Factors that Influence the Image Acquisition of Direct Marking Data Matrix Code

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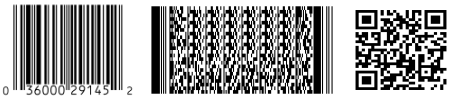
***Abstract* — Data matrix are 2 D codes printed on the labels or marked directly on the material. Their advantage is the possibility of retrieving up to 25 % of error volume. At capture, appear some errors caused by several factors such as the degree and angle of lighting, texture materials and/or quality of the optical photoelectric system of the reader used. Calculating the histograms of the images captured, we can observe that they have different values. Depending on these factors presented, in many cases the code is hard to identify. In this paper it is demonstrate, how the light angle influence the histogram of the images, and also how influence the ability to identify the cod. Photographing different plates illuminated on 0, 45, and 90 degrees angles between light and plates, we have the conclusion that the best histograms are obtained when the light angle is 45°. The best plat material for identify the code is mat aluminum with no scratches or spots.**

***Keywords* — data matrix, image acquisition, factors that influence the image acquisition of direct marking data matrix code, light angle influence.**

I. INTRODUCTION

A GROWING number of areas, even in everyday life, use reading systems, automatic recognition and interpretation of codes. The best known example is the bar codes for product identification (library books, postal codes). For linear bar codes exists the following types of codes: Code 39, Code 93, Code 128, Codbar, GTIN-12, ITF-14, MSI Barcode, UPC [1]. Currently developed are the 2D codes, based on a combination of bars and/or matrix codes which do not consist of stripes but on the „grid" square cells. Some examples of such codes are: PDF417, Aztec Code, **Data matrix**, EZ code, or QR Code. [1]



a) b) c)

Fig.1, a) Bar Code-GTIN-12;
b) 2D Code-PDF417; c) 2D Code- AZTEC

Code 2D unlike the bar code, encodes information in two dimensions, the information contained is redundant, so the error recovery it is possible to a volume error up to 25%. For reading, are not sufficient one-dimensional laser scanners, but digital cameras are required to produce two-dimensional images.

Encryption is make by black spots interspersed with white space, from which are obtained the binary images. These types of codes have a even higher spreading, given the possibility of encode a larger quantity of information on the same surface as that of a bar code, and thus the possibility of correcting errors that result from the partial damage of the codes.

II. DATA MATRIX

Data Matrix are 2D bar codes which consist of black and white cells or modules, arranged in a square or rectangular prints, allowing storage of 2335 characters. Information that is encoded may be text or data size from a few bytes to 2 kilobytes. The length of data encoded depends on the size of symbols used. In the matrix codes are added error correcting codes that increase the significance of symbols, they can be read even if are partially damaged. [2] Depending on the situation, one light module represents 0 and a dark one means 1. Each code has two solid borders adjacent L shaped which is mark identification, other two adjacent border cells containing dark or bright alternative comprising the timing mark. Within these borders are the lines and columns of cells in which the information is encoded.

a) b)

Fig.2, a) DataMatrix; b) Finder and timing pattern

The finder pattern is used for location and orientation of symbols, and the synchronization pattern provides information to the number of rows and columns of symbol. The more information is encoded in the symbol, the number of cells increase, they vary from 8x8 to 144x144. ECC200 is the latest version of the matrix codes that supports an encryption algorithm and error correction such as Reed-Solomon.

All symbols using ECC 200 error correction system, may be recognized by the top-right cell which is identical to the background representing binary 0.

III. DATA MATRIX APPLICATIONS

These became common by typing them on the media items, letters or labels and they are quickly to read with a scanner thus the subject being pursued. Codes may

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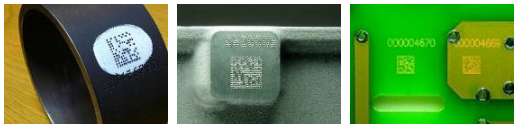
also be marked on other types of materials by drilling, hammering or laser. Due to the ability of encoding 50 characters in a symbol of 2-3 mm^2, and of course because the code can be read with a contrast ratio of only 20%, the most popular application of Data Matrix is marking small objects. They can be infinity scalable, which were used in commercial applications from small to large size of 2-3 mm^2 up to 1 m^2 painted ceiling of trucks. The only limitation is the system of marking and acquisition.



