A Generic Method for Stamp Segmentation Using Part-based Features

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***Abstract*—Traditionally, stamps are considered as a seal of authenticity for documents. For automatic processing and verification, segmentation of stamps from documents is pivotal. Existing methods for stamp extraction mostly employ color and/or shape based techniques, thereby limiting their applicability to only colored and specific shape stamps. In this paper, a novel, generic method based on part-based features is presented for segmentation of stamps from document images. The proposed method can segment black, colored, unseen, arbitrary shaped, textual, as well as graphical stamps. The proposed method is evaluated on a publicly available dataset for stamp detection and verification and achieved recall and precision of 73% and 83% respectively, for black stamps which were not addressed in the past.**

I. Introduction

Stamps and signatures are considered as seal of authenticity for documents. Almost all official documents, e.g., financial, governmental, security documents, bank checks, and even utility bills, are sealed with stamps and/or signatures. With time, there is seen an enormous increase in the amount of documents which need processing, be it for legal or financial purposes. In fact, this processing is required to ensure the authenticity of documents (to check whether they are genuine or not) before integrating them into the normal work flow of any process, e.g., before issuing cash on bank checks, before releasing the claimed amount on invoices received by insurance companies, etc. Since the number of documents is increasing rapidly and processing needs time, this situation compels towards automatic processing of documents.

Today researchers are actively working on finding different possibilities for automatically processing documents. One such possibility is to analyze seals/stamps on these documents. The stamps are usually parts of documents containing other information as well. They can occur on different angles and on different locations based on the content of a document. Furthermore, stamps could belong to different categories, e.g., graphical, textual, regular shaped, irregular shaped, etc., (see Figure 1). It is, therefore, required to first segment these seals (stamps) from documents for processing them automatically. Since the format of stamps may vary from organization to organization and even from person to person, it is, therefore, not possible to take all different templates for training and segmenting these stamps from documents. However, an important observation about stamps is that they usually exhibit different characteristics from other information, such as text, present on documents. These characteristics include differences in color, ink distribution, size, shape, and etc. Based on these differences humans are also able to distinguish them. In past, different methods have been proposed for stamp detection which usually work by analyzing one or more of these characteristics. In almost all of the existing approaches, it is assumed that stamps are colored objects and/or of some specific shape, and promising results are achieved. However, this is not the case always, as black stamps are also in common use and often scans of documents are only available in gray scale. Moreover, shapes of stamps also vary from organization to organization.

Fig. 1: Stamps of different categories

In this paper, we propose a generic, novel method for segmentation of stamps from document images. The method is generic in a way that it can segment single/multicolored, monochrome, and even black stamps. In addition, it is capable of segmenting unseen as well as stamps of any arbitrary shapes. The novelty of the method lies in the use of part-based/local features for segmentation of stamps from document images. Part based features have already shown potential in segmentation of signatures [1], logos [2], and other objects. In this method part-based/local features are combined with geometric features. Two different part-based descriptors are analyzed in terms of accuracy as well as computational time.

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The proposed method is evaluated on publicly available dataset for stamp detection and verification [3] and achieved recall and precision of 73% and 83% respectively for black stamps detection, a task not generally addressed in past.

The rest of the paper is organized as follows. Section II summarizes the previous work on stamp detection. Section III highlights the methodology used for stamp segmentation. Evaluation of the proposed approach is presented in Section IV. Finally, Section V concludes the paper.

II. Related Work

In the past different methods are proposed for segmentation of stamps from document images. Some use color and other geometric features to separate stamps from other content in document images, whereas other viewed it as an object recognition problem.

In [4] an approach for detection and extraction of signatures and seals using color information from bank checks is presented. It is assumed that color of signatures, seal, and background pattern is different, therefore three different clusters are extracted. A major problem with this approach is the assumption that only three different clusters exist on checks, which is not always the case. Fuzzy integral for the selective extraction of color clusters are used in [5] to detect seals from documents. It is assumed that stamps are of single color.

In [6] a method is proposed to detect and verify seal imprints. However, it is required to register the seal in prior. This means that seal template must be available apriori.

