Barcodes

Contents:

Synopsis:

This piece of coursework is about the use of barcodes, how they are used in today's world of stock control at the point of purchase and their relative advantages over more conventional methods of storing information. Bar coding by its very nature demonstrates the versatility of digitally encoded systems as opposed to their analogue counterparts including their in build ability to allow error correction on the fly.

I will go through in detail, a variety of different types of barcode, both linear and two dimensional as well as talking about the origins of the different barcode systems, how they are read, and how they work. Also I will include a few working examples.

What is a barcode?

A barcode is data that is machine readable, yet it is usually nothing more than blobs of ink on a sheet of paper. A scanning device compares the blobs of ink to the background, and converts that into a series of 1s and 0s, a binary code, to read the data.

The barcode was patented in 1952 by Joseph Woodland and Bernard Silver, originally created to identify railway carriages, and became commercially used in 1966, but only became popular in the 1980's. Today linear barcodes are mainly used to identify products in supermarkets. Originally, they could only hold numerical data, but later they were developed to store any ASCII (American Standard Code for Information Interchange) character.

The above image shows a CODE128 Linear barcode, if scanned, it should decode and print the message written beneath it. ("This is a CODE128 Barcode!")

In this project, I hope to investigate the different types of barcode, and their benefits in the information age.

Barcodes are essentially another way of imputing data into a computer system, when used in supermarkets, the code is usually a reference to a product stored on a database. The scanning system itself saves the user having to type in a 12 digit product code every time they sell an item. The database would then send back the data of what the item is, and how much it costs, almost instantly.

Another set of barcodes are 2D (2-Dimensional), this means instead of long "bars" of code, the data is made up of dots. This naturally means one can store a lot more information in a smaller space.

The above is an example of a 2D barcode, known as QR Code, (when this one is scanned, it should output: "This is a 2D barcode system known as QR Code"), I will be looking more into different types of barcodes later on, including a more in depth explanation of both CODE128 and QR Code.

Barcodes can be used to track items, a barcode would be placed on the item, and when it reaches destinations, it can be checked with a database for information like, where it's come from, where it's supposed to go, when it was sent. The same sort of system can be used to sort documents too, a user could encode data like, what category a certain document would be filed under, then when scanned, the user would be told where the selected document should be filed.

Reading a barcode

There are a variety of ways of reading barcodes:

- CCD Scanners – A CCD (Charge-Coupled Device) is at the heart of this system. The scanner is essentially just a miniature camera (like the ones found in most camera Mobile phones), that will simply look for light and dark patches and recognise it as a barcode, it will then decode what is written in the barcode and sent it to the target machine. For them to work, the scanner needs to be quite close and needs a good light source.
- Laser Scanners – This time, a laser provides the light, and a set of mirrors or prism deflects the returning light to the sensor (a photo diode). Laser is an acronym for “Light Amplification by Stimulated Emission of Radiation” and is a device that emits a bright light at a specific wavelength.
- Camera based Scanner – This is almost like a CCD scanner, only usually the target machine has the software to decode the code.

None of these examples can be classed as “the best” way to scan a barcode, as the different kinds of code and where they are found can be a factor, for instance, INTACTA.CODE (which I'll discuss later) is best scanned with a CCD flatbed scanner, whilst U.P.C.'s (the barcode that's used by supermarkets to track products) are better scanned with laser readers

More about a Laser:

To understand lasers, you need to think of atoms as nucleus's with electrons “orbiting” around them, though this is not exactly true, it illustrates the point more clearly. Electrons want to be as close the the nucleus as possible, the laser system stimulates the atom into an “excited” state. When the electrons move to a closer “orbit” they emit photons of a particular colour, this is the light that we see. The colour produced depends on the atom used. What makes light from a laser unique is that the beam is directional, meaning more light is focused in one place, making the beam brighter.

Illustration 1: Photons are given off when electrons move closer to the nucleus

Digital Data:

Data on barcodes are digital, meaning that the information is either “on” or “off”, this is known as binary data. “On” is usually represented by the number 1, whilst “off” is usually 0. When printed, each bit marked as “1” would be printed as a black dot, whitest “0” would be a white dot. Some systems (like INTACTA.CODE) are able to tell when the images is inverted, this means in some cases, if the barcode system knows what is representing a 1 and a 0, it should be able to decode it regardless.

The advantage of using a digital system over an analogue system (I.e. Using a high density barcode to archive a picture, than scanning a photograph) is when the barcode is decoded, it will be an exact (1:1) copy of the original file that used before being encoded. The analogue version is susceptible to dust, dirt and “noise”. The down side is that the digital version is limited as to its size, and compression, so the quality is never as good as its analogue equivalent.

