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READABLE TEXT RETRIEVAL FROM NOISE-INFLUENCED DOCUMENTS USING IMAGE RESTORATION METHODS

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Abstract

Documents scanning has become a necessary phase in official record keeping of everyday business environment. Typically, scanned document images in digitized format suffer from various types of noise which create serious problems at document reading time. This noise may be due to several reasons low quality paper, paper aging, scanner assembly and tonner, unskilled machine operator, or due to some copying machine artifacts. The removal or elimination of noise in scanned documents is still a big challenge for researchers in the digital era. Already performed work on digitized handwritten, and machine-printed degraded historical documents, but we have experimented with different datasets such as the Media Team Document Database manually scanned noisy documents, and decided to use, a collection of scanned noise-affected documents, which are available on the websites. We have transformed the noise-influenced image document into a binarized document. After this, we applied noise reduction techniques for textual data enhancement so that the text would be in readable and noise-free form. An Adaptive Gaussian Mixture Model based on Expectation Maximization (EM) has been used to restore the image pixels, with the values expected to be the original ones. The enhanced text in its visual aspect and improved quantitatively measured parameters show the restored documents. We have calculated Signal to Noise Ratio (SNR), Mean Square Error / Mean Square Difference (MSE/MSD), Peak Signal Noise Ratio (PSNR), Contrast, and Energy for quantitative parameters to evaluate the performance measures of the proposed method of document restoration comparative to the state-of-the-art methods. Our research is quantitative, as we have performed experiments on digital sensor data and the evaluation of the results based on computational techniques. Our results are successful, support the proposed methodology, and perform well in comparison to the state-of-the-art methods. Overall, the proposed methodology is easy to understand and simple to implement.

INTRODUCTION

The use of the computer has become an important part of every person's life due to its so many features and benefits. It is an attractive emerging development to share soft copies of documents on websites, social media, portable communication devices, etc. for quick response. Scanning documents is a process of converting hard copies or printed text documents into digital format shown in Figure 1. It has been observed in the last few decades that the users of computers are attracted to converting text documents into digital and readable formats because it has also become a necessity of time. There are thousands of valuable historical handwritten and printed documents that are useless due to unreadable text presence of noise in documents, degradation, and noise factors in text images. Therefore these noisy scanned copies are not in readable form but if these could be de-noised and restored then play a fundamental role in economic and social development (Hedjam & Cheriet, 2013). So, it is problematic to read these noisy documents since these historical documents are of great importance, we must restore these documents to read easily.

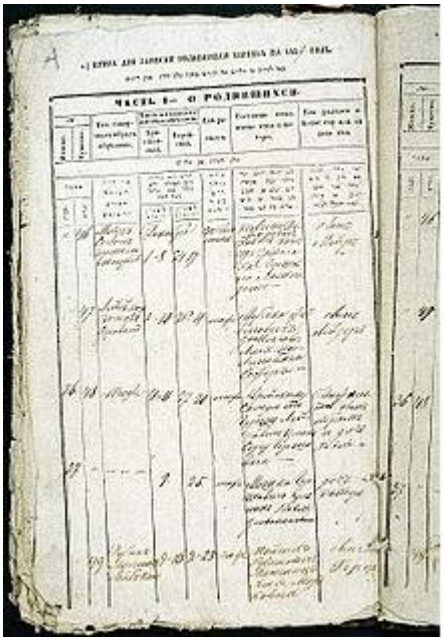


Fig. 1. Scanned copy of the birth certificate with noise artifacts from 1859 (Likforman-Sulem, Darbon, & Smith, 2011).

Digital image processing (Gilanie, Nasir, Bajwa, & Ullah, 2021) systems for the objective of retrieval of straightforwardly readable text may be concerned primarily with a source as image data of text or text-like records (e.g., names, numbers, and alphanumeric codes), a processing building block and a destination for the processed output image or results. The source of document image data may be a camera, a scanner, a website on the internet, an available dataset, a mathematical equation, etc. The processing component of noisy textual data is a computer system, and the output of the processed image data perhaps is a display, created for the human visual system.

