



Word Spotting in Offline Handwritten Documents Recent Progress and Future Challenges

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Abstract—*In this paper, we reviewed the recent word spotting techniques employed to retrieve and index the document image since last two decades. We critically realized the strength and weakness of the various proposed algorithm, we have investigated the gap between the algorithms which have the primary challenges to focus in our future work*

Keywords— *Document Analysis, Optical Character Recognition, Document Indexing and Retrieval*

I. INTRODUCTION

Information Retrieval holds the intellectual aspects of the document description and specification for search, many methods and techniques are exposed to carry out the retrieval operation. An efficient and effective information retrieval method is necessary for fetching the relevant document from a huge storage of documents in response to user query and ranks the related documents in order. In this aspect an effective method is necessary for matching the document, and digital image processing(DIP) fields have been made effort to build efficient document interpretation machine to move towards paperless office, huge use of computer a large volume of information is digitized, and available in the form of document image without adequate or index information. So retrieval of information is much harder for image data then text data. To analyze the document or retrieve from the database a proper mechanism is necessary to characterize document image data in systematic manner, this can be done through DIP(Digital Image processing) using two different approaches, one is OCR (optical character recognition),and another is document image retrieval(keyword spotting)techniques (Doerrman 1998). OCR (optical character recognition) deals with the machine recognition of character present in the document image scanning operation is used to convert editable text or ASCII representation. More ever the efficiency of the DIP is relies heavily on scanned document image and it has several weakness if document image is poor quality or complicated layout, motivated by this observation some extraction methods are applied to compensate recognition errors of OCR have been exposed later (ohtam et al. 1997) and additionally different OCR candidates were reported to improve an information retrieval (kameshiro et al. 1999; katsuyama 2002). Many methods are investigated for correction of the OCR errors with its own limitations and advantages. In information retrieval DIR is a by-pass technique of OCR because it is very particular to result with respect to user query. Moreover, DIR can achieve good result in terms of recall, precision and speed then OCR (Lu and Tan 2004a). Therefore many researchers are moved towards DIR techniques, because information retrieval can achieve without converting the whole image document into editable text, therefore text are identified at word level using image property(Deormann 1998) this method is also called keyword spotting. Many interesting work has been done on keyword spotting in document image using word image property instead of text. Word spotting is the alternative way for document image processing to retrieve and indexing the existing documents. Here we can measure the features at two different (word and character) level with segmentation or without segmentation. Key word is sub field of speech reorganization that deals with the identification of the user desire word/phrase in the document or keyword spotting is the technique to find the isolated word in the entire documents image for document classification, retrieve and indexing purpose for easy access and analysis.

II. SCOPE

The goal of this survey is to provide a comprehensive study of the keyword spotting techniques in the research field of document image retrieval. The term “information retrieval” here refers to both printed as well as hand written document. Detailed research of this keyword spotting have been published in recent years. Techniques for spotting the words in documents can be distinguished as being either online or offline, depending on the particular processing strategy used. If the documents consisting more than one. language or multilingual documents stored in a single database, using key word spotting techniques possible to make documents classification as well as information retrieval for fast access and analyzing the feature work.

III. APPLICATION : ARCHIVAL OF EXISTING DOCUMENTS

The most and important application of document image processing is convert hard documents into machine readable text in this scenario many documents are scanned and kept in the database without adequate or index information. Without

index information it very difficult to access and process documents this problem can be overcome by using word spotting techniques Informational retrieval. Using word spotting technique we can retrieve the information from the documents and to make documents classification in huge storage of documents in the database also.

IV. WORD SPOTTING APPROACHES

- **SEGMENTATION FREE APPROACH**

This is the global approach to search the keyword in the document and treats each word as a single entity, due to degradation of the documents, touching character, and cursive letters it is not feasible to segment the hand written documents into individual word and character, therefore a segmentation free approach is well suited for hand written documents, in this approach features are extracted at word level in both document word and query word, then matching is performed by various matching algorithm.

