Imaged Based Codes Performance Comparison for Mobile Environments

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Abstract. By spreading of smart phones, mobile barcodes are used widely. However, there are so many 2D barcodes to be available. So, it is important to compare those mobile barcodes. In this paper we performed decoding performance comparison between popular mobile barcodes. ColorCode is using color information to get information. So it shows most improved performance in distance and size. Also, it can provide magnifying decoding mode, and it shows more enhancing result.

Keywords: 2D Barcode, Image based Code.

1 Introduction

The spread of smartphones is expanding as the digital information access becomes available in the mobile environment. Especially, because of uncomfortable entering devices, using the Tag Interface is simple and faster to access the information that person wants. Among those tag interfaces, the 2D barcode is being used a lot because of the advantage that can easily access to it.[1] The 2D barcode is developed to overcome the capacity limitation. Hence, it was researched on design and recognition of high-capacity code in the beginning, but other area of study such as the feature for the user point of view became an important study area. Unlike previous 2D barcode market, users access to information by recognizing the code that is located at the long distance in the mobile code recognition. Therefore, the performance comparison about recognition distance for each code is needed. Also, the barcodes obstructs the existing contents. To minimize the bothering, the smaller size of the code the better. For this, it is necessary to measure the smallest size of each code by comparing the minimum size of code that can be recognized.

In this paper, we performed the capacity comparison which is required in mobile code recognition. In capacity comparison, we compared the capacity between QR Code Data Matrix, and ColorCode that are mostly used in Korea mobile code market. The capacity comparison was performed on the comparison of the minimum size of code that can be recognized and the distance that code can be recognized. Through these experiment data, we can use them as the guideline to utilize the mobile code in real life.

J.A. Jacko (Ed.): Human-Computer Interaction, Part I, HCII 2011, LNCS 6761, pp. 653–659, 2011.

In addition, in the case of ColorCode, the magnifying recognition mode is supported. It is a mode that supports long distance recognition by digital zoom the video manually. Since ColorCode uses the color and recognizes the ID, the size of one cell is bigger than B/W code. With this, the information of cell can be protected even though in the case of long distance video was digital zoomed. On the other hand, B/W codes uses B/W pattern to perform the recognition. Therefore, it was hard to recognize in despite of magnified because the cell was blurred.

In this paper, we will analyze the performance of mobile code through these experiments and provide guide line of recognition to business people and mobile code users. We will explain the 2D barcode technology and mobile code technology on second chapter, the performance result and experiment design on third chapter, talks about the experiment about magnifying recognition mode of ColorCode in chapter 4, and conclude on chapter 5.

2 Mobile Barcode

The previously developed codes can be divided into 1D barcode and 2D image code. 2D image code can be divided into B/W code which only uses black & white colors and the ColorCode which make the record density high by providing the colors to code.

In the case of 1D barcode, with the fast recognition speed and the correct recognition with free direction, it is being used in many industries. However, because of some information expression limitation and low density of recording information, there are some disadvantages that the size of code gets bigger to express lots of information[2, 3].

For the 2D image code, it is developed for improving the amount of storage problem of 1D barcode[4]. The various codes have been developed, but there was a problem that they had to use the expensive reader to decode. The examples for these 2D image codes are QR code[5] from Denso which can be read fast by finder pattern, the PDF 147[6] from Symbol Technologies which has a high rate of restoration when it got damaged, the Data Matrix from International Data Matrix[7] that is available to microminiaturize and high density of recording, the Maxi Code[8] from UPS that was developed for fast classification of parcel service cargo, the CyberCode[9] from Sony that was developed for augment reality, Ultracode from Zebra, ColorCode[10] from ColorZip Media, and Microsoft's HCCB[11]. These codes have an advantage on the amount of recording, types of data, and improved high density of record. From among these, ColorCode , Ultracode, and HCCB are using colors so that it can express more information on the same area.

Especially, the codes that can be recognized with normal camera not with the dedicated reader are spreading it as the mobile code. These mobile codes are being used as the connection of webpage for the product, advertisement, and information. Therefore, it is more likely to focusing on the usability on mobile instead of the capacity of storage which was the main focus of 2D barcode technology in the beginning.

We classify these codes with following features.

