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An Approach to Facilitate Business System by Multiple Barcode Detection using Faster RCNN

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ABSTRACT
Barcoding system is a cheap and reliable way of tagging the products. The barcode detection process is needed for an inventory system to detect the barcodes of the products and for the billing system of the products. Nowadays, laser scanners are used to detect single barcode in super shops, but they are costly. If multiple barcodes could be detected from an image, it may help everyone to save some more time than scanning them separately. In this paper, a model that has been proposed to develop which will work better for detecting and decoding multiple barcodes simultaneously. In this work, the Faster RCNN model is used for the detection of multiple barcodes. The detection process is also done using the Pyzbar library separately. But Faster RCNN gives us better output to detect barcodes from an image than this library does. With the help of TensorFlow API, we worked on our dataset for the detection process of barcodes using transfer learning method. The decoding process is done on the Arte-Lab dataset with the help of the Zbar library. Though the detection rate using Faster RCNN is a little bit slower, but it gives better accuracy. The detection and decoding accuracy throughout a model can facilitate a business system for faster transaction.

Keywords
image processing, barcode, scanners, EAN13, Pyzbar, Faster RCNN, transfer learning, Arte-Lab.

1. INTRODUCTION
This is an era where everything, every process in each sector is being automated. The attributes which are common to automation include advantages are higher production rates and increased productivity, better product quality [1]. So, the maximum profit will be ensured if the proper usage of the automation process is implemented. Automation requires no human interaction. Barcodes were introduced to automate the super shop management but human interaction is not eliminated. People buy products and then make one or more queue for scanning those products where some employees are appointed for scanning barcodes with a barcode scanner. Here, we have to focus on two things which seem common. Firstly, a lot of time is wasted by both consumers and sellers for the scanning method in this system. Moreover, the barcode scanners which are normally used in the super shop, are much costlier. For the barcoding system, laser scanners are needed to detect, and those scanners detect barcodes one by one which requires more time in the shopping system. After analyzing these factors, we thought that if we use a better version of barcode scanners to scan multiple products simultaneously, the problem would be solved. In this way, we can easily minimize the time spent and can get rid of a long time spent in the queue. There are two types of barcodes which are mainly used nowadays.

They are 1D barcodes and 2D barcodes. The 1D barcodes are linear barcodes which consist of vertical lines of varying widths with specific gaps resulting in a pattern. The 2D barcodes are more complex than a 1D barcode. They encode data generally in square or rectangular patterns of two dimensions [2]. In general, 2D barcodes can represent more data per unit area and they support a bigger character set than all types of 1D barcodes. 1D barcodes can be scanned with traditional laser scanners or using camera-based imaging scanners. 2D barcodes, on the other hand, can only be read using imagers. With laser etching and other permanent markings technologies, 2D barcodes have been used to track everything from delicate electronic printed circuit boards to surgical instruments [3]. While there is a difference between 1D and 2D barcode scanning, both types are useful and both are cost effective methods of encoding data.

112345 678900

Figure 1: 1D Barcode

Figure 2: 2D Barcode

There are mainly two tasks for barcode readers: barcode locating and barcode decoding. Barcode localization methods have two objectives which are speed and accuracy. For the industrial environment, accuracy is crucial since undetected (missed) codes may lead to loss of profit. The processing speed is a secondary desired property of the detectors. The accuracy is not so critical in smartphone, since the device interacts with the user, but a fast (and reasonably accurate) barcode detection is desirable. There are various techniques which are used to locate and decode barcodes from photographs, from the classical line scanning technique [4], through the widely studied morphological approaches, and recent studies using wavelets [5]. Once an image is obtained, the first step is to localize the barcode within the image. Many methods to do this have been developed. Again, after the barcode is localized using one of the methods, it must be decoded to obtain the product's information. We have followed these processes by implementing this using Python. Firstly, we have processed an algorithm to detect the barcode from the snap, then we have to decode it. And the main benefit in this process is, we can detect multiple barcodes simultaneously and can detect the barcode of cylindrical objects too. We have used the Zamberletti algorithm using OpenCV and Pyzbar library to detect and decode the barcodes from the snap.

While detecting the barcodes, there are some issues in Zambarletti algorithm. This algorithm is helpful to detect and decode barcodes simultaneously. But it does not detect properly, basically, the blurry barcode or small regional barcode is not detected by this algorithm. In this case, a Deep Learning approach has a better solution. Deep learning is one type of machine learning where artificial neural networks, algorithms inspired by the human brain, learn from large amounts of data. We refer to "Deep Learning" because the neural networks have various layers that enable learning depending on different situations [6]. And RCNN is a method involved in Deep Learning. Based on the Region Proposal, RCNN fulfills the object detection using selective search for the feature extraction from CNN and SVM classification. We have used popular transfer learning approach in deep learning. In this paper, section 2 describes the related works on this topic. Section 3 and 4 describe about our proposed method and experimental analysis. Challenges and Conclusion are described in section 5 and 6.

