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Retrieval System for Patent Images

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Abstract

Patent information and images play important roles to describe the novelty of an invention. However, current patent collections do not support image retrieval and patent images are become almost unsearchable. This paper presents a short review of the existing research work and challenges in patent image retrieval domain. From the review, the image feature extraction step is found to be an important step to match the query and database images successfully. In order to improve the current feature extraction step in image patent retrieval, we propose a patent image retrieval approach based on Affine-SIFT technique. Comparison discussions between the existing feature extraction techniques are presented to assess the potential of this proposed approach.

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Keywords:Image retrieval, patent, search engine, feature extraction;

1. Introduction

The patent office has a huge amount of patent information that describes ideas and solutions to a variety design problems ranging from mechanical, chemical, electronics and many fields. These descriptions are usually

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documented both in text and in graphical/imagery forms. However, the current patent documentation is arranged in a poorly structured manner and these graphical information is almost unsearchable [1]. In other word, although the patent information in the patent documentation is consisted of texts and graphics/images describing the patent, the graphics/images information is ignored in the search. Therefore, it is common in any particular patent search, a large amount of data is retrieved and a significant amount of the data retrieved is irrelevant or not useful to the user. For a user, the search for patent information is a very time-consuming and a very tedious process which inevitably does not help the users to perform their work better. Research has shown that "graphical representations or diagrams are sometimes worth more than ten thousand words". This reflects the importance of the graphical information and this also means graphics/images retrieval is very important [2].

Table, block diagram, flowchart, plot, time chart, line drawing and pictorial information are different classes of figures in patent documents and the categorisation of these figures is illustrated in Fig 1[3]. Figures in patent documentation are usually binary images. They have no colour and texture [4]. Patent image retrieval (PIR) techniques are used to search similar patent images for query image in image database by analyzing the image contents. The techniques support users and patent experts to understand the content in the patent images and to find the related patent images. In a common patent image retrieval process, a user submits a patent image as an image query for finding similar images in patent database. The system extracts features either in a text or shape form or both of these forms from the submitted image (query image) and compares the features with all the images in patent database. Similarity is calculated based on the distance of the two images using their features vector. A common content-based image retrieval system is depicted in Fig 2.

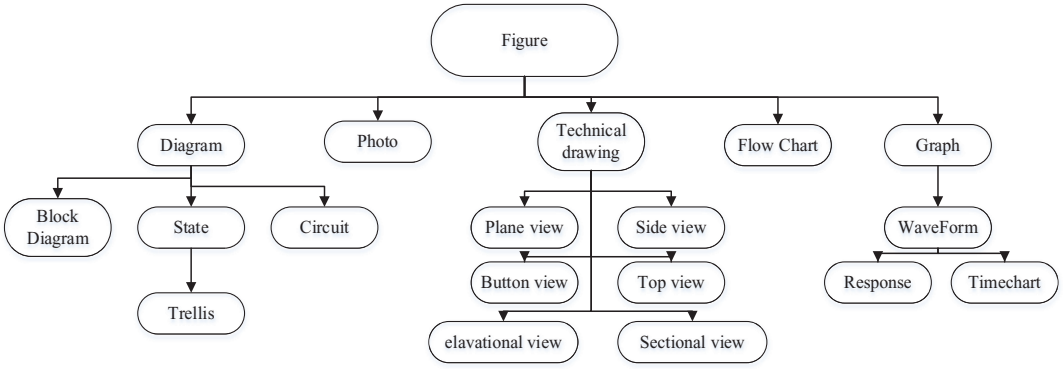

Fig 1. The patent technical drawing [3] .

However, the literature review in Section 2 shows that there is very little published work in the field of patent image retrieval [3, 5] and most of the published works are focused on trademark search [6-9]. Therefore, there is a need to improve the current patent image retrieval (PIR) techniques and to meet users requirements [3, 4].

