

A High Density Colored 2D-Barcode: CQR Code-9

*Max E. Vizcarra Melgar*¹, *Mylène C. Q. Farias*¹,
*Flávio de Barros Vidal*² and *Alexandre Zaghetto*²

Dept. of Electrical Engineering¹ and Dept. of Computer Science²
University of Brasilia (UnB)
maxvizcarra@ieee.org



SIBGRAPI 2016
São José dos Campos, October of 2016



Programa de Pós-Graduação em

Engenharia de Sistemas Eletrônicos e de Automação

Controle e Automação - Engenharia Biomédica - Microeletrônica - Processamento de Sinais

Summary

- ① Introduction.
- ② CQR Code-9 Features.
- ③ CQR Code-9 Results.
- ④ Conclusion.

Introduction: 2D Bar Code - QR Code

- Proposed in 1994 by the Japanese company Denso Wave Incorporated.
- Two-dimensional structure used to transmit information through a print-scan communication channel.
- Used in advertisements, business cards, storefront displays, etc.



Figure: Example of QR Code.

Introduction: 2D Bar Code - HCCB

- High Capacity Color Barcode - HCCB.
- Created by Microsoft Corporation.
- It uses clusters of colored triangles instead of the square pixels conventionally associated with 2D barcodes or QR codes.
- It uses a palette of 4 or 8 colors for the triangles.
- Closed-source software.

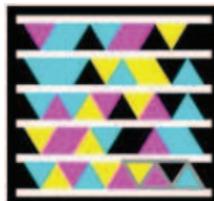


Figure: Example of a 4 Color HCCB Code.

Introduction: 2D Bar Code - HCC2D

- High Capacity Colored Two Dimensional Code - HCC2D.
- The two-dimensional barcode prototype is based on the QR Code standard.
- Proposed by the University of Tor Vergata - 2010.
- It uses a palette of 4 or 16 colors for the modules.



(a)



(b)

Figure: (a) HCC2D prototype for 4-colors and (b) HCC2D prototype for 16-colors HCC2D.

Introduction: : 2D Bar Code - CQR Code-5

- Proposed in 2012 by the University of Brasilia.
- Structure with 49×49 modules.
- It stores 1,024 information bits and 3,392 Reed-Solomon parity bits.
- It uses a palette of 5 colors (black, white, red, green and blue) for the modules in different versions.
- It has 38.40% error correction capability using the Reed-Solomon algorithm.



Figure: Example of CQR Code-5.