A framework for segmentation of stamps from document images using characteristics of stamp patterns is proposed in [7]. It is based on estimation of connected edge features. Although it is able to segment even overlapping stamps, but it is limited for elliptic/circular (oval) shaped stamps. In [8] an approach for detection of seal imprints on Chinese bank checks is presented. It is based on region growing approach. Different regions are first located using region growing algorithm and later fused together. The method is only able to deal with the seals if no other objects (e.g, logos) are present on check.

A method for seal object detection in document images is presented in [9]. Generalized Hough Transform is used to detect the seal and based on voting seal object is located. They viewed the problem as object recognition, and therefore first require template of stamp.

An approach for detection, localization and segmentation of stamps in the scanned documents is proposed in [10]. This method is flexible in terms of detectable stamps shapes, as it is not limited to only oval shapes. It is based on analysis of document in YC_bC_r color channels using horizontal and vertical projection profiles and five different shape descriptors. As documents are processed in YC_bC_r color space, it is also limited to only color stamps. In addition, it not able to detect the textual stamps which do not contain any regular or irregular shape around them.

Recently, an automatic method to segment and verify stamps from document images is proposed in [3]. It is based on segmentation of the image by color clustering in YC_bC_r color space and classification of candidate solutions by geometrical and color-related features. One of the main advantage of this approach is that it is not restricted to stamps of particular shape. In addition, it is also capable of detecting textual stamps. Similar to [10], they have also performed complete analysis in YC_bC_r and are not able to deal with black stamps.

From the above short survey, it is clear that in past color stamps remained under the focus. Only the method proposed in [7] can detect black stamps as well, however, it is limited to oval shaped stamps only.

In past, part based features have been successfully used for segmentation of different type of information from documents. In [1] SURF features are used for signature segmentation in document images. In [2] SIFT features and bag-of-words model is used for detection of logos in administrative documents. Up to the best of authors' knowledge, part based features have not been used for the purpose of stamp detection.

III. Methodology

In the proposed approach, a two step classification is performed to separate stamp from non-stamp components. In the first step, part-based features are used to extract candidates for stamps. Nearest neighbor classifier is used for finding the similarity between descriptors. In the second step, simple geometrical features are used to filter out non-stamp objects from the extracted candidate components.

For part-based classification of components, two different part-based descriptors are used. For calculation of part-based features, it is first required to find out those parts/keypoints in documents for whom descriptors should be computed. Hence, in the proposed approach, Features from Accelerated Segment Test (FAST) [11] is used as keypoint detector to detect keypoints in document images. FAST keypoint detector is computationally efficient in comparison to well known keypoint detection methods, e.g., SIFT [12], Harris [13], and SURF [14]. In addition, FAST gives a strong response on edges, which makes it suitable for document images.

Once the keypoints are detected, descriptor for each of the keypoints is computed using recently proposed part-based descriptors, Binary Robust Independent Elementary Features (BREIF) [15] and Oriented FAST and Rotated BRIEF (ORB) [16]. As their names suggest, both BREIF and ORB are binary descriptors, which posses high discriminative power with a few bits. These descriptors are computed using simple intensity difference test around keypoints. BRIEF descriptor is sensitive to large rotations, whereas ORB is rotation invariant version of BREIF. These descriptors are also computationally very efficient as compared to other local descriptors, e.g., SIFT [12] and SURF [14]. As mentioned earlier, for the second step in classification, geometric features are used to filter out non-stamp objects. For this simple geometric features are used which include, bounding box height, and width.

To detect stamps in document images, first a training set is created for stamp and non-stamp objects. The stamp training set contains a few stamps from each category, i.e., textual,

(a)
Gray Scale Document Image

(b)
Marked Stamp Components Using Part-based Features

(c)
Marked Stamp Components after Geometric filtering

(d)
Marked Detected Stamp

Fig. 2: Stamp segmentation steps

graphical, regular shaped, and irregular shaped. It is important to mention that our training set does not include all the stamps, it just needs a few samples from each category. In the non-stamp training set we included images with text, logos, and tables. For each image in the stamp training set, connected components are extracted. For each bounding box of the connected component, keypoints are then extracted using FAST [11] keypoint detector. Furthermore, descriptors are extracted for each of the detected keypoints using BREIF [15] and ORB [16] feature descriptors methods, separately. In addition to these part-based features, simple geometric features are also extracted for each connected component, i.e., bounding box height, and width.

