Augmented Reality Using Multiple Barcodes

Tohru HIROI, Masaaki FUJIYOSHI, and Hitoshi KIYA
Tokyo Metropolitan University, Hino-shi, Tokyo 191–0065, Japan
E-mail: hiroi-tohru@sd.tmu.ac.jp, mfujiyoshi@m.ieice.org, kiya@sd.tmu.ac.jp

***Abstract*—This paper proposes an augmented reality (AR) system using multiple two-dimensional barcodes. The proposed system uses a barcode as a fiducial marker, and the system retrieves information directly from barcodes. In contrast, the conventional AR systems send a marker image captured by a camera to a server to identify the marker by pattern matching with any possible markers in a marker pattern database, and then retrieve the information related to the marker from the marker-information database. Moreover, in the proposed AR system, the superimposed information changes depending on the combination of barcodes. These features of the proposed system reduces the cost for construction of AR systems.**

I. Introduction

Augmented reality (AR) systems are one of mixed reality systems which mix a real scene viewed by a human and a virtual scene generated by a computer. An AR system superimposes a virtual scene and/or information onto a real scene to augment the real scene. Traditional information presentation systems show information on a display or paper, so a user must see the information aside from what the user should take notice or control in the real scene. In contrast, an AR system can directly present information at what a user should take notice or control in a real scene, thus the user can see information or virtual objects generated by a computer as if it were in the real scene. Consequently, an AR system enables users to receive information naturally and viscerally.

In addition, in recent years, the performances of CPU and GPU are improved and the low price web cameras are available in the market. Moreover, powerful developer's toolkit [1] are bound in many computer languages and new libraries [2], [3] are being developed enthusiastically. It makes a development of AR system easy and encourages developers to build a wide variety of applications of AR systems, such as, medical, navigation, and entertainment [4]. However, to overlay information on the appropriate place in a scene in ordinary marker-based AR systems, a marker artificially installed in the real world should be identified by pattern matching among all possible markers in pattern database to retrieve the appropriate information from a marker-information database. This fact stunts the diffusion of AR systems.

This paper proposes a new AR system using multiple two-dimensional barcodes. A barcode becomes a fiducial marker as well as a marker itself in the ordinary marker-based AR system, but the barcode carries the corresponding information in itself whereas the marker does not serve the corresponding information to be overlaid by itself. So, neither pattern matching among all possible markers nor retrieval the corresponding information from a marker-information database is required in the proposed system. Moreover, superimposed information changes due to the combination of barcodes. By using multiple two-dimensional barcodes as a marker, the system requires less markers than conventional systems for displaying the same different information with above advantages.

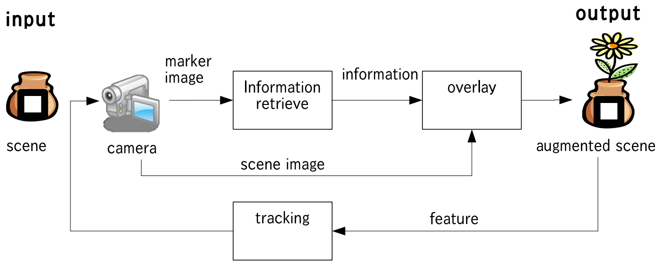

Fig. 1. A typical marker-based AR system.

II. Preliminary

This section firstly gives an overview of a typical AR system using markers. Then, a retrieval process of information corresponding to the acquired marker image and marker tracking process are mentioned. In addition, QR code that is one of two-dimensional code that will be used in the proposed AR system is briefly introduced.

A. AR System Overview

Fig. 1 shows a block diagram of a typical marker-based AR system. The following process runs repeatedly.

1. A real scene is captured by a camera
2. A marker is detected from the scene image
3. The information corresponding to the marker is retrieved
4. The obtained information is overlaid to the marker in the captured real scene
5. A mixed scene is given to the user

A user usually uses a mobile camera for AR systems, so the marker moves in the captured real scene shot-by-shot, i.e., between the iteration of the above mentioned process. To superimpose the information to the appropriate point in the scene, an AR system may have to track the recognized marker among shots. Some vision-based tracking techniques tracks feature points of the marker or the captured landscape.

The next two sections further mentions Step 3 of the above mentioned process, information retrieval depending on the marker, and the marker tracking.