CQR Code-9: Structure

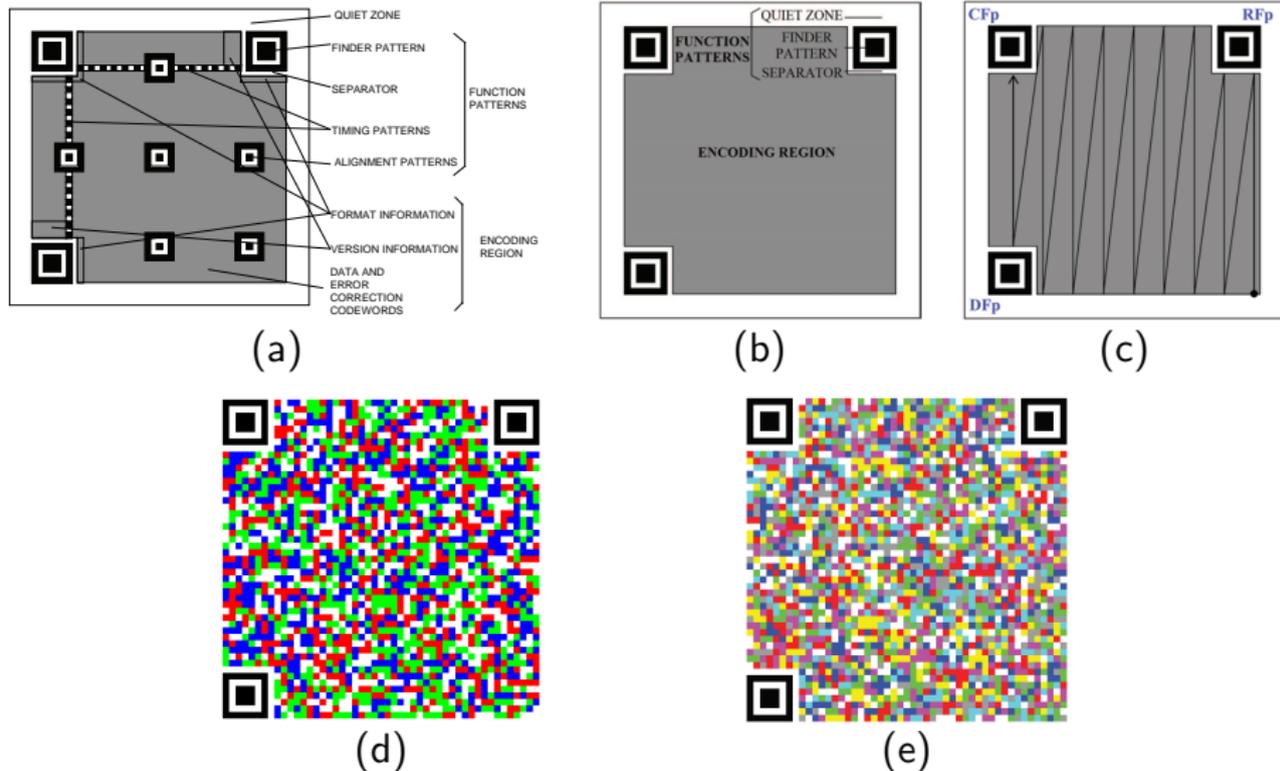


Figure: (a) QR Code Structure, (b) CQR Code Structure, (c) CQR Code filling direction (d) Example of CQR Code-5 and (e) Example of CQR Code-9.

CQR Code-9: Analysis

- CQR Code with $49 \times 49 = 2401$ modules.
- Finder patterns and separator modules with $3 \times 8 \times 8 = 192$ modules.
- Encoding region with $2,401 - 192 = 2,209$ modules distributed in:
 - Information modules = 682.66 (128 symbols of 16 bits each).
 - Reed-Solomon parity modules = 1525.33 (286 symbols of 16 bits each).
 - Unused modules = 1.
- Module mapping: Red='000', Green='001', Blue='010', Cyan='011', Magenta='100', Yellow='101', White='110' and Gray='111'.
- Information bits storage = 2,048 bits.
- Parity bits storage = 4,576 bits.
- Error correction capacity of 34.54% or 2,288 bits.

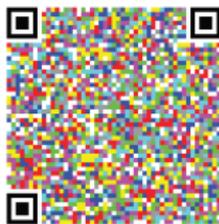


Figure: Example of CQR Code-9.

CQR Code-9: Error Correction

- Berlekamp Reed-Solomon error correction algorithm.
- Symbols with numbers between $[0 \text{ a } 65,536]$ (16 bits each).
- Error-correction capability of 143 symbols according $t = (n - k)/2$, or 38.40%.
- Primitive polynomial = $D^{16} + D^{12} + D^3 + D + 1$.
- Symbols distribution: $RS(414, 128) = [D_1 \cdots D_{128} \text{ } RS_1 \cdots RS_{286}]$.

CQR Code-9: Data Density Comparison

Table: Density of two-dimensional barcodes.

Two-Dimensional colored barcode	Data Density [KBytes per square inch]
QR Code	0.627
HCCB	2.000
HCC2D	1.881
CQR Code-5	2.057
CQR Code-9	3.086

