ISSN: 0976-9102 (ONLINE) ICTACT JOURNAL ON IMAGE AND VIDEO PROCESSING, FEBRUARY 2017, VOLUME: 07, ISSUE: 03
DOI: 10.21917/ijivp.2017.0205

DOCUMENT IMAGE REGISTRATION FOR IMPOSED LAYER EXTRACTION

Surabhi Narayan[1] and Sahana D. Gowda[2]
Department of Computer Science and Engineering, B.N.M Institute of Technology, India

Abstract

Extraction of filled-in information from document images in the presence of template poses challenges due to geometrical distortion. Filled-in document image consists of null background, general information foreground and vital information imposed layer. Template document image consists of null background and general information foreground layer. In this paper a novel document image registration technique has been proposed to extract imposed layer from input document image. A convex polygon is constructed around the content of the input and the template image using convex hull. The vertices of the convex polygons of input and template are paired based on minimum Euclidean distance. Each vertex of the input convex polygon is subjected to transformation for the permutable combinations of rotation and scaling. Translation is handled by tight crop. For every transformation of the input vertices, Minimum Hausdorff distance (MHD) is computed. Minimum Hausdorff distance identifies the rotation and scaling values by which the input image should be transformed to align it to the template. Since transformation is an estimation process, the components in the input image do not overlay exactly on the components in the template, therefore connected component technique is applied to extract contour boxes at word level to identify partially overlapping components. Geometrical features such as density, area and degree of overlapping are extracted and compared between partially overlapping components to identify and eliminate components common to input image and template image. The residue constitutes imposed layer. Experimental results indicate the efficacy of the proposed model with computational complexity. Experiment has been conducted on variety of filled-in forms, applications and bank cheques. Data sets have been generated as test sets for comparative analysis.

Keywords:

Document Image Registration, Template, Input Image, Convex Hull, Minimum Hausdorff Distance, Connected Component Analysis

1. INTRODUCTION

Scanned document images undergo geometrical distortion due to air pressure and placement of the document on the scanner bed. Extraction of filled-in information from geometrically distorted input document image in the presence of template image is by registration [1]. Document image registration [1] is a technique to align the input image to the template image in consideration with the geometrical distortion.

Input document image consists of three layers, background, foreground and the imposed layer. Imposed layer contains filled-in content which is vital and unique for an individual, Foreground layer contains the common information generated by the source, Background is a null document image without any content. Foreground layer is imposed on the null background. Imposed layer is added on the document containing the foreground imposed on null background. Template document image consists of two layers, foreground layer and null background.

In this paper, a novel document image registration technique has been proposed to extract imposed layer by estimating the transformation values for rotation and scaling. The input image and the template image are tight cropped to remove the exterior empty region. Convex Hull [2] extracts the exterior contour points of the content. The contour connectivity of the exterior points generates a convex polygon. Due to the presence of imposed layer and geometrical distortion in the input image, the polygon of the input and template differs in terms of number of vertices and geometrical transformations. The proposed method iteratively computes the sum of distances between the paired vertices for the permutable combination of rotation ranging from -30 degrees to +30 degrees with step size of 1 degree and scaling ranging from 0.9 to 1.1 with step size of 0.01. The range is learnt by measuring the geometrical distortion due to air pressure in the scanner bed and the angle of capture. Pairing of vertices between the input polygon and the template polygon is based on minimum Euclidean distance computed between the vertices. The sum of distances between the paired vertices for every combination of rotation and scaling is computed. Minimum Hausdorff distance corresponds to one combination of rotation and scaling which is identified as estimated transformation values. The input image is transformed by the estimated values to align it to the template image.

The transformation estimation is an approximation process due to which components do not overlap exactly even after registration of the input image to the template. To overcome this, text components at world level are bounded by contour boxes using Connected Component Analysis [3]. Contour boxes corresponding to the input image and the template image are overlapped. Identical components that overlay on each other exactly are removed from the input image. Partially overlapped boxes are subjected to equivalence by extracting geometrical features such as area, density, degree of overlapping and if found identical are eliminated from the input image. Residues are the components of imposed layer. The rest of the paper is organized as follows. Section 2 signifies state of the art, complete mathematical model has been explained in section 3, section 4 depicts the experimental analysis and the results and in section 5, paper is concluded.

2. STATE OF ART

For various applications, documents are scanned and converted from hard copy form to soft copy form. These images undergo geometrical distortion like translation, rotation and scaling due to air pressure or placement of the document on the scanner bed. Document image registration [1] is a technique to align two images by estimating the transformation parameters and transforming one of the images. Vital component extraction [4], mosaicking [5,6] reconstruction of the missing parts [7] are the applications of document image registration.

Document image registration aligns the input image to the template image resulting in overlapping of components common to input and template. Extraction of the non-overlapping components results in imposed layer components.

