TAG INTERFACE FOR PERVASIVE COMPUTING

Paper Tag Interface using Imae Code

Dong-Chul Kim, Jong-Hoon Seo
Media System Laboratory, Dept. of Computer Science, Yonsei University, Seoul, Korea

Cheolho Cheong, Tack-Don Han
Media System Laboratory, Dept. of Computer Science, Yonsei University, Seoul, Korea

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Abstract: Recently, computing environments move to pervasive computing age with rapid growth of internet and appearance of various mobile devices. This means computer offers more convenient life with linking between physical object and digital information. With these advance of computing environment, several researches are progress that are about tag interface to link between various physical objects and digital information, which are image code like as barcode, or wireless technology based like as RFID. It leads high expenses to read or write because RFID has to buy tags – as much as wanted – and has to need exclusive hardware. But image code can be printed to paper and can decode from camera connected to computer, so it is convenient and less maintenance cost. In this paper, we developed encoding and decoding algorithm for image code and applied algorithm to the tag interface to access the information more easy and fast in pervasive computing environment and develop.

1 INTRODUCTION

As the paradigm of computing evolves to pervasive computing, physical objects and digital information are being linked organically and life goes more convenient. These changing affect not only performance, but also user usability to more human-friendly manner. By these evolution, it is more important in pervasive computing environment that linking naturally between physical space and digital space with using tag interface. Tag interface connects between digital information of virtual space – which is in the computing environment or on the network - and real objects in the physical world. Many researches are in advance to progress computing environment and to make more intelligent with tag interface. There are so many input devices - e.g. keyboard, mouse, character recognition, etc - which digitalize physical information. However, some drawbacks are exist, e.g. many user effort, slow input speed, and high error rate. Also, to digitalize huge information which has complicated structure takes so many time and frequent errors. [Kambayashi, 2001]. To overcome these drawbacks, we proposed tag interface. Tag interface is classified into RFID and image based code. Image based code is used in various fields as like barcode. Many services based on tag interface use RFID instead of barcode. Because RFID tags become more miniaturized, high effectiveness, and less-expenses. However to construct these system, it needs exclusive tags, readers, and writers, so initial investment expenses are increased. Also, it is difficult that user approach, and at cognition process, many drawbacks exist - i.e. interferences, distance recognition.

In this paper, we proposed paper tag interface which uses image-based code to overcome drawbacks of conventional RFID limited user access, and expensive cost, and to diversify application fields. At section 2, we survey tag interface related conventional works, and section 3 shows proposed paper tag interface. At section 4, we apply variety practical fields, and section 5 concludes the paper.

2 IMAGE CODE

Conventional image-based codes are divided into 1D bar-code, and 2D image code. Firstly, 1D code is the barcode that can be met in general. However, 2D image codes are classified into Black-and-White codes which use just two colors, and colourful code

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- this code uses multiple colors to enhance the capacity of the code in Table 1. The 1D bar-code is used in several industries, with merit about fast recognition and direction-free cognition ability. It is most popular tag interface which is used in circulation, logistics, etc. Also it has very high recognition rate about 100%, and it can be printed various place, i.e. paper, wrapping vinyl, etc, and with inexpensive cost, and it can be diverse size. It consists of white background and black lines which has different thickness, and is recognized using CCD or laser. Code system for barcode is supported in EAN (European Article Number) which is international standard and UPC code system. However it has a defect that the size of the code would be larger to represent a large size of data, since the code has limited capacity and even lower recording density. In 2D image codes, developed to overcome a defect of 1D barcode - i.e. low capacity and density, they have been developed widely, but they have to be used with expensive and exclusive readers only.

Table 1: Generation of image based code.

	First	Second	Third
Code	1D Barcode	2D Barcode	2D Color Image code
Keyword	Speed, Correctiness	Capacity, Speed, Error Correction	Color, Mobility
Example	EAN/UPC, Codabar, etc	QR code, PDF417, Data Matrix, Maxi code, etc	ColorCode, Ultracode, etc

Many codes have been developed for large capacity and density. Denso have made QR code which can be recognized quickly. Symbol Technologies developed PDF 417 that has high restoration rate[Pavlidis, 1992]. International Data Matrix made the Data Matrix which can be made in small size. UPS developed the Maxi Code to separate postal matter in speedy. Sony made the CyberCode for augmented reality. The Ultracode from Zebra, the DataGlyphs from Xerox[Hecht, 2001], the ColorCode from ColorZip Media and so many codes are developed, and these codes have several advantages - e.g. data capability, data type can be represented, recording density, etc - than 1D barcode. Of these, the ColorCode and the Ultracode use multiple colors and can store more data in same size[Palmer, 1995]. In these semantics, 2D barcode has portable data file and can be the data bridge between computers they do not connected each other[Want, 1999]. In other words, a data file printed in 2D symbology from a computer system can re-input to another system without keyboard.

