# Verification of linear barcodes according to ISO/IEC15416 specifications

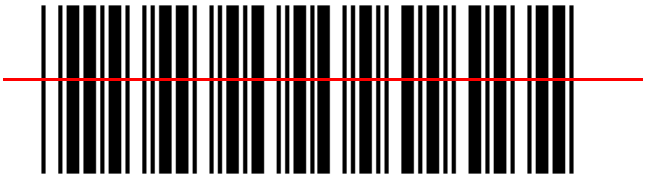
## 1) Objectives

Given a set of images, each containing a linear barcode, student should develop a software system capable of:

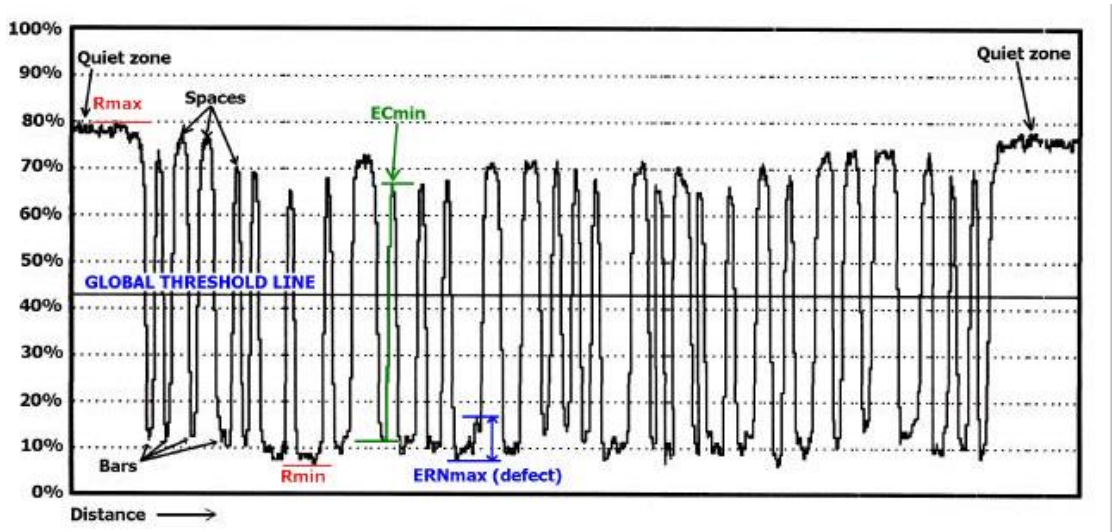
- Localizing the ROI (Region Of Interest) containing the barcode and extracting features therein (as described hereinafter).
- Compute several parameters related to the print quality of the barcode, as defined by the ISO/IEC 15416 specifications (see the attached document "The Layman's Guide to ANSI, CEN and ISO Bar Code Print Quality Documents"). In particular, the following print quality parameters shuold be computed:

  1.Symbol Contrast
  2.Min reflectance
  3.Min edge contrast
  4.Modulation
  5.Defects
  Overall Symbol Grade

It is worth observing here that the project does not require computation of the come Decode e Decodability parameters. A detailed description of the quality parameters is reported in the attached document. Nonetheless, we provide here one example together with some considerations useful to gain a better understanding of the project. One linear barcode type is the so-called Code39 depicted below:



If we draw a line across the code (e.g. the red line above), we get a so-called *scan reflectance profile* (i.e. the image intensity profile along the line), as shown below:




| Parameter | Description |
|---|---|
| *Decode* | The DECODE parameter gets grade A if the barcode can be decoded by the standard refererence decoding algorithm, grade F otherwise. |
| *Decodability* | DECODABILITY is related to teh accuracy of the printing process. |
| Min Reflectance | R*min*: minimum reflectance (i.e. intensity) value along the considered scan reflectance profile. |
| Min Edge Contrast | MIN EDGE CONTRAST (EC*min*) is the minimum difference (in percentage) between the minimum reflectance in a space (bright area) and the maximum reflectance in a bar (dark area), over pairs of adjacent spaces-bars. |
| Symbol Contrast | SYMBOL CONTRAST is the difference (in percentage) between the maximum and minimum reflectance (i.e. Rmax – and Rmin, respectively). Rmax, Rmin are computed considering both the barcode as well as the so-called QUITE ZONE (bright area before and after the code). |
| Modulation | MODULATION is the ratio between MIN EDGE CONTRAST and SYMBOL CONTRAST. |
| Defects | ERN is defined as the difference between the highest peak and the lowest valley within an element (which may be either a bar, a space or also a quite zone) . Then, DEFECTS is tha ratio between MAX ERN and SYMBOL CONTRAST. |
| Overall Symbol Grade | Overall grade assigned to the barcode as a function of the qulity parameters computed along 10 evenly spaces scan lines taken from the top and bottom borders. |

## 2) Dataset

The dataset is provided by DATALOGIC and includes a set of images together with a Table showing the associated quality parameters. The first part of the dataset can be divided into groups of images that allow to verify the variations of a specific parameter:

Images UPC#03..07 exhibit CONTRAST with grades A,B,C,D,F.
Images UPC#08..12 exhibit MODULATION with grades A,B,C,D,F.
Images UPC#13..17 exhibit DEFECT with grades A,B,C,D,F (the defect being localized into bars).
Images UPC#18..22 exhibit DEFECT with grades A,B,C,D,F (he defect being localized into spaces).
Images UPC#23..32 exhibit DECODABILITY with grades A,B,C,D,F.

Instead, the second part of the dataset (images C39* and C128), dealing with barcodes of types Code39 and Code128, is not divided into groups related to parameter values.

The project described in this document requires computation of all the parameters (but DECODE and DECODABILITY) on every image of the dataset.

| FileName (*.BMP) | Decodability TestChart | Contrast TestChart | Modulation TestChart | Defect TestChart | |
|---|---|---|---|---|---|
| UPC#01 | 95,8 | 75 | 87,2 | n.a. | **Master Perfect To System** |
| | | | | | |
| UPC#03 | 78,8 | 83,6 | 85,3 | 2,3 | **Contrast-A** |
| UPC#04 | 84,2 | 63 | 89,1 | 0 | **Contrast-B** |
| UPC#05 | 87,7 | 47,7 | 87,6 | 0 | **Contrast-C** |
| UPC#06 | 87,8 | 38,2 | 84 | 5,3 | **Contrast-D** |
| UPC#07 | 90,9 | 15 | 84,7 | 0 | **Contrast-F** |
| UPC#08 | 84,7 | 74,4 | 75,5 | 0 | **Modulation-A** |
| UPC#09 | 84,4 | 75,7 | 64,6 | 0 | **Modulation-B** |
| UPC#10 | 85,2 | 75,8 | 56,2 | 0 | **Modulation-C** |
| UPC#11 | 83,9 | 82,6 | 47,5 | 3,6 | **Modulation-D** |
| UPC#12 | 84,6 | 76,4 | 29,2 | 0 | **Modulation-F** |
| UPC#13 | 96 | 76,5 | 86,5 | 6,9 | **Defects Spots-A** |
| UPC#14 | 96 | 75 | 87,9 | 17,7 | **Defects Spots-B** |
| UPC#15 | 96,4 | 72 | 87,5 | 21,7 | **Defects Spots-C** |
| UPC#16 | 96 | 75,7 | 85,7 | 27,4 | **Defects Spots-D** |
| UPC#17 | 96,3 | 74,5 | 87,5 | 31 | **Defects Spots-F** |
| UPC#18 | 95,9 | 74,7 | 83,1 | 11,5 | **Defects voids-A** |
| UPC#19 | 95,2 | 71 | 86,5 | 17,8 | **Defects voids-B** |
| UPC#20 | 96,2 | 73,7 | 87,3 | 21,8 | **Defects voids-C** |
| UPC#21 | 94,8 | 74,4 | 86,9 | 28,4 | **Defects voids-D** |
| UPC#22 | 96,4 | 74,3 | 87,7 | 33,8 | **Defects voids-F** |