Dot-Peened Pin punched Lasered

Fig.3, Exemples of direct marking with data matrix code

Data Matrix are used in many industries like: Chemical and biomedical analysis instruments, electronic circuit boards, pharmaceutical packages, mails, letters, but especially in aerospace where quality control is vital. Through matrix codes can be identified details of components including specific data, such as the number and production batch.

IV. ACQUISITION OF THE MATRIX CODE

Code readers have constituted a light source, a lens and an optical sensor just like the office scanners. Depending on the reading technology there are:

CCD readers use a matrix of hundreds of light sensors lined up in rows and columns at the top of the reader. Each sensor measures the intensity of light before him so building the image.

The readers using a video camera for high resolution capture an image with 2D code. The reader uses sophisticated techniques for image processing to create a matrix code.

Omni-directional scanners using laser beam, are used embedded in supermarkets stands.

Regardless of the reader used, the capture operation of data matrix is going through several stages. The scanned image is first converted into a binary image. The clarity of the binary image is useful, because the scanning method is based entirely on it. The binary image treshold is chosen depending on the lighting conditions. After tresholding, is searching the region containing the information code. Original image can contain other objects not knowing where the code is. The detection region is done by scanners from the center and its extension in four directions. Once the region of interest is known the next step is finding the edges of the finder pattern. After knowing the limits of the code, depending on finder pattern recognition based on it, can be scaled and rotated until all cells of the timing pattern are overlapping on an imaginary grid code. Depending on both timing and finder patterns can be found the code size matrix. [3]

Now the encoded surface can be scanned, to find the necessary binary information. The Code base can be processed by the Reed-Solomon decoding algorithm.[4]
If scanned errors may be corrected, correct matrix can be obtained. If there are too many errors in scanning, error correction process will be canceled and the matrix code symbol should be rescanned again.

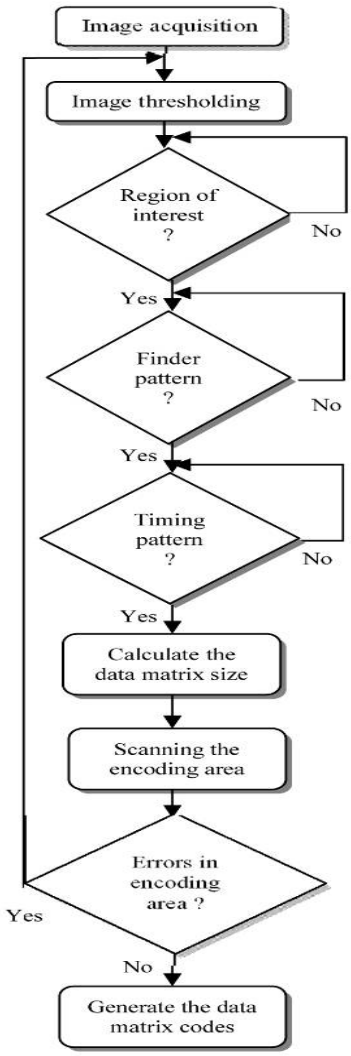


Fig.4, Process diagram

V. ERRORS THAT APPEAR AT CAPTURING OF 2D DIRECT MARKED CODES

Following the capture of the 2D codes may appear some errors caused by several factors. To determine the types of errors arising from image capture with matrix code, I photographed a few sets of different plates in different angles of ight. Every plate was photographed for 3 times, the light angle between the source of light and the plates is 90, 45 and 0 degrees. I used a digital camera, which taken pictures at 640x480 pixels in black and white mode. Also the camera was fixed vertical in front of plate. The plates are marked by drilling, all bearing the same code on them. The quality of the drilling is good. To investigate factors that introduce noise in captured images, I have created these plates histogram images: [5]

After I having studied, and calculated the difference between background histogram and marked image histogram it can easily identify the marked code grey level. The next figures shows 5 sets of different plats with 3 images and 3 difference histograms. In every set of pictures the material plate is the same.

