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A paper proposed for presentation at the
I. D. Expo Meeting
April 20-22, 1988

and for publication in the proceedings

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OCR VISION SYSTEM, AN ALTERNATIVE TO BAR CODE

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BACKGROUND

The Savannah River Laboratory does research and development in support of the manufacture of nuclear fuel elements for the Department of Energy Savannah River Plant. One recent task involved development of a system for serial numbering aluminum-clad fuel slugs in such a way that the number could be read by machines as the slugs progressed through various process steps. The slug product specifications require that the surface must be free of any foreign material. This eliminated the use of tags, dye, ink or oxide coatings. The only acceptable method of marking was some form of engraving. After the slug is marked it passes through a number of steps that change the surface finish, including a grit-blasting operation that removes a uniform thickness of metal from the entire surface. The first choice of a keyless data entry system was bar code, but after a long and fruitless search, no bar code system that would work under existing process conditions and limitations could be found. This paper was written to share the information learned in the process of developing an optical character reader vision system as an alternative to bar code.

INTRODUCTION

Bar code is clearly the keyless data entry system of choice for most applications. It is fast, accurate, relatively inexpensive, and universally accepted. There are scores of manufacturers of hardware and software, and the technical press now has monthly publications that devote most their available space to some aspect of the bar code industry.

But bar code, like any other system, has its limitations, and when needs fall outside of those limits, bar code cannot be used. The three major limits of bar code are: (1) size, (2) print contrast, and (3) appearance.

SIZE

There is a lower limit to the size of a bar code label. The standards specify a minimum bar or space width for dependable service, but with careful selection of the scanner, the print media and the printing process, it is possible to develop a system that will work well with labels that are considerably smaller. But the engineering limit is reached when the size of the bar or space in the code approaches the size of the spot of light that is used to scan the code. At the same time, the ability to print a bar of uniform thickness on a tag becomes a real problem.

CONTRAST

The ability of a scanner to read a bar code depends entirely on the optical contrast between the bars and the spaces. Dark black bars on a white background are best, but many other color combinations are possible. There are some combinations that may not be read well with a laser scanner that work perfectly with infrared, and others that are read best with a laser, but some bar code that appears clear to the eye can simply not be read with any bar code scanner. The best example of this is a bar code engraved on a metal surface. There are some special systems in use where bar code engraved in a metal surface is being read, but in general it is too difficult to be considered practical.

APPEARANCE

Because bar code must be at least a certain minimum size and must be preceded and followed by a quiet zone, a bar code label can take up a major part of the available surface of a small product. Whatever other virtues bar code may have, beauty is not one of them, and there are cases where the presence of a bar code is undesirable because of its appearance.

If you have a need for a keyless data entry system to read identification numbers and can't use bar code for some valid reason, an optical character reader vision system may meet your needs.

Before I can discuss vision systems, I must present some background information because of the bad reputation of optical character readers. Optical character readers were the first system to reach the point-of-sale market many years ago, and they had problems. The point-of-sale character readers use a simple template-match system that requires a good match between the character and the template in computer memory. At the time these systems were introduced, computers were not as powerful as they are today, and the tag printing industry was not aware of the precision required by machine readers. The result was that point-of-sale systems were just short of a disaster. By the time bar code was introduced as competition, new generations of computers were available, and the developers of bar code were careful to enforce rigid specifications on printers. The result was that the public in general associates optical character readers with the frustration of poor operation, and bar code readers with efficient operation.

The vision systems of today have about the same relation to early optical character readers as a single engine private plane has to a supersonic jet. They both do the same thing, but they go about it in an entirely different way. Modern vision systems use a method similar to the reasoning process of the human mind to recognize characters. A character can be recognized if enough unique characteristics are visible to distinguish it from all other possibilities. Engineers have become aware of the importance of print standards, and detailed specifications have been written for print fonts to be read by optical character readers.

Although machine vision systems are used today for a wide range of applications from reading printed text to quality control inspection, this paper will be limited to finding and reading identification codes or serial numbers.

Machine vision systems use a video camera to acquire an image. In general, if it is possible to get a clear readable image of a character set on a video monitor, that character set can be read by a vision system. The size of the character set on the product can be too small to be read without a magnifying glass, or as large as a billboard, but it can be read with a vision system if it can be magnified or reduced to the proper size for presentation to the video screen.

Optical character reader vision systems have limitations that must be understood when considering an alternative to bar code:

COST

An optical character reader vision system may cost ten times the amount required to purchase a good industrial bar code reader system.

PORTABILITY

There are no truly portable systems on the market today, because vision systems use a video camera that must be focused on the object containing the character string. All of the technology necessary for development of a portable system, including automatic size scaling software, search and translation software, multiple font recognition software, and autofocus camera lenses are available, but to date, no vendor has integrated all of the components into a marketable portable optical character reader.

POSITION AND ORIENTATION

Until recently, it was necessary for the character set to be printed in a horizontal straight line and presented to the video monitor at a known location with only a small allowable variation in position. Recent advances in vision system technology make it possible to read characters that are printed around the circumference of a circle, such as the part number on the plane surface of a ball bearing race. Other non-linear configurations can also be read. In addition, it is possible for the system to search the entire video monitor field of view to find an object, and then find and read the character set printed on that object. Of course the vision system has to be programmed to know the shape of the objects and the relative location of the character set on the object before it can perform a successful search-find-and-read operation.

