# IMAGE-BASED DISCOUNT AND BARCODE RECOGNITION SYSTEM

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***ABSTRACT***

*Current Point-of-Sale processing is complex and time consuming. In this paper, we propose an image-based discount sticker and barcode "scan" system for automation. Recognition of discount stickers and barcodes is quite a big challenge, as different shooting conditions can result in different appearances. We design a deep learning classifier of various discount rates and barcode basing on YOLACT detection network. We also propose a data augmentation to generate various data that are close to real scene to improve the classification performance of deep learning model. Evaluation with our original data set shows that the proposed approach achieves high performance and is applicable to real-world scenario.*

***KEYWORDS***

*Classification, data augmentation, discount sticker, barcode, image-based, deep learning.*

## 1. INTRODUCTION

Point-of-Sale (POS) system is widely used in the retail industry. It is a general term for systems required to digitize and manage daily sales and sold products. It has various functions such as sales management, inventory management, customer management, headquarters as well as accounting management. Of these, the accounting function is most basic.

A smooth accounting is required without waiting for customers. However, it is necessary to learn how to handle and operate each different cases, which increases the burden on staffs. In normal accounting, staff register a product by scanning the barcode one by one with a scanner. However, the operation of discounted products such as time sales is complex. If a discounted "barcode" sticker is affixed on the product, it is easy for staffs to register the discount just by passing it through the scanner as a normal checkout. If there is a discount sticker such as ○% off, the staffs will need to find and enter a pre-registered discount button on the screen or press a handmade discount rate button to send the discount information to the system.

Based on the various complexity of accounting operations, we aim to provide an automatic image-based scanning system to facilitate the accounting process of the cash register. The system uses a webcam or digital camera or smart device to capture an image or video stream, and it has function to recognize both discount stickers and barcodes. This system can handle various accounting situations by simply recognize the discount stickers and barcodes of products, making it easy for non-experts to get the job done.

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## 2. RELATED WORKS

Several barcode detection techniques have been proposed. Some approaches take advantage of the feature that barcodes are a set of parallel vertical lines [1][2][3][4]. Some approaches use different filters to extract barcodes in different orientations and sizes [5][6][7]. Some approaches take measures for moving motion blur or complex backgrounds [8] [9]. We have proposed a deep learning-based approach using synthetic-to-real data augmentation to deal with multiple challenges [10].

Some techniques have been integrated into barcode processing systems. In [11], N. M. Z. Hashim et al. propose a system that converts colour images to grayscale images to reduce noise, enhances image contrast between bars and spaces, applies edge detection algorithm to demarcate barcode region, and uses MATLAB toolbox to visualize the image data. In [12], Xia uses a deep learning-based detector of You Only Look Once to design a barcode recognition system for barcode localization and recognition of express delivery. However, there is currently no system that recognizes both discount stickers and barcodes.

To achieve accounting automation, technology that can recognize both discount stickers and barcodes is required. In this paper, we propose a deep learning-based approach than can handle both. Currently, we use this technique for accounting automation, it can also be used for inventory and other uses. The remainder of the paper is structured as follows: Section 3 presents the proposed discount stickers and barcodes recognition techniques. Section 4 demonstrates the effectiveness of the proposed method through some experiments. Section 5 draws conclusions.

## 3. OUR APPROACH

In this section, we first explain the proposed “scan” system, then explain the proposed discount stickers and barcodes classification network, and finally explain our data augmentation for robust classification.

### 3.1. System Design

The system architecture is designed as shown in Figure 1. The part inside the grey frame is the proposed system, and the grey background part shows the POS system.

We first input the camera input. We then use classification network to detect discount sticker region and barcode region and determine the classification category of them. Categories include various discount rates and barcode. In the case of a discount sticker, the classification result of the discount rate such as 5% discount, 10% discount, 50% discount is output. For barcodes, the barcode category result and segmentation of the barcode region are output. If a barcode is detected, we then use its segmentation information to get a partial image containing the barcode, then apply an open-source Python package to perform barcode recognition in the region and output decoded information. We finally send the result combining the discount rate and the barcode in the process of linking the “scan” system and POS system. We set a switch to control the process. If the classification process only detected the barcode, the barcode recognition result is sent to the POS. If the classification process outputs both the discount rate and the barcode, we then use these two pieces of information to generate a discount barcode that reflects the information of the product and the discounted price and send it to the POS.