A digital text document image is a discrete two-dimensional (x-axes, y-axes) function f (x, y), that consists of 'x' rows and 'y' columns. The resolution of such textual image is written as X × Y.

Text is the most important and useful part of document images, but the noise factor degrades its character and geometric structures, which reduces its readability (Khera et al.; Yaseen et al., 2022). To read such a type of document the readers must face many difficulties. It is a fact that free textual documents are much better and charmingly full rather than

degraded and unreadable or distorted ones. The accuracy rate of text document image restoration can be measured and evaluated by analysis parameters like SNR (Signal to Noise Ratio), PSNR (Peak Signal to Noise Ratio), and MSE / MSD (Mean Square Error / Mean Square Difference) for this purpose transformation is performed by optical character recognition (OCR) (Gilanie, Bajwa, Waraich, Asghar, et al., 2021). The OCR systems are very profound and sensitive: when facing noise or non-textual objects (Ghaffar et al., 2022), they perform poorly for both segmentation and recognition tasks (Likforman-Sulem et al., 2011). The OCR software produces better results on documents that have a good readability view and typically works best on clean text documents. Text enhancement or its extraction (Attique et al., 2012) from noisy data is a multifaceted procedure and, in such cases, the removal and elimination of noise in scanned document images is a challenging task.

The scanned text document image design can be divided into physical and logical layout analysis. The physical layout analysis of a document decomposes the image of a document into homogenous or identical regions such as "text", "graphics", and "lines" While logical layout analysis assigns functional labels such as ("title", "author", and "footnote") to some of the classified regions and to discover reading order of different parts of a document (Behin, Ebrahimi, & Ebrahimi, 2010; Naveed et al., 2024).

The word "document" signifies a textual record, and it can rightly be regarded as physical evidence. With remarkable advancements in communication (Gilanie, Bajwa, Waraich, & Habib, 2019a) and emerging technologies, computerized documentary record keeping, and management is one of the most important components of office information system (OIS). So, the digitization of documents by the use of optical scanners from many sources such as books, old historical and handwritten documents, manuscripts, makuta, certificates, letters, technical reports, notifications, memorandums, services rules, registration books, files, invoices, images (Shafiq, Gilanie, Sajid, & Ahsan, 2023), photographs (Gilanie et al., 2024), etc. has become the essential part of daily life as well as in offices (Janjua, Andleeb, Aftab, Hussain, & Gilanie, 2017; Prachanucroa & Phongsuphap, 2013).

In a gray scale document image, the pixel values can range from 0 to 255 (Khera et al.), such as the value 0 which is the minimum value that represents black or darker pixels and 255 represents white or brighter pixels in the document. The following Figure 2 shows increasing pixel values from left to right and in the table different gray level values of different pixels are shown.

