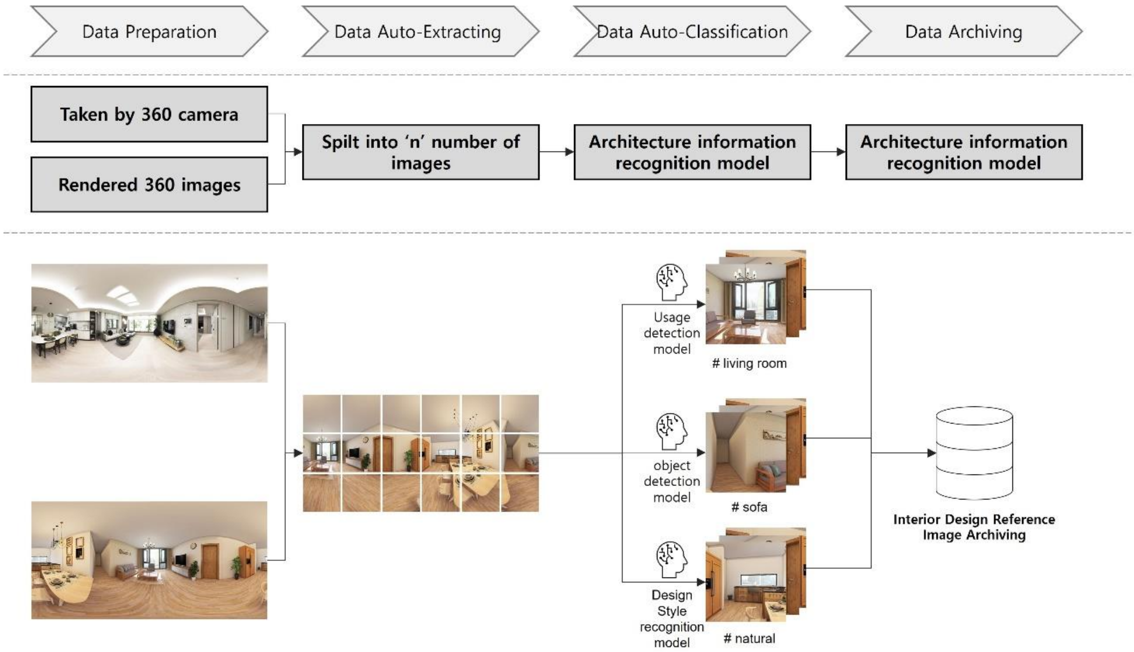

Figure 1 Intelligent archiving of interior design reference images process

As a preliminary study for the implementation of this approach, this paper explores the ways to segment 360 panorama images into ordinary images and to infer design reference images or pictures using the deep learning-based model. The scope of this paper is on training deep learning models that recognize space usage of images, calculate visual similarity with other images, and propose an approach to visual input-based auto-labeling on segmented images.

For training such intelligent models, this paper utilizes a deep convolutional neural network (CNN) model that showed the successful performance of understanding general object [8], context [9]and even design attributes of interior design object [10] on visual data [11]. The feature map data is used as input data to train models recognizing design attributes of space usage. The results of recognition are used to label segmented images from 360 panorama images. The labelled images are stored in an interior reference image database.

2 Background

2.1 Interior Design Reference Image

Interior design visualization methods have changed over a long period of time [12]. What is now known as the beginning of the design representation is a painting of the architecture of ancient Mesopotamia on top of shells [13]. To date, various tools and technologies have emerged, and the methods of design visualization have changed accordingly. As design visualization methods change, various studies and developments have been conducted on databases that store drawings and photographs, which are the results created through design representation results.

2.2 A Panorama Image as Interior Design visualization Method

360 panorama image is characterized by a single image expressing various views. It has the advantage of being able to acquire multiple angles of view from one image based on those features and the various information contained in the panorama images. Based on these advantages, there has been active discussion on how to utilize 360 panoramic images in the AEC-FM (Architecture, Engineering, Construction, and Facility Management) industries. It is used in various stages of design, construction, and maintenance.

In the design stage, it is used to implement virtual reality that allows users to experience virtual design created through CAD and BIM authoring tools more realistically. The development of three-dimensional model-authoring and rendering visualization tools has made it easier to create panorama images. A study is conducted to encourage non-expert consumers to participate in the design process using augmented reality [14]. There is also a prior study to develop a unified design process for laboratory layouts using Virtual Reality (VR) instruments to create ways to interact with users' thoughts [15].