All of these descriptors and geometric features are saved in a database. The same process is applied for the non-stamp training set. Finally, we have a bag-of-features each for stamps and non-stamp components separately. It is to be noted that no vocabulary is constructed for these features as each feature is of importance here. Therefore these bags-of-words contain all of the extracted features.

To detect a stamp in the query image, it is first converted into gray scale (Figure 2 (a)). This conversion is done to make sure that no color information is being used during further analysis. This image is further binarized to extract connected components. In the first step, keypoints for each bounding box are detected using FAST keypoint detector. Furthermore descriptor for each detected keypoint is then extracted using BRIEF and ORB local descriptors. All the descriptors of connected components from query image are then compared to stamp and non-stamp descriptors from the database.

As the descriptors extracted using BRIEF and ORB are binary, therefore Hamming distance is used for comparison of descriptors extracted from bounding boxes and descriptors in the bags-of-features. The use of Hamming distance in-turn makes it computationally more efficient, as it can be computed using a simple XOR operation on bit level. A component is then classified as stamp or non-stamp based on majority voting. This means, if the number of descriptors similar to stamps are greater, then an object is marked as a stamp, otherwise as a non-stamp component.

All of the objects which are detected as non-stamps are removed from query the image. Thereby, we are left with stamps and some misclassified components only. Figure 2 (b) shows the query image after removing non-stamp objects and marked stamp objects. This miss-classification occurs because, stamp training set also contains textual stamps, which are nothing but characters. Therefore, some descriptors in the stamp database are similar to descriptors in the non-stamp database. For example, features for logos are very similar to graphical stamps, which cause miss-classification of logos as stamps.

In the next step, filtering is performed using the earlier mentioned geometric features. For all of the components which are marked as stamps in the previous step, their geometric features' values are computed. A component whose geometric features' values are not in the range of those of stamp training set features' values, is removed. This range is computed using the mean and standard deviation of each feature. Figure 2 (c) shows the image after filtering out non-stamp objects using geometric features. Finally, the remaining components are referred to as stamp components, and regions for these components can be extracted from the original image. Figure 2 (d) shows the query image where detected stamp is marked.

It is to be the noted that the method is not a typical bag-of-words approach: In a typical bag-of-words, samples from all the objects that need to be detected are taken. However, in proposed approach, features from only few stamps are taken and detect even unseen stamps.

IV. Evaluation

A. Dataset

The proposed method is evaluated on a publicly available dataset for stamp detection and verification [3]. This dataset contains 400 scanned document images. Out of these

(a) (b) (c)

Fig. 3: Extracted,ground truth, and overlapped stamps

400 documents, 80 documents contain black stamps whereas remaining 320 are color stamps documents. All of these document images are available in 200, 300, and 600 dpi. For each image two different types of ground truths are available. One contains the pixel level ground truth, which means all of the pixels which belong to stamps are marked in one image. The other ground truth format contains the bounding box information for each stamp. Hence this dataset can be used for both pixel level as well as patch level evaluation of stamp detection. In addition, it contains different types of stamps ranging from rectangular, oval, to irregular shaped, and most importantly textual stamps.

For evaluation of proposed approach, training set is generated by using 36 documents out of 400. Out of these 36 training documents, only 6 contains black stamps whereas remaining 30 are with color stamps. Testing is performed on the remaining 364 documents. Results for black stamps are reported on remaining 74 documents, and color stamps on 290 documents. All results are reported at 200 dpi documents.

B. Evaluation protocol

In this paper, the pixel level evaluation is used for reporting results as it is more realistic than the patch level, especially in terms of recall. To get the pixel level results, we looked for the number of pixels in the ground truth image which correspond to the pixels in the detected stamp image. These common pixels are then divided by total number of pixels in the ground truth image, which correspond to Recall of the proposed method in terms of pixels. Figure 3 shows (a) the detected, (b) the ground truth, and (c) the overlapping stamps, respectively.

C. Results and Discussion

Table I and Table II show the recall and precision of our method for black and colored stamps respectively. Table I shows that our method has good recall and precision, in the case of black stamps. It can be seen that the method for stamp detection in [3] is not applicable to these stamps, as all of the processing is performed in YC_bC_r with an assumption that stamps are always colored objects and, therefore, clustered in different colors than that of text. However, this assumption does not hold true for black stamps and, therefore, existing methods are not applicable to black stamps.