PERSONNEL TRAINING

Initial installation and programming of a vision system requires the services of a person who is familiar with computers and has had up to a week of training to learn the details of the vision system. Once the system has been programmed for a particular task it can be operated by production operators.

If you need a keyless data entry system, can't use bar code, and feel that you can accept the limitations of a vision system, I would like to offer some suggestions for the design and specification of your system.

SERIAL NUMBER DESIGN

Any machine system will work better if it operates in a favorable environment. Your vision system will give you the best service if you can include as many of the following suggestions as possible.

Print Fonts

Optical character readers can be trained to read any print font, but there are likely to be fewer errors if the print font is designed to make each character unique. It is possible to confuse the letter "O", the number "0" and the letter "Q" in most standard print fonts. A special print font called OCR-A designed for use with optical character readers (see Figure 1) gives each character a unique shape that is still quite legible. Use this print font if you can.

ABCDEFGHIJKLM

NOPQRSTUVWXYZ

0123456789

FIGURE 1. OCR-A Font (uppercase).
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Print Quality Control

Verify that the print font you specify is the print font that you get. If you simply specify a font by name, the shape of characters may vary from one vendor to the next. Many firms that do printing and engraving have not had experience with optical character readers, and are more concerned about the artistic appearance of a font than adherence to a specification. You are most likely to get good results if you send your vendor a detailed specification similar to that shown in Figure 2 for OCR-A. The vendor is not likely to have this information if you don't send it to him.

AMERICAN NATIONAL STANDARD X3.17-1981

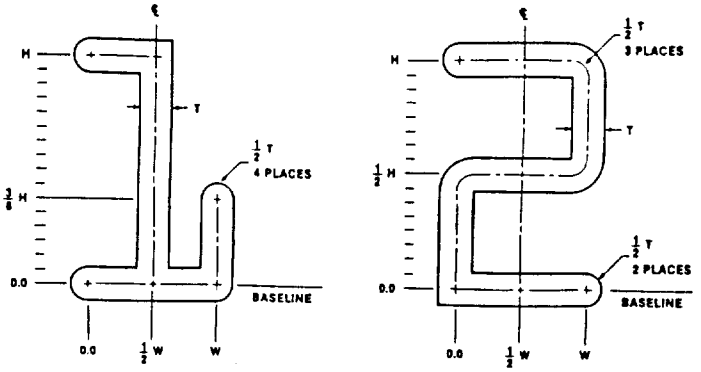

Fig. 1
Digit One

Fig. 2
Digit Two

Table 2
Nominal Character Sizes and Stroke Width Tolerances

	Nominal Centerline				Nominal Stroke Width (T)		Tolerances					
	Height (H)		Width (W)				Range x*		Range y†		Range z†	
Size	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
I	0.094	2.40	0.055	1.40	0.014	0.36	±0.003	±0.08	±0.006	±0.15	±0.008	±0.20

FIGURE 2. Typical Character Specification.
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Print Contrast

One of the major strong points of vision systems is that they work with a grey-scale image and do not require black print on a white background, but there are limits to the grey scale system too. Try to make characters as clear and as bold as possible within the limits of your capability.

Fielding

If you can design your character string so the range of possible characters in a certain position are always numbers or are always letters, the character reader will have improved speed and accuracy. If the number 0 appears in a position that is known to contain only numbers, the computer will not have to verify that it is not the letter Q or the letter O.

Check Character

The use of a "Check Character" will reduce the chances of error in any keyless data entry system and should be used if at all possible. A check character is a number or letter that is related by a formula to the ASCII value of the individual characters in a character string. There are different formulas in use for check characters, but for

illustration, assume that the first character of a serial number is the check character, and the value of the check character is selected to make the total of all of the characters sum to the value 10. Then:

SERIAL NUMBER	CHECK CHARACTER	ACCEPT-REJECT
5023	5	ACCEPT
4013	4	REJECT
1711	1	ACCEPT
41?2	4	See Below

There is an error in the serial number 4013 because the sum of the digits is eight, not ten as required by the system. The reader will reject this number. The number 41?2 has a missing or illegible character in the third position that would ordinarily make the number a reject, but because it is known that the digits must sum to the value ten, the missing number is a three.

Specification of an optical character reader system includes both the reader and the print. In many cases a factory must mark a serial number on a production part that is later read by the character reader. Marking a serial number in a straight line is a routine task that can be done by a number of different machines, but until recently if a number had to be marked on a plane surface around the circumference of a circle, a laser was the system of choice. This was of no concern to users of vision systems until last year, because vision systems couldn't read numbers that weren't in a straight line. Now that vision systems can read in circles, there are also computer controlled dot matrix engraving machines that can print in a circular format. These machines use a single punch that is directed to print characters in a 5x7 dot matrix font.

The user who cannot use bar code is forced to write the specifications for an optical character reader system, a serial number system, a print font, and perhaps even the printer itself. It is then necessary to train personnel to write programs and learn the operation of the equipment. All of this is significantly more costly and time consuming than the purchase of a "turn key" bar code system, but if there is a need for a keyless data entry system, and bar code cannot be used, a vision system can be designed to give the same good results.

ACKNOWLEDGMENT

The information contained in this article was developed during the course of work under Contract No. DE-AC09-76SR00001 with the U. S. Department of Energy.