| | | | | | |
|---|---|---|---|---|---|
| UPC#23 | 95,5 | 74,8 | 87,7 | 0 | **Decodability Edge-A** |
| UPC#24 | 55,8 | 73,8 | 87,5 | 0 | **Decodability Edge-B** |
| UPC#25 | 43,3 | 77,5 | 86,9 | 0 | **Decodability Edge-C** |
| UPC#26 | 29,5 | 75,4 | 88 | 0 | **Decodability Edge-D** |
| UPC#27 | 14,3 | 76,8 | 86 | 0 | **Decodability Edge-F** |
| UPC#28 | 72,7 | 74,9 | 88,1 | 0 | **Decodability Bar-A** |
| UPC#29 | 59,2 | 75,9 | 88,2 | 0 | **Decodability Bar-B** |
| UPC#30 | 47,5 | 75,8 | 87,6 | 0 | **Decodability Bar-C** |
| UPC#31 | 36,2 | 77 | 88,3 | 0 | **Decodability Bar-D** |
| UPC#32 | 22 | 76,8 | 87,6 | 0 | **Decodability Bar-F** |
| C39_4.4_UP | 89,1 | 74,8 | 65,4 | 3,4 | **Code39-Xdim=4.4mil** |
| C39_4.4_LOW | 41,2 | 74,9 | 55,2 | 22,4 | **Code39-Xdim=4.4mil** |
| C39_7.5_UP | 89,7 | 76 | 77,9 | 0,9 | **Code39-Xdim=7.5mil** |
| C39_7.5_LOW | 45,5 | 76,4 | 57,4 | 22,6 | **Code39-Xdim=7.5mil** |
| C39_4.4_UP | 82 | 78,9 | 63,2 | 3,4 | **Code128-Xdim=4.4mil** |
| C39_4.4_LOW | 44,1 | 80 | 62,1 | 21,7 | **Code128-Xdim=4.4mil** |
| C39_7.5_UP | 83,8 | 75,3 | 77,5 | 2,4 | **Code128-Xdim=7.5mil** |
| C39_7.5_LOW | 42 | 76,7 | 74,7 | 22,9 | **Code128-Xdim=7.5mil** |
| C128_4.4_UP | 89,1 | 74,8 | 65,4 | 3,4 | **Code39-Xdim=4.4mil** |
| C128_4.4_LOW | 41,2 | 74,9 | 55,2 | 22,4 | **Code39-Xdim=4.4mil** |
| C128_7.5_UP | 89,7 | 76 | 77,9 | 0,9 | **Code39-Xdim=7.5mil** |
| C128_7.5_LOW | 45,5 | 76,4 | 57,4 | 22,6 | **Code39-Xdim=7.5mil** |
| C128_4.4_UP | 82 | 78,9 | 63,2 | 3,4 | **Code128-Xdim=4.4mil** |
| C128_4.4_LOW | 44,1 | 80 | 62,1 | 21,7 | **Code128-Xdim=4.4mil** |
| C128_7.5_UP | 83,8 | 75,3 | 77,5 | 2,4 | **Code128-Xdim=7.5mil** |
| C128_7.5_LOW | 42 | 76,7 | 74,7 | 22,9 | **Code128-Xdim=7.5mil** |

One example:

The CONTRAST of the barcode below should turn out 46.3%

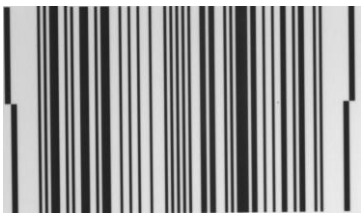

## 3) Detailed specifications

Considering as an example the image below:

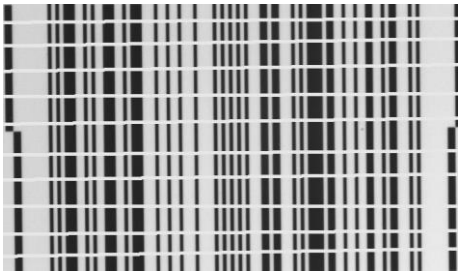

The software system to be developed should:

1. Localize the barcode (initial and final bar);
2. Compute the orientation of the barcode and then rotate the image so to render the bars perfectly vertical.
3. Compute the size in pixels of the thinnest bar (usually referred to as X dimension);
4. Draw a bounding box enclosing the barcode plus a surrounding background area (quite zone) of size (quite zone):
    - X dimension, above and below the code
    - 10*X before the first bar, 10* X following the last bar


5. Compute the height of the barcode as the minimum height of a vertical bar. Accordingly, text elements such as numbers can be removed so to create a smaller box that would not include them.



**6.** Take 10 evenly spaces scan lines (horizontal lines) within the smaller box including the barcode but not the text elements (i.e. the box based on the minimum bar height).



**7.** Foe each of the 10 scanlines:

- Compute the number of edges,
- Compute the required quality parameters (Decode and Decodability should not be computed and their grade is just assumed to be A in each scan line). Assign a grade to the parameters (A,B,C,D,F) according to the following table:

| Grade | **min reflectance** Rmin | **Min edge contrast** ECmin =Rsmin - Rbmax | **Symbol Contrast** SC=Rmax – Rmin | **Modulation** MOD=ECmin /SC | **Defects** =ERNmax /SC | **Decodability** | **Decode** See ANSI ref. decode algorithm |
|---|---|---|---|---|---|---|---|
| **A** | ≤ 0.5* $R_{max}$ | ≥ 15% | ≥ 70% | ≥ 0.70 | ≤ 0.15 | ≥ 0.62 | PASS |
| **B** | | | ≥ 55% | ≥ 0.60 | ≤ 0.20 | ≥ 0.50 | |
| **C** | | | ≥ 40% | ≥ 0.50 | ≤ 0.25 | ≥ 0.37 | |
| **D** | | | ≥ 20% | ≥ 0.40 | ≤ 0.30 | ≥ 0.25 | |
| **F** | > 0.5* $R_{max}$ | < 15% | < 20% | < 0.40 | > 0.30 | < 0.25 | FAIL |

- Compute the grade of the scan line as the minimum grade computed for a parameter.
- Assign to the scan line grade also its numerical value. (A=4,B=3,C=2,D=1,F=0)

**8.** Compute the overall numerical grade of the barcode as the mean grade across the 10 scan lines and convert such numerical grade to a symbol according to the following table:

| Symbol grade | Symbol average |
|---|---|
| **A** | $3.5 \leq$ **A** $\leq 4.0$ |
| **B** | $2.5 \leq$ **B** $< 3.5$ |
| **C** | $1.5 \leq$ **C** $< 2.5$ |
| **D** | $0.5 \leq$ **D** $< 1.5$ |
| **F** | **F**$< 0.5$ |

9. Create an output file (either in text or EXCEL format) including the following information:

- Image name
- Overall barcode grade
- The quality parameter values computed in each of the 10 scan lines.
- X-Dimension (in pixel)
- Height of the barcode (in pixel)
- Vertexes and centre of the bounding box containing the barcode. Orientation of the barcode (angle with respect to the horizontal image axis).
- Number of edges in each scan line.
- Sequence (from left to right) of the sizes of the found bars and spaces, in units given by X dimension.

## 4) Optional project work

Modify image UPC#01 (Master Perfect) so as to study the variation of quality parameters with respect to noise. Accordingly, the image should be modified by adding Gaussian noise with zero mean and different standard deviations. Purposely, suitable plots showing the behavior of the parameters as a function of the standard deviation of noise should be provided in the project report.