- **SEGMENTATION APPROACH**

In this approach we need to pre-process the document in well manner, word spotting goal is reached through by segmenting the document into line, words and characters then feature are extracted at character level of the query word as well as segmented character, various methods are available to recognize the character and word spotting

V. PREPROCESSING

Document image of hand written text or words are different in size, angle and slant with respect to base line orientation; therefore all most all word spotting techniques apply preprocessing operations that attempt to normalize the appearance of the writing, with respect to these three aspects size, slant and angle. Usually, in some phase of preprocessing, the word or text line images are binarized for separating dark ink pixels from the documents.

VI. FEATURE EXTRACTION

Feature extraction is the process of reducing the dimensionality of the image that efficiently represents the interesting points of the image as a minimal feature vector, this minimal feature vector is useful for quickly complete the task such as image retrieval and image matching process. Features can be classified in to pixel based, local and global features, pixel based features are calculated at each pixel and values are recorded at pixel level. Local pixel are calculated at each result of sub image and finally global feature are calculated on entire image.

VII. RELATED WORK

The key word spotting is the task of detecting the word in the documents, initially proposed in the year 1993 by the authors Shyh-Shiah et al. [1] [3] have used four word shape feature (pixel value itself, transitional information pixel location in row divide by the length of the row and column, for poorly printed English script documents, pseudo 2D HMM are created for representing the actual keyword and all the other extraneous words, respectively. Dynamic programming is then used for matching an unknown input word with the two models and making a maximum likelihood decision these models provide a nice elastic matching property in the vertical and horizontal directions which makes the recognizer to font size and tolerant to noise word, the experiment is performed on synthetically created words written in English script consists of 26000 word, Recognition accuracy of 99% when words in testing and training sets are in the same font size, and 96% when they are in different sizes.

In the year 1995 Seung-Ho Lee et al.[4] proposed the method island driven lattice search algorithm for online cursive script reorganization, a key letter HMM is used to represent the statistical of the geometric feature of the letter to spotted, spotting process performed by Viterbi search algorithm, HMM based spotting algorithm is well suited for modelling the time sequenced signal data, speech and handwritten, for letter spotting a word hypothesis is generated then island driven lattice search algorithm is performed to find the optimal path on the word hypothesis lattice which corresponds most probable word among the database words. The experiment is performed on English cursive script of 22900 words and they obtained the result at 85.4% accuracy. In the year 1995 the authors Jeffery c et al. [5] proposed a method via spatial point progress for English script consists of 260 realization per word, pixel based feature are extracted by statistical method for doing optimal detection strategies to set of moments of the spatial intensity function associated with location of non-valued pixel in the image and finally they applied a method called optimal detecting for the moments to make the decision. Another author Patrica et al. [6] proposed a method in the year 1997 for cursive written documents they extracted three types features input profile feature cavity feature and combination of both profile and cavity to characterise word authors show that the global shape information is one of the most important to distinguish the word the general shape of a word may be approximated using simplified profile signature then vertical projection is used to determine upper and lower profile of the word, neighbour profiles are generated by computing horizontal projection used to detect ascender and descenders and cavity feature are essential for gap between the stroke of the word they capture the local variation in the word which are useful to decrement the word having the same shape. And they used keyword signature as the collection of features which are characterise the keyword and which allow the matching with desired word from documents in their work they focused holistic signature that characterize the entire word without braking it into individual character or stroke. Experiment performed on 100 page document scanned at 150 dpi from photocopying copies of manuscript contained in the archives of the Indies, Seville and Spain. All classification percentage reported were computed with no rejection threshold applied to the matching confidence KNN(k=5)classification results obtained using only profile signature with minkowski (r=4)similarity matrix. The overall accuracy obtained 82.58for the cavity feature, KNN (k=5) classification results