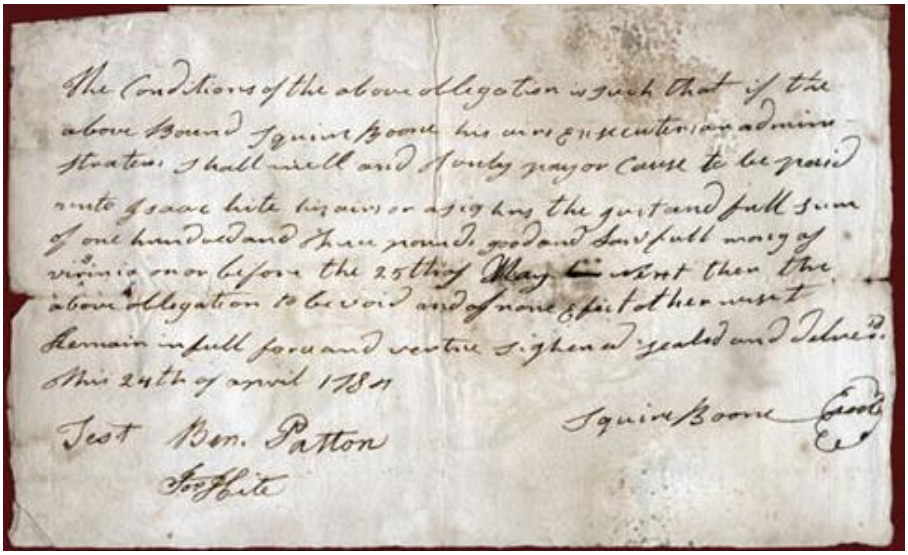


Fig. 2. A copy of the degraded historical handwritten document

The noise in text image is the random variation of brightness produced by the sensor and integrated circuitry of a document scanning device (Gilanie, Batool, Khursheed, et al.). Text image noise is an undesirable by-product of image detention usually quantified by the percentage of pixels which are scanned (Iqbal, Bajwa, Gilanie, Iftikhar, & Anwar, 2022; Olaniyi Kayode, 2013). In salt and pepper type of noise (the sparse light and faint instabilities) type of noise will influence a small number of image pixels, such noisy pixels in the document image are very different in color or intensity from their neighboring pixels (S. Asghar et al., 2023; Gilanie, Attique, Naweed, Ahmed, & Ikram, 2013). The Influenced text image by salt and pepper noise contains dark and white dots just like spray on the document, consequently the phrase salt and pepper noise (Bajwa, Shah, Anwar, Gilanie, & Ejaz Bajwa, 2018). Typical sources include flecks of dust inside the scanning device and defective CCD elements (Afzal et al., 2023; Gilanie, Asghar, et al., 2022; Hafeez et al., 2023).

Noise may occur in various forms, document images often suffer many types of deterioration, such as specks, dots, black borders, spine lines, salt and pepper noise (Gilanie, Batool, Shafique, et al.), and hole-punch marks are very common (Tan et al., 2000). The document page rule line is a cause of noise that interferes with text objects. The marginal noise usually seems in a larger dark region everywhere in the document and it can be textual or non-textual (Batool & Gilanie, 2023; Prachanucroa & Phongsuphap, 2013; Wazir, Gilanie, Rehman, Ullah, & Mushtaq, 2022).

Sending and receiving scanned documents and photocopying from a single existing hard copy source or original copy is not available but only already scanned copy exits by E-mail and other communication is becoming a necessary part of life nowadays (Gilanie, Bajwa, Waraich, Anwar, & Ullah, 2023). Most of the handwritten and printed documents, newspapers, documents from typewriters or typewriters, etc. exist with degraded text due to many kinds of noise and weakened paper quality due to its age or human manipulations. The noise on text documents might be due to low paper quality, the typewriter or typing machine used, or when documents are scanned into digital formats by scanners (Ghani & Gilanie, 2023; Rafiq, Bajwa, Gilanie, & Anwar, 2021). A major part of visible noise just like sprayed on the text is introduced on document images due to the very small particle or grain structure of the medium that causes the text to give the impression of being faint and normally unable to read it properly (Gilanie, Javedb, et al.). Noise removal and skew correction are two major preprocessing operations (Batool et al., 2025; Behin et al., 2010).

The noise due to statistical artifacts is called Low-Level noise (K. Asghar, Gilanie, Saddique, & Habib, 2017) that can be introduced during the transmission as well as communication medium, during a scanning process. Structural noise is an inherent part of the data rather than an artifact, though it may be undesirable in certain contexts. For instance, when recognizing a word within a text line, a comma separating it from the next word is regarded as structural noise (Gilanie, Bajwa, Waraich, & Anwar, 2021; Olaniyi Kayode, 2013).