The brute force approach [4,1] to image registration under arbitrary transformation involves search for transformation in six dimensions: two dimensions for translation, two dimensions for rotation, and two dimensions for scaling. For images of significant size and resolution, the brute force approach seems unreasonable with the limitation of dimension.

Textual information [8], component block projections [9][10][7], invariant features [4], warping the image in the log-polar form [11], fourier-mellin transform [12] and Hausdorff distance[13] are used to register the input document image to the template document image.

Peng et al. [9] proposed document image matching based on component block for registration and retrieval. The raw image is deskewed and preprocessed to remove noise. Each encountered foreground pixel is used as a seed to region grow a rectangular component block. The component blocks of substantial size are retained and the rest are removed as noise. The test document image and the template image are represented as a list of component blocks sequenced from small to large. For each block in the template image a similar block in the test image is found and the distances are accumulated. The template component which yields minimum distance is the matching template. The technique does not register the images but compares corresponding components at word level to identify type of the document. The technique requires all templates to be of normalized size and this is not true for many applications. Bank cheques and student enrollment forms are of different sizes.

Edupuganti et al. [8] proposed registration of camera captured documents under non-rigid deformation for extracting region of interest. Camera captured images undergo non-rigid deformation due to the absence of scan bed and non-uniform lighting. The rectangular boxes in the template image indicate the regions of interest. The invariant points from the test image and the template image are extracted using SIFT or SURF. Before clustering of feature points, there is an incorrect correspondence between the regions of interest (ROI) due to non-rigid deformation. After the feature points are clustered using k-means correspondence is set using histogram. The technique mosaics the images captures in different angles and does not handle affine transformation.

Hao et al. [7] proposed a table image registration technique based on gradient projection for image mosaicking. The gradient feature using Sobel filter is extracted and rate of similarity is used to estimate the nearness. The difference in correlation is used to mosaic the two images. The technique handles very small variations in rotation and scaling. If the considered images have considerable amount of rotation and scaling, then other methods have to be applied to rectify them before registration.

Tong et al. [6] proposed a warped document image mosaicking method based on the inflection point detection and registration. The technique is used to correct the distortion introduced when the same document is photographed from the left and right viewpoints. The document image is dilated to extract the text line and inflection point is determined using curve fitting. Translation, Rotation and Scaling (TRS) transform based on inflection point is used to register the images. Little distortion at the boundary still prevails.

Garris et al. [14] proposed a registration technique based on the dominant vertical and horizontal lines prevalent in forms. To estimate the translation and rotation parameters, the images are down sampled. Rotation is estimated by determining the maximum skew function response. Translation is estimated using the dominant horizontal and vertical lines. The technique does not handle scaling. The transformations, rotation and translation are handled separately.

Wolberg et al. [11] proposed a robust image registration technique using log polar form. The transformation parameters are computed iteratively in a course to fine hierarchical framework using variation of Levenberg-Marquadt non-linear least squares optimization method. The technique performs a coarse registration and brings the two images into sufficient alignment.

Hutchinson et al. [12] proposed a fast registration technique for tabular images using Fourier-Mellin transform. Each component of the transformation is handled separately. The parallel lines in the image produces peaks in magnitude in the frequency domain which are used to compute rotation and shear. Scale is recovered in the log-polar form. Once the rotation and scaling are recovered, translation is estimated using straight 2D correlation. The accuracy of the technique depends on the presence of tables in the image.

Chao et al. [4] proposed document image registration using geometric invariance and Hausdorff distance. The technique is based on projective invariance. A set of non collinear points that are invariant to geometrical transformation are identified manually on the image. Five points on the reference image are selected manually. Approximately 15 points on the input image that might correspond to the five points on the reference image are identified manually. Cross ratio is computed to find a set of geometrically invariant point pair between five points on the reference image and five points on the input image. After pairing of vertices, coarse transformation is applied to align five vertex pairs. A convex pentagon is constructed on the reference image and the input image. Finer transformation values between the boundaries of the two convex pentagons are determined using Partial Hausdorff distance. Partial Hausdorff distance is the maximum distance between the K^{th} and the L^{th} paired vertices of the convex pentagons of reference and input image. The accuracy of the technique depends on choosing points that are geometrically invariant. The technique is used to fine tune the transformation parameters and cannot handle arbitrary rotation, scaling and translation.

From survey it is evident that the techniques available require manual identification of vertices to construct polygons and transformation values are computed by restricting the dimensions of rotation, scaling and translation. It is also observed that transformation values are computed to fine tune the registration by handling each transformation individually. Hence there is a need for a registration technique which estimates the transformation values considering the permutable combination of rotation and scaling without manual identification of contour points. The method should be free of content format. Such a technique can be applied to structured/unstructured document images in the presence of a template.

3. PROPOSED METHOD

Based on the design of application forms, receipts and cheques, document images may have tables and lines in addition to printed text, handwritten text, logo and seal. Tables are removed from input image and template image to reduce the number of contour points as tables contain horizontal and vertical lines. Noise may be introduced during scanning or due to aging of the document. Hence removal of noise, tables and lines are treated as preprocessing to registration.