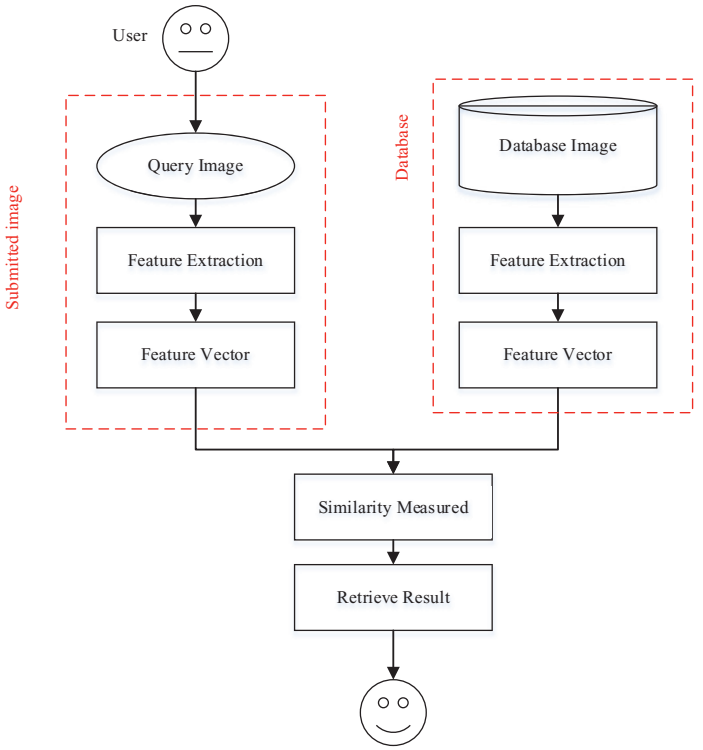

Fig 2. A common content-based image retrieval.

This remaining paper is organised as follows: Section 2 presents the related work and discuss on potential, benefits and challenges existing Patent Image Retrieval (PIR) approaches; Section 3 presents the architecture of the proposed approach, Section 4 presents the discussions and comparisons and Section 5 concludes this paper.

2. Related work

In this section, we present the reviews and discussions on the recent patent image retrieval systems which are applicable to our research domain.

Huet [10] experimented a patent image retrieval system in 2001. The experiments were performed on European Patent Office (EPO) database. They used relational skeletons also known as the Voronoi skeletonization as a main method to capture the geometric structure of the line patterns in images. The two main relational features: relational angle and position were calculated in addition to the calculation on the pairwise attributes. In their experiments, two retrieval algorithms were investigated: the Histogram and Graph based retrieval. In the Histogram retrieval 2-dimentional histogram were employed to capture the local visual information. Angle attribute was captured by one dimension for 36 bins and position attribute was presented by other dimension for 12 bins. The Bhattacharya correlation was used for calculating the similarity between query and database images. In Graph retrieval, 6 nearest neighbor graphs were employed to increase the authority local visual information. The Hausdorff distance was used for calculating the similarity. The recall measure was employed for performance evaluation. 57 queries from 180 patents were presented. The processing time was depending on size and complexity of the images but it was not reported in the paper.

Tiwari [11] presented a content-based patent image retrieval system. The experimental was done on United State (US) database. The system consisted of two subsystems: The first subsystem created the feature vector and another

one retrieved similarity between query image and existing images of database. The graphical interface was provided for user to search by keyword and image. Some pages contained more than one figure. Connected components were used to segment the figures as individually. The images were stored in database with separated patent number and page number. The edge orientation autocorrelogram (EOAC) was used for feature extraction step because it was independent of translation but computationally inexpensive. The rotation angle range for query image was between 0 to 180 degrees scaling. 200 images were used for evaluation. Recall rate was 100% for 15 queries. The number of returned image was not reported. A total of 90 seconds processing time was reported for a query image in this system.

Vrochidis [12] experimented a content-based image retrieval framework in 2009. The experiments were performed on EPO patent database. The system provided a hybrid query: textual and visual query. In their work, the authors segmented the figures in each page manually and each segmented figure would be stored in database. The adaptive hierarchical density histogram (AHDH) was used as the main approach for extracting the features in query image and database. After noise removal and image normalization, the centroid of the image was calculated and then divided into four regions. The distribution of the black pixels in white region was calculated to form a feature vector. Finally feature vector was sent to a supervised classifier known as the support vector machine for classification. 110 query images were chosen for implementing the framework. Recall and prediction were calculated for performance evaluation. 77.4 % recall and 49 % prediction was reported. The processing time below 10 seconds was reported.

Zhiyuan [13] presented a patent image retrieval system based on contour description matrix in 2007. The experiments were carried out on US patent database. The patent figures were converted to gray scale and then canny edge detection was applied to extract the counter information. The center of the shape was found to form a polar axis and edge points were converted using polar coordinate system. This approach divided a patent figure into grids with γ and θ range. The ratio between edge points to all the points was calculated and formed the elements in a contour description matrix. The performance of the recalls and prediction rates were reported but the processing time and the number of images returned was not mentioned.

Csurka [14] presented a patent image retrieval system using Fisher vector in 2011. This system was implemented on flowchart, table, graph, drawing, etc. They used SIFT-like histograms and Gaussian mixture model (GMM) to build a visual vocabulary for patent images. Linear classification was employed to train the Fisher vector. Two strategies based on mean and max were used to compare the query image and images in database. The mean was the average distance of two images and max was the maximum distance of similarity on two images. The patent image retrieval system was evaluated on CLEF-IP 2011 track. The max strategy was found better than the mean strategy on 211 queries. The authors also proposed a text based patent retrieval system based on weighted late fusion technique to combine with the visual approach. The best patent retrieval system was obtained from the combination of these two approaches.