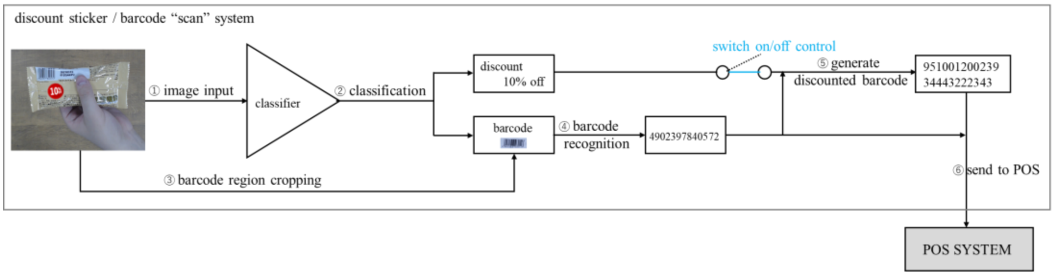


Figure 1. The proposed “scan” system

## 3.2. Classifier Network

Classifier network is the core recognition engine of the system. The Design of the classifier is our second solution to effectively maintain the balance between processing speed and cognitive performance.

We adopt YOLACT [13] from the existing classifiers. It is a one-step deep learning network that performs independent instances of object detection and mask generation. It provides real-time processing, high-quality masks, and stable detection results. In our system, we design each discount rate and barcode detector / classifier basing on the YOLACT.

## 3.3. Data Augmentation

Data augmentation is one of the key factors in deep learning performance. In [10], we propose a synthetic-to-real data augmentation to generate various barcodes that are close to the real scene. This improves the training performance of deep learning model. In this classification task, we extent the methodology to generate various images that contain various discount stickers and barcodes, which achieves coexistence of both data collection cost and data volume and data quality.

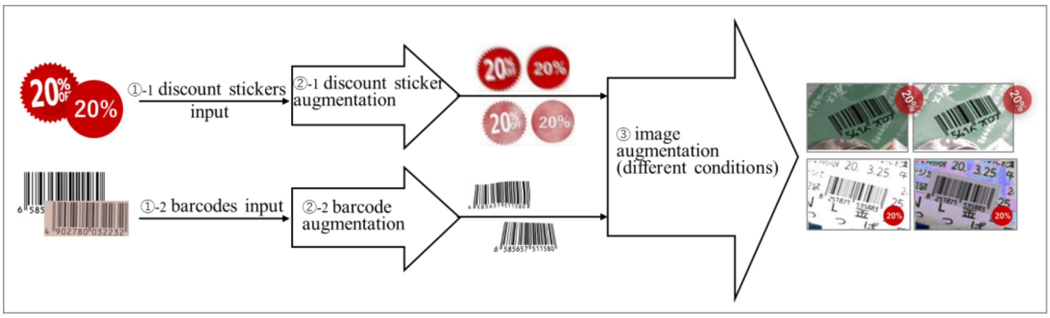


Figure 2. Processing flow of data augmentation

The data augmentation is mainly composed of two steps as shown in Figure 2. We first individually augment discount stickers and barcodes themselves by applying computing vision process to generate a variety of data that is close to the objective states of the real world. We then paste the generated discount stickers and/or barcodes on various background images such as product package and augment the images to bring them closer to the actual shooting environment. The existing augmentation is just to generate images vary in different angles, horizontal/vertical flips, random cropping, and aspect ratios. However, this usual augmentation is not enough for processing the products of super-market. There are various states on the discount stickers attached to the products and the printed barcodes. Here we give some real samples of discount stickers and barcodes. In Figure 3, (a) shows clear discount stickers and barcodes. (b) shows distortion caused by the shape change of the products' packages, especially in the case of bending of plastic packages or bottles and cans. (c) shows some reflections caused by various lighting conditions. (d) shows motion blur caused by movement of the products. (e) shows some obstruction caused by multiple discount stickers, or peeled off, or by a hand or something while holding the products. (f) shows some discount stickers attached or printed barcodes on complex backgrounds. (g) shows different perspective of images caused by different lighting conditions.


Figure 3. Real samples of discount stickers and barcodes

## 4. EXPERIMENTS

### 4.1. Experiment 1

The purpose of this experiment is to investigate effectiveness of our classification network and our data augmentation in the real-world scenario.

#### 4.1.1. Data Set

As mentioned in the previous part, no automatic "scan" system has been proposed yet, and there is no data set to evaluate performance of both discount stickers and barcodes. Accordingly, we build our own assessment data set including various challenges. In Japanese supermarkets, the discount rates of discount stickers are mainly 10% off, 20% off, 30% off and 50% off, so we set these discount rates as the main evaluation targets. In addition to common products, we also collect natural soft-packed products that are prone to distortion and products with new discount stickers to old ones, covering evaluation targets from easy to difficult. And we shoot them at different shooting angles and lighting conditions to reproduce various distortions, reflections, blurs, etc. In this data set, one image only contains one barcode and/or discount sticker.

