

Mobile Augmented Reality System for Design Drawing Visualization

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Abstract— This paper suggests 3D Model Visualization System of Design Drawing based on Mobile Augmented Reality which supports information needed in real environment, which is made with adding virtual 3D objects to the 2D drawing by applying technology of augmented reality. The proposed visual system makes those who don't have any specialized knowledge understand the drawing easily, because 3D model is augmented over the drawing through camera of smart phone was added without any marker. Recognition time of suggested 3D model visualization system is reduced roughly 4 to 33 % compared with the existing method by extracting and matching feature point only in ROI, and recognition rate shows improvement of 5 to 15%. Performance testing on the Android phone of the proposed system shows display of video faster over 7 to 8 frame per second compared to the existing method.

Keywords—Augmented Reality, Ship Design, Virtual Design, Design Visualization, Digital Shipbuilding

I. INTRODUCTION

As the use of personal telecommunication devices such as smartphone becomes popular, a wide variety of contents correspondent to those devices have been generated by applying new technologies. From the perspectives of efficiency and convenience, these contents require technologies supporting interaction between human and computer. Among the technologies involving human computer interaction(HCI), an augmented reality(AR) has drawn attention recently. In particular, mobile augmented reality(MAR) gets spotlight[1]. AR enhances or augments information of an object or an image in a real environment by blending real world information and synthetic information. AR is also called as an extended reality from the viewpoint that it enables to extend human sense and perception for an object [2-4]. Since the AR tends to improve the user's sense of immersion and sense of reality, it has been applied to lots of applications in various areas such as broadcasting, shopping, medicine, education, army, game, construction and manufacturing area etc. [5-7].

In cases of manufacturing, mechanics, construction and shipbuilding industries, a two-dimensional design drawing is usually used as design document in order to build an actual structure. The drawing helps a construction manager and an

engineer identify user requirements and understand what they are physically constructing. In the design phase, user requirements are identified and reflected to the design drawing. In this process, the design drawing is an important tool because designer, construction manager, builder, engineer and users are using it when they are communicating with each other. Unfortunately, interpretation and correct understanding of drawings are one of biggest challenges for people who are involved in construction, because the drawing generated at the design phase is usually expressed numerically. To overcome those kinds of challenges, a variety of researches have been conducted with a focus on visualizing two-dimensional drawing using AR technology in some industries like manufacturing, mechanics, construction and shipbuilding [9-11].

In this paper, Mobile AR based 3D model display system, which augments 3D structures on top of the 2D drawing, is implemented. This paper also proposes techniques enabling to improve its performance.

II. 3D MODEL DISPLAY SYSTEM USING MOBILE AUGMENTED REALITY

This paper proposes 3D model display system for visually presenting a design drawing using AR. The system can be a useful tool to identify user requirements and to aid builders and engineers to have a better understanding of real structure. Figure 1 is Conceptual Diagram of Mobile Augmented Reality System for Design Drawing Visualization.

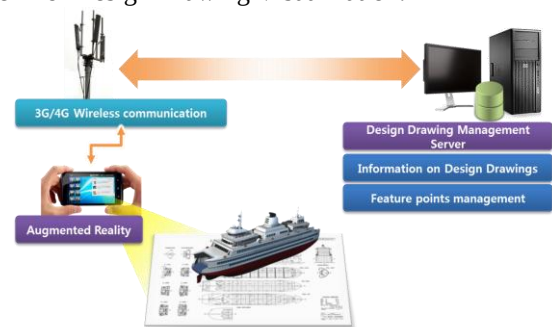


Figure 1. Conceptual Diagram of Mobile Augmented Reality System for Design Drawing Visualization

A. Recognizing Design Drawings

The mobile augmented reality system for design drawing proposed by this paper is implemented using non-marker based AR technology which enables to recognize existing design drawings without inserting specific marker into the drawing. The processes in which design drawings are recognized is shown in figure 2.