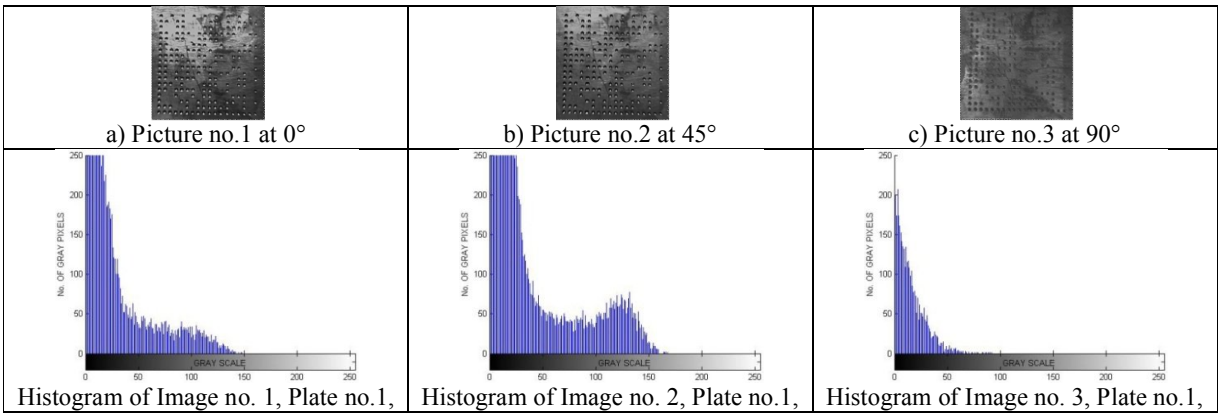


Fig.5 Plate no. 1, Material type is stained metal

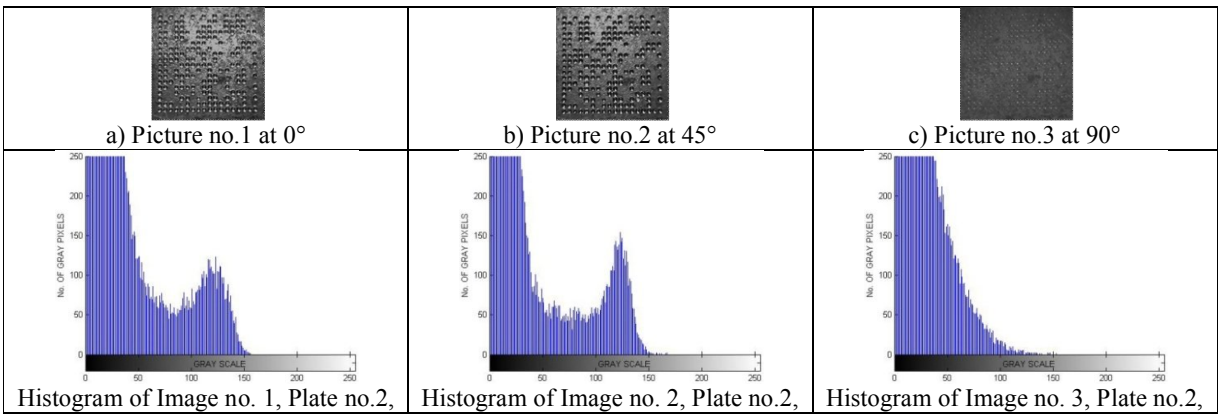


Fig.6 Plate no. 2, Material type is metal with rusty points

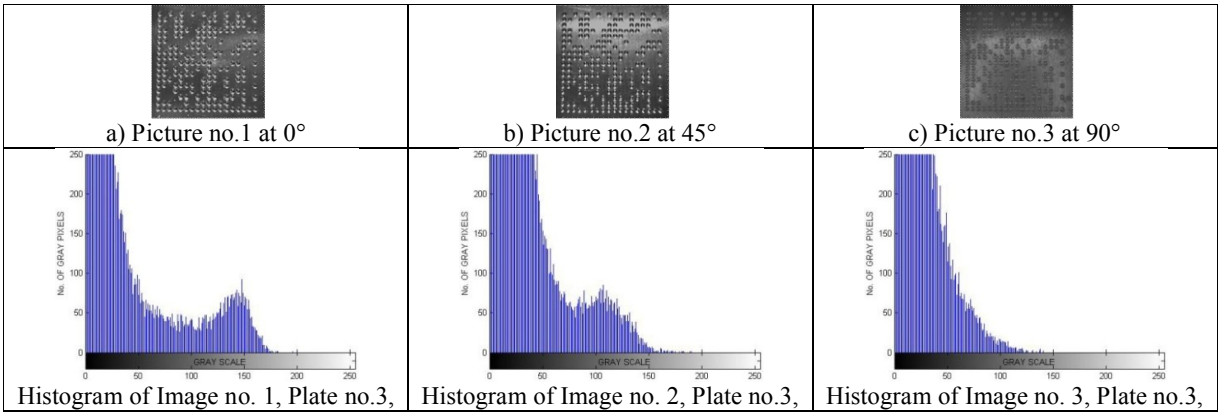


Fig.7 Plate no. 3, Material type is clear copper

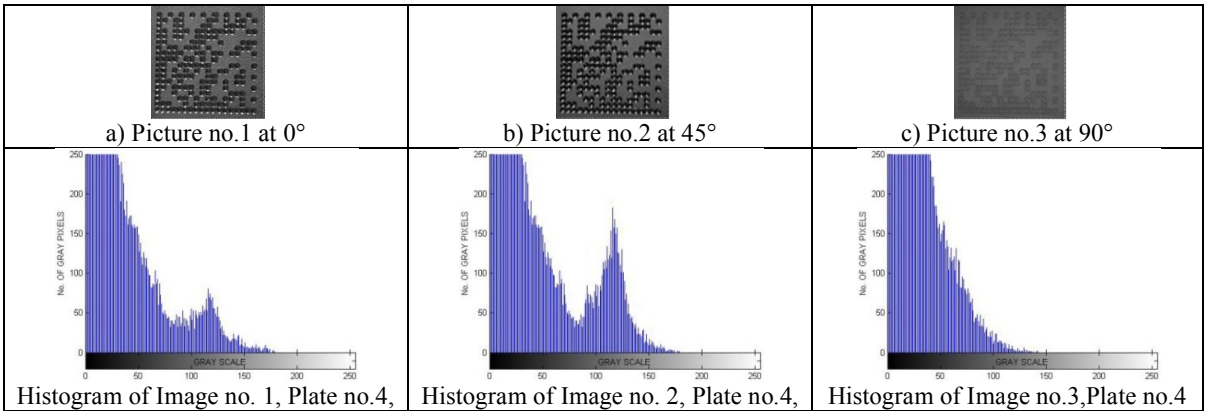


Fig.8 Plate no. 4, Material type is clear mat aluminum

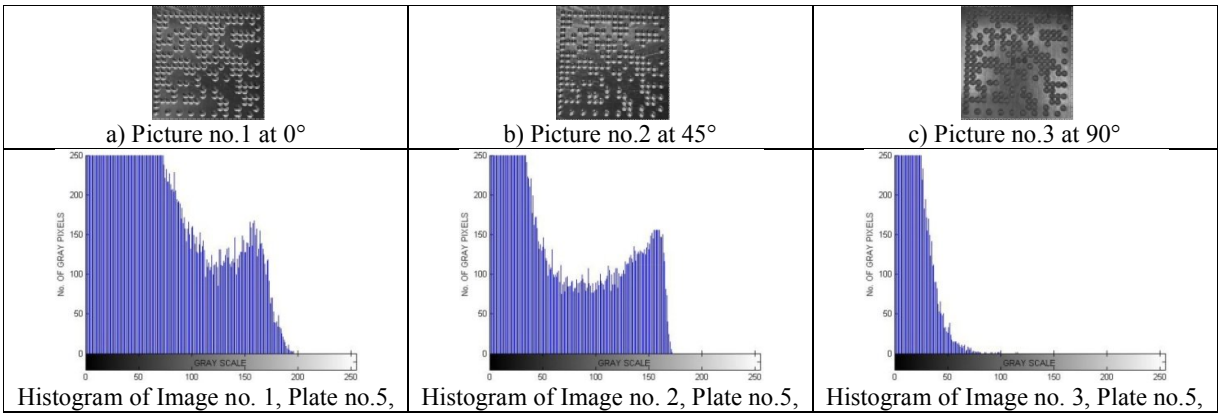


Fig.9 Plate no. 5, Material type is shining aluminum

We can observe that the most noise is introduce by the material texture and analyzing the histogram, the materials which vary in texture range we cannot distinguish all cells from background symbol. Another important role is the reflection of the light. It can be noticed from the plates that at different angles of inclination, the light plays an important role and can show much more of the mark code. Is observe when the light is vertical on the plate (90^0), cannot distinguish the marked points of the code. Also in diagram histogram is shows only the gray level of the background pixels.

In case when the light is falling down on the plate at 45^0, the results are much better. In all types of plates, the marked cod can be easy seen. The histograms shows the background gray levels, and also it shows the marked points gray level. The shape of histograms seems like 2, 3 sticks or like the humpback of a camel. In diagrams, the high level represents the pixels of the marked points in the picture.