obtained at 78% and finally using keyword signature the result achieved at 91.7%. In the year 2002 Catalin et al. [7] propose a method transcript mapping for the word by segmenting the line into word because they assumed inter word spacing is grater then inter character spacing, punctuation information together with inter word gap is used for word separation coarse word mapping based on documents constraint is used for lexicon reduction then word mapping is refined by word reorganization with dynamic programming algorithm. Another author YueLu et al. [8] proposed a method based on pixel by stroke density features for Chinese script consists of 132 image documents and word spotting performed based on weighted housed off distance experimental results showed that this method can effectively search the user keyword from horizontal or vertical text lines of documents image and accuracy obtained 81.5%. In the year 2003 Toni M. Rath [9] proposed word image matching based on dynamic Time Wrapping (DTW)for English script, authors have used projection profile and word profile features They used word image matching algorithm by information retrieval approach the experiment is performed on collection of Georg Washington collection 10 pages of two sets good quality and degraded quality of each. Accuracy is measured in terms of average precision 99.52% to 94.75 and average recall is 25% to 60.25%. In the year 2004 YueLu et al. [14] have used straight stroke features and traversal features for information retrieval in digital image database consists of 3200 pages of NSDUL database written in English script they proposed an approach with the capability of matching the partial word image, address two issues word spotting and similarity measurement the inexact string matching technique is used for similarity measurement the experiment results are evaluated using average precision from 99.36% to 89.06% and recall from 97.08% to 95.94 % . In the year 2005 B. Gatos et al. [11] have used zone based projection profile with segmentation free approach for word spotting, they experimented with 50 documents of the Greek script. zone based feature and features based on word projection profile are extracted from the key word as well as words in the documents the process of word matching is performed by Manhattan distance, matching the synthetic word with all other segmented words then experiment evolution is performed using precision vs. recall curves, they used user feedback mechanism to improve the result of the matching process.

In the year 2006 K. Zagories et al. [13] have used WDIRS use nine distinct features which are employ to discrete the word image as well as word in the documents then similarity measurement is performed by Euclidian distance then exact matching is performed for word spotting for web document, experiment evaluation is performed by mean precision is 53.43% and mean recall is 94.78%. In the year 2007 Lin Lin Li et al. [15] proposed a method for a fast keyword spotting for English script by using pixel based features are extracted via stroke feature, ascender and descender feature of the word to handle the touching character in the documents with segmentation free approach authors proposed a method based on word shape coding techniques ,the strength of the method is proposed in the document filtering techniques authors have used minimum edit distance to get the similarity measurement the experiment is performed using precision /recall value as 96.22%/90/08 respectively authors have compared their method with OCR the performance is measured as 98.33% to 96.08. so their method is robust to handle different font and character size.

In the year 2007 Kengo Terasawa et al. [16] have used a sliding window to obtain edit distance features of the word and converted multidimensional descriptor into pseudo codes by using K-mean quantization techniques, the experiment is performed on document written in Japanese script the accuracy achieved 66.12 to 69.70. Another author Christophe Choise et al. [17] proposed NSHP-HMM based key word spotting features are extracted at binary pattern column by column at HMM level and pixel by pixel considering a neighbour pixel at MRF and they applied Bayes thermo for classification and experiment is performed on 1522 mail pages written in French script, result is reported in the form of score from 71.03% to 51.1%. In the year 2007 Josep Llados et al. [18] described a method for Indexing historical documents by word shape signature for English script they used shape contexts (Skelton) features for word image, a shape contexts of a feature points captures the spatial distribution of the other point relative to it in polar coordinates and to speed up the search the desired word they adopted a shape contexts distance is defined contexts are threshold and encoded as binary code word for the shape detection authors applied a voting approach. Experiment is performed on 194 documents image although their work is still preliminary stage; results are promising from the point of view of shape reorganization task instead of classical approach based on OCR. Although their method can handle little bit noise image.

In the year 2008 P.Bilane et al.[19] have used directional roses features for robust directional features for word spotting in the degraded Syria script for the spotting process authors proposed a method that can find all occurrence of a certain query word image, based on a selective sliding window techniques directional features are extracted finally matching the query word with word in the documents performed Euclidian distance correspondence between the features, this method does not require any prior information and segmentation process(word to character). Results are obtained by combining two indicators (directional signature of the window and pre-selected area of interest using gravity centre motion) and results are promising. In the year 2008 Marcal et al. [20] have used local SIFT and proximity graph features for word and symbol spotting for a industrial documents consists of textual information and symbols using spatial organization of local descriptor the task of the author is to Spot both text word and symbol, key points are extracted from a document image then a local descriptor is computed at each of the points (using harries corners) and similarity measurement obtained by voting scheme, validates the hypothetic location and finds the object under certain pose, result is promising in terms of accuracy Another author Jose A. et al. [21] have used a sliding window techniques to extract the features