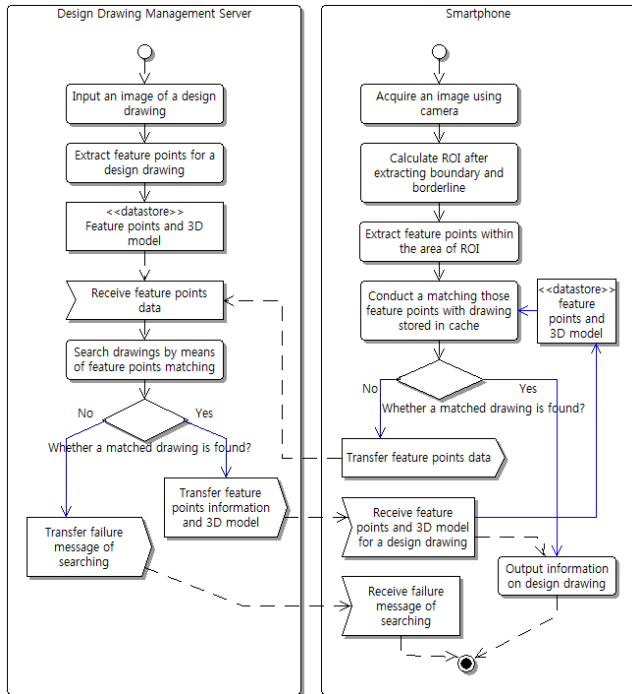


Figure 2. Design Drawings Recognizing Process

Firstly, design drawings are entered to the server by using scanner. Feature points are extracted from the drawings using feature points extraction algorithm. The extracted feature points are stored in database together with 3D model. Subsequently, drawing image is acquired by taking photo using a camera embedded in a smartphone. From the obtained image, boundary and borderline are extracted. Then regions of interest(ROI) for a rectangle area of the drawing are calculated. After extracting feature points within the ROI, a matching operation is carried out by comparing between extracted feature points and the feature points of drawings stored in a cache. If there exists the drawing with matched feature points, fetch the information about the drawing from cache memory. Otherwise, send the feature points to the server in order to search data stored in server. Once the server receives the feature point data, it retrieves the design drawings stored in its database using the method of feature point matching. In this case, the drawings with highest similarity are searched using SURF(Speeded Up Robust Features) algorithm. When the search is completed, the found feature points and 3D model would be transmitted back to cache memory in a smartphone. The smartphone shows the message to the user, so that the user recognizes that the drawing data with matched feature point now exists in cache memory. However, if the server

couldn't find the matched drawing in its database, it returns failure message back to the smartphone. Then smartphone displays failure message to the user.

B. Design Drawing 3D Model Visualization

Once a drawing is completely recognized, the process to augment 3D model on top of the 2D drawing is being conducted as illustrated in figure 3. 3D model and the feature points for the design drawing stored in cache memory are loaded into a smartphone visualization module. Then camera takes a photo of a target drawing. Based on the photo image, ROI coordinates are detected for the rectangle area of the drawing. The edge coordinates of the rectangle are tracked and then a distance and an angle between a camera and a drawing are estimated. Corresponding to an estimated distance and angle, 3D model would be adjusted like moving, expanding, shrinking or rotating. Finally shading effect is added to 3D model. The resulting 3D model is visualized on a screen of the smartphone. In the meanwhile, if there is no user input, all of the above processes are executed under an iterative loop starting from getting input of a camera image. When a user input occurs, correspondent events are handled such as expanding, shrinking, rotating and terminating.

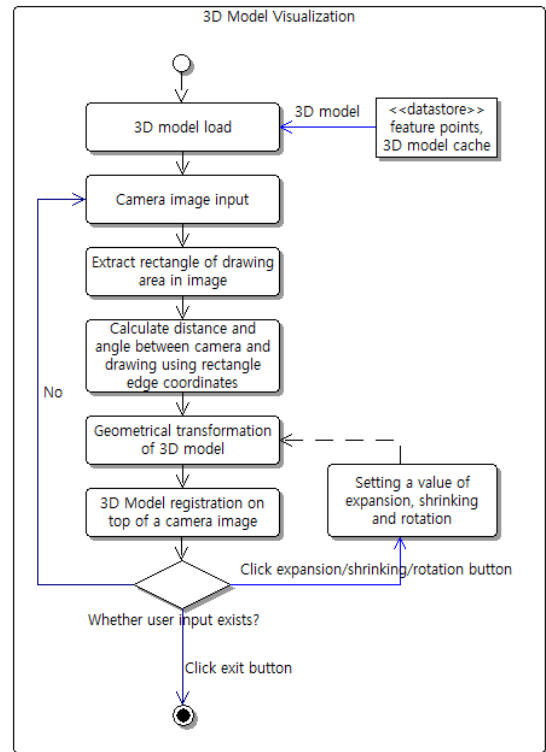


Figure 3. 3D Model Visualization Process

III. IMPLEMENTATION AND PERFORMANCE ANALYSIS

A. System Implementation

Developing environment: To analyse feasibility of the proposed mobile AR system for design drawing visualization,

android-platform smartphone application and a drawing management server were developed. For a design drawing management server, hardware specification is as follows: INTEL i7 3.40GHz, 16GB Memory and SSD 256GB. As for smartphone, hardware specification is Qualcomm Snapdragon S3 Dual Core 1.5GHz and 1GB memory. Android 4.1.2 Jelly-bean is used as platform. Screen resolution is 1280×800.

