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2D Color Code Interference Cancellation by Super Imposing Methodology

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Abstract*— Today the 2-D barcodes have become more popular for information embedding. To encode information with high spatial density while ensuring robust reading by an optical system is the main goal of a barcode system. To enhance the density of information, different ink colors could be used. A High Capacity Color Barcode framework is proposed by exploiting the spectral diversity afforded by the Cyan, Magenta, Yellow print colorant channels and the complimentary Red, Green and Blue channels, respectively, used for capturing color images. Here a three-fold increase in the data rate is achieved by encoding independent data in the C, M, and Y print colorant channels and decoding the data from the complimentary R, G, and B channels captured via a mobile phone camera. This paper presents a framework of color barcode for mobile phone applications by exploiting the spectral diversity afforded by the cyan (C), magenta (M), and yellow (Y) print colorant channels which is more commonly used for color printing and the complementary in order to red (R), green (G), and blue (B) channels, respectively, used for capturing color images. In this paper the system exploit this spectral diversity to understand three-fold increase in the data rate by encoding independent data in the C, M, and Y print colorant channels and decoding the data from the complementary R, G, and B channels captured via a mobile phone camera. To mitigate the effect of cross-channel interference among the print colorant and capture color channels, the system develops an algorithm for interference cancellation which is based on a physically-motivated mathematical model for the print and capture processes. To collect the model parameters which are necessary for cross-channel interference cancellation, this scheme proposes a super imposing methodology. Experimental result clears that the scheme framework successfully overcomes the impact of the color interference, providing a low bit error rate and a high decoding rate for each of the colorant channels when used with a corresponding error correction scheme.

***Index Terms*—2-D barcodes, Quick response (QR) codes Aztec codes, color barcodes, interference cancellation.**

I. INTRODUCTION

Today for number of reasons the two dimensional barcodes have become much popular in mobile applications. In that first is the increasingly prevalent camera phones inherently capture 2-D images and can therefore be directly used with 2-D barcodes, unlike conventional laser-based 1-D barcode scanners that would require hardware modifications for capturing 2-D barcode images. The second reason is the 2-D codes provides high satisfied rates per unit substrate area which provides available mechanism for patching the physical world of print and the cyber world of the Internet. Particularly the 2-D barcodes facilitating access to online information about products and services advertised in print media such as magazines, posters and billboards.

The universal resource locator (URL) for the online information is embedded within the print as a 2-D barcode, which can be captured with a cell phone camera after decoding it allow user to access the information without the tedium of manually entering the URL. Different options are available for 2-D barcodes for mobile applications that are quick response (QR) code which is used most extensively in practice. The QR code standard defines a flexible solution with competitive data rates to support the multiple character sets, features for rapid and robust synchronization under lighting and orientation variations, multiple data density designs, and built in variable error correction capability for handling differing application requirements. Other popular 2-D barcode designs include the Aztec code which is extensively used in electronic ticketing or the Data Matrix common in industrial component labeling. For example, Microsoft's High Capacity Color Barcode (HCCB) technology uses 2-D barcodes enhanced with four or eight different colors. The density of information (in bits per area unit) is proportional to log2 N, where N is the number of colors used. So it would be desirable to use a large number of colors to embed more information in the same barcode. For example, using 16 colors instead of 4 would allow one to encode twice as many bits in the same area. The main problem with using many colors in a barcode is that the observed surface color depends not only on the surface reflectance spectrum, but also on the (unknown) illuminant spectrum, which thus represents a nuisance parameter. Consequently, determining the color index of each surface patch in the barcode is a challenging operation, especially if multiple light conditions (indoor/outdoor) are expected. Other nuisance parameters include: secularities; color drift during printing; color

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fading; unknown or poorly calibrated camera color response; camera non-linearity; color mixing from two nearby patches due to blur; quantization and noise.