Table II reveals that recall and precision of our method is low in comparison to the method in [3]. It is because, we are not using any color information, therefore it is difficult to separate especially those stamps which are severely overlapping with other components. Figure 4 shows some of the cases where our method was not able to detect stamps, as most of them are overlapping with neighboring non-stamp components. Whereas, in the case of [3], color clustering is done for finding candidates for stamps, therefore, it is possible to segment overlapping stamps if they are of different colors than that of the non stamp components/text. In our method, however, it is possible to include color information, if available, to segment these stamps. This will in turn increase recall and precision of our method even in the presence of severely overlapping stamps. Nonetheless, if stamps are partially overlapping, our method is capable of detecting them. This is because, in our approach for partially overlapping objects, the number of votes in connected components are higher for stamp objects as compared to non-stamp objects. Figure 5 shows some cases of overlapping stamps which were successfully segmented by our method.

TABLE I: Evaluation Results for Black stamps

Detector	Descriptor	Recall	Precision
FAST	*BRIEF*	72	74
FAST	*ORB*	73	83
Micenkova et.al. [3]		Not Applicable	Not Applicable

TABLE II: Evaluation Results for Color stamps

Detector	Descriptor	Recall	Precision
FAST	*BRIEF*	56	48
FAST	*ORB*	57	62
Micenkova et.al. [3]		82.7	82.8

(a) (b) (c)

Fig. 4: Severely overlapping stamps missed by proposed approach

As mentioned before our training set for non-stamp objects also contain logos. However, some part-based as well as geometric features of non-stamp objects are more similar to graphical stamps and even in some case textual stamp. That is why sometimes, logos are also marked as stamp components. The drop in precision is because of the presence of logos in documents. Figure 6 shows the cases where logos are marked as stamp component. There are already part based methods available for logo detection. Therefore, precision can

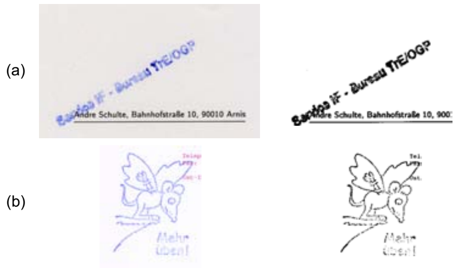

Fig. 5: Partially overlapping stamps detected by proposed approach

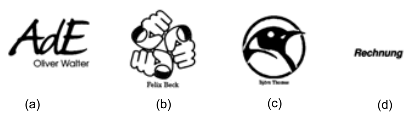

Fig. 6: Misclassified objects as stamp objects due to similarity with graphical stamps

be improved by simply applying a logo detection method next in hierarchy.

In terms of computational time, both BREIF and ORB features in combination with FAST keypoint extracter and naive nearest neighbour classification require around 16.29 secs to segment stamp from a document image of 200 dpi. To compare the computational different between SURF and other descriptors, we also performed an experiment where SURF is used as keypoint detector as well as descriptor. Results of this experiment reveals that, it take more then 150 secs on average to segment stamp when using SURF. This shows that using SURF as keypoint detector is computationally very expensive in comparison to using FAST in combination with binary descriptors. The method method can be improved further in term of computational time by using different sophisticated classifiers like SVM.

V. Conclusion

A generic and novel method for stamp detection is proposed in this paper. The proposed method is based on a combination of part-based and geometrical features. It is able to segment stamps of all categories, i.e., textual, graphical, regular shaped, and irregular shaped. In addition, the proposed method is able to detect colored as well as black stamps. The main highlight of the proposed method is segmentation/extraction of black stamps, as the existing methods for stamp detection are not able to segment black stamps since they are based on the assumption that stamps are colored objects. We have achieved recall and precision of 75% and 84%, respectively.

In future we are planning to integrate logo detection to further increasing the precision. Furthermore, other geometric features can be integrated to increase recall of the system as well. Also, we are planning to use Approximate Nearest Neighbor to avoid the brute force matching of features. To overcome the problem of overlapping stamps we are also working on using part-based features in the way presented in [17].

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