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The Study of Barcode and It's Application

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Abstract— *A barcode is an optical, machine-readable representation of data; the data usually describes something about the object that carries the barcode. Traditional barcodes systematically represent data by varying the widths and spacings of parallel lines, and may be referred to as linear or one-dimensional (1D). Later, two-dimensional (2D) variants were developed, using rectangles, dots, hexagons and other geometric patterns, called matrix codes or 2D barcodes, although they do not use bars as such. Initially, barcodes were only scanned by special optical scanners called barcode readers. Later application software became available for devices that could read images.*

Keywords—Barcode, barcode readers, data transfer, differential phase shift keying, one-dimensional, two-dimensional.

I. INTRODUCTION

Barcode technology is now becoming an essential tool for successful companies for businesses to effectively utilize this technology, however, a base level of knowledge of how barcoding works is necessary. This guide will lead new end-users of barcode technology through the Barcode Basics and the devices that make them work.

Now when you used to go to a store, pick the items from a shelf and reach the point of sale; cashier used to look upon the items, check the items prices from the list and add it to the total bill. This was time consuming, irritating for the customers and often times the price and product information entered manually was faulty. Advancements in technology has affected virtually all walks of everyday life; Likewise, computerized point of sale systems were introduced and if there was anything left in completely automating POS, barcodes were introduced.

II. HISTORY OF BARCODING

The barcode was invented by Norman Joseph Woodland and Bernard Silver and patented in US in 1952 (US Patent 2,612,994). The invention was based on Morse code that was extended to thin and thick bars. However, it took over twenty years before this invention became commercially successful. An early use of one type of barcode in an industrial context was sponsored by the Association of American Railroads in the late 1960s. Barcoding, also known as Automatic Identification (Auto ID), was invented in the early 1970s. It was created to help large retail and grocery stores process their goods. It used to be that Cashiers would take a product, enter the price into the register by hand, and the Cash Register would calculate change and print a receipt. Today, with the help of sophisticated computer systems, a series of numbers representing the product in the form of a barcode is scanned. The computer looks up the price in a master database, subtracts it from the store inventory, and calculates the change.

III. BARCODING

You see barcodes everywhere – from identification cards, to mail, to goods you purchase in a store. The small image of lines, or bars, and spaces are affixed to nearly everything you can imagine, for identification purposes. Specifically, barcodes use a sequence of vertical bars and spaces that represent numbers and other symbols; typically, a barcode consists of five parts – a quiet zone, a start character, data characters (often including an optional check character), a stop character, and another quiet.

What are the uses of barcodes?

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Almost every industry is employing barcodes for automating their product information storage and retrieval purposes. Following are some of the general application areas of barcodes.

1. Whole sale dealers and retail shop owners make use of barcodes for product identification.
2. Medical and surgical industry places barcodes on medicine, surgical equipment and diagnosis machinery.
3. Shipping and marine industry make use of barcodes for secure shipment and product information.
4. Electronic and computer industry employ barcodes on electronic devices and hardware components.
5. Postal industries use barcodes for efficient parcel routing and mail delivery across the board.

Apart from the above mentioned applications, there are hundreds of other areas where barcodes are being widely and successfully used.

IV. CATEGORIES OF BARCODES

Barcodes have now become an essential part of almost every Brick and Mortar Company. You will rarely find a product without a barcode Tag. Different types of barcodes are used for different purposes in business sectors. There are several advantages of using barcodes as compared to manual data entry. Typical usage of barcodes include

1. Tracking sale and purchase of large number of items in an inventory.
2. Barcodes are pasted on sports tickets which allow one to enter a sports arena.
3. Barcodes are often placed on gift tokens that when decoded tells which gift that token corresponds.

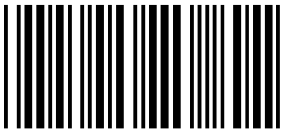
V. TYPES OF BARCODES

There are two major types of barcodes. Bar code symbologies can be either linear or two-dimensional. A linear bar code symbology consists of a single row of dark lines and white spaces of varying but specified width and height.