2. RELATED WORKS

The barcode detection process was critical and less accurate in previous papers. The authors of some papers tried to implement the detection process using a webcam, some of them focused on camera resolution, some of them proposed the detection process of 2D barcodes. Upasani et. al proposed a method of extracting information from the barcode at a lesser cost compared to typical electronic barcode scanners [7]. They had analyzed their diagram by following three levels: level 0, level 1, level 2. They saved the product information in the database then. After that, they take a snap with a USB webcam and make ready the image for scanning by removing noise and eliminate unnecessary surrounding information. They perform cropping by observing the intensity of each pixel and extracting the rows of a barcode. By that time the contrast of the image improves to distinguish between bars by making the black bars one shade darker on the grayscale compared to white bars. Then the contrast-enhanced image is firstly binarized and edge detection is done successfully. After that, the barcode number is decoded using the array of bar widths and then, after matching the product information, the product bill had been updated. EAN-13 barcode was used for this experiment. Another work was about to detect single and plural barcodes in which the barcodes were detected continuously and the accuracy was 0.7 seconds to detect the barcodes [8]. The authors of the paper proposed a method which was about to extract candidate barcode skeletons to locate barcodes in an image. Their method was capable of searching rotated barcodes in a high-resolution image. Firstly, the image was preprocessed by skeleton extraction in the downscaled image plane and verified barcode location in the original image plane. After the preprocessing, cross-scanning was employed to scan the binary downscaled image in a first direction, and then the binary downscaled image was scanned in a second direction perpendicular to the first direction. After that, a grading scheme was used to determine whether a detection window may contain a portion of a barcode. The scheme was designed by exploiting the nature of barcodes as much as possible. It used the Sobel operator to track the main direction.

Tseng et. al proposed a method to detect QR codes from a cylindrical object like bottles, cans [1]. These works influenced us to work on 1D and 2D barcodes at a time that means multiple barcode detection. The extraction of finder patterns was one of the major procedures for locating a QR code in a paper. In the preprocessing stage, the source gray image was converted to a binary image using the adaptive thresholding method which is very robust and less computational complexity [9].

After finding the three position detection patterns, a corner searching algorithm is run to obtain the four corner points as it is necessary to get the boundaries as a precondition to determining the fourth corner under the circumstances that the other three corner points have been located previously. After obtaining boundary the curved QR code is transformed into the square plane through geometrical correction. Since QR codes might be perspective distorted because the camera can be held in a rotation or elevation angle. Zhang et. al proposed a noble method on detecting barcodes through cross identification using a mobile platform [10]. This paper approach had been made for fast and robust color barcode detection. A feature detector was proposed for finding crosses formed by differently colored cells. After performing its detector on the input image, candidate barcode regions were generated by Niblack's thresholding method, which was robust to varying light conditions and complex background. Finally, shape consistency tests were performed on detected barcode regions to further exclude false detections. Another work proposed that it might be used to detect and decode multiple 2D barcodes (i.e. Datamatrix) [11]. Most of the techniques discussed in literature, work for single 2D barcode detection and decoding. Lin et. al proposed a method of identifying the QR and Aztec barcodes by using a connected component labeling algorithm to compute the tag for each connected component, then search for the innermost connected component of the finder patterns in the tag image [12]. The method could identify rotated or defocused barcode images. At first, it labeled the connected components in the barcode image. Another work has been done on making this system angle invariant and less or not at all user interactive [13]. Standard thresholding algorithms, such as the Otsu's algorithm, were used for thresholding [14]. The CCL algorithm assigned every connected component a unique number called the tag. This algorithm scanned the image from left to right and from top to bottom. Another paper implements the barcode detection process using deep learning. They mainly followed the YOLO method for the detection process. They described how to adapt the state-of-the-art deep learning-based detector of You Only Look Once (YOLO) to detect barcodes in a fast and reliable way. The detector is capable of detecting both 1D and QR barcodes [15]. The work was about to locate the barcode region from the product.

After analyzing those works, we have planned to implement a method that will accurately detect the barcodes in any resolution. We have used transfer learning for this process. Transfer learning is a machine learning method in which a model is developed for a task, is reused as the starting point for a model on a second task. It is a popular approach in deep learning where pre-trained models are used as the starting point on computer vision and natural language processing tasks given the vast compute and time resources required to develop neural network models on those problems. And the decoding process will also help to store the product information. Because there were some limitations like these in previous papers and it is a challenging issue for us to operate these two processes simultaneously.

