C-Band: A Flexible Color Ring Tag System

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ABSTRACT
This paper presents a new visual tag system, C-Band, which is based on a ring with a color pattern code. C-Band has several flexibilities that cannot be achieved by the existing visual tag systems: the visual tag may be any convex shape and contain any figure, and it provides a size-scalable code. With these features, C-Band has the potential for widespread use as a camera-based user interface.

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INTRODUCTION
Visual tags that are printed on paper or displayed on a screen can be used for various camera based user interfaces [1-6]. For example, a printed visual tag, such as a bar-code, can augment printed content and bridge the gap between paper and digital media. However, current existing visual tag systems have limitations on the flexibility of the outward appearance or the size of the embedded code. This limitation reduces the potential of a camera based user interface. To overcome the limitation, we proposed a new color ring tag system called "C-Band". The new tag can be any convex shape and may contain a figure to show human-readable, graphic attributes of the tag. The proposed code generation technique provides a size-scalable encoding by using a color-difference pattern on the ring. The pattern allows the C-Band system to manage variable bit-length data sizes such as an application-specific ID or a short URL. These features lead to many potential applications. We have built a trial system and confirmed that C-Band works well in several practical conditions.

RELATED WORK
All existing visual tag systems require their tags to be a system-specific shape which is either square or circle [1-6]. Most of existing systems do not allow their tags to contain any figures. The surfaces of those tags are filled with ugly, uninformative, geometric patterns [1-4]. For some tagging systems, a user points to a tag to execute a desired function. However, since the tags cannot contain a figure, graphical/textual function attributes must be shown outside the tag boundary to let the user see the semantics of the function. This requirement makes it difficult to use many tags which are densely arranged. The tags proposed in [5, 6] can contain a figure. However, their feasible code sizes are limited since those systems use a pattern matching technique for identification. Watermarking technologies also have a limitation on the size of the embedded code [7].

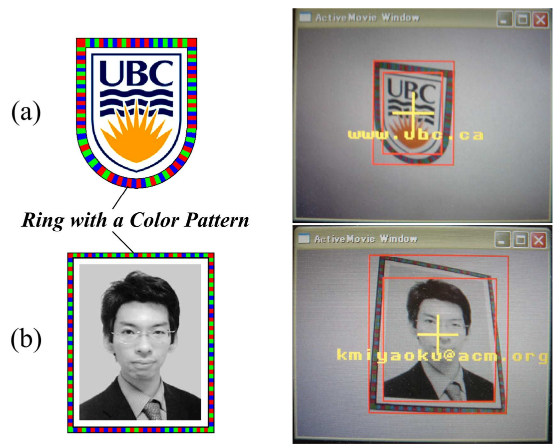

Figure 1: Examples of C-Band tag (left) and detection results (right).

C-BAND
Tag Structure
A C-Band tag consists of a color ring and a figure in the ring (Fig. 1). The ring forms a convex shape. The shape can be designed to fit the figure's shape as shown in Fig. 1. The ring is divided into *N* color sectors. Every sector has a predetermined color difference from the colors of its adjoining sectors, so that a scanner can recognize the *N* sectors by detecting the color differences. This approach also allows each sector to have different widths.

Color Difference Based Data Encoding
A data code is converted into color difference signals and embodied as a color pattern on the ring. We applied the same technique with C-Blink [8] to generate the color difference signals. Using three colors of RGB with the technique enables a color pair to express a single bit. Concretely, color changes from R to G, form G to B, from B to R indicate *'0'*, and color changes from R to B, from B to G, from G to R indicate *'1'*. In this manner, a data code and check bits are converted into a sequence of *N* color differences which appear on the ring in the anti-clockwise direction. If *C* bits are used for check, a ring with *N* sectors can contain a data code of *N-C-2* bits (*2* bits are lost for start and stop bits).

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Detecting Process Overview

For detection, first, a scanner transforms a captured image (Fig.2 (a)) into a binary image (Fig.2 (b)). After labeling all connected components in the image, a candidate for a ring component is selected by considering the shape and the positional relationship with other components (Fig.2 (c)). Next, a sequence of M (>>N) points on the candidate component is obtained by the 'radial scan' from the centroid of the component (Fig. 2 (d)). As long as the shape of the captured ring is convex and the centroid is in the inner ring, the obtained point sequence always preserves the original color pattern on the ring. The color pattern in the sequence is converted into a binary sequence. Then, every possible code in the binary sequence is checked. If no error is found, the scanner decides that a tag and its code were detected.

