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RELIABILITY OF AUTOMATIC IDENTIFICATION SYSTEMS IN LOGISTICS SYSTEMS

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Abstract: *This paper discusses basic issues affecting the reliability of automatic identification systems, which use 1D and 2D bar codes. The impact of significant factors on the reliability of reading information from bar codes was discussed. The impact of the spot size on the module and the background colour on the colour of bars were discussed as were the effects of the depth of field. The test station in the Laboratory of Automatic Identification in Logistics Systems at the Wroclaw University of Science and Technology was presented where as yet unpublished research had been conducted on the reliability of reading 1D and 2D bar codes under static and dynamic reading conditions, with varying number of coded characters. Research results were compiled in a collective graph.*

Keywords: Reliability, Automatic identification, Bar codes.

1. Introduction

A continuous strive in logistics systems is to increase the efficiency of automatic identification systems. Furthermore, yet another objective is to achieve the maximum possible reliability of reading scanned information in the paper Kwasniowski (2004). Self-adaptation to changing working conditions is not one of the characteristics of automatic identification systems, the effect of this being more and more errors connected with data transmission processes. In the Laboratory of Automatic Identification in Logistics Systems at the Wroclaw University of Science and Technology, tests of reliability of reading different 1D and 2D codes were conducted in order to determine the reading reliability both under static and dynamic conditions. Results of the said tests may be useful in applications in various practical situations.

2. Reliability of reading bar codes – causes of errors

There are several most common reasons why reading bar codes is reliable. A condition for correct reading is for a reader's beam to scan a code across its length. With each passing of the beam, an autocheck of the so-called control digit is carried out. The majority of codes have an autocontrol algorithm. Causes of errors may be as follows: laser spot diameter emitted by the reader, inconsistency of laser beam diameter relative to the size of code's module. Due to such reasons, it is necessary that the diameter of the beam does not exceed 0.8 of the size of code's module. Failure to meet this condition may cause signal interference in the electrical domain, which is emitted in the photoresistor's circuit. Possible situations were shown in Fig. 1.

The second cause in code reading is a ratio of the background grey to the grey of code's bar. This situation applies to colour codes on colour backgrounds. Contrasting codes are read most accurately (black code on white background). In the case of codes of various colours and background colours, the optical signal has a smaller value, is less contrasting and therefore generates electrical signals with smaller value differences which in turn may cause reading interference. This situation was shown in Fig. 2.

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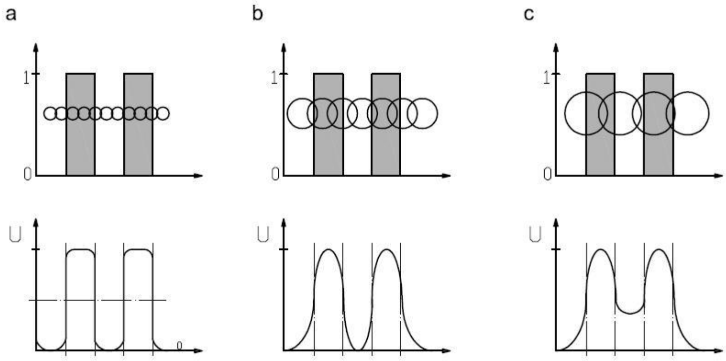

Fig. 1: Configuration of a beam with code's bars as the background vs. electrical signal value in the scanner's circuit. Cases a and b – correct relationship, c – incorrect relationship. Own work.

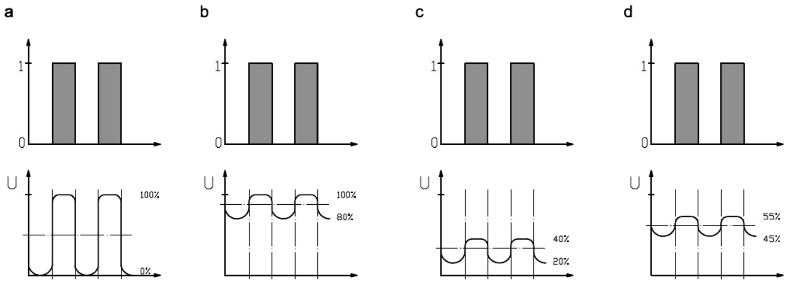

Fig. 2: Signal value at various code contrasts relative to the background: a) black code on white background, b) dark code on dark background, c) bright code on brighter background, d) approx. 50 % grey code on little contrasting background. Own work.

