Emerging Trends in Auto ID Symbologies and Data Matrix Readers

Auto ID Symbology Evolution

Bar codes are an automatic identification technology originally implemented in the late 1960s. Over the last 30 years, the uses for bar codes have proliferated so rapidly that the bar code has become a ubiquitous presence in our daily lives.

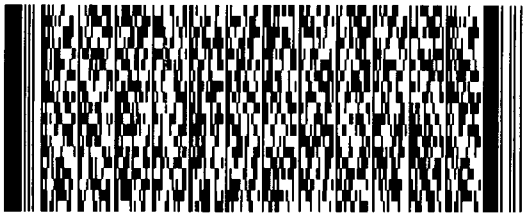
However, the traditional linear bar code is proving inadequate to meet industry's ever-increasing need to encode and control large amounts of data, such as expiration dates, lot/batch numbers, serial numbers, product codes, traceability codes, and the like. The demand for including more and more information in automatic ID messages seems to have no limit.

Traditionally, the bar code industry has reacted to this demand by continuously shrinking the size of linear codes. However, reducing the size of linear codes further is constrained by the printing technology available to produce them. Ultimately, in response to the need to encode increasing amounts of information in limited label space, a number of two-dimensional symbologies have evolved. In contrast to linear bar codes that are scanned along the x-axis only, 2D (two-dimensional) symbols must be scanned in both the x and y axes to be decoded. Two-dimensional symbols are capable of encoding hundreds of times more data per unit area than traditional bar codes.

In addition to the physical constraints on creating denser linear bar codes, 1D (one-dimensional) bar codes have another point of vulnerability in today's information-hungry market place: while a bar code functions simply as a *license plate*, or *key* to an external database, a 2D code is actually a *portable data file* that travels with the product it is affixed to, and provides large amounts of machine-readable information, without reference to an external database. In this way all 2D symbologies are fundamentally different from - and superior to - traditional 1D bar codes.

2D symbologies can encode any data that can be digitized or typed on a computer keyboard such as ASCII, alphanumeric, or binary data. They also utilize sophisticated error/erasure correction algorithms to compensate for lost or missing data, extraneous marks, or label damage. Currently there are approximately two dozen 2D symbologies in the market place. For the sake of discussion, they can be divided into two main categories: Stacked Linear Codes and Matrix Codes. Examples are illustrated below.

Stacked Linear Codes



Stacked Linear Code (PDF417), 569 characters
Size = 10 columns x 50 mils
Error Correction level = 3

Matrix Code (Data Matrix), 500 characters
Size = 10 mils square
Error Correction level = 200

Code 49, the first stacked bar code to receive AIM standards approval, was introduced by Intermec in 1987. Since then, a number of stacked symbologies have been developed, the most prominent being PDF417, developed by Symbol Technologies. PDF417 is capable of encoding over 100 times more data than a traditional linear bar code of the same length. However, for the same amount of data, stacked codes require much more space than matrix codes.

Strictly speaking, stacked codes, are not truly 2D codes. They are, in fact, multiple rows of 1D bar

codes. During decoding, rows are read in sequential x-axis scans. This process results in slower label-reading speeds because, as each row is scanned and decoded, its data must be bundled with that of each subsequent row, and this heavy-duty data processing task limits the numbers of possible scans per minute in automated applications. In addition, label orientation is critical to achieving accuracy. Tolerances of ±3° to horizontal are required. This means that the processes for placing the coded label on the product and presenting the label to the scanner must be tightly controlled.

Matrix Codes

The most widely used matrix codes are MaxiCode (used by United Parcel Service for package tracking) and Data Matrix. This discussion will focus on Data Matrix, which resembles a scrambled checkerboard. Data Matrix, an extremely robust, high-density code, can be applied to a wide variety of flat and curved surfaces and can be read in any orientation. The area of a Data Matrix symbol can vary from as small as .001 square inches up to a maximum of 14 square inches. A .100 square inch Data Matrix symbol can hold 500 bits of data; the larger matrixes can encode up to 2334 characters.