High-level noise in documents refers to unwanted elements within textual image data. These may be inherent to the input image itself or introduced by hardware equipment or the processing system. Any component that is not textual data is classified as high-level noise (Gilanie, Rehman, et al., 2022; Haji, Bui, & Suen, 2012). The text from such noise-affected scanned document images is unable to be read properly. For present and future needs the updating, editing, formatting, and de-noising of old records has become the most challenging task due to various types of noise. It is the precondition of many newly established offices throughout the country such as the Land Record department which is trying to convert manual and printed records from hardcopy sources to soft copy as digital data in the computerized record (Ahmed, Gilanie, Ahsan, Ullah, & Sheikh, 2023; Rubab et al., 2022). The reduction of noise from historical and handwritten document images with so many types of random noise is more challenging, due to character pixels variance in intensity levels (Gilanie, Saher, et al., 2021; Mitianoudis & Papamarkos, 2014). The following figures are listed normally which cause degradation of textual documents and decrease their text readability (Ullah, Batool, & Gilanie, 2018). The document images that got the attention of the

researchers for their visual enhancement are real historical printed documents in scanned format as well as in digitized format which comprises of several deficiencies in their document background and also on character edges (Likforman-Sulem et al., 2011; Rashid, Gilanie, Naveed, Cheema, & Sajid, 2024).

We propose a robust method for retrieval text from unreadable or degraded scanned document images. Our chief contribution will be identifying different approaches to noise reduction and improving the visual aspect of text after solving background problems in the scanned document images. To achieve the goal of retrieval of unreadable text in scanned images, we focused on the noise affected area of the document, where the best technique of noise reduction would be performed.

Reconstruction of scanned text images from the degraded one with the help of image restoration technique is termed as restoration. Image restoration is a main branch of digital image processing in which noise, faintness and blurriness is removed from the degraded text document. It also makes digital images as well as text documents suitable for human perception. Our basic purpose is the retrieval of simply readable text from degraded documents and agreeable view for the human perception. All the noisy pixels are turned to "0" (which represents the gray scale value as a white background) and textual data to "1". Though text document image retrieval has been studied for many years, to enhance the quality of visual text of scanned documents, to accomplish this important work so many algorithms are being developed, to process the degraded image into readable format or de-noising document images we will use image processing techniques as well as MATLAB programming.

The goal of this research work is to develop an efficient scanned document text representation mechanism and algorithm for retrieval of unreadable text, effectively noise reduction without any textual data loss. This can be accomplished by implementing the following objectives.

The drive of this research work is to investigate the computer-vision/image-processing methods that could de-noise scanned documents for their proper reading of the text, with the possible applications of noise reduction. Conventionally, there are billions of document images, which during transformation into digital formats, suffer some type of noise as an unwanted part of text that will be improved into their optimal view without loss of text data. By this research work the imperative benefit to historical and handwritten documents will be the availability of better visual aspects and electronic representation of documents in digitized formats with cheap memory, compact storage, quick transmission, editing, formatting, effective retrieval, long-time maintenance, manipulations, and the possibility of sending copy easily, etc.

This paper comprises different sections. A brief description of the included sections is presented below: Section No.1 highlights the importance of the paper after this background, research objectives, and important questions about this research are presented. Section No.2 describes the related work of different researchers and discussions, based on the theoretical framework for this research work in the form of a literature review. Different types of noise detection and removal techniques are also discussed in it. Section No.3 presents our proposed novel technique for the removal of noise from documents, representation of documents, and retrieval of unreadable text techniques. Furthermore, in this chapter, the flowchart and top-down approach of the proposed methodology represent the step-by-step process of denoising image documents. Section No.4 presents experimental work, results, and discussions, including the experimental designs for this research work in the form of figures (before and after the process) and tables. Section No.5 presents a discussion of the analysis of the experimental results, the concluding remarks of the research work, limitations and scope for Contribution, and future work. The achievements, shortfalls, and future endeavors are discussed in this chapter.

2. Literature Review

Most of the researchers have proposed methods like histogram, thresholding, Gaussian filter; and average technique to remove noise problems of textual quality degraded in scanned document images. Prachanucroa and Phongsuphap have used the Projection profile-based method to remove noise without loss of textual data as well as to enhance text from noise-affected document images and obtained

an accuracy rate of 93.8% (Prachanucroa & Phongsuphap, 2013).