This can be compared to a Compact Disc (CD) and a Vinyl Record, whilst a Vinyl has almost an infinite range of frequencies, CDs can only reach a maximum of 22.05kHz per channel. The downside to vinyl (or any analogue standard) is that any small blemishes, can still be heard (pops, crackles, hiss, etc.)

But the main advantage of the digital technology is that it is far more resistant to background noise, as there are only supposed to be two signals (black and white), in this case, noise can be filtered out with a threshold filter.

Illustration 2: An example of threshold.

The above illustration shows this, the gradient is almost too bright (on a computer screen, this may not be the case when printed) to read the “K” from my website's address, but when the threshold setting is adjusted using a graphics editing suite (like Adobe Photoshop) the full address is readable, and the noise that was preventing it being read is now removed.

Another sound example shows how an analogue sound with noise can be remastered to remove the noise, but the doesn't sound the same as the original. But a digital one can be easily remastered as it is easy to see where the high and low point should be.

Illustration 3: Example of the advantages of digital noise correction

Types of Barcode

Linear:

U.P.C. (Universal Product Code)

This is by far the most common type of barcode, used in almost every supermarket, book store, music shop, or anywhere that sells stuff using tills.

Illustration 4: A UPC-A barcode

Above is a UPC-A barcode, used in most stores, if the above is scanned, the output should be “012345678905”, the leading 0 and the end 5 represent the “quiet zones” (and are shown outside the barcode to let a human know where these quiet zones are) which are needed for a scanner to read UPC-A codes correctly as it tells the scanner where the beginning and the end of the barcode is.

Error correction, the 5 on the end of the code is a check number, how it is worked out is to add the odd numbered positions (0,2,4,6,8,0 --> 20) and times by 3 (60) then add the even numbered (1,3,5,7,9 --> 85) remove the leading 8 (5) then subtract it from 10 (5)

12 Digits are encoded into a UPC barcode, these can only be numbers. The start and end patterns take the form of 101 (3 bits of binary data), and a middle section 01010 (5 bits), this and 12 digits at 7 bits each total 95 bits in each barcode.

Below is a table showing exactly what each decimal number represents.

Digit	Pattern	Digit	Pattern
0	0001101	5	0110001
1	0011001	6	0101111
2	0010011	7	0111011
3	0111101	8	0110111
4	0100011	9	0001011

As you can see, there are a lot of unused codes, 12 bits could be used to encode up to 128 characters....

CODE 128

Illustration 5: A CODE 128 barcode

This barcode is a little different to the UPC we saw above, this time, instead of being limited to the digits 0-9, CODE 128 can encode any one of the 128 characters in the

ASCII (American Standard Code for Information Interchange) system, and is able to store upto 128 characters on one code. This is where the 128 in the name comes from. If the above example is scanned, it should output “CODE128 Barcode” and is able of encoding 2 characters in the space of one, making it “double density”

MSI

Illustration 6: MSI Barcode

MSI is also known as “Modified Plessey” based on the original Plessey standard, this kind of code only supports numerical data. It is mainly used in warehouses.

Other linear barcode systems include:

Codabar: (1972) early barcode system that was designed to be easily printable by dot-matrix printers

Code 93: Similar to Code 128, but only supports 93 Characters (made in 1982)

Plessey: Only able to display Hexadecimal numbers (0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F)

2D Barcodes:

Data Matrix:

Illustration 7: A Data Matrix code

The above is an example of a Data Matrix code, (when this one is scanned, it reads “This is an example of a Data Matrix code!”) they can encode as little as a few byes, to up to 2kB (2 Kilobytes). When there is too much data encoded in one symbol, more are added, there is always a square number of symbols.

Illustration 8: Many Data Matrix symbols connected together

Data Matrix is a free standard, but there is no free documentation that explains how it works.

It is often used for digitally summarising documents, and product information on labels. It is often seen on the back of computer products containing its serial number.

QR Code:

Illustration 9: Another example of QR Code

QR Code is a popular barcode in Japan, it is mainly used for storing URLs for mobile website. It is also used for storing text data to read later, McDonald's (Japan) have started using it to display the nutritional information in their foods. Most modern mobile phones have applications to read both Data Matrix, and QR Code

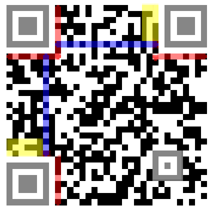
Illustration 10: A Nokia N95 8GB reading the QR Code in the previous illustration

The QR code reads "This is a QR Code, QR stands for Quick Response."

QR was originally used in tracking parts for vehicle manufacturing, but is now used widely across Japan, in magazines (instead of putting URLs to websites that could be mistyped), on signs and business cards (to give more information).

Different sections of a QR Code are reserved for the encoding system itself:

The Sections in YELLOW represent the version information, whilst the bits in RED represent the format. The BLUE parts are the timing code. The small GREY block is an aligenment section whilst the bigger GREY blocks are position.



