Cylindrical M-sequence Markers and its Application to AR Fitting System for Kimono Obi

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ABSTRACT

This paper proposes an *m*-sequence cylindrical marker, which is an optical barcode marker that can be applied on cylindrical objects, such as parts of a human body and everyday things such as furniture, bottles, and cups. We use two cycles of an *m*-sequence barcode to maintain continuity at the joint of the cylindrical marker. By using the *m*-sequence characteristics, the marker is able to acquire the rotation angle by recognizing only a certain part of the barcode. To confirm feasibility, we have made a cylindrical marker that fits on the waist of a human, and have implemented an AR fitting application for kimono obi.

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

Author Keywords

Augmented Reality; barcode optical marker; virtual fitting

INTRODUCTION

An optical marker with a two-dimensional code is generally used in augmented reality (AR) applications to present information on objects and places in the real world. They are useful for recognizing the planar surfaces or objects in a living space such as walls, tables, and books. Apart from planes, however, the world consists of many cylindrical objects such as parts (waists, arms, and legs) of human body and industrial products such as furniture, bottles, and cups. We could use several AR markers to detect and determine the positions and rotations of cylindrical objects; however, it is troublesome to attach and register multiple markers. Moreover, the recognition rate decreases because of the deformation by the curved surface.

We propose a cylindrical barcode optical marker for the purpose of attachment to a three-dimensional object having a cylindrical surface. This barcode is encoded by special binary sequences, called *m*-sequence, which enable detection of the rotation angle from the visible part of the cylinder.

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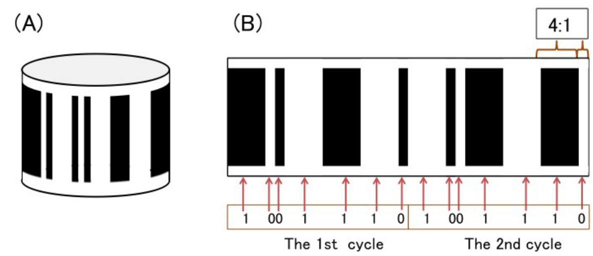

Figure 1. (A) *M*-sequence marker. (B) Barcode pattern.

M-SEQUENCE MARKER

An *m*-sequence marker is a cylindrical optical marker with a barcode that is encoded by a binary number of two *m*-sequence cycles, as shown in Fig. 1.

M-sequence

An *m*-sequence consists of binary patterns of 1 and 0. The generated sequence has a period of $2^p - 1$, and every consecutive subsequence of p bits within an *m*-sequence is unique. When $p = 3$, *m*-sequence is 1001110 and has a period of 7. Each consecutive subsequence of 3 bits, for example, 100, 001, 011, and so on, is unique.

Barcoding

A barcode has white and black bars of two kinds of line widths alternately arranged. We assigned thick bars and thin bars to 1 and 0, respectively. In consideration to constructing a cyclic barcode from a sequence of bars, as shown in Fig. 1, the first and last bars should be of different colors; otherwise, they cannot be identified. We use two *m*-sequence cycles with even binary numbers to prevent the joints from having the same color. Although each partial sequence appears twice within two cycles, they can be distinguished by the color. For example, a partial sequence of 100 appearing in the first cycle is a combination of black, white, and black, while the combination in the second cycle is white, black, and white. By optically detecting a sequence of p or more consecutive bars and their colors, the system specifies the rotation angle of the cylindrical marker. The ratio of the width of the bars influences factors such as resolution and stability and is dependent on the application.