CQR Code-9: Decoding Process

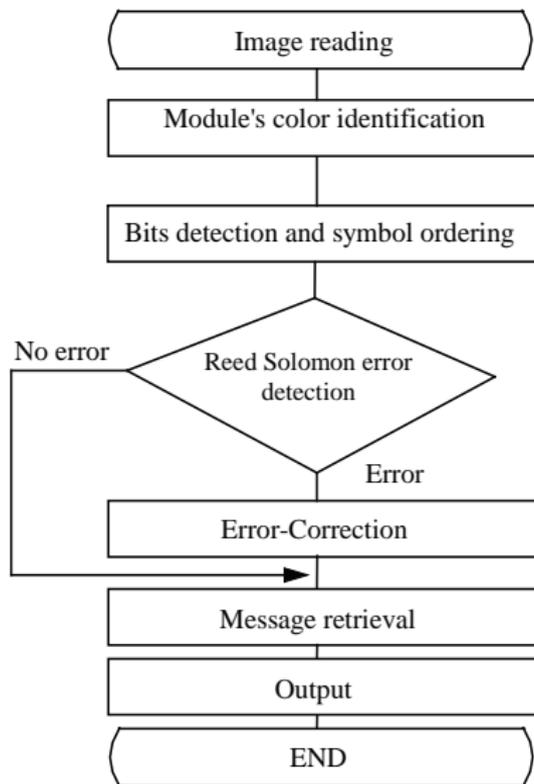


Figure: CQR Code-5 and CQR Code-9 decoding process flowchart.

Results: Acquisition and Decoding Process - Example

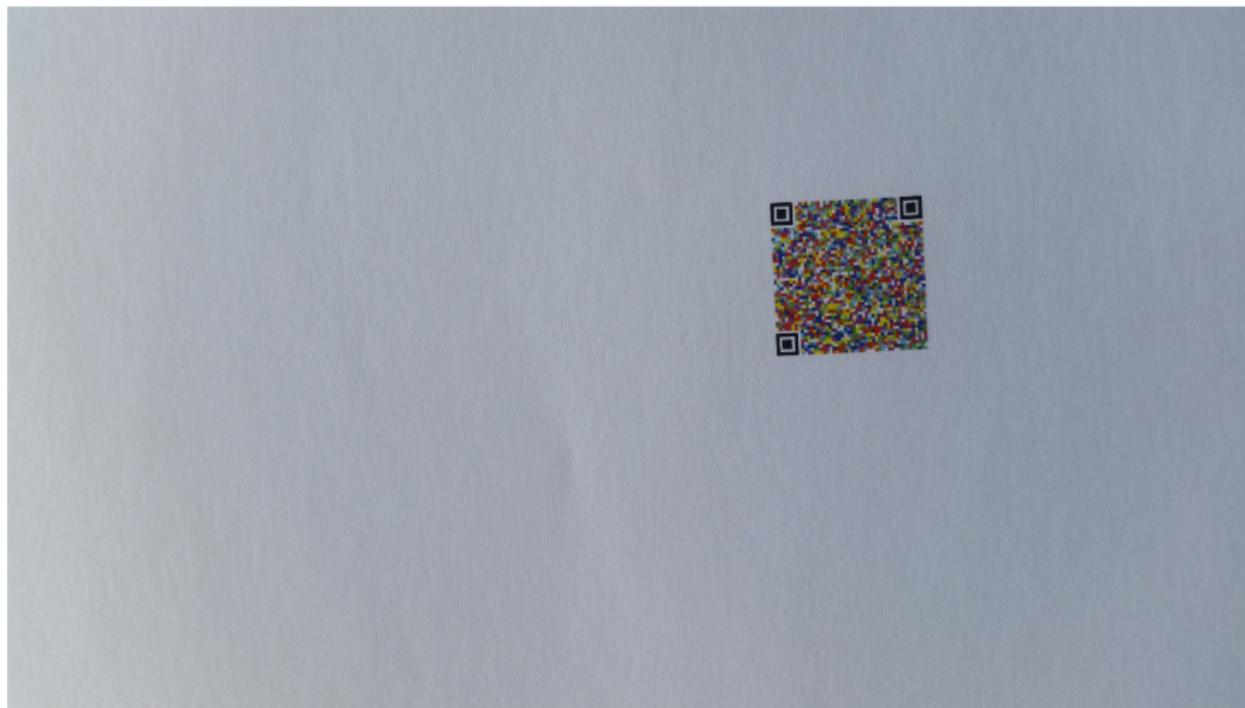
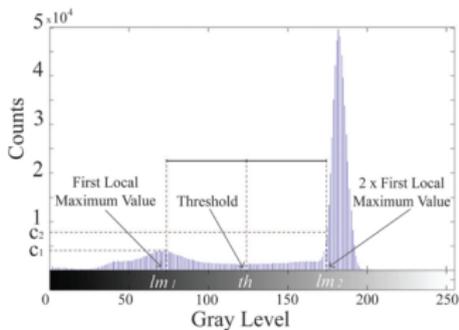


Figure: CQR Code-9 printed on $1.3\text{cm} \times 1.3\text{cm}$, captured and correctly decoded at a distance of 9 cm using the Samsung Galaxy S5 camera.