The third cause of difficulties in correct reading of a code may be incorrect distance of a scanner from the code's plane. Scanner, as an electro-optical device, is characterised by such parameters as focal length and depth of field (Fig. 3). Code image is only clear within a certain range of distance from the scanner.

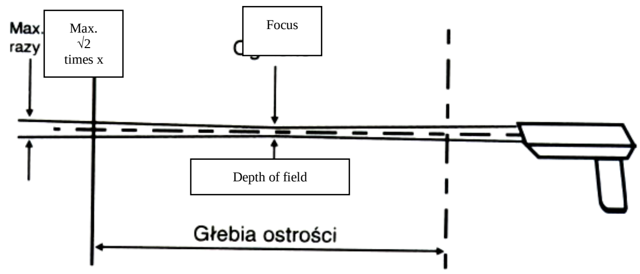

Fig. 3: Scanner and depth of field.

Yet another cause of difficulties in reading may be an illegible code overprint, e.g. highly hygroscopic background which smears the ink in the case of a wet overprint. Difficulties may also occur when the surface with overprinted code is not flat, e.g. it is highly curved (vial or small bottle) in the papers Bujak and Zajac (2012 and 2013). Then the code image will be distorted and the direction of code placement on packaging has to be changed, in the paper Kwasniowski (2011a).

3. Test of reliability of reading bar codes under static and dynamic conditions

In order to shorten the reading of codes and the transmission of information, readings are carried out while marked items are in motion. The aim is to achieve reading and transmission of information in real time, without the need to slow down the stream of scanned items. The test of reliability of reading bar codes also included the following bar codes: code 39, 128, PDF-417, AZTEC, DataMatrix, UPC in the paper Kwasniowski (2004). It was conducted at the measurement station in the Laboratory of Automatic Identification in Logistics Systems at the Wroclaw University of Science and Technology. The test was carried out in accordance with ISO/IEC 15416. The schematic diagram was shown in Fig. 4.

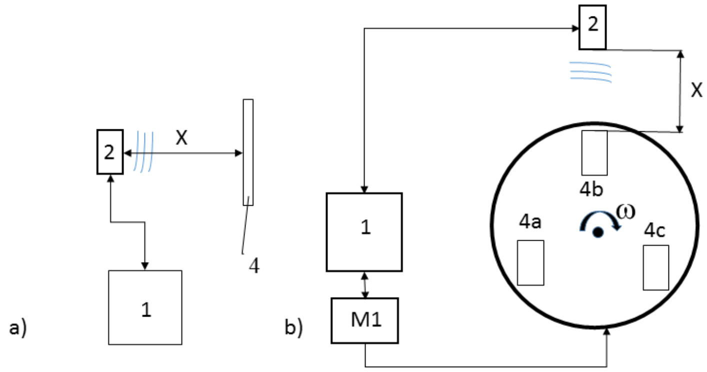

Fig. 4: Measurement station diagram: a) static tests station; b) dynamic tests station.

In the case of a static reading, the code reader (2) was connected with a computer (1) using a wired interface (3) with the RS 232 connector. The reader was powered by a power supply. In order to measure the maximum code reading distance, a card (4, a, b, c) with code symbology was being brought closer and closer to the reader. In the case of a dynamic test, a rotating disc was used which was powered by a motor (M1) with speed control. The motor drove the disc with bar codes stuck on top of it. The reader was placed perpendicularly to the surface of the disc with rotating bar codes. The distance between the reader and the disc was being changed during the test.

Initially, before reading a code, the quality of its symbology was measured: symbol's contrast is the relationship between the smallest factor of bar reflection and the largest factor of space reflection. The higher the contrast, the better the quality of a symbol. The minimum edge contrast is the smallest contrast value when passing from a space to a bar. The higher the value, the clearer the symbol. Modulation is a relationship between minimum edge contrast and symbol contrast, reflecting the constancy of contrast within a symbol. Defects of irregularity of light reflection from an element. Decodability describes print precision in relation to a comparative decoding algorithm. All those parameters are measured separately, the obtained mark of a bar code being the smallest result for any the parameters. Rules of assessment of overprint of codes were compiled in Tab. 1.

Tab. 1: Rules for assessing bar codes.