In the construction stage, it is used for on-site management, such as reviewing the progress of construction at the construction site, reviewing the quality of construction, and safety management. The prior research was conducted on architectural and design visualization using VR, construction health and safety education, equipment and operation work training, and structural analysis for training workers at construction sites [16]. Many studies have been conducted on the use of VR in the field of safety management. To protect workers at construction sites, which are sites of high-risk industries, complex tasks were visualized in advance and risk factors could be eliminated in advance [17].

During the facility maintenance stage, it is being used in various fields such as change history management of space changes through regular filming and virtual VR home tours. Studies have been conducted to use VR to visualize the applicable technical information related to the wear and tear aspects of materials defined over a specific period for each element of the structure [18]. In the maintenance stage of the building, not only academia but also various industry sympathizes with the advantages of panorama images and actively utilize them.

3 Preparing Input Image

3.1 360 panorama picture sources generation

There are a variety of spaces that are subject to 360 panorama images for interior design visualization and tools used to author source images. In this paper, apartments, a typical residential facility in Korea, were designated as the target space for source image authoring. There are two methods of creating panorama images: 1) photographing the actual space with a 360-degree camera, and 2) generating it using 360-degree rendering in a 3D model authoring tool. The former method is used for the maintenance of facilities in the space in use. In the latter case, the architecture after completion in the initial design stage can be experienced in advance. Subsequently, written models and images may be used as data to manage the entire life cycle of a building until the maintenance of a facility.

3.1.1 360 cameras

In 2015, 360-degree cameras began providing 360-degree video playback services on the ‘Y’ platform, a video playback platform, and various models and products appeared in the market. We select as the target space for generating input images using 360 cameras an 84-square-meter apartment located in Seoul, South Korea. Input images were collected and proceeded with e-model house images that existed on the web without being photographed directly by researchers. Due to the covid-19, the Korean real estate market has been actively using the e-model house. The process of creating an e-model house to sell apartments can be seen in Figure 2. Figure 2 shows the location of the panoramic image of the apartment on the floor plan of the apartment and the source image was taken. For small spaces, the entire space can be represented by a single panoramic image. However, for larger spaces, such as living rooms in apartments, the images taken without blind spots can be obtained by dividing the space into grids. It also enables the collection of input data taken by a space from various angles of view.

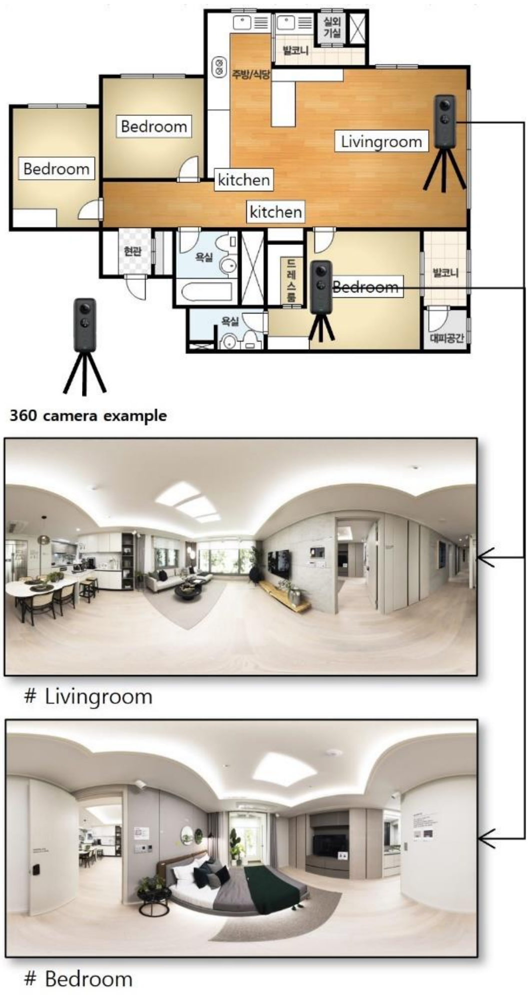

Figure 2 Real space 360 panorama images taken by 360 cameras

3.1.2 Rendering 360 images using CAD/BIM SW

The target space for creating source pictures using 360 landing is also an 84-square-meter apartment in Seoul, South Korea. Figure 3 shows the generation of 360 panorama images based on three-dimensional modeling authoring tools. Generating 360 rendering based on three-dimensional model authoring tools is now supported by various tools due to advances in computing technology. In this paper, we used the 'H' program, a web-based three-dimensional modeling authoring tool. A three-dimensional model was created based on an apartment floor plan (Figure 3).

