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A ternary barcode detection system with a pattern-adaptable dual threshold

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Abstract

A ternary barcode detection system employing a dual-threshold detection method is proposed to increase detection speed and detection range. This system, providing adaptability to any ternary barcode pattern through the attenuation of an enveloped line of a detected barcode signal and subtraction from the original barcode signal, enables detection over a longer range and also at higher scanning speeds while remaining compact and containing a great amount of information. The system was tested and confirmed to operate at a maximum scanning speed of seven times that of conventional CCD cameras under the practical detection range. It is estimated that a combination of ternary barcodes consisting of nine elements per character will enable the system to express at least 640 characters, over 14 times more than the conventional binary barcode Code39. This system is expected to enable the real-time identification of goods in automated warehouses and production lines.

Keywords: Optical detection system; Barcode; Ternary; Laser scanner

1. Introduction

The identification of goods in real time is an attractive application for areas of industry in which high-speed detection is required, such as in goods management on production lines or in automated warehouses. In order to realize real-time identification, product barcodes needs to contain a lot of information. Until now, the use of high-density two-dimensional (2D) binary barcodes or color 2D barcodes [1,2] for identification systems has been considered. However, the maximum scanning speed in these techniques is limited to approximately 50 scan/s by complicated image processing using CCD (charge coupled devices) cameras [3,4], and this causes the problem of difficulty in achieving the high-speed sorting of goods. Further, since the depth of the field in a CCD camera lens is shallow (<2 cm), focus adjustment is required to realize a longer detection range. Although laser scanners are now being used for identifying binary barcodes in production lines, etc., no laser scanner enabling the system to identify color barcodes or half-tone barcodes has been developed yet. This is attributable to the extreme difficulty of realizing a signal-processing scheme for these barcode detection signals.

In this paper, a ternary barcode detection system (TBDS) with the laser scanner employing a dual-threshold (DT) detection method is proposed, providing a long detection range without having to adjust the focus. It also provides a high scanning speed, while maintaining a great amount of information and small system size.

2. Dual-threshold ternary barcode detection system

An outline of the DT TBDS using a laser diode scanner is shown in Fig. 1, and its detection method is explained in Fig. 2. This system obtains an enveloped line of a detected barcode signal (obtained when scattered reflected laser light from the barcode is detected by a photo-diode and detection amplifier) using an enveloped line detector and obtains two reference signals by decreasing this enveloped line to two levels with 60 and 25% attenuators. These reference signals, subtracted from the

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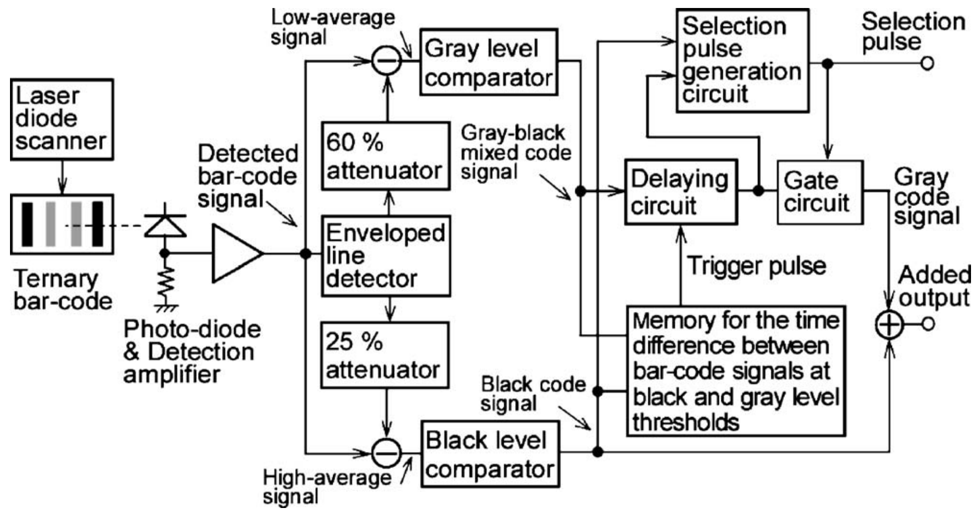