#### 4.1.2. Evaluation Metrics

We set up two evaluation tasks. One task is to evaluate the detection performance of discount stickers and barcodes, and the other is to evaluate the classification performance. In our detection task, we use MAP evaluation matric, which is a commonly used metric. MAP stands for Mean Average Precision, a method of summarizing the precision-recall curve into a single value that represents the average of all accuracy. On the other hand, we use Accuracy evaluation metric for the classification task. Accuracy is the ratio of the number of correct predictions to the total number of predictions made to a data set.

#### 4.1.3. Evaluation Result

Table 1 shows the detection and classification results of discount stickers and barcodes. We achieve good performance on them both. The average mAP for detection task is over 0.97, and the classification accuracy is over 0.98. The barcodes failed to be detected are those having serious distortion, reflection or having multiple challenges, which is possibly dealt with multiple frames.

Table 1. Results of discount stickers and barcode detection with our original data set.

| Target | classification | Number of images | mAP | Accuracy |
|---|---|---|---|---|
| discount stickers | 10% off | 458 | 0.998 | 1.00 |
| | 20% off | 418 | 0.998 | 1.00 |
| | 30% off | 315 | 0.997 | 1.00 |
| | 50% off | 175 | 0.997 | 1.00 |
| Barcodes | | 1366 | 0.972 | 0.981 |

## 4.2. Experiment 2

The purpose of this experiment is to investigate the work efficiency improvement of the proposed system.

We measure and compare the processing time of the current product scanning method and the proposed method. Current product scan measurement time includes bringing the product closer to the barcode scanner, barcode scan, and entering the discount rate information from the UI screen. The processing time of the proposed approach includes placing the product under the camera, performing discount rates and barcodes recognition. The PC we use for recognition process is a laptop having GPU. In this experiment, we only compare the processing time of discounted products.

Figure. 4 shows a comparison of the average measurement times for one discounted product. The current process has an average processing time of 3.5 seconds, while the proposed method takes only 1.1 seconds overall, giving a negligible recognition processing time. The result shows a high processing efficiency of the proposed method.

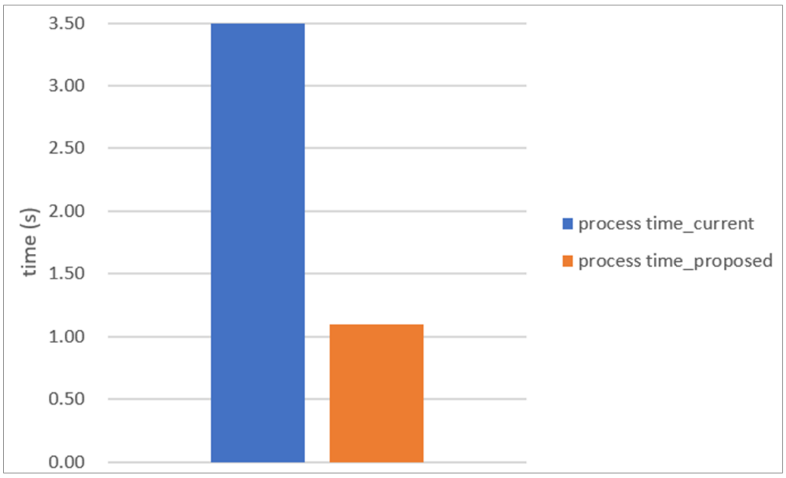


Figure 4. Scanning time comparison for discounted products

## 5. CONCLUSIONS

In this work, we propose a robust deep-based discount stickers and barcodes recognition system. We designed the classifier basing on the YOLACT object detection network to simultaneously detect and classify various discount rates and barcodes. To improve the training performance of deep learning model, we propose a novel data augmentation approach to generate various data that are close to the actual scene. The data augmentation consists of two steps. The first step is to individually augment discount stickers and barcodes with different status such as distortion, blur, complex background, etc. The second step is to paste the generated discount stickers or barcodes or both to complex backgrounds and then augment images with various real lighting conditions. The evaluation with our original data set shows that our proposed approach is effective and robust in discount stickers recognition and barcodes detection. This approach enjoys accuracy and speed. We believe our approach is applicable and contributable to the automation of POS processing to improve productivity.

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