They used statistical approach that builds a model for hand written words, a word image is described as a sequence of feature vector or frames then each keyword modelled using SCM-HMM and they performed the experiment on two popular statistical adaptation techniques (a maximum A posterior and minimum likelihood regression) and obtained set of source dependent parameters from the souse independent set, adaptation is evaluated in the context of a word detection task experiment is conducting on 630 scenes letters written in French FR is 40% and average false acceptance rate is 0.32% using MLLR full adaptation techniques false acceptance is reduced to .26%, absorbed that 19% error significant

reduction of the no of misclassified word. From this method good result is obtained when 32 Gaussian matrix. In the year 2009 Seema Yadav et al. [22] has proposed a method for capabilities of matching partial word image to address two issues document retrieval based on word spotting and similarity measurement between documents the straight stroke line feature and Transvaal features are extracted from the query word and word in the documents in their work features are used to represent the word bitmap image from left to right string, line and Transvaal features are used to extract the primitives of the word afterwards inexact string matching is performed for query word with document words using similarity measurement the advantage of inexact string matching can handle not only kerning but slant and also word with heavily touching character and does not require any prior training to use this method is similar to word recognition based on HMM then experiment is performed on scanned books, students thesis etc. results are promising in terms of accuracy. Shuyan et al. [23] developed a method for keyword spotting for document image through word shape coding word shape features are extracted (7 different feature) then word is converted into a WSC that describe these features in a left to right manner based on word shape model or position for each word a feature code is marked after that each word image defined by concatenation of feature codes. Author used a globalised sequence alignment similarity measurement for the word spotting and experiment is performed on 636 document pages written in English script result is 92.6% accuracy.

In the year 2010 Andress Fiscer et al. [31] have used a sliding window features are extracted one pixel width moving from left to right on the image, at each of the n position of the sliding window n=9 geometric feature are extracted with the combination of three global feature and six local feature an author proposed a method based on HMM for individual letters, the advantage of this method is does not to segment the line into word because the HMM model uses a sequence of letter model to represent text lines image and return a score for each text, but the drawback of this method is it needs prior training model for the text. Standard template matching is performed based on DTW method, an experiment is performed on IAMDB database consists of 1539 page and GWDB (English script) consist of 20 pages, accuracy of the experiment is obtained through precision and recall curves and they achieved good results. Hajime Imura et al. [32] proposed a method for converting multidimensional image vector into encoded representations, this method works independently of difference in language and different fonts, because it uses a new pseudo coding scheme based on statistical feature of character shapes and method is evaluated by recall-precision curves for n gram based query string in Japanese manuscript and word based query string in English manuscript, result obtained precision rate is 50% and recall point is 80%. By using this method it evident that HMM based filtering method and pseudo coding can significantly improves performance in terms of retrieval precision. In the year 2010 Muhammad Ismail Shah et al. [33] have used various profile and transitional features are