3. PROPOSED METHODOLOGY

Deep learning surrounds us in every moment. Computers using deep learning technologies remain a constant learning process step by step. This learning process enables communication between computers and humans. Not only their function will increase over time, but it will also impact most industries as well as the jobs that come with them. Eventually, it will impact all of us possibly daily. The era of digitalization has allowed the technology to flourish, and computers that are able to analyze massive amounts of complex data which can now provide more accurate results.

Earlier barcode decoding and detection processes were all about image processing. But nowadays, deep learning processes are helpful in this area. Already some paper has been published based on deep learning on this purpose but they worked on the YOLO model and CNN model. They have already outperformed the previous techniques to detect and decode barcodes. So, we would like to investigate whether the use of deep learning can benefit the locating of barcodes by using the Faster RCNN model. Barcode detection system is very important for all kinds of shop so that the products of the shop can be arranged systematically.

After reviewing all of these papers, we thought that there were many scopes to improve the method for barcode detection in many ways. We worked on multiple 1D barcode detection. We would put effort to detect a barcode on a complex background. Figure 3 describes the flow diagram of our total work.

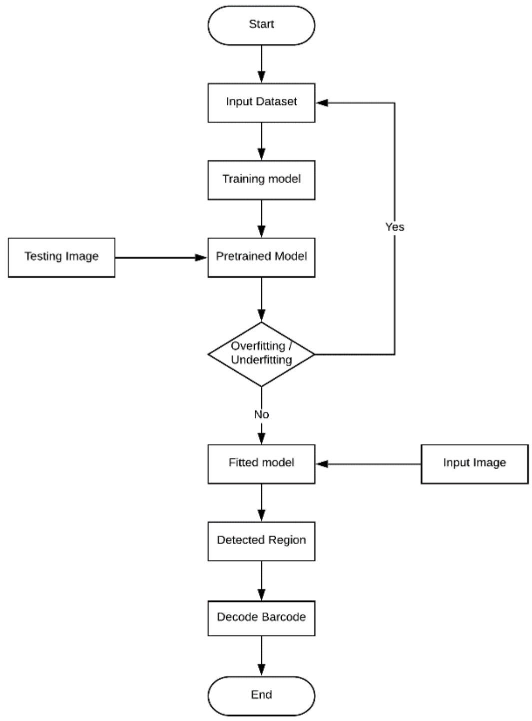

Figure 3: Flowchart of Barcode Detection Method

For this project, our initial plan was to work on some portions. We have got success on those tasks. The working portions are given below:

- Single 1D and 2D barcode detection and decoding
- Multiple 1D and 2D barcode detection and decoding
- Angle invariant barcode detection and decoding
- Barcode detection in complex background with higher accuracy.

There are many types of barcodes. 1D and 2D barcode are the main two types of barcodes. The single 1D barcode detection process is done with the help of Faster RCNN. For multiple barcode detection, we have to crop the portion of those 1D barcodes one by one. Again, for the decoding process we have used the OpenCV library with Spyder IDE. The type and value will be shown after the decode operation.

4. EXPERIMENTAL ANALYSIS

Our proposed methodology has two parts: detection and decoding. For detection, we have built a deep learning-based detector. For the detectors' training purposes, we have created a new dataset.

4.1 DATASET

As discussed earlier, to execute the first step of our idea, we need proper data collection. It is a necessary step because until we achieve proper data collection, we will find ourselves constantly coming back to this step. Data can be collected by two sources; one is a primary source the other one is a secondary source. Collecting data from a secondary source means reusing data. Reusing data means that data has already been collected and experimented by other sources. We have obtained our dataset because there was no suitable dataset available to fulfill our training purpose. The only available dataset is the Arte-lab dataset which is used for decoding.

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This dataset is not suitable for our detector training purpose because there is a lacking of multiple barcodes. Among the 1D single barcodes on the dataset, only the barcode regions were focused. There was a lacking of complex backgrounds too. Complex background is necessary for training because it will be beneficial for the detector to learn better. It is difficult to find barcode exact regions while detecting multiple barcodes. Barcode dataset could be created using dummy barcodes or computer-generated barcodes. Computer generated barcodes are not suitable to serve our purpose. Firstly, images have many constraints that dummy barcodes do not have. Another fact is that the Faster RCNN models learn by selecting regions within the image. That means it needs to be compared within the region where the barcode is located. Our dataset has three hundred images consisting of 1D barcodes.