1- One Dimensional or Linear Barcodes
2- Two Dimensional Barcodes

One Dimensional Barcodes

One dimensional or linear barcodes are commonly referred as first generation barcodes. These barcodes consist of vertical lines at specific gaps resulting in a particular pattern. Hardware scanners are used to scan these patterns and decode the information stored in those particular patterns. These barcodes are also commonly called discrete, one dimensional or UPC barcodes.



Linear bar code

Advantages of Linear Barcodes

- In linear barcodes, vertical lines are used to store data; hence data is generated in one direction which is easier to generate as compared to generating data in multi-dimensions.
- Linear barcodes are easier to scan. Just like barcode generation, barcode decoding is also done in one direction which is easier to perform.
- No special hardware or software is required to scan these barcodes and a simple and inexpensive scanner can be used to generate and scan linear barcodes.

Disadvantages of Linear Barcodes

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- Linear barcodes can only store small amount of data. In order to store large amount of data in linear barcodes, it has to be stretched horizontally with additional vertical lines and spaces, resulting in large barcodes.
- Barcode, once distorted cannot be scanned correctly. Small damage, line at the start or end of the barcode can modify or destroy the data stored in the barcode.

Two Dimensional Barcodes 2-D barcodes are more complex and store data in the form of a matrix or stack. Stacked 2-D barcodes contain data in the form stacks of linear barcodes whereas matrix 2-D barcodes store data in the form of hexagonal, square or circular cells. They can store data in both vertical and horizontal direction.

2-D symbology

Advantages of 2-D barcodes

- These barcodes can store much larger amount of data ranging up to thousands of alphanumeric characters.
- Error correction formula can be embedded into barcode which helps in the retrieval of data in case barcode is damaged up to 15 to 20%.
- Variety of data can be embedded into these barcodes such as numeric, binary, text and Unicode data.
- Disadvantages of 2-D barcodes
- Specialized hardware and software scanners are required to generate and decode these barcodes which can be expensive.
- Complex algorithm needs to be designed for 2-D barcodes which make things much complex as compared linear barcodes.

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VI. APPLICATION

Modular Arithmetic -Another application of the division algorithm that will be important to us is modular arithmetic. Modular arithmetic is an abstraction of a method of counting that you often use. For example, If it is now September, what month will it be 25 months from now? Of course, the answer is October, but the interesting fact is that you didn't arrive at the answer by starting with September and counting off 25 months. Instead, without even thinking about it, you simply observed that $25 = 2 \cdot 12 + 1$, and you added 1 month to September. Similarly, If it is now Wednesday, you know that in 23 days it will be Friday .This time, you arrived at your answer by nothing that $23 = 7 \cdot 3 + 2$, so you added 2 days to Wednesday instead of counting off 23 days. Surprisingly, this simple idea has numerous important application in mathematics and computer science. You will see few of them in this section. The following notation is convenient.

When $a = qn + r$, where q is the quotient and r is remainder upon dividing a by n, we write a mod n = r

or a = r mod n. Thus,

- 3 mod 2 = 1 since $3 = 1 \cdot 2 + 1$,
- 6 mod 2 = 0 since $6 = 2 \cdot 3 + 0$,
- 11 mod 3 = 2 since $11 = 3 \cdot 3 + 2$,

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More generally, if a and b are integers and n is a positive integer, we often write a = b mod n whenever n divides $a - b$.

In our applications, we will use addition and multiplication mod n. When you wish to compute $(ab)\ mod\ n$ or $(a + b)\ mod\ n$ and aor b is greater than n it is easier to "mod first." By this we mean

$(ab)\ mod\ n = ((a\ mod\ n)(b\ mod\ n)\ mod\ n.$

Similarly, $(a + b)\ mod\ n = ((a\ mod\ n) + (b\ mod\ n)\ mod\ n.$

Here are some Examples:

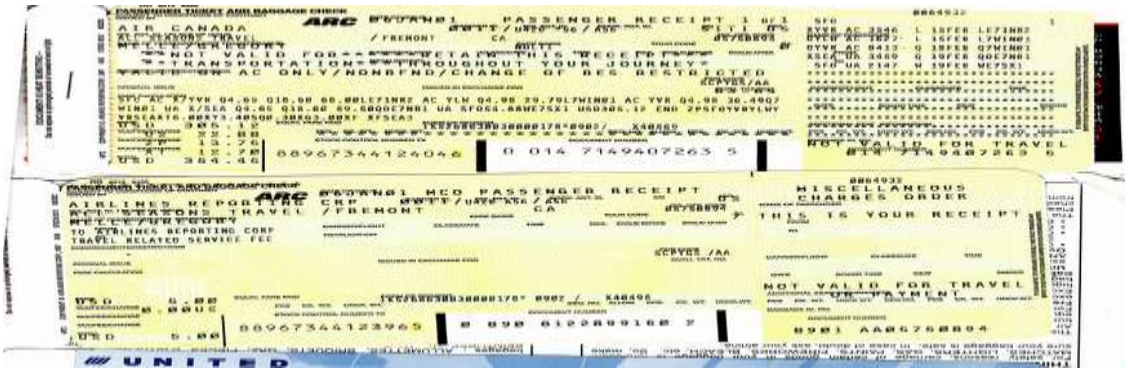
$$(17\ \cdot 23)\ mod\ 10 = ((17\ mod\ 10)(23\ mod\ 10))\ mod\ 10 = (7 \cdot 3)\ mod\ 10 = 21\ mod\ 10 = 1(17 + 23)\ mod\ 10$$
$$= ((17\ mod\ 10) + (23\ mod\ 10))mod\ 10 = (7\ mod\ 10 + 3\ mod\ 10)\ mod\ 10 = 10\ mod\ 10 = 0$$

Moduler arithmetic is often used in assigning an extra digit to identification numbers for the purpose of detecting errors. We present such applications.

Example: Airline companies, united parcel service, and Avis and National rental car companies use the modulo 7 values of identification numbers to assign check digits. Thus, the identification number 00121373147367 (see in figure 1) has the check digit 3 appended to it because 121373147367 mod 7=3. Similarly, the UPS number 00147494072635,Shown in figure 3 has the check the digit 5 appended to it and number 089801228991602 has the check the digit 2 appended to it.

Figure 1

Figure 2



The methods used by the postal service and the airline companies do not detect all single-digit errors as well as nearly all errors involving the transposition of two adjacent digits, is easily achieved. One method that does this is the one used to assign the so-called Universal product code (UPC) to most retail items (see in figure 3).A UPC identification number has 12 digits. The first six digits identify the manufacturer, the next five identify the product, and the last is a check. (For many items, the 12th digit is not printed but it is always bar-coded)

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In figure 3, the check digit is 8. To explain how the check digit is calculated, it is convenient to introduce the dot product notation for two k-tuples:

$$(a_1, a_2, \ldots, a_k).(w_1, w_2, \ldots, w_k) = a_1w_1 + a_2w_2 + \ldots + a_kw_k.$$

An item with the UPC identification number $a_1a_2 \ldots a_{12}$ satisfies the condition

$$(a_1, a_2, \ldots, a_{12}).(3,1,3,1 \ldots,3,1) \bmod 10 = 0$$

To verify that the number in figure 3 satisfies the above condition, we calculate

$$0 \cdot 3 + 2 \cdot 1 + 1 \cdot 3 + 0 \cdot 1 + 0 \cdot 3 + 0 \cdot 1 + 6 \cdot 3 + 5 \cdot 1 + 8 \cdot 3 + 9 \cdot 1 + 7 \cdot 3 + 8 \cdot 1 = 90 \bmod 10 = 0$$

The fixed k-tuple used in the calculation of check digits is called the weighting vector.

Now suppose a single error is made in entering the number in figure 3 into a computer say, for instance, that 021000658798 is entered (notice that the seventh digit is incorrect). Then the computer calculates

$$0 \cdot 3 + 2 \cdot 1 + 1 \cdot 3 + 0 \cdot 1 + 0 \cdot 3 + 0 \cdot 1 + 6 \cdot 3 + 5 \cdot 1 + 8 \cdot 3 + 9 \cdot 1 + 7 \cdot 3 + 8 \cdot 1 = 99$$

Since $99 \bmod 10 \neq 0$, the entered number cannot be correct.