3.1 PREPROCESSING

Noise is removed using median filter [15]. The image is processed in the binary form as in document, the visual foreground information is always in contrast to the null/plain background. The template image and the input image are binarized using Otsu's binarization [16]. Tables and lines from the template and input image are removed using a line removal technique based on Hough transform [17].

Line detection and removal using Hough transform [17]: Hough transform is a powerful tool to detect lines in an image due to its robustness. To detect a straight line, the high pixels of the image are transformed into a sinusoidal curve in the Hough parameter space.

$$r = x \cos\theta + y \sin\theta \tag{1}$$

The collinear points in the image space intersect at a point (r, θ) in the Hough parameter space. Therefore a peak in the Hough parameter space indicates the presence of a straight line in the image space. The peaks from the Hough space are mapped back to the image space to detect the lines. Hough transform based line removal technique detects dashed or mildly broken lines also. The detected lines are removed from the input image and the template image.

3.2 DOCUMENT IMAGE REGISTRATION

The preprocessed input images contain text, handwritten and printed along with signature, logo and seal. Template image contain printed text along with logo. In the proposed technique, convex hull [10] is used to identify the exterior boundary points of the content. The contour points are connected using gift wrapping algorithm [10] to construct a convex polygon. The convex polygon of the input is different from that of the template convex polygon in terms of number of vertices and shape due to the presence of filled-in content and geometrical distortion. The number of contour points in the input image is always equal or more than the number of contour points in the template image.

3.2.1 Hausdorff Distance:

Hausdorff distance [7] is a measure of distance between two polygons. Given two vertex sets A and B, where A and B are polygons, the Hausdorff distance is defined as,

$$H(A,B) = \max(h(A,B),h(B,A)) \tag{2}$$

where,

$$h(A,B) = \max\min(\|a.b\|)$$

$a \in A$ and $b \in B$ and $\|\cdot\|$ is the Euclidean norm.

The function $h(A,B)$ is called the directed Hausdorff distance from A to B.

Euclidean distances between the points in set A and set B are computed and the minimum distance from every pair is tabulated. The maximum distance among the tabulated set of distances is defined as the Hausdorff distance between the two polygons.

Hausdorff distance is computed iteratively pairing points in set A and B using Euclidean distance. The method is computationally expensive and exhaustive in pairing the vertices. To overcome this Minimum Hausdorff distance has been proposed in this paper where pairing of vertices from set A and set B is done as an initial step and Minimum Hausdorff distance is computed iteratively for every combination of rotation and scaling for the same paired set. By this method there is a gradual alignment of input to template in two dimensions (rotation and scaling) is achieved.

3.3 MINIMUM HAUSDORFF DISTANCE

For initial correspondence, template vertices are paired with the input using Euclidean distance. Euclidean distance is defined as the straight line distance between two points in the Euclidean space.

Given two vertex sets A and B where A is the template and B is the input, pairing is given by,

$$P(a,b) = \min(\text{Euclidean distance}(a,b)) \tag{3}$$

where, $a \in A$ and $b \in B$.

The input image always consists of equal or more contour points than that of the template image due to the presence of filled in content/imposed layer components. For transformation parameter estimation, the vertices from set A are paired with the vertices from set B. The unpaired vertices from set B if any are not considered for transformation parameter estimation.

Minimum Hausdorff distance between two paired vertex sets A and B is given by the Eq.(4),

$$H_K(A,B) = \sum(h_K(A,B)) \tag{4}$$

where, $h_K(A,B)$ is the distance between the paired vertices given by Eq.(3). Minimum Hausdorff distance is tabulated for the permutable combinations of rotation and scaling. The minimum value identifies one combination of rotation and scaling which identifies the transformation values to register the input image to the template.

3.4 GEOMETRICAL TRANSFORMATION

The input image is geometrically transformed by the estimated values of rotation and scaling.

If I is the input image matrix, then the transformed image is given by the equation,

$$I_s = M\,I \tag{5}$$

where,

$$M = s\begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \text{ and } s = [s_x s_y]$$

s_x is the scaling factor in x direction,

s_y is the scaling factor in y direction,

θ is the angle of rotation in degrees,

M is the estimated transformation parameters,

I is the input image and

I_s is the transformed image.

3.5 CONNECTED COMPONENT ANALYSIS

Geometrical transformation of the input image aligns the input image to the template image approximately. Since alignment estimation is an approximation process, one to one pixel overlap between the template image and the input image is not possible. The components common to both input and template image are identified by analyzing the contour drawn around the components. The contour boxes of the input image is overlayed on the contour boxes of the template image and the overlapped contour boxes are analyzed for similarity based on geometrical features; area, density and degree of overlapping. The components enclosed by the contour boxes are removed from the input image if a match is found in the template image. The residues constitute the imposed layer components.