ISBN: 978-602-8944-11-3

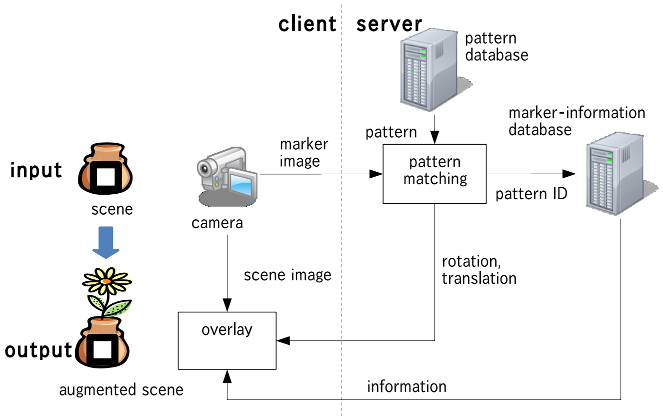

Fig. 2. Information Retrieval Depending on Markers.

Fig. 3. A typical AR marker.

B. Information Retrieval Depending on Markers

In a marker-based AR system, the acquired marker is firstly identified to retrieve the corresponding information as mentioned in the previous section. To serve a practical AR service, a bunch of markers should be artificially installed in the real world. So, the captured marker have to be identified among all possible markers.

As shown in Fig. 2, to recognize the marker, the captured scene image or a part contains a marker from the image is transmitted to a server in which the marker image is compared with all possible markers in a marker database by a pattern matching technique. Then, the corresponding information to be overlaid is retrieved from a marker-information database. It is noted that a marker-information database here is assumed to only stores the simple information or the pointer to a large volume information such as CG objects.

These processes costs highly for the practical AR systems in which a huge number of markers are used, and it may stunt the diffusion of AR systems.

C. Marker Based Tracking

As previsouly mentiond, an AR system has to track the marker shot-by-shot to superimpose the corresponding information to the marker in the scene. A vision-based tracking technique firstly extracts the feature points from a captured marker image. Giving the artificial features to markers may help this feature extraction process, e.g., the marker shown in Fig. 3 has the sharply-defined structure so that the feature points are easily extracted.

A marker used in AR systems usually has a rectangle shape and consists of black and white colors. In other words, any marker can be used for AR systems as long as the marker has simple and obvious structure so that feature extraction to track the marker is easy.

Fig. 4. A sample of QR code.

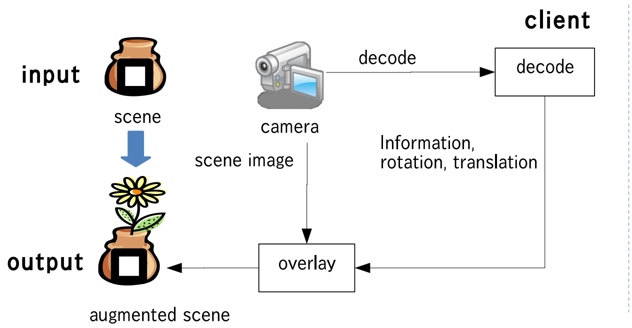

Fig. 5. Proposed System.

D. QR Code

QR code [5] is one of two-dimensional barcodes. Fig. 4 is an example of a QR code. A QR code can carries 7089 alphanumeric characters in itself, if QR code with 2953 bytes capacity is used. In addition to such large capacity, QR code is robust to distortions on its surface, such as blots and breaches, as well as to three-dimensional projective deformation by capturing.

QR code usually has a square shape and has three large squares called positoin detecting pattern in it. Moreover, QR code usually uses two colors; black and white. That is, QR code has simple and obvious structure. In addition, thanks to software and web services for QR code encoding, QR codes are easily generated now.

The next section proposes a novel AR system that uses QR codes as markers. The proposed system can change the superimposed information depending on the combination of QR codes in the scene.

III. Proposed System

The proposed system is shown in Fig. 5. It uses multiple two-dimensional barcodes as shown in Fig. 6 in which image "lena" is used as the background to explicitly show the relation between barcodes. Hereafter, QR code is used as the two-dimensional code in this paper.

In the proposed system, information is directly retrieved from a QR code. Furthermore, depending on the combination of QR code, the proposed system change the overlaid information. It is noted that a large volume information such as CG

Fig. 6. Multiple two-dimensional barcodes.