At 0^0, or when the light direction is horizontal with the plate, the marked points are not so well visible like in the second case, also the diagram is not so clear. But on the clear plates without texture or rusty points, the grey level of the code points can be identified from the histogram of images.

VI. Conclusions

In this paper it is presented the influence of several negative factors, that may interfere with the image quality of matrix binary codes. The light, the reading angle, the position, a scratch via the code can influence negative the content of the code. I intend to remove or mitigate these factors, by passing successively the code image through several operations and filters that in the end can detect the mark points and generate the final matrix.

In above experiments, it is demonstrated the importance of the light angle which illuminate the plates. Comparing all images histograms, the best results which can be positive appreciate are in cases when the intersection between the light and the plate, forms a 45^0 angle. The ideal image histogram is when the plate material is clear mat aluminum without any textures or rusty. Also in this case, is obtained a good picture and histogram, when the light is horizontal with the plate forming a 0^0 angle. The issue of eliminating the errors that occur when capturing the matrix binary codes can be solved by using 2 D sensor resolution and high quality with a very precise optical system in a properly lighting environment. By using digital image processing techniques, we act directly on the image noise code. Thus we get a cleaner and clearer picture can be taken further and then can be decoded. This issue is of top priority and of great interest in all industries that use this type of code, so by these image techniques can be obtained a system that can identify and decode matrix codes in any situation without errors in the information encoded.

VII. References

[1] Roger C. Palmer - The Bar Code Book
[2] ISO/IEC, 16022: 2006 (E), Information technology - Automatic identification and data capture techniques - Data Matrix bar code symbology specification
[3] A Scanning Method for Dotted Data Matrix - Yuan-Fei Cheng, Department of Information Management, Meiho Institute of Technology, Ping Tung, Taiwan
[4] Todd K. Moon - Error Correction Coding (Hoboken, NJ:John Wiley & Sons, Inc., 2005)
[5]Vasile Gui - Prelucrarea numerica a imaginii