We summarized PIR system in Table 1 according to the existing approaches in patent image retrieval domain. The relational skeleton approach proposed by Huet [10] was sensitive to the image translation, rotation and scaling because the use of the line segments. The approach by Tiwari [11] was not sensitive to image scaling and translation but the processing time was 90 seconds for a query image which was a major problem of the system. The drawback of the AHDH which was used by Vrochidis [12] for patent image retrieval on EPO database is geometrical invariance. The approach presented by Zhiyum [13] was not sensitive to rotation and scaling but the processing time was not reported. According to the review in [5], the contour description matrix had higher processing time when high resolution images were used. The run time of the system again was not reported in Csurka [14] but the fisher vector achieved 91% accuracy and thus it was the best method among the existing PIR systems. SIFT was only used in the Fisher vector among all the existing approaches [5]. Since there were only a limited number of feature extraction approaches being experimented in the patent image retrieval problem, there is a need to further investigate other advanced feature extraction techniques to improve the current image retrieval system. Thus, we proposed an improved approach in the area of patent image retrieval which would be presented in the next section of this paper.

Table 1. The comparison table of existing patent image retrieval system.

Author	Date	Dataset	Feature Extraction Methodology	Result	Time (sec)
Huet	2001	EPO	Relational skeleton	Histogram 36.46 Graph 52.16	-
Tiwari	2004	US	edge orientation autocorrelogram	Recall rate 32%	90
Vrochidis	2009	EPO	adaptive hierarchical density histogram	Prec:90.69% Recall:71.80 F-score:78.95%	-
Zhiyum	2007	US	contour description matrix	precision-recall curve	-
Csurka	2001	-	SIFT	91% accuracy	-

3. Proposed patent image retrieval approach

From the review in Section 2, SIFT algorithm was found to be the best feature extraction method. However, SIFT algorithm was only limited to four transformation parameters namely rotation, translation, expansion and contraction [15] and there was an improved Affine-SIFT being introduced. This Affine-SIFT (ASIFT) was introduced by [15] to perform full invariant objects matching in images. ASIFT treats the camera axis orientation and angle defining (latitude, longitude) left over by the SIFT algorithm [15, 16]. Hence, we propose Affine-SIFT (ASIFT) algorithm to find matched objects in patent images. When a user submits a patent image query, the proposed approach extracts features based on the Affine-SIFT algorithm. The extracted features are stored in a feature vector and a similarity measure is applied to find relevant images. The proposed approach is depicted in Fig 3.

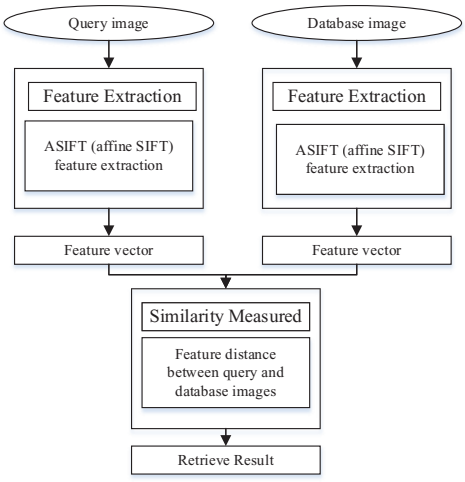

Fig 3. The proposed approach for patent image retrieval.

4. Discussion and comparison

Patent image search is normally accomplished manually to find any image matches. This manual approach is time-consuming and it has poor rate of finding the right information. Image processing-based technique is a better way to overcome this limitation and thus content-based patent image retrieval (CBPIR) is used to identify and finding matches in patent images. From literature, image matching techniques are found to be extensively utilised for CBIPR systems. Some of the techniques which known as the affine transformation algorithms are popularly used

in image matching techniques due to the invariant features capabilities. The typical features include scale, rotation transformations invariants and they are effective to find similarity between images in patent content. Among these affine transformation algorithms, Affine-SIFT (ASIFT) is the latest improved version and it is more robust compared to other algorithms. Table 2 shows the comparison of SIFT and ASIFT to verify the efficiency of ASIFT algorithm based on [15, 17]. Since Affine-SIFT image matching technique has the potential to enhance the matching process, we proposed a content-based patent image retrieval (CBPIR) based on ASIFT algorithm in this paper.

Table 2. Comparison of image matching techniques.

Evaluation parameter	SIFT-based algorithm	Affine-SIFT algorithm (in proposed system)
Processing time	Relatively longer time for feature extraction process	Faster in feature extraction process
Performance	Efficient but partial invariant for scaling, rotation and translation	Efficient and full invariant for scaling, rotation and translation

5. Conclusion

Patent Image Retrieval (PIR) is used to search similar patent images from image database based on an image query. However, there are shortages of published works in patent image retrieval system and thus there is a need for more research in this patent image retrieval domain. This paper is intended to propose a better patent image retrieval system with the feature extraction step as the main focus in our system. We proposed a patent image retrieval approach using a fully invariant affine image comparison technique which is known as ASIFT. This algorithm is not sensitive to scaling, rotation and transformation and thus the proposed patent image retrieval approach has the potential to get promising results.

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