Matrices encode each data bit in cells of equal size. Within a given symbol, all cells are the same size and shape. As a result, matrix readers do not need to determine edge locations or ratios of light to dark spaces, as laser scanners do with bar codes, but only whether the center of a cell is dark or light. This means that print quality and contrast are much less critical than with 1D bar codes or stacked bar codes. In fact, matrix codes can be printed directly on silicon wafers, printed circuit boards, automotive components, or other applications where a paper labels are inappropriate.

In the electronics, automotive, and pharmaceutical industries, Data Matrix is quickly becoming the symbology of choice because of its high data density per symbol size, flexibility, high readability, and reliability. Data Matrix symbology has been adopted by Semiconductor Equipment and Materials International (SEMI) as the standard for coding silicon wafers and wafer box labels. The Electronics Industry Association (EIA), Automotive Industry Action Group (AIAG), and Health Industry Business Communications Council (HIBCC), are currently finalizing similar recommendations regarding the use of Data Matrix symbology for component marking.

Data Matrix's advantages include:
- Highest data density/size
- Better aesthetics. A matrix code can be hidden in other graphics or even a logo
- Can be created with any computer keyboard in any human language
- Can be printed with any type of computer-controlled printing device
- Only 20% color contrast is required
- 360° readability versus ±3° requirement for PDF417 bar codes
- In the public domain

Data Matrix Reader Trends

Although the Data Matrix code offers many clear advantages over other symbologies, its acceptance in the marketplace has been hampered by a lack of affordable, user friendly matrix code readers, also called 2D CCD scanners.

A 2D CCD scanner is essentially a "snap shot" video camera. At the most basic level, the CCD scanner floods the moving code with light and takes a picture of it. The entire image is transferred from the sensing area to a storage area on the microprocessor. Data is then read out from the storage area. The resulting image is processed, and any matrix codes in the image are decoded. Traditional 2D CCD scanners are based on measurement-and-inspection cameras, cabled to remote reader/decoder units, and utilizing a separate light source. Traditional systems are expensive, and notoriously difficult to set up and maintain, and are inefficient at reading fast-moving codes in automated applications.

A new 2D CCD reader developed by Microscan Systems, Inc, of Renton, Washington, promises to solve the problems associated with existing 2D CCD systems and in the process, bring Data Matrix symbology into wider use. Microscan engineers are building on experience gained in over 15 years of designing and manufacturing reliable, high-speed, fixed-mount laser scanners for industrial applications. Microscan's new 2D CCD reader is called Quadrus.

Quadrus is the world's first truly integrated, fixed-mount, 2D code reader. The optics reader/decoder, and light source is housed in a compact, rugged enclosure. Quadrus is equipped with a state-of-the-art image sensor, microprocessor, and custom lensing. Illumination is provided by an array of 20 high-output LEDs. Quadrus also features built in controls (I/Os, matchcode routines, trigger lines, etc).

Quadrus utilizes unique "Light Mapping" technology that combines proprietary optical illumination with high speed image processing - critical to rapidly locating and decoding fast moving matrix labels in automated applications such as pharmaceutical packaging, printed circuit board production, electronic component manufacturing, document handling, clinical/diagnostic applications, and automated tape libraries.

While traditional 2D CCD scanners are widely regarded as being difficult to set-up, Greg Love, Microscan CEO, promises Quadrus users a good "out-of-box-experience," accomplished with Microscan's Windows®-based ESP program. The Quadrus 2D code reader is also priced well below all other competing systems.

All sectors of industry are anticipating the next generation in auto ID symbology. While Data Matrix has the potential to fill current and future symbology needs, its adoption has been hampered by expensive and cumbersome 2D CCD scanner technology. With the dramatic improvements in 2D CCD technology and cost promised by Microscan's Quadrus 2D code reader, Data Matrix has the potential to become even more widely used than today's familiar linear bar code.◆

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