For three-dimensional models, three virtual design proposals were created based on the same apartment floor plan to show various examples. After the modeling is completed, a 360 panorama source picture is created based on cloud rendering. Cloud rendering is a technology that transmits 2D or 3D graphics rendering from client servers to cloud servers. This has the advantage of being fast and being able to perform other tasks during the operation by proceeding to render on the server's computer without using the client-side computer. The reason why we used the 'H' program in this study is that it provides the most realistic cloud rendering service. In addition, web-based interfaces make it easier for users to access three-dimensional modeling.

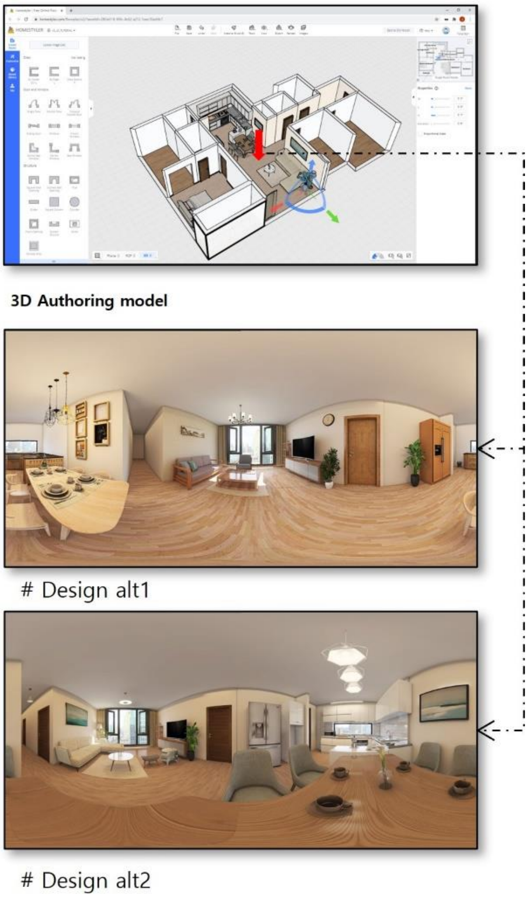

Figure 3 360 panorama images of virtual design alt images

3.2 Extracting of panorama images

For 360 panorama images created using the two mentioned methods, it is difficult to utilize them as interior design reference images. While VR devices allow for immersive observation of visualized spaces, images themselves that can be observed with planar displays are distorted and represented. Post-processing is required to utilize the generated source images as an interior design reference image without the help of other devices. Post-processing methods of panorama images vary according to their attributes and purposes. Based on the web interface, this study proposes not only segmenting 360 panoramic images into images of multiple typical angles of view but also restoring distorted images to their original shape.

Figure 4 shows two methods of extracting 360 panorama images. The first method is to divide the 360 panorama images by inputting the desired angle of view, left and right angles, up and down angles, and the size of the image. This method has the advantage of allowing users to cut out specific parts using the location, angle of view, size, etc. they want. The number of images that are divided can also be set arbitrarily by the user. For the second method, source panorama is divided into cube maps which are hexahedrons. For this method, a 360 panoramic image is divided into the ceiling, and the floor, and four sides of the wall. It also has the advantage of being able to easily return to the existing source panorama images by combining all the extracted images.

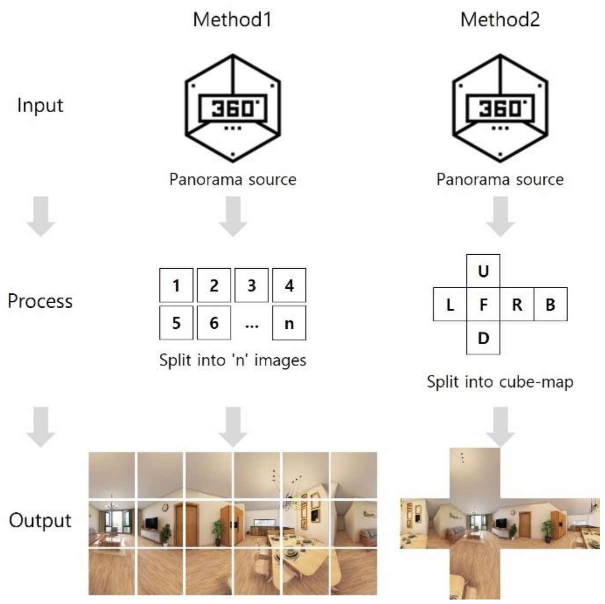

Figure 4 Auto-extracting from source 360 panorama pictures

4 Intelligent Archiving of Interior Design Images

4.1 Auto-classification

This paper proposes an approach to auto-labeling architectural information such as space usage and object of extracted images. The architectural information contained in photographs varies, including metadata, geometric data, and topology data, but this paper deals only with space usage data. If the usage of the space is inferred, a variety of architectural information, including the furniture object information placed there, can be obtained together.