Fig. 1. A schematic outline of the dual-threshold ternary-barcode detection system.

original barcode signal in different subtraction gates, get low-average and high-average signals. Thus, a bent barcode signal with a hyperbola-shaped enveloped line is easily changed to unbent low- and high-average signals. Gray-black mixed and black code signals are obtained by comparing these low- and high-average signals with independent thresholds V_{T1} and V_{T2} in gray-level and black-level comparators, respectively. This method automatically allows the system to control comparison levels to a proper level depending on the barcode signals. Therefore, ideally code signals can be obtained properly regardless of the detection distance. The mixed code signal is delayed by a time difference Δt between the gray-black mixed and the black code signals at each of rise or fall change (caused by the difference of comparison levels) in order to obtain a selection pulse for producing a gray code signal. The selection pulse is created using a sampling circuit, which samples the black code signal selectively at the falling edge of the delayed mixed code signal. When the black code signal is low, the selection pulse becomes low at the first pulse of the black code signal, and this state is maintained until the high state of the following black code signal is sampled. Therefore, the gray code signal is obtained by deleting only the signal parts corresponding to black bars using the logical product gating operation of the selection pulse and the delayed mixed code signal. The gray and the black code signals are then added together in the summing gate, and the added output is decoded in a decoder, which chooses the gray or black code signal with the selection pulse.

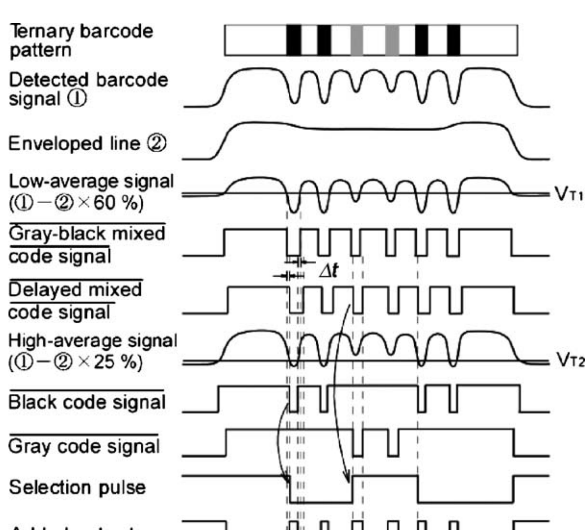

Fig. 2. Waveforms in the ternary-barcode detection system employing the dual-threshold detection method to explain operation principle.

The proposed system does not need complicated image processing or focus adjustment. Therefore, it is expected to detect barcodes at higher speeds and over longer ranges.

3. Estimation of the amount of information

When the ternary barcode is used, the amount of barcode information greatly increases compared to that of a conventional binary barcode. As an example of the amount of information, consider an independent type nine-element barcode consisting of three wide and six narrow bars (five colored bars and four white bars inserted between neighboring colored bars) per one character. Here, elements represent pieces of white or colored bars comprising a barcode, and characters represent information units consisting of several elements (see Fig. 3(a)). In the binary barcode known as Code 39, with a character consisting of five black and four white bars, the combinations of different bar patterns can be constructed depending on the position of wide and narrow black bars and wide and narrow white bars (Fig. 3(a)–(e)). In each combination of Fig. 3(a)–(e), black bars are fixed at both ends. The maximum number of expression characters $N_{(2)}$ is given by the total sum of the number of combinations n_{x2}. That is:

$$N_{(2)} = 3\,{}_4C_1\,{}_3C_2 + 2\,{}_4C_1 = 44 \quad (1)$$

However, when the n-ary barcode using black or halftone bars as the colored bars is used, the number of expression characters $N_{(n)}$ is generally given in the following formula, assuming that