A barcode is an optical machine-readable representation of data relating to the object to which it is attached. It is used for tagging objects with identification and tracking data for automating sales and inventory tracking tasks [8]. Originally barcodes represented data by varying the widths and spacing of parallel lines, referred to as linear or one-dimensional. Later they evolved into rectangles, dots, hexagons and other geometric patterns in two-dimensions (2D). Common examples of 2-D barcodes include QR (Quick Response) code [7], Aztec code, Data matrix, HCCB (High Capacity Color Barcodes) etc. These are used for the purpose of facilitating access to online information about products and services advertised in print media. The URLs (Universal Resource Locator) for the online information can also be embedded within the print and upon decoding, allow the users to access the information. Color 2-D barcodes are referred to as 3-D codes where color represents the third data embedding dimensions [11]. Color is a common image property that can be used to increase information density and is sometimes used to improve the visual appeal of barcodes [13].

Most of the color barcodes provide increased data rates by encoding data in the color of small shapes like triangles, rectangles etc. Here a new framework for High Capacity Color Barcode construction is proposed that enables extension of existing monochrome barcodes to color. Data is independently encoded in three monochrome barcodes which are then combined as the Cyan, Magenta, Yellow colorant channels within a single print leading to a three-fold increase in data rate compared with the corresponding monochrome barcode. The data in the Cyan, Magenta and Yellow colorant channels are decoded from the corresponding complimentary Red, Green and Blue camera sensor channels. An Expectation Maximization (EM) type approach is used to minimize the intercolorant channel interference which iteratively estimates the modal parameters and print colorant channels.

II. RELATED WORK

Barcodes are intended for consumer use like, a consumer can take an image with his/her cell phone camera of a barcode on a product, and retrieve relevant information about the product. The barcodes are usually read using computer vision techniques. Barcodes can be used to link interested parties to any information of interest, by re-directing their internet enabled device to the appropriate webpage [5,9].

With proper access privileges, the camera user can also obtain information related to product security, from track and trace to product provenance, authentication and forensics. The proper design of color based barcodes often results in doubling of payload density over default conditions and hence provides a more effective security solution [14].

Two dimensional color barcode can hold much more information when compared to a binary barcode. Two dimensional barcode is gaining popularity as a pervasive technology for mobile applications. When used along with camera phones, the 2Dbarcode can provide a link between the digital and the real world .2D barcodes have increasing significance as the ubiquity of high-resolution cameras, combined with the availability of variable data printing, drives increasing amounts of "click and connect" applications[15].

Barcodes hence, serve as an increasingly significant connection between physical and electronic portions, or versions, of documents itself. Microsoft's High Capacity Color Barcode technology uses 4 or 8 colors per patch .But, the observed color of a surface depends on the illuminant spectrum and on the surface reflectivity, which complicates the task of decoding the content of the barcode. One of the popular solutions is to append a "palette" to the barcode with the reference colors. The algorithm helps in decoding groups of color bars at once, exploiting the fact that joint color changes can be represented by a low-dimensional space[2].

The HCCB uses Cyan, Magenta, Yellow colorant separations available in color printers and enable high capacity, by independently encoding data in each of these separations .In each colorant channel, payload data is conveyed using a periodic array of elliptically shaped dots whose individual orientations are modulated to encode the data. The overall color barcode is obtained when these color separations are printed in overlay as in color printing. The barcode data is extracted from a conventional color scan of the barcode, using Red, Green, and blue channels complementary, respectively, to the print Cyan, Magenta, and Yellow channels. For each channel, the periodic arrangement of dots is exploited to enable synchronization by compensating for both global rotations/scaling in scanning and local distortion in printing .To overcome the color interference, an interference minimizing data encoding approach is proposed along with a channel model that captures the characteristics of the interference, enabling more accurate data recovery[5]. An error correction methodology is also included that can effectively utilize the channel model. There is surprisingly little research work in the literature on the topic of color barcodes besides Microsoft's HCCB technology cited earlier. Perhaps the first reported attempt to use color in a 2-D barcode can be found in a patent by Han et al. [8], who used reference cells to provide standard colors for correct indexing. This technology, named ColorCodeTM, is marketed by Color zip Media (colorzip.com). A different type of color barcodes is marketed by ImageId (imageid.com). Bulan et al. proposed to embed data in two different printer colorant channels via halftone-dot orientation modulation. Grillo et al. used 4 or 16 colors in a regular QR code. PM codes use color to define layers, each of which makes up a 2-D barcode.