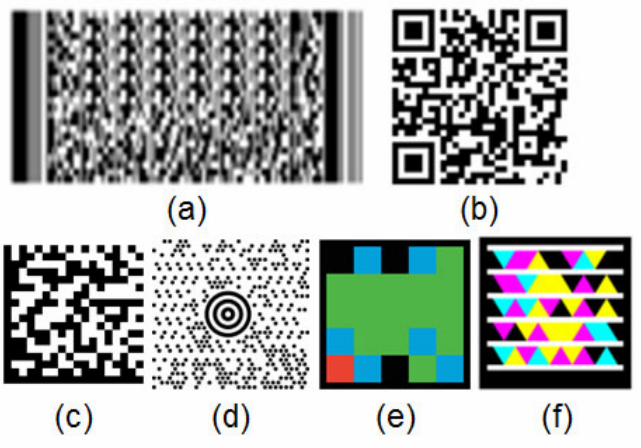

Fig. 1. Various 2D Barcodes. (a) PDF417, (b) QR Code, (c) Data Matrix, (d) MaxiCode, (e) ColorCode, (f) HCCB.

Table 1. Classification of Barcodes

	1st Generation	2nd Generation	3rd Generation
Code	1D Barcode	2D High Capacity Barcode	2D Mobile Code
Feature	Accuracy	Capacity, Speed	Color, Mobility
Example	EAN/UPC, Codabar	QR Code, PDF417, Data Matrix, CyberCode, etc	QR Code, Data Matrix, HCCB, ColorCode, etc

3 Experiments and Analysis

In this paper, we performed a comparison using three mobile codes - QR Code, Data Matrix, and ColorCode. Our experiment results show the recognition performance. For this experiment, we used iPhone as a detecting device, AT&TScanner application for Data Matrix and QR Code, and the Colorzip application for ColorCode. It is the experiment about the mobile code so all three code were encoded to have URL information. We put up the codes on the LCD monitor to measure the changes of size easily.

3.1 Minimum Size Experiments

Minimum Size from Fixed Distance. 2D barcode has many advantages, but there is a problem that interrupts the user and covers the existing media content because it is printed in visually[12]. To provide the same function, it is preferred to print the code in minimum sizes to not to cover the existed content. Therefore, we performed an experiment to examine the minimum size of the code that be recognized.

For the first experiment, we measured the minimum sizes that can be recognized in the fixed distance (50 cm). This experiment is important because it can measure the recognition performance for code itself. We calculate the average with 10 repeated experiment performed.

Table 2. Minimum size of decodable codes in a fixed distance

Fixed Distance (50cm)	Data Matrix	QR Code	ColorCode
Minimum Size (mm)	20.4 x 20.4	31.0 x 31.0	14.8 x 14.8

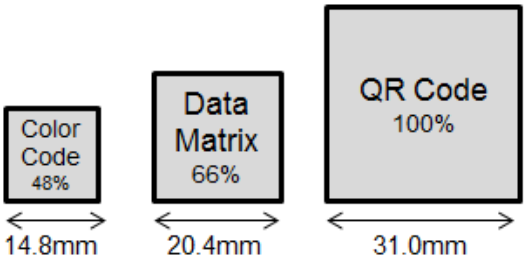

Fig. 2. The comparison of relative size (When we set QRCode as 1)

The ColorCode was able to recognize with the half size of QRCode. This can be analyzed that ColorCode increased the data integration by using the colors. The reason why Data Matrix can be recognized with the small size than QR Code is because the area of the bit amount of Finder Pattern area.

Minimum Size from free distance. The next experiment considers the mobile code recognition environment. When the user decodes the code in the real mobile life, users hold their mobile phone with hand and tries in the most appropriate angle and the distance that can be recognized easily. This experiment assumes that experimenter is in this situation and tries to decode the code with the comfortable location and the angle and measures the smallest size of code that can be recognized. As mentioned above, we experimented 10 times and calculated the average.

Table 3. Minimum size of decodable codes in a free distance

Free Distance	Data Matrix	QR Code	ColorCode
Minimum Size (mm)	7.8 x 7.8	10.4 x 10.4	2.6 x 2.6

In the case of ColorCode the minimum size of the code that can be recognized was 2mm x 2mm. By using the color, it showed as the increase of the cell's integration and very little area was needed compared to other codes. This means that it can have the information with the 1/4 size of QR Code. The smaller area was reported in the free distance experiment than the fixed distance experiment and the ColorCode had a

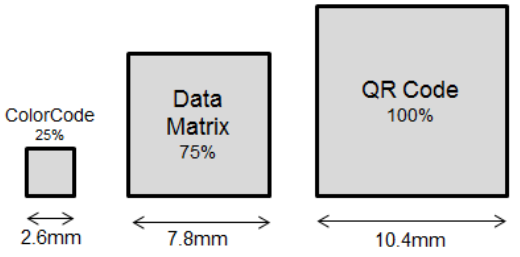

Fig. 3. The comparison of relative size (When we set QRCode as 1)

bigger gap than any other codes. It is analyzed as the cause of increasing recognition rate because of the good preservation of colors in the everyday environment that users make to photograph well.