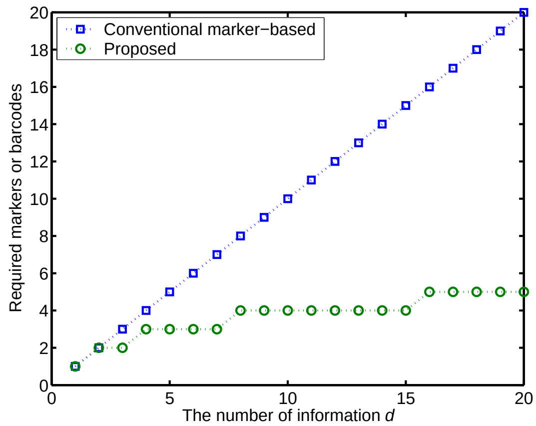

Fig. 7. Required markers or barcodes for overlaying d different information.

objects and so on is only pointed by the obtained information as well as the conventional systems described in Sect. II-B.

Moreover, QR code is robust to distortions and deformation, conveyed information is decodable in the most scenes. In addition, QR code has a simple and obvious structure as shown in Fig. 4, so tracking the QR code is easy as well as tracking a marker in the conventional systems.

A. Features

This section summarizes two main features of the proposed system, namely, barcode-based and usage of multiple barcodes.

1) Barcode-Based System: The proposed system uses barcodes instead of traditional markers. Since a barcode can carry the corresponding information in itself, two processes in the conventional marker-based AR systems can be omitted in the proposed system; an identification of the acquired marker among all possible markers in a marker database by a pattern matching technique and a retrieval of information that corresponds to the marker from a marker-information database.

A two-dimensional barcode, in particular, QR code, has a simple and obvious structure. So, a barcode is suitable for marker-based tracking as well as a marker in the conventional systems [6].

2) System with Multiple Barcodes: The proposed system changes the overlaid information due to the combination of barcodes. This feature reduces the barcodes to be prepared and to be artificially installed to the real world. When d difference information will be superimposed to the real scene, the proposed system requires $\log_2(d+1)$ barcodes, whereas a conventional system using ordinary markers needs d markers. This advantage decreases the cost for construction of practical AR systems.

IV. Experimental Results

The proposed system is implemented on a computer with an external camera as listed in Table I. In addition, a QR Code Decode Library [7] is used for decoding QR codes, and speed up robust features (SURF) [8] served by the open source

Fig. 8. Only using the lower left barcode.

computer vision (OpenCV) [9] is used for tracking feature points. OpenGL [10] to show virtual objects in the mixed scene.

TABLE I
Configuration.

device	product name	specification
computer	hp EliteBook 8530w	Intel Core2 2.66 GHz CPU 2.93 Gibytes RAM
camera	Logicool Webcam C300	130 megapixel resolution 30 frames per second

Three barcodes are used in this evaluation as shown in Fig. 6, so the number of combinations among barcodes is seven as shown in Fig. 7. As shown in Fig. 7, the proposed system requires less barcodes than conventional systems for displaying the same d different information.

Different CG object is assigned for different combination. Figures 8, 9, 10, 11, 12, 13, and 14 show composite scenes for the Fig. 6 that all results are generated by the implemented system. As shown in these seven figures, different CG objects are overlaid on the scene depending on the combination of acquired barcodes with only three barcodes. To achieve this result by a conventional marker-based system, seven different markers have to be installed in the real world, and each captured marker should be compared with all seven markers to identify the acquired marker.

Fig. 9. Only using the upper left barcode.

Fig. 10. Only using the upper right barcode.

Fig. 12. Using the lower left and upper right barcodes.

Fig. 13. Using the upper barcodes.

Consequently, it is desired that the proposed system reduces the cost to construct practical AR systems.

V. Conclusions

This paper has proposed an AR system using multiple two-dimensional barcodes. The proposed system uses barcodes as a fiducial marker in which the feature points of barcodes are useful for tracking. A barcode directly gives the information corresponding to the barcode, so the proposed system require neither pattern matching-based marker identification with all possible markers in a marker database nor information retrieval from a marker-information database. Furthermore, the proposed system changes the information to be superimposed due to the combination of barcodes. These features of the proposed system reduce the cost to construct practical AR systems. This system can be used for instruction of products via CG animation. For example, in the case of adding accessory to a computer, the system guide user how to install the accessory to the computer depending on the combination of the computer and the accessory. We are going to develop more applications.

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Fig. 11. Using the left barcodes.

Fig. 14. Using all three barcodes.

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