Design drawing and 3D model database: For implementing the proposed system, management server for dealing with design drawings were developed. In conjunction with the server, database was also developed. The database was designed to be used for storing 20 types of design drawing images, feature points and correspondent 3D model. The 20 types of models were generated using Catia modeling tool.

Implementation result: The implementation result is explained here. Total 20 models were entered to the system as an input. The system supports to expand, shrink and rotate the image as user wants. Each part comprising the whole image can be displayed. Figure 4 shows a demonstration of running mobile AR-based 3D model display system.



Figure 4. AR execution demonstration

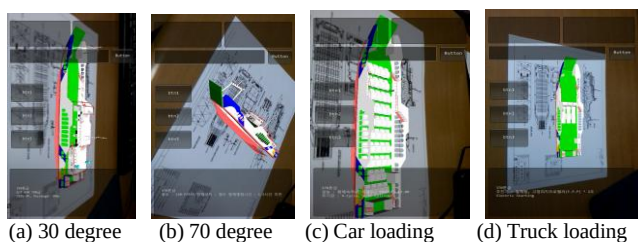


Figure 5. Rotation and Partial display screen of an augmented 3D model

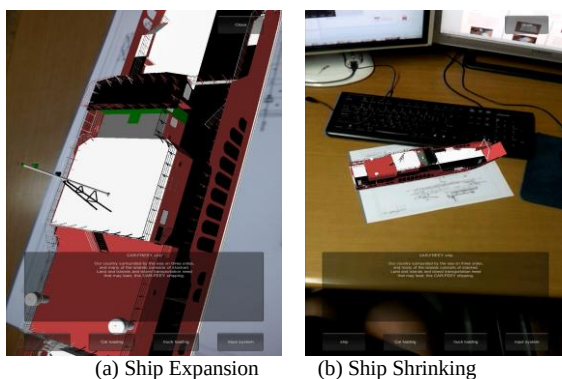


Figure 6. Expansion and shrinking screen of an augmented 3D model

Figure 5 shows screens where an augmented 3D model is presented as rotated image and as partial display. Figure 6 shows screens where a ship is presented as expanded and shrunk image respectively.

B. Performance Analysis

Performance regarding a recognition of design drawing:

To estimate system performance, a comparison between the proposed technique and an existing technique was conducted by measuring a recognition rate and recognition time duration for the design drawings. In the proposed technique, ROI is firstly detected within the drawing image and then matching is done by using only feature points extracted from ROI. In contrast, the existing technique extracts feature points from an entire region of the drawing image. For carrying out the system performance analysis, 20 different types of design drawings were taken pictures using a rear camera of the smartphone which was used in this study. When taking pictures, camera angle and distance to the drawings were varied. Those pictures were entered to the system as inputs. Figure 6 shows a scene how a design drawing is taken a picture using the smartphone which is a component of mobile AR 3D model display system.



Figure 7. Drawing test process

Total 20 tests were carried out. In each test, the design drawing was taken from a different direction, for example, front, side and diagonal direction. For each angle and direction, tests were conducted for the pro-posed method and an existing method. Therefore, total number of tests conducted is 180. In this test, measurement items are two: recognition rate and recognition time duration. To get rid of any effect of a lagging time which might occur in communicating between the server and the smartphone, feature points and 3D models were stored in a cache memory of the smartphone prior to conducting tests. The process to detect feature points by extracting ROI from the design drawing is shown in figure 8. The technique proposed in this study detects and extracts ROI first as illustrated in (a). Secondly, remaining area except for the ROI is marked to be black as presented in (b). Finally, feature points are extracted using SURF algorithm.

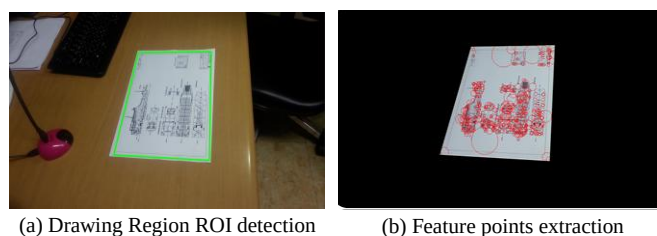


Figure 8. Feature Points Extraction from Design Drawing

Figure 9 (a) and (b) shows a matching result for the proposed method and an existing method respectively. In case of (a), matching process is carried out only for ROI region. It implies that time to be taken for matching can be lower and matching accuracy can be better than that of an existing technique. In case of (b), however, matching needs to be conducted for an entire region of a drawing. It indicates that time to be taken for matching would be increasing. Furthermore, other objects surrounding the core part affects and distracts the matching task.