ISO/IEC 15416 mark	Minimum reflection	Symbol contrast	Minimum edge contrast	Modulation	Defects	Decodability
4	<= 0.5	>= 70 %	>= 15 %	>= 0.70	<= 0.15	>= 0.62
3		>= 55 %		>= 0.60	<= 0.20	>= 0.50
2		>= 40 %		>= 0.50	<= 0.25	>= 0.37
1		>= 20 %		>= 0.40	<= 0.30	>= 0.25
0	> 0.5	< 20 %	< 15 %	< 0.40	> 0.30	< 0.25

Source: ISO/IEC 15416 standard.

The following explanations make it possible to choose the appropriate mark depending on the scanning environment: 3.5 – 4.0 is the highest mark, 2.5 – 3.4 is an acceptable mark (good), 1.5 – 2.4 is the minimum mark, 0.5 – 1.4 means that there is a very high probability that the symbol will not be read – it is doubtful whether such codes will be accepted in a supply chain and 0 is a mark given to symbols which are unusable.

4. Conclusions

The test results were compiled in the form of a diagram illustrating areas of application of bar codes in technical systems.

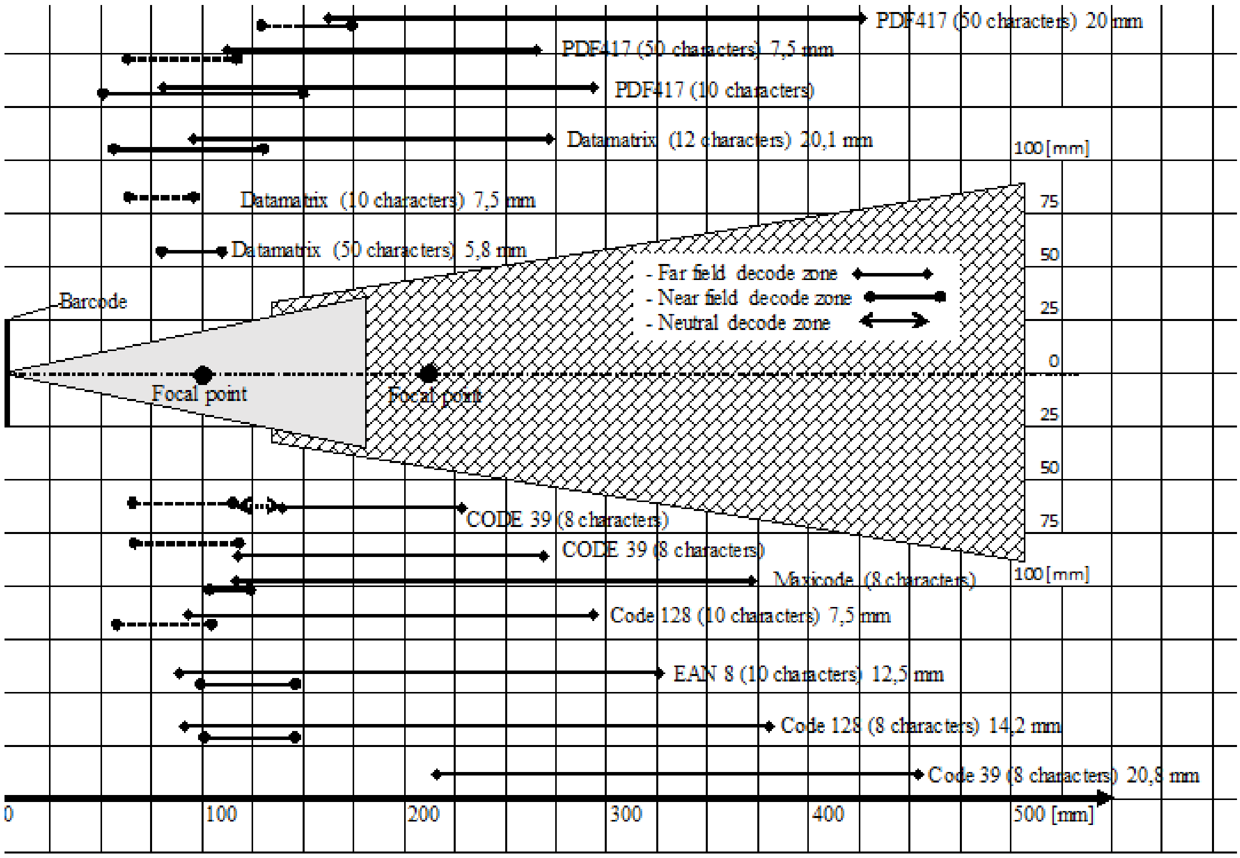

Fig. 5: Areas of application of bar codes.

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