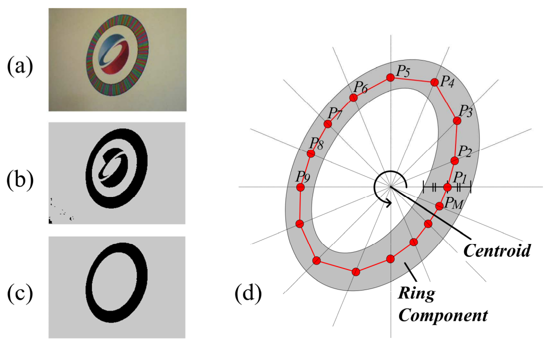

Figure 2: The detecting processes

PRELIMINARY PERFOMANCE EVALUATION

To confirm the performance of C-Band, we built a trial system by using a MS-Windows laptop with the Pentium(R) M 1GHz CPU and a USB-Camera (Sony PCGA-UVC11A). The system captures images of 320x240 pixels. The evaluated detecting program which uses floating point operation can run at 30fps on the system. Circular tags with a 16bit-CRC were tested. The tags were printed by a HP Deskjet 5740. The diameter of the tag was 8.0cm, and the width of the ring was 1.0cm. Circular tags which have 30, 60, 90, 120, 180 and 360 sectors were examined, achieving 12, 42, 72, 102, 162 and 342 bits code, respectively.

As a result, every tag except the one which has 360 sectors performed very well if the distance between camera and the markers was about 10.0cm. They could be detected if the markers were captured at an angle, or the paper surface was a bit bent. This robustness depends upon the captured ring keeping a convex shape. It was also confirmed that the tags could be detected under outdoor lighting. Due to the low resolution used above, the 360 sector tag could not be detected. However, theoretically, increasing the resolution of the processed images should improve this limitation. Adding an error correcting code would make it more robust.

POTENTIAL APPLICATIONS AND FUTURE WORKS

C-Band has many potential applications with phone camera-based interfaces, such as described next.

Hot Frame – Physical URLs

A C-Band ring surrounding a printed or displayed picture can work as an indicator of a linked hot spot as well as containing the actual link information (Fig. 1). Unlike the watermarking technology [6], C-Band can provide a short URL encoded within the tag removing the need to access a database server.

Printed Keypad

C-Band tags arranged as keys on a keyboard can act as an interesting input device for small camera phones (Fig. 3). Embedding a Unicode in each tag enables the device to input various characters.

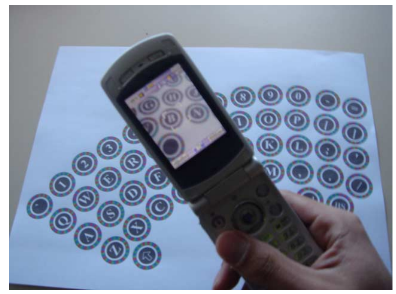

Figure 3: A keypad with C-Band tags for text entry.

Graphical Tag for Camera Based Screen Interaction

C-Band based graphical tags displayed on screens can be used for some of the camera based interaction techniques presented in [2].

The described C-Band system, unlike the existing systems for AR, do not support detecting accurate tilt and orientation of their tags. Another potential issue with C-Band is the influence of colored lighting. We continue investigating the performance under various lighting conditions. We are also developing suitable algorithms for improved detection of C-Band tags to support thinner rings and larger data using high resolution images, and run faster. We intend to install a C-Band system in commercial camera phone devices.

REFERENCES

1. Rohs, M., Zweifel, P. A Conceptual Framework for Camera Phone-based Interaction Techniques. PERVASIVE, LNCS No. 3468, Springer-Verlag, 2005, pp.171-189.
2. Toye, E., et al. Using camera-phones to interact with context-aware mobile services. Technical report, UCAM-CL-TR-609, University of Cambridge, 2004.
3. Naimark, L., Foxlin, E. Circular data matrix fiducial system and robust image processing for a wearable vision-inertial self-tracker, Proc. of IEEE ISMAR, 2002, pp. 27–36.
4. http://www.denso-wave.com/qrcode/index-e.html
5. Kato, H., Billinghurst, M. Marker tracking and HMD calibration for a video-based augmented reality conferencing system. Proc. of IWAR 1999, pp. 85–94.
6. Hansen, T.R., et al. Mixed Interaction Space - Designing for Camera Based Interaction with Mobile Devices. CHI 2005 extended abstracts, pp. 1933-1936.
7. Alattar, A.M. Bridging printed media and the internet via digimarc's watermarking technology. Electronic Proc. of ACM Multimedia 2000 Workshops.
8. Miyaoku, K., et al. C-blink: A hue-difference-based light signal marker for large screen interaction via any mobile terminal. Proc. of ACM UIST 2004, pp. 147–156