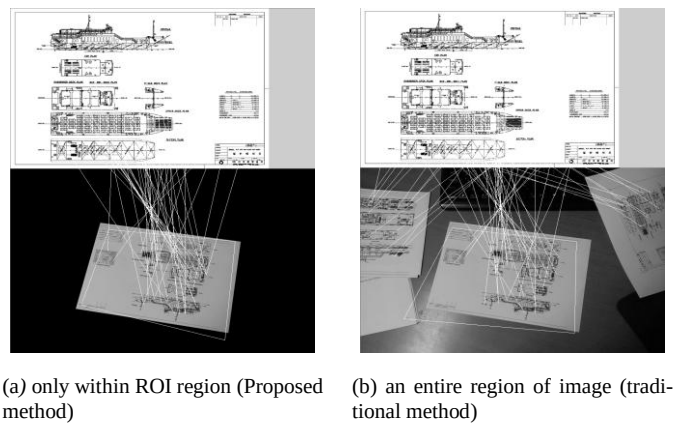


Figure 9. Feature points matching for design drawings

Recognition results for the drawings are listed as table 1. According to the figures in table 1, the proposed technique shows higher recognition rate than a traditional method by 5~15%. In terms of recognition time duration, the proposed method shows 23~32% lower than a traditional method. These results come from the fact that the proposed method excludes remaining region by detecting ROI of rectangle area for the drawing prior to carrying out feature point matching. The total number of feature points to match becomes less than that of a traditional method. Therefore, calculation amount would be decreasing.

TABLE 1. DESIGN DRAWING RECOGNITION RATE TEST RESULTS

Test Item	Angle	Proposed technique			Traditional technique		
		Front	Side	Diagonal	Front	Side	Diagonal
Recognition Rate (%)	30	95	90	85	80	75	70
	50	100	95	90	90	90	75
	70	100	100	100	100	95	95

Performance Analysis for Design Drawing Visualization: To estimate the performance especially for image registration technique used in the proposed visualization method, time to be taken for augmenting process was measured by the number

of frames per second. In case of a traditional method, feature points are extracted first. Secondly, a distance and an angle between camera and the design drawing are calculated by matching the feature points. And then, 3D model is geometrically transformed for performing image registration. In the process of feature point matching, a significant amount of calculation is required, so that the image registration cannot be performed in smooth way. In contrast, the proposed method firstly detects ROI of rectangle from a camera image. A distance and an angle between the smartphone and design drawing are to be calculated only within the ROI. Then image registration is performed after geometrically transforming 3D model. An amount of calculation necessary for each frame would be lower. Hence image registration can be performed smoothly. Model visualization test results are presented in table

TABLE 2. 3D MODEL VISUALIZATION TEST RESULTS

	The number of frames per second
Traditional Method (Tracking an entire region. And then performing image registration)	14~20 Frames
Proposed Method (Tracking ROI rectangle. And then performing image registration)	21~28 Frames

IV.CONCLUSION

In this paper, mobile AR-based 3D model display system is proposed. The proposed system is capable of recognizing the design drawing without being necessary to insert an additional marker or label to an image. The proposed system enables the display of 2D drawings into the real world visualization using mobile AR reality technology in a way that can aid people’s better understanding for the design drawing, which contributes to more accurate and efficient design and manufacturing process management.

In terms of performance of the system, recognition rate is higher and calculating amount is lower compared to the performance of a traditional method, because the proposed system extracts feature points concentrating on only ROI of the design drawing rather than an entire region. Furthermore, 3D model can be visualized by only very low amount of calculations since it tracks rectangle area of ROI. Compared to matching for an entire image area, the proposed technique shows increased recognition rate by 5-15%. In terms of time duration to be taken for recognizing image, the proposed technique shows to be lower by 4-33%. In case of 3D model visualization, image output speed is also more than 7-8 frames per second quicker.

This system is expected to be a communication tool for aiding people who are not familiar with two-dimensional drawings, or who are lack of basic knowledge about ship, mechanics, construction and manufacturing industries.

For future work, it is necessary to generate 3D model for an internal structure of specific part of a design drawing as panoramic images and to display them efficiently.

ACKNOWLEDGMENT

“This research was financially supported by the Ministry of Education (MOE) and National Research Foundation of Korea(NRF) through the Human Resource Training Project for Regional Innovation (No. 2013H1B8A2032217).”

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