KIMONO OBI AR FITTING SYSTEM

We implemented an AR fitting system for a kimono obi. To wear a kimono, we use an obi, which is a traditional Japanese sash. The manner in which the obi is tied and what color is picked will change how the wearer looks. However, time and

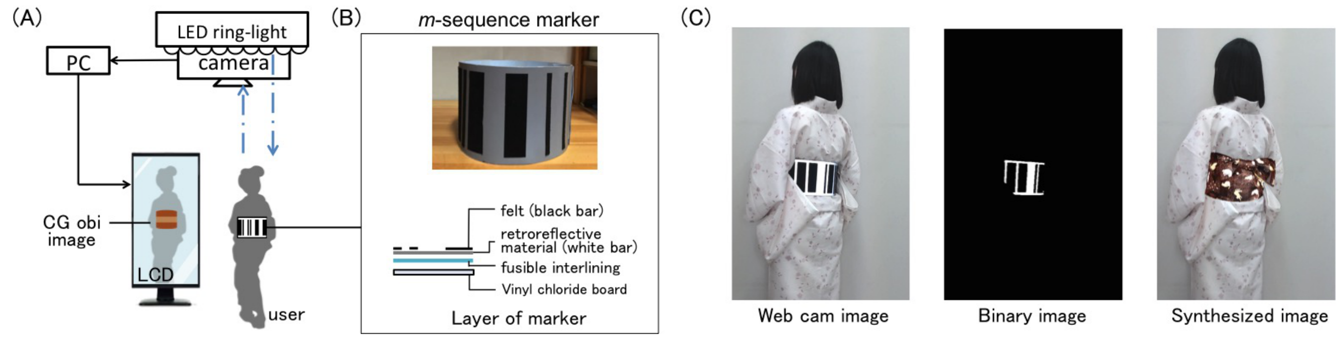

Figure 2. (A) System overview. (B) Structure and appearance of *m*-sequence marker. (C) Web cam image (original image), binary image, and synthesized image.

technique are necessary for putting on an obi. Moreover, the commercial value of an obi drops because wrinkles remain when it is tied. Clerks generally do not allow a prospective customer to tie it in a fitting room. Therefore, an AR system to provide a virtual obi over a customer wearing a real kimono will possibly be accepted by both customers and clerks.

The *m*-sequence marker used in this system is shown as Fig. 2B. Black bars are made of black felt, and white bars are made of a retroreflective material. Figure 2A shows a system overview. The user, who tries AR obi fitting, wears a kimono and a belt with an attached *m*-sequence marker instead of a real obi. The system gets the image of the user with a webcam[1]. A 47-inch LCD displays the image of the user as if it was reflected in a full-length mirror. A LED ring-light around the camera illuminates the user and the marker. The system specifies the position, size, and rotation angle of the marker by getting the image of the belt in which the brightness of the retroreflective part is saturated. In the end, it displays a 3D CG image of an obi on the image of the user. We prepared CG images of obi by 3D scanning the real obi that is tied and worn on a torso. The user can try several virtual obis by replacing them during use of the fitting system.

RELATED WORK

Lumitrack [6] uses *m*-sequences to detect the position of a device that projects *m*-sequence barcode patterns to a rectangular area. We implemented endless cylindrical *m*-sequence patterns to detect cylindrical objects.

DodecaPen [5] proposes a highly accurate tracking of a pen by attaching multiple markers to a dodecahedron fixed to the end of the pen. Usami *et al.* [4] implemented an L-shaped rod-like RGB color code. Our *m*-sequence markers are also applicable to similar applications with simple and robust recognition of barcodes.

We implemented an AR fitting system for kimono obi as an application example. A depth camera, such as Kinect [3, 7], and optical markers [1, 2] are generally used in AR fitting systems. They are capable of AR fittings for garments such as T-shirts [1], sweaters [2], jackets, and skirts [7]. We focus on a kimono obi, which has a big advantage for implementation in an AR system because of the difficulty in trying one on, unlike clothes that people can easily try on.

[1] Logicool C920r

CONCLUSION

We propose an *m*-sequence marker, which is suitable for human bodies and everyday cylindrical objects. We also have successfully implemented an AR fitting system for kimono obi as an application.

In the current implementation, the system uses only the front part of the cylindrical marker and eliminates the distorted parts at both ends of the marker image. As the distortion is predictable, we will improve the detection method to be more robust against obstacles by utilizing the entire marker image.

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