Though our dataset does not have 2D barcodes, still we can say we have achieved proper data collection. Several factors were kept in mind while creating the datasets. Firstly, the shapes of objects were considered to create the dataset. It is easy to locate barcodes from regular shape objects like square or rectangle, but it is challenging to find barcodes in round or cylindrical objects. After that, the area that we focused, is the size of the objects. It is easy to find barcodes in big objects but it is challenging to locate the barcodes in tiny objects. The images were taken from a different angle of barcodes located. There are lighting conditions such as images in proper lighting, images in darker lighting conditions, reflections due to light. And the background conditions are like: a white background in a darker background, overlapping barcodes, scaling, etc. Different categories of objects were taken because it will be useful for analyzing barcodes to do various classifications. The device that was used to take the images was the iPhone 6s. The original images were big in the resolution which was about 1600×1200. This would require a lot of memory so the images were resized to 784×588 to keep an aspect ratio.

4.2 DETECTION PROCESS

Our primary focus was to identify multiple barcodes at a time. Firstly, the model was trained on very fewer images around (50 images) to see if the barcode region is correctly recognized using transfer learning of deep learning techniques. We re-trained the Faster-RCNNInception-V2-COCO model provided by TensorFlow API for our purpose. In training process, classification loss values are the result of loss values are the result of loss functions and represent the price paid for inaccuracy of predictions in the classification problems. Each step of training reports the loss. It will start high and get lower and lower as training progresses. Allowing the model to train until the loss consistently drops below 0.05. As in the following figure 4, it is seen after 6000 iterations, the loss nearly drops to 0.

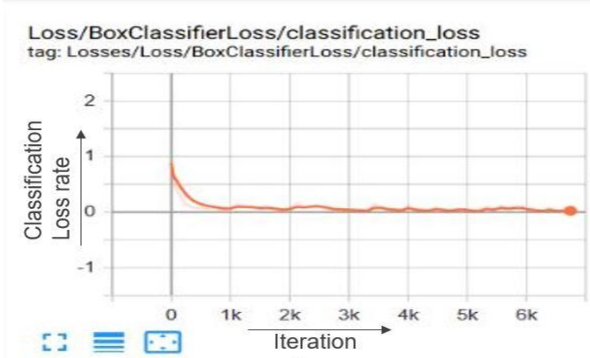


Figure 4: Classification loss while training in the latest hour of training

One important graph is the Loss graph, which shows the overall loss of the classifier over time. In figure 5, we can see the total loss being optimized after the model is finally trained that being loss being totally zero.

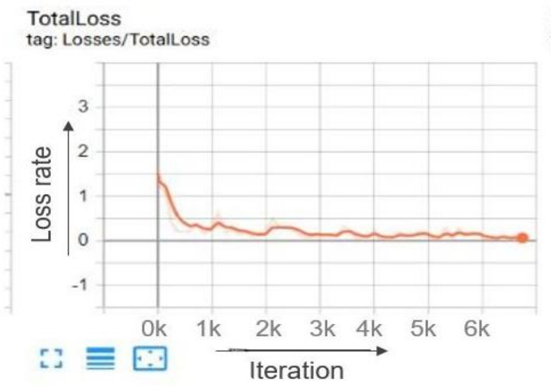
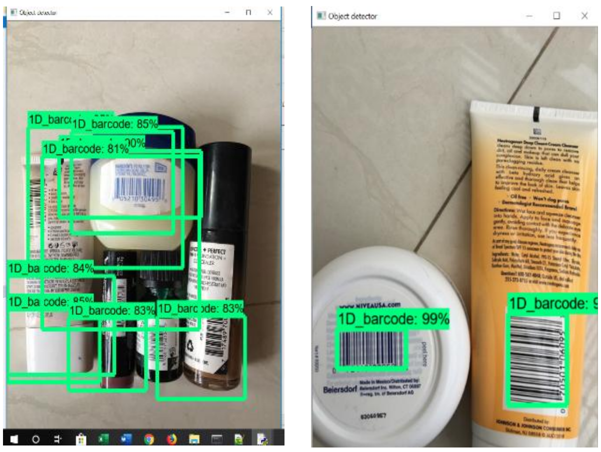


Figure 5: Total loss after training is completed

After the training process, sometimes the detector was not able to locate properly. There were false-positive regions included in the bounding box. As we can see in figure 6(a), when the model was trained on fewer images the object detector was unsuccessful in providing the desired result. The detector located the regions but there were regions included which do not have barcodes, it is including the background also.