3.6 ALGORITHM

1. Load input image and template image for registration.
2. Apply median filter to remove noise from input and template image.
3. Apply Hough transform to detect table and lines and eliminate them from input and template image.
4. Apply convex hull to extract contour points from input and template image.
5. Generate convex polygon by connecting the contour points for input and template image.
6. Overlay input polygon and template polygon on XY plot.
7. Pair the vertices of input image and template based on Euclidean distance.
   a. Tabulate Euclidean distance between every pair of vertices of input polygon and template polygon.
   b. Minimum Euclidean distance from every vertex of the template polygon is used to pair the vertices.
8. Compute Minimum Hausdorff distance between the input and template polygon for permutable combination of rotation and scaling
   a. Compute and tabulate minimum Hausdorff distance between the paired vertices of input and template polygon.
   b. Apply rotation and scaling and transform the vertices of the input polygon.
   c. Repeat step (a) for all permutable combinations of rotation and scaling.
9. Identify the combination of rotation and scaling that yielded minimum Hausdorff distance between the vertices of input and template polygon.
10. Transform the input image by the identified rotation and scaling values.
11. Apply Connected Component Analysis to generate bounded boxes around the word components in transformed input image and template.
12. Overlay the bounded word components of input image on the template.
13. Analyze overlapping bounded boxes for geometrical features; area, density and degree of overlap and eliminate components from the input if a match is found in template.
14. Residue consists of the components in the imposed layer.

4. EXPERIMENTAL ANALYSIS

To test the efficacy of the proposed model, data set consisting of 1000 images has been generated. The data set includes student record documents that keep track of academic progress of students, bank cheques consisting of transaction details and application forms consisting of personal details and printed seal. All document images in the data set contain printed text, filled-in handwritten text and signatures. Student record has text enclosed in tables, bank cheques have lines over which handwritten text is imposed and application forms have neither tables nor lines. Images in the data set are analyzed in terms of layered architecture. Student record and application forms have a null background layer whereas bank cheques have water marked background layer. All images have general printed text, lines and tables as foreground layer components and handwritten text and signatures as components of the imposed layer. These data sets also have various degrees of geometrical distortion incurred during capture/generation phase as tabulated in Table.1. The distortion in terms of rotation is heuristically considered to be between -30 degrees and +30 degrees in consideration with placement of the document on the scanner bed. The step size of 1 degree is learnt through experimentation with different types of documents. The range for scaling is between 0.9 and 1.1 and is learnt from experimentation. Expansion in range increases the time complexity of the algorithm.

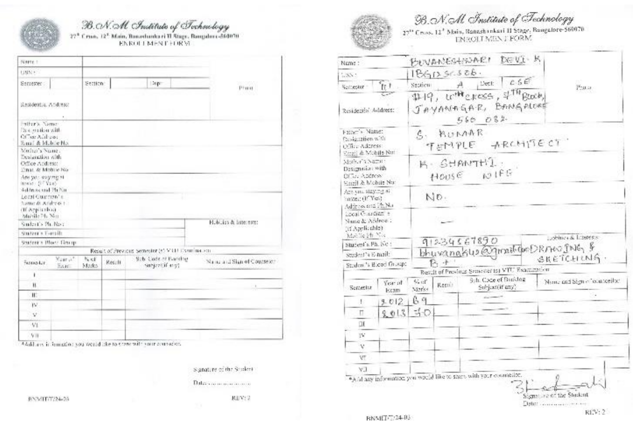
Table.1. Description of the data set

Type of the document	Number of images	Tables/ Lines	Noise	Rotation Range in degrees	Scaling factor Range
Student Record	400	Yes	Minimal	-30 to + 30	0.9 to 1.1
Bank cheques	400	Yes	Minimal	-30 to + 30	0.9 to 1.1
Application form	200	No	Minimal	-30 to + 30	0.9 to 1.1

4.1 STUDENT RECORDS

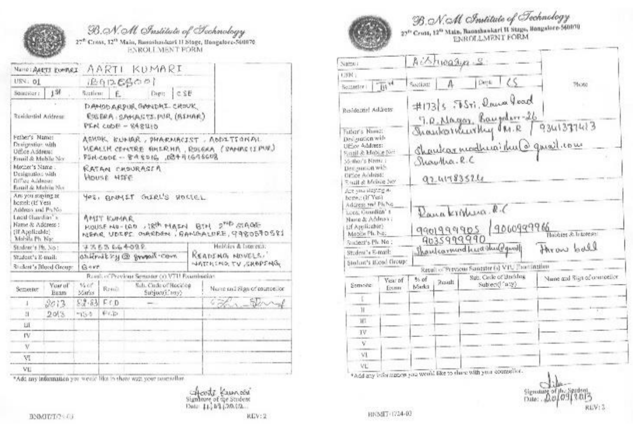
Student record keeps track of academic progress of a student over time. Student record images in the dataset have printed text, filled-in handwritten text and signature enclosed in tables. Student record is documented over a four year time period during which handwritten text is added.