INTACTA.CODE:

I first became aware of this barcode system on the 17th May 2000 when it was featured on BBC's “Tomorrows World”, sadly, trying to find information on INTACTA.CODE is incredibly difficult!

The next page contains an example

I should have included a CD with software to decode this. What happens is, the software interacts with the computer's scanning software, and will allow one to scan the code. INTACTA.CODE's error correction works incredibly well, if one was to stab a few holes into the code, the software should still have no problem decoding it.

To get a result out of the image, it should be scanned at about 600dpi on the Black and White (Lineart) setting, if it's still unsuccessful, try adjusting the “threshold” setting.

Once scanned, the program should produce a reasonably high resolution JPEG (Joint Photographic Experts Group) of the following picture:

Illustration 11: The picture that was coded into the INTACTA.CODE

(If the example STILL can't be read, try the smaller example in the Appendix section)

The INTACTA.CODE system is proprietary so finding information about it is near impossible, and the ability to write my own INTACTA.CODEs is non existent.

INTACTA.CODE uses compression, meaning that it can put high amounts of information into a small space. If the software was readily available, any computer file can be turned into code, all the users need is a printer, and a scanner. INTACTA.CODE can also be encrypted so only the people it was intended for can read it. The robust error correction means that the file you extract from the code should be exactly the same when it's decoded.

In Japan, Fujitsu developed INTACTA.CODE for use in newspapers and magazines, to include video clips, audio files, document files and web links for the reader to scan in using a regular flat bed, or hand held scanner. (The reader program I have included is a translated version from the archived Japanese site). The reader was included with all new (at the time) Fujitsu computers. There seems to be no information as to why the code is no longer being actively developed and used.

Illustration 12: INTACTA.CODE

High Capacity Color Barcode:

The High Capacity Color Barcode is a system designed by Microsoft, because colour is also a factor in the reading of the barcode, more data can be compressed into a smaller space. An 8 bit (1 byte) sample, usually taking up 8 symbols, now can be compressed into 2.66 symbols.

Illustration 13: 2 Different "color" barcodes.

Illustration 14: A diagram showing how 8 bits can be compressed into the space of 4 and even 2.66

Not being a fan of Microsoft, I didn't spend much time looking into this particular system, but 2000 bytes of data can be compressed into a square inch.

PaperDisk:

Illustration 15: PaperDisk

PaperDisk is made by Cobblestone Software, and is rather similar to INTACTA.CODE, they provide a Shareware version of their software which allows one to encode any file to its barcode program. It will allow you to make your code as long as you want or as short as possible. Obviously the bigger you make it, the more reliable it is, the down side is it will use more pages. The code itself is a lot bigger and less compressed than INTACTA.CODE.

If you scan this image into the PaperDisk program (I have provided) you will get the Ponteland High School logo:

Illustration 16: The PaperDisk sample outputs this

Systems like this can also allow one to send data securely as most of the examples I've researched can allow someone to encrypt the data that goes into them. Intacta Technologies claims that their INTACTA.CODE is military standered encryption.

PaperDisk also has an encryption system, so the recipient would have to type a password to retrieve the data that is encoded in the code.

Dolby Digital / Sony Dynamic Digital Sound (Cinematic film):

Illustration 17: A sample of 35mm film showing 3 different sounds encoded (From L to R) SDDS, Dolby, analogue optical sound, to the far right there is also a time stamp

Barcodes are used in the cinema to encode sound, on the left hand side of the above image, you can see Sony Dynamic Digital Sound, and between the sprocket holes there is Dolby Digital (the barcode is designed to have the Dolby "Double D" logo in the middle.

The advantage of using a barcode on the film is that one only needs one physical media to both watch and hear the movie, and more than just 2 sound track (as limited to in the analogue system on the right) can be encoded (like Dolby Digital 7.1 which has 8 sound channels)

Reduced size barcodes and radio barcodes are being developed, which will allow one to attach a barcode to a smaller item, and allow it to be scanned from a distance.

Barcodes are a great way to store data in a unique way, in theory, the data they carry is less prone to being corrupt.

Appendix A: Second INTACTA.CODE Example:

Above is another example of INTACTA.CODE (in case the other one doesn't work on your scanner), when scanned, you will see:

These are the only two INTACTA.CODE examples I have.

Appendix B (PaperDisk)

The next few pages will include “tiles” of PaperDisk, the software I've included will be able to decode this. The code should produce a PDF copy of this coursework (without the images (as it would mean there would be 31 data tiles!). This shows what a barcode system like PaperDisk is capable of.

To use, open the PaperDisk program, accept the shareware licence, click “Scan, Decode” and scan each page, then click “Scan, Decode, Run” for the last tile.

You will need a PDF reader like “Adobe Reader” to open it

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