Kato et al. select colors that are maximally separated in a plane of the RGB color cube. The same type of color barcode (named MMCC) was used in a study the effect of JPEG compression on decoding. Pei et al. used four colors in a color barcode technology named "Continuous Color Barcode Symbols" [3].

None of these previous works tried to model the changes of the observed color due to changing illuminant, except for the patent of Sali and Lax ,which uses a k-means classifier to assign the (R,G,B) value of a color patch to one reference color. Note that existing color constancy algorithms (e.g. [2,3,4,6,10]) are not of much use here. Classic color constancy assumes that neither the surface reflectance nor the illumination are known a priori, and aims to infer the surface colors under some specific scene hypotheses (e.g., gray world model, low-dimension illuminant/reflectance spectra). In this scheme have full control over the selection of the surface colors that can be part of a barcode. This facilitates detection, but also poses the problem of which surface colors and color combinations are best suited to the task.

Closest to proposed work in a recent paper by Wang and Manduchi[4], who studied the problem of information embedding via printed color. Their algorithm used one or more reference patches of known color, seen under the same illuminant as the color to be decoded. Observation of the reference patches produces an estimate of a parametric color transformation between a canonical illuminant and the current illuminant, which is then used to decode the information-carrying color patches. The reference patches thus play a similar role to the color palette attached to the HCCB barcode, without the need to display all colors in the palette (usually one or two reference color patches suffice). Scheme study borrows the idea of statistical modeling of joint color changes from the work on color eigen flows by Miller and Tieu [11]. However, rather than trying to represent the variation of all printable colors as a function of illuminant, scheme concentrate on the variation of small groups of printed colors. One-dimensional barcodes can be categorized as being discrete or continuous, as well as having two bar widths or many bar widths. Continuous symbologies have characters adjoined, with one character ending in a bar and the next beginning in a space, or vice versa. Discrete symbologies use characters that begin and end with bars. The inter-character space is generally ignored. Two-width symbologies have one designated narrow bar width and one wide bar width. The widths are specified in relative quantities, usually with the wide width being two or three times greater than the narrow, so there is no dependency on the absolute measurements. Many-width symbologies use bars and spaces that are all multiples of a specified width, called the module of the code. One-dimensional barcodes are read using optical scanners, often called barcode readers. The scanners are either hand-held or xed-mount. The two-dimensional concept was initiated in 1984 when the Automotive Industry Action Group introduced a standard for shipping and identification labels which consisted of four Code 39 barcodes (a linear symbology) stacked on top of each other. Then in 1988, Code 49 was introduced by the Intermec Corporation to become the rst truly two-dimensional barcode on the market. Like the stacked Code 39 barcode, Code 49 also used the idea of layering linear barcodes along the vertical axis. Several different two-dimensional barcodes have been introduced since Code 49. For the most part, they can be categorized as having either a stacked or a matrix symbology.