The document image is generated at the end of the four year tenure. The images have a null or empty background. Printed text, logo and table lines form the foreground layer whereas the filled-in handwritten content and the signature constitute the imposed layer. These images are either camera captured or scanned images. Due to the variation in the scanner resolution and placement of the document on the scanner bed, the scanned images have various degrees of geometrical distortion. Template and input student record images are shown in Fig.1(a) and Fig.1(b) respectively.



(a) (b)

Fig.1. (a) Template (b) Input image

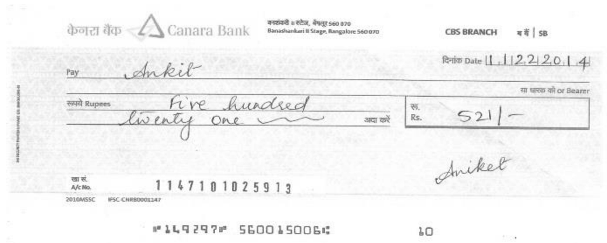


(a) (b)

Fig.2. Input images

The Fig.2(a) and Fig.2(b) shows input student record images.

(a)



(b)

Fig.3. (a) Template and (b) Input image

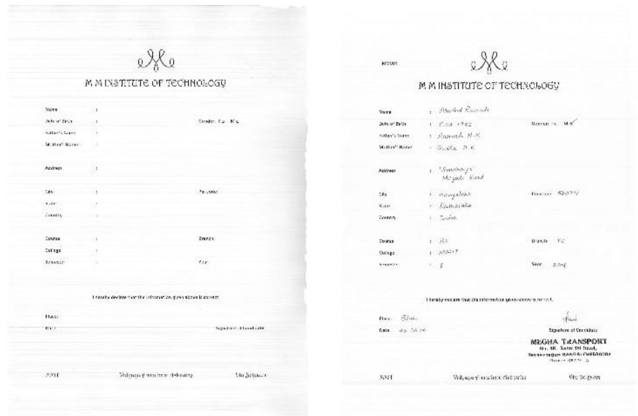
4.2 BANK CHEQUES

Bank cheques are documents generated to keep track of financial transactions. Bank cheque has watermarked background layer. The foreground layer consists of minimal machine printed text like the account number, name of the bank, instructions and lines. The imposed layer contains handwritten components like name of the payee, amount, date and signature. These components are present at fixed locations on the cheque. Geometrical distortion in bank cheques is mainly due to the placement variation of the cheques on the scanner bed. Template and input cheques images are shown in Fig.3(a) and Fig.3(b).

4.3 APPLICATION FORMS

Application forms contain common information in the machine printed form in addition to the filled-in handwritten components and a logo. These documents have a null background. Printed text and logo constitute the foreground layer. The application forms do not contain lines or tables. The handwritten text, signature and printed seal component constitute the imposed layer.

The Fig.4(a) shows a template application form image and Fig.4(b) and Fig.4(c) show input application form image.



(a) (b)

(c)

Fig.4. (a) Template (b) and (c) Input image

Case 1: There are 400 student record images in the dataset. Student record images contain machine printed and handwritten text enclosed in tables. The table lines are non-uniform in thickness. Machine printed text in the student record images are of varying fonts and font sizes. Logo of the institution and signature component of the student is present outside the table. Signature component is imposed on the printed text in all student record images. Due to non-uniform thickness of lines, some residue line segments remain after line removal. The image after line removal is shown in fig 5

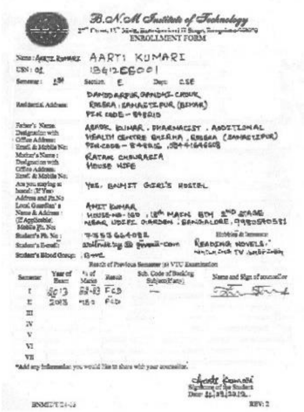


Fig.5. Line removed input image

The line removed image is tight cropped by identifying the topmost-leftmost, topmost-rightmost, bottommost-leftmost and bottommost-rightmost foreground pixels. This process reduces the processing of background layer that exists around the content border.

Convex Hull identifies the exterior contour points of the content. Convex polygon is constructed by connecting the contour points of the content. Convex polygon overlapped on the input image is shown in Fig.6. The process is repeated for the input image.

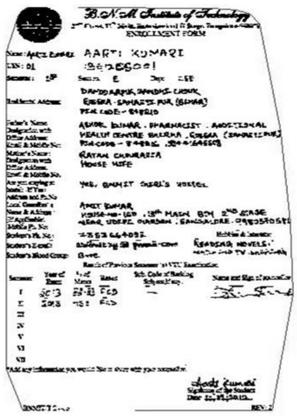


Fig.6. Convex polygon overlapped on the input image

Input and template polygons are overlapped on the x-y plot. The input and template polygons on the x-y plot is shown in Fig.7.