extracted from gray scale word image and these gray scale feature vector is converted into binary feature vector by replacing each value within the gray scale feature vector for Pashto documents written in Arabic script, then correlation similarity measurement is applied for image matching. The method can handle efficiently for different writer, for the experiment an average precision rate achieved 94.75% and an average recall is 60.25, and they observed that time taken for matching every set of words is 1.43 ms. Yong Xia et al. [34] have used a new stroke and convex-concave features of the word. Font and style cause many problems in coding word shape. Robust features are needed to overcome this problem. Stroke is a good feature that is not very sensitive to font and style. Two key problems are how to extract stroke and how to distinguish words based on stroke. Besides, the typographic features, such as Ascender and Descender Attributes (ADA) of character or word, are also good features that can overcome the problem of font and style. Furthermore, Horizontal Position Attribute (HP A) of a stroke is adopted for word matching. Especially, a new feature, Convex-Concave Attribute (CCA), is provided to overcome character degradation. A method called intelligent indexing based on recognition confidence introduced which is adaptive to image quality and finally inexact matching is used for spotting the word, an experiment is performed on italic script consists of 1553 scanned document image, Euclid-distance based nearest neighbor classifier is used and each class has 8 prototypes. L VQ is used for modification and optimization of prototypes. The recognition accuracy is 99.14% in training collection and 99.03% in testing collection. The cumulative recognition accuracy with 10 candidates for training collection and testing collection is 99.99% and 99.98% respectively In the year 2011 A.L.Kesidis et al. [36] proposed a method; two different types of features are combined to provide a hybrid features vector for each dataset word as well as for the query keyword. The first one divides the word image into a set of zones and calculates the density of the character pixels in each zone. The second type of features is based on word (upper/lower) profile projections. The word image is divided into two sections with respect to the horizontal line that passes through the center of mass of the word image. Upper/lower word profiles are computed by recording, for each image column, the distance from the upper/lower boundary of the word image to the closest character pixel. The process of word matching involves the comparison/matching between the query keyword image and all the segmented words using a cosine similarity, an experiment is performed on 153 document pages written in English script and they investigated a method to cut-off the ranked list in order to provide best result between recall and precision rates total accuracy of the experiment they achieved at 92.93%. Another author Sudha Praveen et al. [38] have proposed a method called character n-gram spotting in document images, the character n-grams are represented with profile features which have been shown to perform well for the word recognition task Profile features have outperformed HOG and SIFT based representations, in an evaluation performed over 32K word-images. The profile features that are extracted include: The Projection Profile is the number of ink pixels in each column, Upper and Lower Profile measures the number of back ground pixels between the word and the word boundary, Transition Profile is calculated as number of ink background transitions per column. Each profile is a vector whose size is the same as the width of the word. A fixed length representation is typically required to use simple distance measures, which can then be used for easy indexing. This is obtained by scaling all word-images to a canonical size and extracting profiles from them, A ranking mechanism is proposed that combines the retrieval results