III. PROBLEM DEFINITION

Barcodes have been widely used from many years, which perform the important role of accessing a database. However, the traditional one-dimensional bar codes have information storage density. The vertical dimension does not carry any information but only provides a redundancy that is especially convenient for decoding by handset laser scanner when the user is not careful about the orientation and registration. Now a days more and more applications require a much longer bar code to encoding larger amount of information tips such as the price, product name, manufacturer, functionality, and expiration date of a product. Therefore the 2D bar codes were designed to carry significantly more data than its 1D barcode. A scanner, such as a charge coupled device (CCD) scanner, is generally used in industries to scan a 2D bar code. The evaluation of camera phones may change the current status. Resolution limit, distortion, out of focus blurring, and noise with illumination variety induced by the phone camera are the killers of direct use of most existing 2D bar code for mobile phones[6]. In this paper scheme trying to solve this problem by designing and experimentally evaluating algorithms for retrieving digital data from color cells by using interference cancellation framework so as to minimize their error rates. Scheme is going to perform an experimental study of the practical performance of several color classifiers and clusters. This allows to identify the most effective algorithms for decoding color barcodes in terms of their error rate and their total running times. Here the main focus is on interference cancellation framework and data capacity for 2D color barcodes. This allows to optimize the data storage, addressing the need for high density barcodes.

IV. SYSTEM ARCHITECTURE

1) **Overview of System-**2D color barcodes have been introduced to obtain larger storage capabilities than traditional black and white barcodes. Unfortunately, the data density of color barcodes is substantially limited by the redundancy needed for correcting errors, which are due not only to geometric but also to chromatic distortions introduced by the printing and scanning process. The higher the expected error rate, the more redundancy is needed for avoiding failures in barcode reading and thus, the lower the actual data density. Scheme addresses this trade between reliability and data density in 2D color barcodes and aims at identifying the most effective algorithms, in terms of byte error rate and computational overhead, for decoding 2D color barcodes. Particularly scheme performs a thorough experimental study to identify the most suitable color classifiers for converting analog barcode cells to digital bit streams.

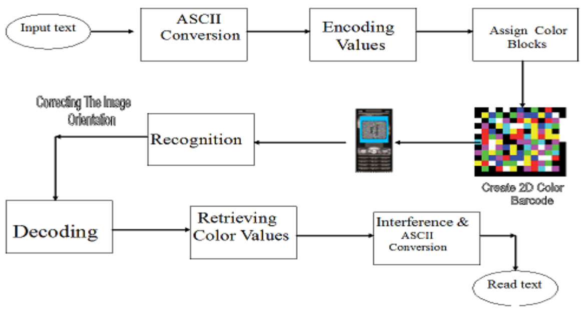

Fig1. Architecture of color barcode

2) **Working of System-**system architecture is the conceptual model that defines the structure, behavior, and more views of a system. An architecture description is a formal description and representation of a system, organized in a way that supports reasoning about the structures of the system. System architecture can comprise system components, the externally visible properties of those components, the relationships (e.g. the behavior) between them. It can provide a plan from which products can be procured, and systems developed, that will work together to implement the overall system. There have been efforts to formalize languages to describe system architecture; collectively these are called architecture description languages.

3) Super Imposing Methodology-Android any built device camera capturers the barcode image and while at same time of capturing the image the proposed system will captured three or n-number of images to provide better accuracy at the time data recovery. Here, a captured barcode may be captured in different angles due to capturing through different angles in degree. It reduces the accuracy throughout system. To remove that by using localization and geometry correction by using pilot block. After getting this localization, scheme will generate per channel barcode that is scheme will generate R, G, and B channel or barcode for R, G, and B channel each

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and every individual captured barcode of the same unique barcode. The meaning of same unique barcode that represent original barcode itself. Now again this R, G, and B channel will be forwarded for color interference cancellation or correction. Here this interference cancellation are done then developed estimated C, M and Y.