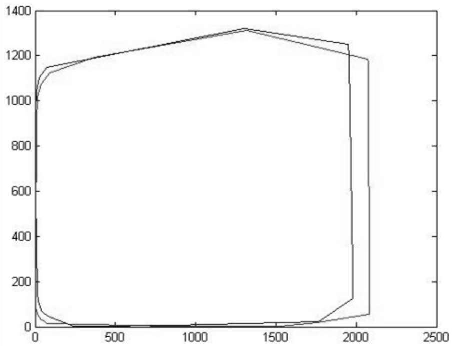


Fig.7. Input and template polygons on the XY plot

Modified Hausdorff distance is computed iteratively varying the rotation parameter with a step size of 1 degree and scaling parameter with a step size of 0.01 in x and y direction. The minimum Hausdorff distance determines the transformation values. The input image is transformed by the estimated values. Connected component analysis is used to generate contour boxes around the word components in the input and the template image. The contour boxes of the components common to both input and template image either overlap or are located very near to each other. The components overlap with four different possibilities as shown in Figures 8 and Fig.9.

Fig.8. component overlap possibility 1 & 2

Fig.9. Component overlap possibility 3 & 4

The overlapping boxes are analyzed for similarity in area and density. Based on the similarity, the contour boxes are eliminated from the input image. The residues are further analyzed for nearness based on area and density.

Contour boxes that are identical in area and density and do not overlap but are very near as depicted in Fig.10 are eliminated from the input image. The residues are the imposed layer components.

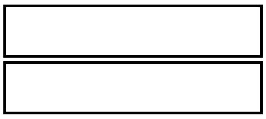


Fig.10. Non overlapping component boxes with identical geometrical features

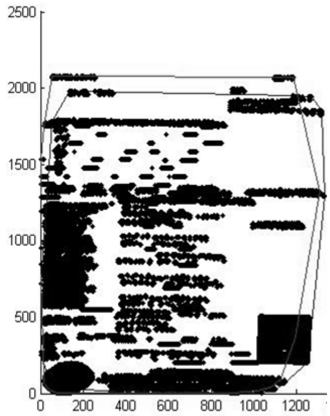


Fig.11. Input image overlapped on Template before registration

It is evident from Fig.11 that due to the presence of imposed layer components in the input image, the number of input polygon vertices varies from that of the template polygon vertices.

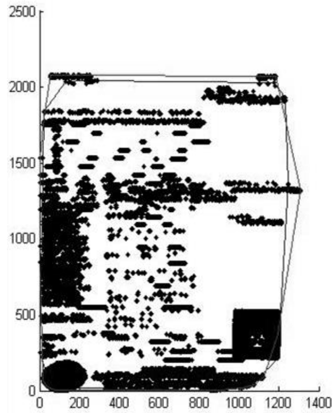


Fig.12. Input image overlapped on Template after registration

As seen from Fig.12, the components in the input image and the template image do not overlap pixel to pixel after the transformation of the input image. Therefore connected component analysis is applied to identify the components common to input and template image.

Case 2: Cheque images have a water marked background layer over which the foreground and the imposed layer are imposed. The water marked background is removed in the binarization phase. Cheque images contain lines on which the imposed layer components are imposed. Due to the non-uniform thick lines, residue line segments remain after the application of line removal technique. Convex polygon of the input and the template are overlayed for transformation estimation. The input image is transformed by the estimated values and connected component analysis is used to draw contour boxes around the word components in template and transformed input image. The contour boxes are analyzed for 4 overlapping possibilities based on area and density. Components corresponding to similar contour boxes are eliminated from the input images. The residues are the imposed layer components. In Fig.15, the input polygon depicting the input image is overlayed on the template polygon depicting the template image for transformation parameter estimation. The input image is transformed by the estimated parameters and the overlay after transformation is shown In Fig.16.

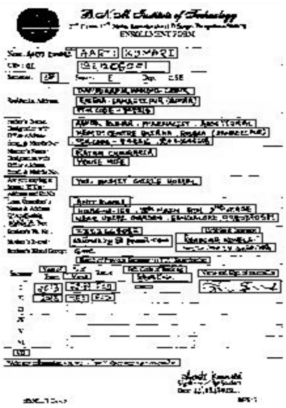


Fig.13. Imposed layer components enclosed in a blue box

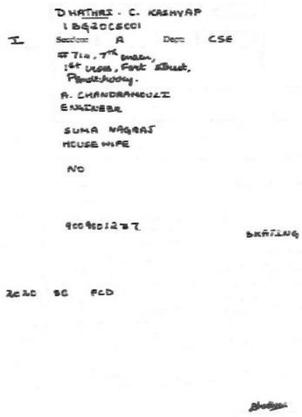


Fig.14. Extracted imposed layer

The identified imposed layer components are shown in Fig.13 and the extracted imposed layer is shown in Fig.14.