In this paper, the feature map data derived from apartment images are used to get semantic information of picture and visual similarity information. To get test images we age segmentation tools which method are written above. These images are input image into the deep convolutional network [19]. We use VGGnet [20] model that previously trained the ImageNet dataset [11].

Table 1 Results of auto classification of space usage

Image	Livingroom	Kitchen
	99.64%	0.36%
	21.87%	78.13%
	99.37%	0.63%
	26.81%	73.19%

The number of data used to train the model is 300 pictures of each living room and kitchen. Image crawling is used to collect train and test images. An extension program is used for image crawling. The program allows users to download images that are available from G's search engine. Table 1 shows the results of the trained model. The accuracy of the test model is 88%. Table 1 shows the resulting values from two 360 panorama source pictures as input values for the classification model. We show each image and probability of having the highest probability of living room and kitchen among images extracted from two source pictures.

4.2 Archiving image data

We propose a method for recognizing the architectural information of extracted images and storing them with text. Storing recognized information with extracted images is important in terms of archiving data. Storing recognized information with extracted images is important in terms of archiving data. Storing images based on recognized information is a requirement in terms of accumulating and utilizing structured data.

The prototype developed in this paper is to label the usage of the space using the deep learning-based classification model. Figure 5 shows a developed web-based prototype. The prototype usage is as follows; 1) the user enters the source 360 panorama picture, 2) the image is extracted accordingly when the user chooses

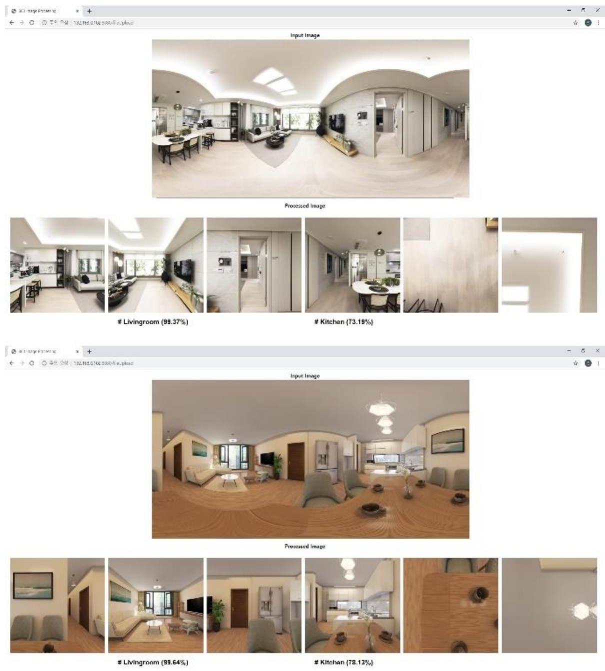

Figure 5 Web-based image extraction and labelling prototypes

the image segmentation method, 3) Among the split images, the living room and kitchen are labeled with the most likely living room and kitchen using a classification model, 4) the result is shown to the user.

5 Conclusion

This paper proposed the approach to developing a database of interior design reference images using indoor 360-degree panorama picture sources and deep learning-based image recognition. The suggested process of developing database is as follows; 1) Collecting 360-degree panorama images. 2) Image-processing to extract significant parts of a 360-degree panorama image as design reference. 3) Recognizing design-related information on extracted parts of image using CNN-based image classification model. 4) Archiving processed images with recognized information. This paper also implemented and demonstrated the prototype app that automatically archive interior design reference data from inputted 360-degree panorama images.

Results of this study can be summarized as follows. As source of the 360-degree panorama images in this process, not only the high-definition taken picture using 360-cemera but also photo-realistic rendering virtual images that are generated by CAD or BIM are utilized. The methods to divide given indoor 360-degree panorama image include a parametric way and pre-set cube-map way. Through the first method, given image are divided into gird with specific view angle and image size. On the other hand, the cube map method generates only 6 images with difference view and static image size. Trained deep learning-based CNN models label design-related information such as space usage, design style etc. on each of divided images. The divided images are automatically archived with labelled data at database.

The paper contributes to facilitating to archive and utilize massive and qualitative 360-degree panorama image data in the field of architectural design. Especially, it is expected to standardize the way of archiving interior design reference that are dealt with an ad-hoc way by people. As the future works, the author are extending the scope of recognized information (e.g. each design-related object) from given interior design images, and developing way to utilize archived data in design process.

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