from multiple lists corresponding for each n gram, experiment is conducted on sizeable collection of English and Malayalam book with mean AP of 0.64%

VIII. FUTURE CHALLENGES

From the above discussion we critically realized the feature challenges of word spotting, -word spotting in Multilingual Documents, Classification of the documents in the huge database, word as well symbol spotting, Information Retrieval(Cursive Letter & Hand written Documents). We will attend these challenges in our future work.

IX. CONCLUSION

Key word spotting is one of the best ways for indexing and retrieval of document images without optical character recognition. Many researchers have been studied on word spotting but they concentrated on single script documents, word spotting in multi-script document has big room in future. There are many methods are proposed but there is need to evaluate the different methods on single benchmark data set for the advancement of research in word spotting. Our future work involves the development of Script independent model for word spotting in Indian Multi-script Documents.

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REFERENCES

- [1] Shuyong Bai, Linlin Li and Chew Lim Tan Keyword Spotting in Document Images through Word Shape Coding 978-0-7695-3725-2/09.
- [2] A.W.Senior ,F. Fallside Using constrained Sna kes for Feature Spotting in Off-line Cursive Scr ipt 0-8186-4960-7/9\$33 .008 1993 IEEE
- [3] Shyh-shiaw Kuo and Oscar E. Agazzi Keyword Spotting in Poorly Printed Documents Using Pseudo 2-D Hidden Markov Models 0162- 8828/94 IEEE
- [4] Seung-Ho Lee*, HyunKyu Lee and Jin H. Kim On-line Cursive Script Recognition. Using an Island-Driven Search Technique' 0-8186-7128.
- [5] *Jefrey C. O'Neill, Alfred O. Hero III, and William J. Williams* WORD SPOTTING VIA SPATIAL POINT PROCESSES 0-7803-3258- W96 IEEE
- [6] Patricia Keaton, Hayit Greenspan and Rodney Goodman Keyword Spotting For Cursive Document Retrieval 0-8186-8055-5/9 IEEE
- [7] Catalin I. Tomai, Bin Zhang and Venu Govindaraju Transcript Mapping for Historic Handwritten Document Images Proceedings of The Eighth International Workshop on Frontiers In Handwriting Recognition (IWFHR'02) 0- 7695-1692-0/2002 IEEE
- [8] Yue Lu, Chew Lim Tan Word Spotting in Chinese Document Images without Layout Analysis 1051-465UO 2002 IEEE
- [9] Toni M. Rath and R. Manmatha Word Image Matching Using Dynamic TimeWarping Proceedings of the 2003 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'03) 1063-6919/03 \$17.00 © 2003 IEEE
- [10] Sargur N SRIHARI and Zhixin SHI Forensic Handwritten Document Retrieval System Proceedings of the First International Workshop on Document Image Analysis for Libraries (DIAL'04) 0-7695-2088-X/04 IEEE
- [11] B. Gatos, T. Konidakis, K. Ntzios, I. Pratikakis and S.J. Perantonis A Segmentation-free Approach for Keyword Search in Historical Typewritten Documents Proceedings of the 2005 Eight International Conference on Document Analysis and Recognition (ICDAR'05) 1520- 5263/05 \$20.00 © 2005 IEEE
- [12] Yann LEYDIER, Frank Le BOURGEOIS, Hubert EMPTOZ "Omnilingual Segmentation-free Word Spotting for Ancient Manuscripts" Indexation Proceedings of the 2005 Eight International Conference on Document Analysis and Recognition (ICDAR'05) 1520-5263/05 IEEE
- [13] K Zagoris, N. Papamarkos and C. Chamzas WEB DOCUMENT IMAGE RETRIEVAL SYSTEM BASED ON WORD SPOTTING 1- 4244-0481-9/06 ©2006 IEEE
- [14] Yue Lu and Chew Lim Tan "Information Retrieval in Document Image Databases" 1041-4347/ 2004 IEEE.
- [15] Linlin Li, Shijian Lu and Chew Lim Tan A Fast Keyword-Spotting Technique Ninth International Conference on Document Analysis and Recognition (ICDAR2007)0-7695-2822-8/2007 IEEE.
- [16] Kengo Terasawa and Yuzuru Tanaka Locality Sensitive Pseudo-Code for Document Images Ninth International Conference on Document Analysis and Recognition (ICDAR 2007)0-7695-2822-8/2007 IEEE.
- [17] Christophe Choisy Dynamic Handwritten Keyword Spotting based on the NSHP-HMM Ninth International Conference on Document Analysis and Recognition (ICDAR 2007) 0-7695-2822-8/07 IEEE
- [18] Josep Lladós, Gemma Sánchez Indexing Historical Documents by Word Shape Signatures Ninth International Conference on Document Analysis and Recognition (ICDAR 2007) 0-7695-2822-8/2007 IEEE.
- [19] *P. Bilane, S. Bres, H. Emptoz* ROBUST Directional Features For Wordspotting In Degraded Syriac Manuscripts 978-1-4244-2044-5/08/ 2008 IEEE
- [20] Marçal Rusiñol, Josep Lladós Word and Symbol Spotting Using Spatial Organization of Local Descriptors 978-0-7695-3337-7/08 \$25.00 © 2008 IEEE DOI 10.1109/DAS.2008.24