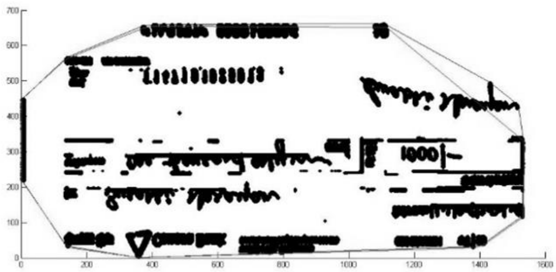


Fig.15. Input image overlapped on template before registration

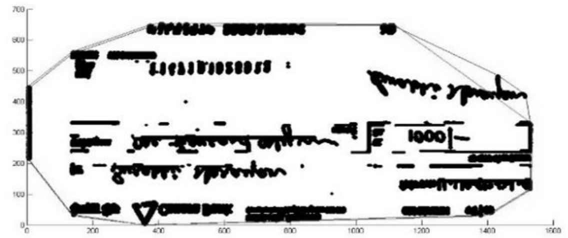


Fig.16. Input image overlapped on template after registration

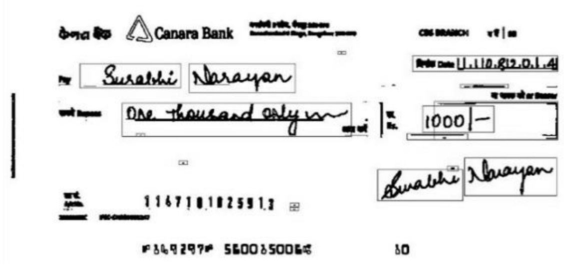


Fig.17. Imposed layer components enclosed in blue box

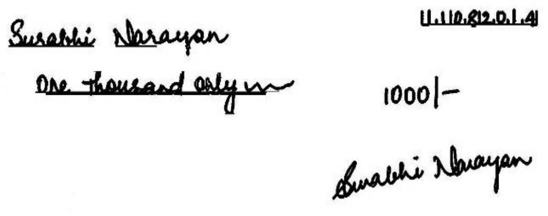


Fig.18. Extracted imposed layer

The Fig.17 shows the identified imposed layer components and Fig.18 shows the extracted imposed layer components.

Case 3: Application form images have a null background layer, printed text and logo constitute the foreground layer and handwritten text and signature constitute the imposed layer. Convex polygon of the input and the template are overlayed for transformation estimation as shown in Fig.19. The input image is transformed by the estimated parameters and overlay of input and template after transformation is shown in Fig.20.

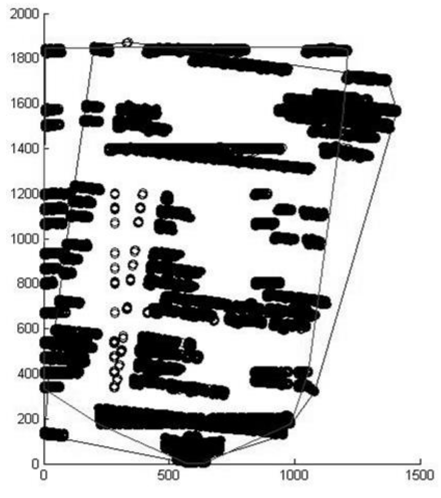


Fig.19. Input image overlapped on template before registration

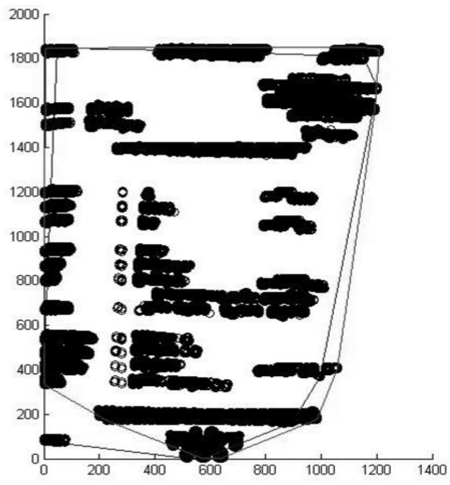


Fig.20. Input image overlapped on template after registration

The identified imposed layer components in the input application form image are shown in Fig.21. The identified components are retained and the rest are eliminated. The extracted imposed layer is shown in Fig.22.

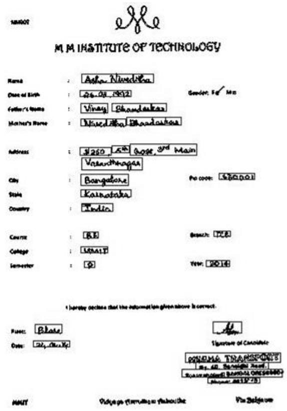


Fig.21. Imposed layer components enclosed in blue box

Fig.22. Extracted imposed layer

5. COMPARITIVE ANALYSIS

Determination of key points is a significant step in alignment estimation. With the supervised knowledge of geometric invariance chao [4] extracted five pairs of points from input image and template manually. This manual extraction of key points has been eliminated in the proposed method.