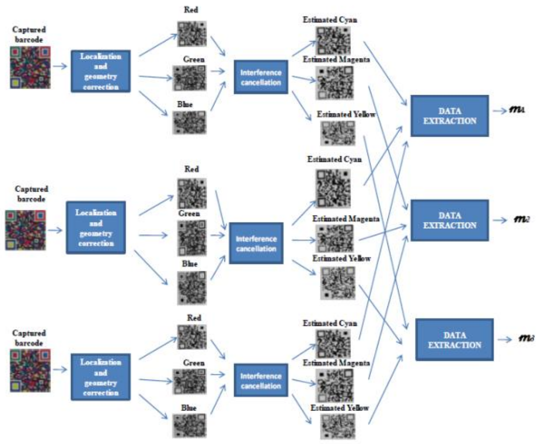

Fig 2. Super Imposing Model

V. MODULES

1) Design barcodes by using multiple colors: Until now only black and white colors are used for designing the barcodes. Here the scheme will use the all colors including white and black for designing the barcode. By using black and white colors scheme can generate only limited number of combination of colors for generating barcodes. But by using multiple color codes scheme can generate more number of combinations for designing the barcodes. Also in this module scheme are storing data of barcode in database. Database contains information like product name, id, price, manufacturing date, etc.

2) Capture image by smart phone: In this module you have capture your image by use smart phone.

3) Remove the noise: Once you have captured image by using smart phone, then you have to remove the noise from the image. Noise may be some shadow or effects of light at time capturing the image or sometimes may be change in intensity of image. This part is related with image processing.

3) Read Barcode and Barcode comparison: After removing the noise from the captured image i.e. colored barcode, then you have to read the barcode. Once you have read data, compare this data with the data which is stored in the database. Once you will get same data as like your database data then scheme can say that scheme have got the correct output.

VI. ALGORITHMS

1) Algorithm For Encoding
Input-Text File
Output- Color barcode blocks
Algorithm-
1. Enter decimal or integer digit.
2. Convert into ASCII.
3. Convert into 9 bit binary string.
4. Divide 9 bit binary string into 3 substring.
5. Assign color block for each substring.
6. Merge all the color block into single image.

2) Algorithm For Decoding
Input- Color barcode blocks
Output- Original text data
Algorithm-
1. Take color block single image.

2. Assign color block for each substring.
3. Divide 9 bit binary string into 3 substring.
4. Convert into 9 bit binary string.
5. Convert into ASCII.
6. Enter decimal or integer digit.

VII. M ATHEMATICAL MODEL

Let the system be described by S,
S={D, CB, LG, CI, EC, DE}
Where,
S: is a System.
D: is the set of Dataset.
CB: Capture Barcode
LG: Localization, Geometry correction
CI: Color Interface Cancellation
EC: Estimated Colors
DE: Data Extraction

VIII. EXPERIMENTAL RESULT

In order to evaluate the performance of the proposed framework, scheme select two popular monochrome 2-D barcodes and extend their functionality to color. Scheme chooses the QR and Aztec codes because they are most extensively used in mobile applications.

Scheme evaluates the performance of the proposed construction of color barcodes by using three different metrics: bit error rate (BER), synchronization success rate (SSR) and decoding success rate (DSR). The bit error rate (BER) is the percentage of bits in error in the extracted bit stream compared to the originally embedded bit stream prior to application of error correction mechanisms.

In contrast with several other color barcode technologies that encode data in color, the proposed construction of color barcodes is significantly more robust to misregistration errors.

Fig3. BERs for color barcodes without interference cancellation, with interference cancellation and using the proposed interference cancellation approaches

Table I: Bit Error Rates In Color Channels, Obtained From RGB Scan Channels And By Using The Proposed Color Interference Cancellation Algorithm

	Estimated Cyan	Estimated Magenta	Estimated Yellow
Without Cancellation	0.1	0.03	0.28
With Cancellation	0.1	0	0.1
Proposed	0.08	0	0.25

Table I lists the bit error rate performance in estimated CMY colorant channels with and without color interference cancellation and of proposed system.

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IX. CONCLUSIONS

The framework proposed in this paper provides an effective method for extending monochrome barcodes to color. Scheme offers color code construction three times better data rates of their monochrome counterparts, it exploiting the spectral diversity provided by color printing and capture systems in conjunction with model-based interference cancellation that mitigates inter-channel coupling introduced by the physical characteristics of the devices. Bit error rates and information capacities vary across the three resulting channels, the error rates are vary in ranges that are readily handled by the error correction coding options available for monochrome barcodes.

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