3 PAPER TAG INTERFACE SYSTEM ARCHITECTURE

Paper tag interface system plays music when user puts down a music tag on the guide line in front of computer. When paper tag is put, the system processes recognition algorithm from the inputted camera image. That algorithm composed of Binarization image, analysis component, and detection candidate area of code. We decode image code and recognize data if no error occurs from candidate code area. We explain the structure of image code and recognition process in 3.1. The computer offers the user a service by performing action – e.g. playing music, open internet browser, etc – after tag recognition. In case of music tag, the computer serves user through one of output devices like as a speaker. We proposed two types of tags. The one is card type and that's size is 8.5 x 5.3 (cm) in Fig. 1. Another is label type size of 5.5 x 1.5 (cm) in Fig. 2. Label type is more portable than card type. In case of card type, it has icon image in centre, Fig. 1-(1). The icon can help user recognize the purpose of the tag. Bottom of the tag – Fig. 1-(2), there exist image code for computer cognition and there is additional information for user in Fig. 1-(3) – e.g. the title, the singer, etc.

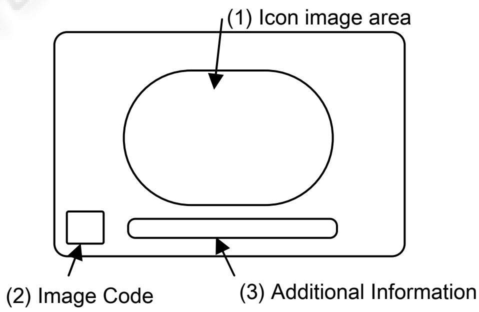


Figure 1: Paper Tag Structure of Card Type.

In case of label type, it has advantages of portable and keeping. There is image code in Fig. 2-(1) and additional information for user in Fig. 2-(2). There are no icon image areas, because this type is so small.

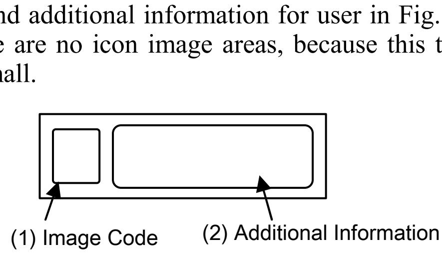


Figure 2: Paper Tag Structure of Label Type.

User can generate tags easy as printing on paper. Paper tag can contain some process of any action and optional data or any file. If the data size is over than image code capacity, then the data can be uploaded server and image code has server address and information of authentication.

3.1 Designing Image Code

We design image code for paper tag interface. Proposed image code is designed by circular strap Fig. 3-(1). The centre of code has directional indicator to inform the decoder the starting position of this code, as like Fig. 3-(2). The circular strap is formed data bits toward clockwise. Left 45 degree and right 45 degree diagonal means '0' bit and '1' bit. Reading data sequence ends at last data bits of k^{th}-layer.

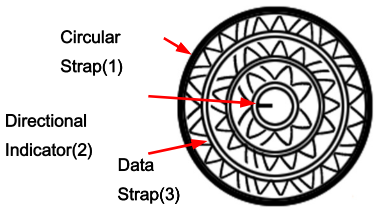


Figure 3: Imae Code Structure.

If we let the index of circle at the code be 1, 2, …, k from the most inner circle to the most outer circle, the total capacity of data in the k^{th} circle is proportional to the circle index k. Let r_k be the radius of k^{th} circle and n_k be the number of codes in k^{th} circle. Then we can say r_k as

$$r_k = kr \quad (1)$$

And, we say θ_k is a central angle of fan-shape which a single pattern occupied. As the size of each pattern is same, each pattern has uniform area and all of patterns have fixed length of circumference.

$$l = \frac{1}{2} r_k \theta_k \quad (2)$$

(1) is substituted for (2), then

$$l = \frac{1}{2} r_k \theta_k = \frac{1}{2} kr \frac{2\pi}{n_k} \quad (3)$$

Therefore the number of codes in the k^{th} layer is,

$$n_k = \frac{\pi r}{l} k \quad (4)$$

As we can see above, we designed to proportion the total number of patterns in k^{th} circle with circle index k.

3.2 Detecting Code Area and Recognition Algorithm

The algorithm – for detecting code area and recognition the code – can be briefly described as following. At first, decoder pre-processes for separating code area from the background image at the inputted image. Filtering process filters candidate areas. This process reduces operation loads of decoding. After detection of code area, decoder computes centre point. Decoder reads circular data strap from the start bit that was found by directional indicator, and recognize all of data sequence after parity check. More detailed description is explained as following 4 steps.

Step 1: Binarization

Decoder thresholds inputted original image, Fig. 4- (1), to binarized image, Fig. 4-(2) before analysis image. Firstly, to find the value of threshold, decoder converts original image to grey, and calculates an average value from min-max histogram. This process called “dynamic binarization”, which provides more flexible adaptation to various environment than fixed value thresholding.