(a) **(b)**

Figure 6: (a) Visual representation of the object detector output and (b) Output of the object detector

All the images that are seen is tested by using single run interface. It means the output is checked by giving one image as input and the output is shown with the detected region along with probability. In figure 6(b), the picture was taken on white background with proper lighting. Multiple barcodes were detected and the detection region was in the probability of 99%.

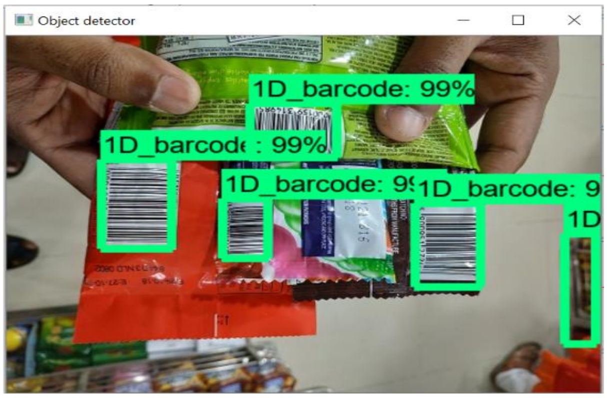


Figure 7: Resultant detected regions after training on large dataset

In Figure 7, the picture was taken in a super shop, to get the exact lighting that is available on super-shops. In this figure there was objects were overlapping. Sometimes false positive region is there.

Figure 8: Resultant detected regions in an angle position

In figure 8, there was objects were in angle with the camera. Camera is not making normal with the objects. The background is more complex than before.

Figure 9: Resultant detected regions on tiny objects

And we have tested our process on tiny object. In figure 9, the output of the tiny objects is shown. Here, the output is much better also.

4.3 DECODING PROCESS

In traditional scanning systems, Barcode scanners read 1D barcodes horizontally. 1D laser barcode scanners are the most commonly used scanners and those scanners typically come in a "gun" model. These scanners do not need to be in direct contact with the 1D barcode to work properly, but typically need to be within a range of 4 to 24 inches to scan. In this portion, we will show the detected regions which were cropped and sent to decode using Pyzbar library.

If you scan a UPC code, for instance, the characters in the barcode have to relate to an item in a pricing database to be useful. These barcode systems are a necessity for business system, and can help increase inventory accuracy and save time. Figure 10 illustrates the decoding process of 1D barcode.

Figure 10: Detecting and decoding single 1D barcode from an image

And, the decoding accuracy between the two types of resolution which is described in 'Dataset' portion, is shown in the following figure.

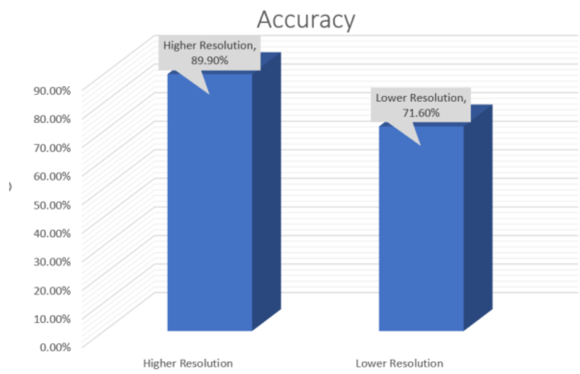


Figure 11: Decoding accuracy rate through resolution

Last of all, we can ensure that our method will work for detecting and decoding single 1D barcode, multiple 1D barcodes from a snap with proper resolution. The simple and complex background does not matter for this process.

5. CHALLENGES

We have achieved success in detecting single and multiple barcodes. We obtained 71% accuracy while decoding single 1D barcodes using the Zbar library. This accuracy rate tells us the library's performance was not up to the mark in decoding in some cases. The library could not decode multiple barcodes. Deep learning-based transfer learning approach was used in detecting multiple 1D barcodes. Afterward for decoding Zbar library was used so that we can get the accuracy of decoding single barcodes. From discussing what we accomplished, it is noticeable that there are some limitations in our current method like detection and decoding works separately. There is no graphical user interference. We will try to overcome all the limitations in the future.

6. CONCLUSION

Barcode is used for all kinds of products and it represents the product specifications. The detection of barcode plays an important role to collaborate the products and match the product id to get trifles about the product. Normal barcode scanners take much time to detect the barcodes one by one. Also, these scanners are very costly and need user guidance. If we could make a user-friendly system that can detect and decode multiple barcodes simultaneously, it will be beneficial for every sector. Hopefully, our idea will help especially those sectors where multiple barcode detection and decoding process would make a system faster than before ever. The optimal goal is to help to increase productivity, lessen user guidance, reduce time, open a new window of comparison to reduce the confusion of consumers.

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