Fig.23. Chao’s Technique and Proposed Technique

Technique proposed by chao [4] constructs pentagons from the key points extracted. The input pentagon is overlayed on the template pentagon and Hausdorff distance is used only to fine tune the alignment. The proposed technique is a complete automated system from key point extraction to alignment estimation.

6. CONCLUSION

Extraction of filled-in content from filled-forms in the presence of template is challenging due to arbitrary geometrical distortion in the input image. In this paper, a novel registration technique to extract imposed layer components is proposed. The transformation values are estimated using Modified Hausdorff distance and connected component analysis is used eliminate components common to input and template image. The results indicate the efficacy of the proposed model.

ACKNOWLEDGEMENT

This work is supported by Visveswaraya Technological University (VTU) under the Research Grant Scheme 2010-11 (Ref.No.VTU/Aca./2011-12/A-9/13097). The authors acknowledge the support provided by VTU.

REFERENCES

[1] Barbara Zitvoa and Jan Flusser, “Image Registration Methods: A Survey”, *Image and Vision Computing*, Vol. 21, No. 11, pp. 977-1000, 2003

[2] Lawrence O’Gorman and Rangachar Kasturi, “*Document Image Analysis*”, IEEE Computer Society Executive Briefings, 2009.

[3] Anoop M. Namboodiri and Anil K. Jain, “*Document Structure and Layout Analysis*”, Advances in Pattern Recognition, Springer, 2007

[4] Chao Sun and Ronghai Cai, “Document Image Registration using Geometric Invariance and Hausdorff distance”, *Proceedings of 1st International Workshop on Education Technology and Computer Science*, pp. 725-728, 2009.

[5] Tong Lijing, Zhang Yan and Zhao Huiqun, “A Warped Document Image Mosaicing Based on Registration and TRS Transform”, *Proceedings of 10th International Conference on Computer and Information Science*, pp. 179-183, 2011.

[6] Lijing Tong, Guoliang Zhan, Quanyao Peng, Yang Li and Yifan Li, “Warped Document Image Mosaicing Method based on Inflection Point Detection and Registration”, *Proceedings of 4th International Conference on Multimedia Information and Network Security*, pp. 306-310, 2012.

[7] Zhanlong Hao and Youbin Chen, “Table Image Registration based on Gradient Projection”, *IEEE Global High Tech Congress on Electronics*, pp. 6-9, 2012.

[8] Venkata Gopal Edupuganti, Vinayak A Agarwal and Suryaprakash Kompalli, “Registration of Camera Captured Documents under Non-rigid Deformation”, *Proceedings of IEEE Conference on Computer Vision and Pattern Recognition*, pp. 385-392, 2011.

[9] Hanchuan Peng, Fuhui Long, Zheru Chi and Wan-Chi Siu, “Document Image Template Matching based Component Block List”, *Pattern Recognition Letters*, Vol. 22, No. 9, pp. 1033-1042, 2001.

[10] Hunchuan Peng, Fuhui Long, Wan-Chi Siu, Zheru Chi and David Dagan Feng, “Document Image Matching based on Component Blocks”, *Proceedings of International Conference on Image Processing*, pp. 601-604, 2000.

[11] George Wolberg and Siavash Zokai, “Robust Image Registration using Log-Polar Form”, *Proceedings of International Conference on Image Processing*, pp. 493-496, 2000.

[12] Luke A. D. Hutchison and William A. Barrett, “Fast Registration of Tabular Document Images using the Fourier-Mellin Transform”, *Proceedings of* 1st *International Workshop on Document Image Analysis for Libraries*, pp. 1-15, 2004.

[13] Daniel P. Huttenlocher, Gregory A. Klanderman and Willian J Rucklidge, “Comparing Images using Hausdorff Distance”, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 15, No. 9, pp. 850-863, 1993.

[14] Michael D. Garris, “Intelligent System for Reading Handwriting on Forms”, *Proceedings of 31st Hawaii International Conference on System Sciences*, pp. 1-10, 1998

[15] Raymond H Chan, Chung-Wa Ho and Mila Nikolova, “Salt and Pepper Noise Removal by Median Type Noise Detectors and Detail-Preserving Regularization”, *IEEE Transactions on Image Processing*, Vol. 14, No. 10, pp. 1479-1485, 2005.

[16] Nobuyuki Otsu, “A Threshold Selection method from Gray-level Histograms”, *IEEE Transactions on Systems, Man and Cybernetics*, Vol. 9, No. 1, pp 62-66, 1979.

[17] Liu Wenyin and Dov Dori, “From Raster to Vectors: Extracting Visual Information from Line Drawings”, *Pattern Analysis and Application*, Vol. 9, No. 1, pp. 10-21, 1999.