3.2 Recognition Area Experiments

The next experiment is using the fixed size of the code and measured the area that can be recognized. For the mobile code, there is an advantage in usability that can be recognized in the long distance. Additionally, it is necessary for users to not only just recognizing at the front but also the recognition in the broad angle to make the code available to recognize on the side. We did the experimentation with the various angles and the code which has a size of 100mm x 100mm.

Table 4. Recognizing area of each codes

Recognizing Area	Data Matrix	QR Code	ColorCode
Maximum Distance(m)	~1.4	~1.3	~2.0
Maximum Angle(‘)	~56	~61	~32

As you can see in this table, the code that has the longest recognition range was the ColorCode. However, for the recognition angle, QR Code was most tolerant. This can be analyzed that in case of ColorCode, the colors has been changed because of light that was chaged by the angle.

4 ColorCode Magnify Decoding Mode

In ColorCode, the magnifying recognition mode is being supported with digital Zoom function. This mode performs on decoder when it selects “Use Long Distance” like figure 4. This mode uses the method that performs the recognition by moving or Digital Zooming after photographing like figure 4-b.

Since B/W codes recognizes B/W’s pattern of cell, the cell pattern becomes blurred when the size gets smaller or the distance increased.

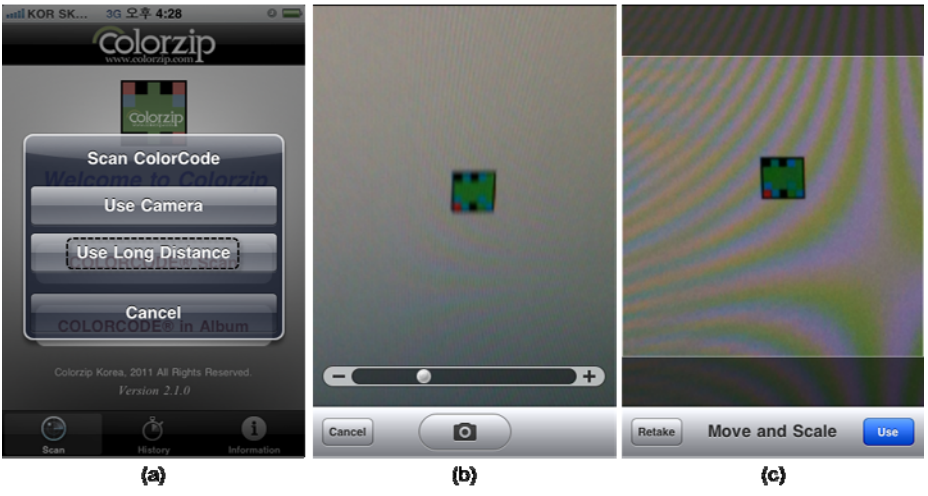

Fig. 4. ColorCode Magnify Decoding Mode

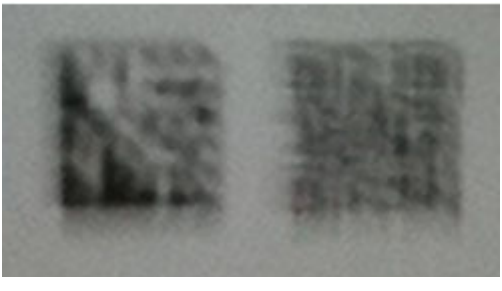

Fig. 5. Blurred Image of B/W Codes - Data Matrix(Left) and QRCode(Right)

On the other hand, ColorCode uses colors so it keeps the information of cell in the long distance since the color increases the integration of each cell. The recognition method that uses this feature is called "magnifying recognition mode." When users use magnifying recognition method, the users need to input but the advantage that the recognition dramatically exists.

The result of magnifying recognition mode is notifying on table 5.

Table 5. ColorCode's magnifying decoding performance

Recognizing Area	ColorCode (100mm x 100mm size)
Maximum Distance(m)	~4.70
Maximum Angle(')	~57

5 Conclusion

In this paper, we performed a comparison experiment between Data Matrix, QR code, and ColorCode that are mostly used for the mobile code. The main purpose for these mobile codes is to access web sites through mobile phones. The mobile codes that are used currently provide these kinds of services, the usability in the recognition process become important issues instead of capacity issue. This paper measures both the minimum size and the maximum recognition distance of code for the usability. ColorCode uses color cells so there were advantages on the aspect of the distance and size. Additionally there was considerable advantage on the distance than any other codes since ColorCode provides the magnifying recognition mode.

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