In general, any single error will result in a sum that is not 0 modulo 10.

The advantage of the UPC scheme is that it will detect nearly all errors involving the transposition of two adjacent digits as well as all errors involving one digit.for doubters let us say that the identification number given in figure 0.4 is entered as 021000658798. Notice that the last two digits proceeding the check digit have been transposed. But by calculating the dot product, we obtain $94 \bmod 10 \neq 0$, so we have detected an error. In fact, the only undetected transposition errors of adjacent digits a and b are those where $|a - b| = 5$ .to verify this, we observe that a transposition error of the form

$$(a_1a_2 \ldots a_ia_{i+1} \ldots a_{12}) \longrightarrow (a_1a_2 \ldots a_{i+1}a_i \ldots a_{12})$$

Is undetected if and only if

$$(a_1, a_2, \ldots a_i, a_{i+1}, \ldots a_{12}) \cdot (3,1,3,1 \ldots,3,1) \bmod 10 = 0$$

That is,the error is undetected if and only if

$$(a_1, a_2, \ldots a_i, a_{i+1}, \ldots a_{12}) \cdot (3,1,3,1 \ldots,3,1) \bmod 10$$

$$= (a_1, a_2, \ldots a_{i+1}, a_i, \ldots a_{12}) \cdot (3,1,3,1 \ldots,3,1) \bmod 10$$

This equality simplifier to either

$$(3a_{i+1} + a_i) \bmod 10 = (3a_i + a_{i+1}) \bmod 10$$

Or

$$(a_{i+1} + 3a_i) \bmod 10 = (a_i + 3a_{i+1}) \bmod 10$$

Depending on whether I is even or odd. Both cases reduce to $(2a_{i+1} - a_i) \bmod 10 = 0$. It follows that $|a_{i+1} - a_i| = 5$, If $a_{i+1} \neq a_i$

Figure 3

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VII. BENEFITS

In point-of-sale management, barcode systems can provide detailed up-to-date information on the business, accelerating decisions and with more confidence. For example:

- Fast-selling items can be identified quickly and automatically reordered.
- Slow-selling items can be identified, preventing inventory build-up.
- The effects of merchandising changes can be monitored, allowing fast-moving, more profitable items to occupy the best space.
- Historical data can be used to predict seasonal fluctuations very accurately.
- Items may be repriced on the shelf to reflect both sale prices and price increases.
- This technology also enables the profiling of individual consumers, typically through a voluntary registration of discount cards. While pitched as a benefit to the consumer, this practice is considered to be potentially dangerous by privacy advocates.
- Besides sales and inventory tracking, barcodes are very useful in logistics and supply chain management.
- When a manufacturer packs a box for shipment, a Unique Identifying Number (UID) can be assigned to the box.
- A database can link the UID to relevant information about the box; such as order number, items packed, quantity packed, destination, etc.
- The informatin can be transmitted through a communication system such as Electronic Data Interchange (EDI) so the retailer has the information about a shipment before it arrives.
- Shipments that are sent to a Distribution Center (DC) are tracked before forwarding. When the shipment reaches its final destination, the UID gets scanned, so the store knows the shipment's source, contents, and cost.
- Barcode scanners are relatively low cost and extremely accurate compared to key-entry, with only about 1 substitution error in 15,000 to 36 trillion characters entered. The exact error rate depends on the type of barcode.

VIII. CONCLUSION

Barcodes are an efficient, reliable, robust and quick way of storing and retrieving useful information, particularly where large number of items needs to be associated with some sort of identification information. In this book, basic categories of barcodes have been explained along with myriad of information associated with each type of barcode. Readers can now read and decide what type of barcode is suitable for them according to their needs and area of business. While almost every area of business is computerized, barcodes can really leverage your business and decision making processes.

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