- [21] Jos'e A. Rodr'iguez+*, Florent Perronnin+, Gemma S'anchez*, Josep Llad'os Unsupervised writer style adaptation for handwritten word spotting 978-1-4244-2175-6/08/ IEEE
- [22] Seema Yadav , Dr. Sudhir Sawarkar Retrieval Of Information In Document Image Databases Using Partial Word Image Matching Technique 2009 IEEE International Advance Computing Conference (IACC 2009) Patiala, India, 6-7 March 2009 978-1-4244-1 888- 6/08/ IEEE
- [23] Shuyong Bai, Linlin Li and Chew Lim Tan Keyword Spotting Document Images through Word Shape Coding 978-0-7695-3725-2/09 IEEE DOI 10.1109/ICDAR.2009.54.
- [24] Reza Farrahi Moghaddam and Mohamed Cheriet Application of multi- level classifiers and clustering for automatic word spotting in historical document images 2009 10th International Conference on Document Analysis and Recognition 978-0-7695-3725-2/09IEEE DOI
- [25] Jos'e A. Rodr'iguez-Serrano, Florent Perronnin Handwritten word-image retrieval with synthesized typed queries 2009 10th International Conference on Document Analysis and Recognition 978-0-7695-3725-2/09IEEE DOI 10.1109/ICDAR.2009.201
- [26] B. Gatos and I. Pratikakis Segmentation-free Word Spotting in Historical Printed Documents 2009 10th International Conference on Document Analysis and Recognition 978-0-7695-3725-2/09,IEEE DOI.
- [27] Kengo Terasawa , Hajime Imura Yuzuru "Automatic Evaluation Frame Work for Word Spotting 10th International Conference Documents Analysis and Recognition 978-0-7695-3725-2/09 \$25.00 © 2009 IEEE DOI 0.1109/ICDAR.2009.119
- [28] Khurram Khurshid, Claudie Faure, Nicole Vincent Fusion of Word Spotting and Spatial Information for Figure Caption Retrieval in Historical Document Images 2009 10th International Conference on Document Analysis and Recognition 978-0-7695-3725-2/09
- [29] Kengo Terasawa , Yuzuru Tanaka "Slit Style HOG Feature for Document Image Word Spotting 10th International Conference Documents Analysis and Recognition 978-0-7695-3725-2/09 \$25.00 © 2009 IEEE DOI 10.1109/ICDAR.2009.118
- [30] Florent Perronnin, Jose A. Rodriguez-Serrano "Fisher kernels for Hand written word-spotting" 10th International Conference Documents Analysis and Recognition 978-0-7695-3725-2/2009 IEEE DOI 10.1109/ICDAR.2009.16
- [31] Andreas Fischer, Andreas Keller, Volkmar Frinken, and Horst Bunke HMM-Based Word Spotting in Handwritten Documents Using Subword Models 2010 International Conference on Pattern Recognition
- [32] Hajime Imura yand Yuzuru Tanaka A Full-text Search System for Images of Hand-Written Cursive Documents 2010 12th International Conference on Frontiers in Handwriting Recognition 978-0-7695-4221- 8/10 IEEE DOI 10.1109/ICFHR.2010.105
- [33] Muhammad Ismail Shah Ching Y. Suen Word Spotting in Gray Scale Handwritten Pashto Documents 2010 12th International Conference on Frontiers in Handwriting Recognition 978-0-7695-4221-8/10 \$26.00
- [34] Yong Xia Guangri Quan Yongdong Xu Yushan Sun KEYWORD SPOTTING IN DEGRADED DOCUMENT USING MIXED OCR AND WORD SHAPE CODING 978-1-4244-6585-9/10/\$26.00 ©2010 IEEE
- [35] Heng Zhang, Da-Han Wang, Cheng-Lin Liu Keyword Spotting from Online Chinese Handwritten Documents Using One-Vs-All Trained Character Classifier 2010 12th International Conference on Frontiers in Handwriting Recognition 978-0-7695-4221-8/10 \$26.00 © 2010 IEEE DOI 10.1109/ICFHR.2010.49
- [36] A.L. Kesidis and B. Gatos Efficient Cut-off Threshold Estimation for Word Spotting Applications 1520-5363/11 \$26.00 © 2011 IEEE DOI 10.1109/ICDAR.2011.64
- [37] Marc,al Rusi~no], David Aldavert, Ricardo Toledo and Josep Llad'os Browsing Heterogeneous Document Collections by a Segmentation-free Word Spotting Method 2011 International Conference on Document Analysis and Recognition 1520-5363/11 \$26.00 © 2011 IEEE DOI 10.1109/ICDAR.2011.22
- [38] Sudha Praveen M., Pramod Sankar K., C. V. Jawahar Character n-Gram Spotting in Document Images 1520-5363/11 \$26.00 © 2011 IEEE DOI 10.1109/ICDAR.2011.191
- [39] Israel Rios, Alceu de Souza Britto Jr Alessandro Lameiras Koerich An OCR Free Method for Word Spotting in Printed Documents: the Evaluation of Different Feature Sets *Journal of Universal Computer Science, vol. 17, no.*