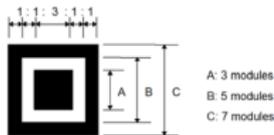
Results: Acquisition and Decoding Process - Example



(a)



(b)



(c)



(d)



(e)

Figure: (a) Typical histogram of the CQR Code-9, (b) Image segmentation, (c) Structure of finder pattern, (d) Cropped version of the original snapshot, and (e) Rotation of the CQR Code-9.

Results: Acquisition and Decoding Process - Example



(a)



(b)

Figure: (a) Final segmentation and (b) Estimated result with 15.70% corrected symbols.

Results: Acquisition and Decoding Process

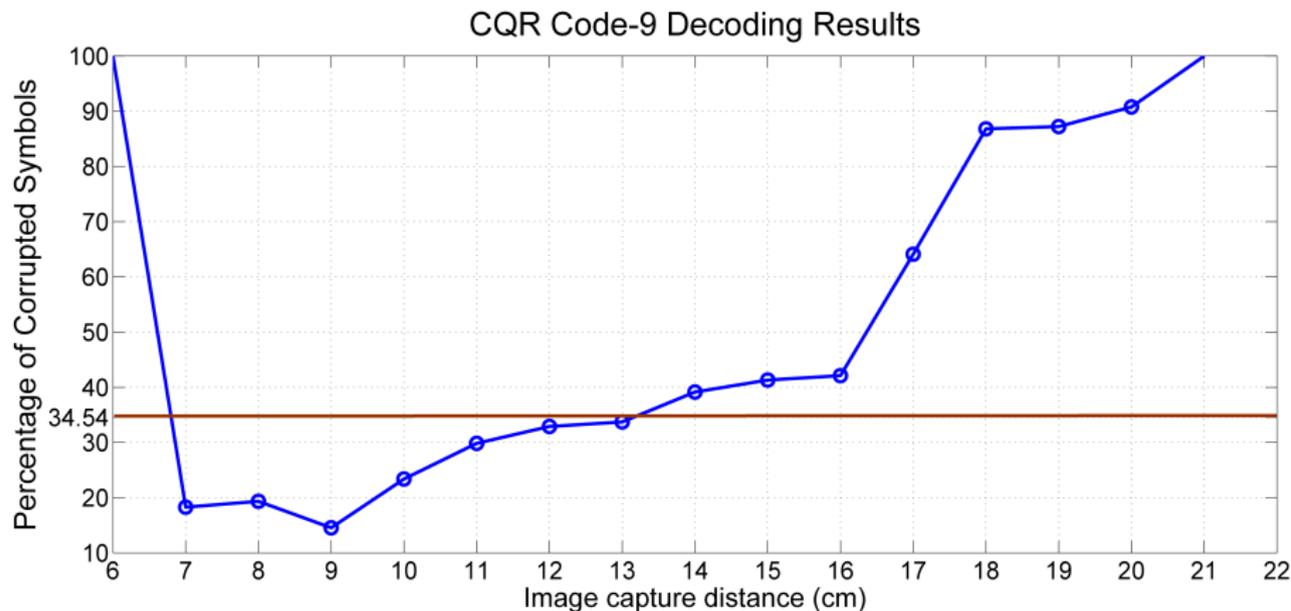


Figure: CQR Code-9 average decoding process results for 170 snapshots using the Samsung Galaxy S5 camera.

- Alternative proposal for a two-dimensional color barcode with higher data density per area.
- The CQR Code-9 stores and retrieves bits efficiently, presenting an acceptable error rate for operation in a real print-scan scenario.
- The smaller printed CQR Code-9 (1.3cm×1.3cm) can be decoded with snapshots between distances of 7cm and 13cm.
- The CQR Code-9 scheme is suitable for storage and transmission of symmetric and asymmetric cryptography codes up to 2,048 bits in small printed areas.

Acknowledgment

This work was supported in part by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and in part by the University of Brasilia.

Thank You! - Questions??

Max E. Vizcarra Melgar, MSc.

maxvizcarra@ieee.org