Step 2: Compnent Shape Analysis

Firstly, to get shape information as like Fig. 4-(3), we apply laplacian mask to binarized image and get contour which have connected component information by tracking edge lines. By applying laplacian mask, we can get good results and less amount of computation loads to get edge. Especially, it is easy to track contour information because laplacian masking produces 1pixel edge result from the binarized image.

Step 3: Candidate Filtering

We get the area which is estimated as code field, with following two filters from the previous contour. The first filter is the outline length information. We use the outline information to remove the noise area. If the length of the outline is too short, we would estimate it as small object of background or noise, so it would be estimated as the background. The second filter is circular rate. We filtered out non-code areas from the result of first filter with using circular rate.

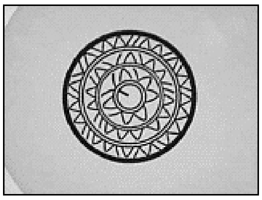
We define circular rate e as following equation.

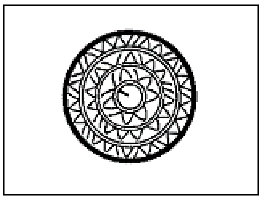
$$e = 4\pi r \times A / l^2 \quad (5)$$

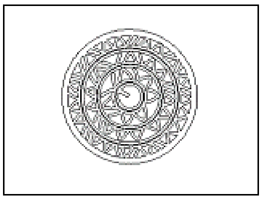
Above equation (5) is gained from the circular area formula ($A = \pi r^2$) and circular circumference formula ($l = 2\pi r^2$). The more the circular rate e is near to 1.0, the more it can be estimated as a circular shape and it would be decides as the final candidate code area, Fig. 4-(4). We can decrease the calculation quantity by filtering non-code area out.

Step 4: Decoding and Error Detection

We compute the center point and the radius from the extracted candidate area, and look for the pattern around the center point circularly. Firstly, we search the indicating sign which is showing the start bit. To start to read the data, we find the start bit from the most outer layer in the direction of the indicating sign. A bit pattern means 0 or 1 – inclined left('/') is 0 and inclined right('/') is 1. After decoding patterns we apply error check algorithm to detect errors. If there are no errors detected, it can be recognized as correct codes, and then decoding process is regarded as done.


(1) Original Image


(2) Binarization


(3) Edge Extraction

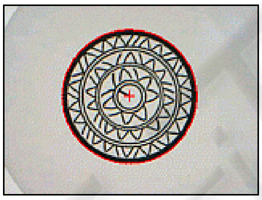

(4) Get Image code Area

Figure 4: Recognition through Preprocessing.

4 EXPERIMENTAL RESULTS AND APPLICATION

We organized 4 layers for test, and data is inserted with ratio of 2:3:4 from the 2^{nd} layer to 4^{th} layer. We tested the printed picture of the 2.5 × 2.5 (cm) size code. We could save the data of 147bits in the used test code if it except the parity code. The size of the data would increase exponentially when more layers appended. At above size, maximum layer can be recognized are 7 and then more than 800 bits can be contained. We experiment paper tag system as following example. We applied the tags as a paper storage media, security and verification keys, multimedia educations system for children, computer interface of easy approach, entertainments interface (photo, music, move) for a media center computer.

(1) File Case Tag


(2) Paper Storage

(3) Music Tag

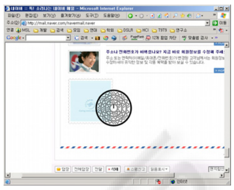

(4) E-mail Tag

Figure 5: Paper Tag Applications.

5 CONCLUSION

In this paper, we have made up tag interface using image code system architecture for easy accessing to digital information in pervasive computing environments. We design and apply image code in this system. It can be possible that there are no needs to hardware devices like RFID. User can use card type or label type tag for their purpose. It is easier and cheaper than RFID tag system to generate tags by printing on paper and to decode by using PC camera. We develop algorithm of encoding and decoding for image code generation and recognition. The following points are left as future problems. Generation of paper tag with no use computer system and increasing tag capacity.

REFERENCES

Kambayashi, Y., Tarumi, H., Morishita, K., 2001. Digital Tags: Data with Restricted Accessibility for e Commerce Applications, *Australian Computer Science Communications*.

Pavlidis, T., Swartz, J., and Wang, Y. P., 1992. Information Encoding with Two-Dimensional Bar Codes, *IEEE Computer Magazine*.

Hecht, D.L., 2001. Printed embedded data graphical user interfaces, *IEEE Digital Object Identifier*.

Palmer, R. C. 1995. *The Bar Code Book, third edition*, Helmers Publishing.

Want, R., Fishkin, K.P., Gujar, A., Harrison, B.L., 1999. Bridging Physical and Virtual Worlds with Electronic Tags, *Proc. of CHI'99*.