Mudit Agrawal and David Doermann have proposed a technique for the detection and removal of stroke-like pattern noise in binary text images; they clean noise from textual data by using the content-based method to reduce noise from binary handwritten and printed documents. They have selected Arabic text images of noise-influenced machine-printed and handwritten documents and obtained precision and recall of 86% and 90% correspondingly for noise pixels (Agrawal & Doermann, 2011).

Tan and his co-researcher have developed a method using edge detection (Canny edge detector) and Ostu's threshold for the removal of interfering strokes in double-sided document images. They used IR standard measures, precision, and recall, to measure the performance of the proposed approach. Their method achieves the average precision and recall, which are 81% and 94% respectively (Tan et al., 2000).

Text image binarization is an important technique in document image processing. It helps to achieve clear document images and finally helps in further processing of image documents. There are different types of binarization techniques like, Otsu, Adaptive, Sauvola, Global threshold based, etc. (Lins, Banergee, & Thielo, 2010).

Mitianoudis and Papamarkos et al., have performed the Gaussian Mixture Model (GMM) to reduce isolated blobs or small misclassified noisy items and image background problems in document images. The reduction of noise from historical and handwritten document images with so many types of random noise due to character pixel variance in intensity levels of the scanned document is complex. They have compared their proposed method by PSNR but the performance varies on the same machine (Mitianoudis & Papamarkos, 2014).

Fan et al., presented Gaussian, Median, and coplanar filters techniques to minimize the noise issues of gray-level distribution of neighboring pixel and their intensities. They have applied binarization on images to process text documents for the reduction of noise artifacts achieved by global or local thresholding. They perform experiments on degraded textual images that are influenced by the background graphics, script interfering with foreground text, skew, dark band, and thumb mark, and images severely blurred (Fan, Fan, & Tan, 2001; Sharma, Dhingra, & Sanyal, 2007).

Sharma et al. have developed a new approach based on morphological operations and connected components for skew correction and removal of insignificant, non-textual, or noisy data from scanned text images. They perform experiments on text documents of Devanagari script which are influenced by noise particles and are unreadable. The Experimental results on these documents clean some part of the noise and they achieve an efficiency of 98.3% (Fan et al., 2001; Sharma et al., 2007).

Mostafavi et al., have applied Coordinate Logic (CL) filters for noise reduction from printed text and handwriting documents. For noise reduction, the image (e.g., I = image) has been defined as a matrix, which consists of binary elements of the original image (decimal matrix elements of image I must be converted to binary elements) (Gilanie, Bajwa, Waraich, & Habib, 2019b). They applied simple coordinate logic filters for noise reduction on printed text and handwritten document images. They applied their original image to other noise reduction methods such as median and Wiener filters. The proposed method produces better results only on printed documents and the accuracy rate is less on handwritten documents (Mostafavi, Kazerouni, & Haddadnia, 2010).

Ping and his co-authors worked on salt-and-pepper noise and used a Modified Directional Morphological Filter (MDMF) for irregular noise removal in binary document images. They achieved an accuracy rate of 80.6% for character recognition for newspaper scanned documents with the MDMF method (Ping, Lihui, & Alex, 2000).

Over recent years, Menget et al., have used a convex hulls-based image reconstruction method to eliminate noise from shading and dark borders influenced images. The comparison of their method with the state of the art is less significant and shading artifacts remain after shading correction (Meng, Xiang, Zheng, & Pan, 2013).

Le and Lee applied morphological operations to extract useful text from salt and paper-type noise and text-stroke width-based noisy document images (Gilanie, 2019). They tested binarized text-based images having some types of noises with their

proposed technique but after processing noise particles remained visible in the output images (Le & Lee, 2010).

Agrawal and Doermann proposed an XML-based LAMP's GEDI tool for attaining better visualization text from degraded and noisy text data, machine-printed and handwritten text documents. The performance of the proposed method is not good and consumes much time in processing the document (Agrawal & Doermann, 2009). Tian et al. have implemented a dynamic threshold method for Back-to-Front ink mark noise elimination. They also used Otsu's algorithm to eliminate the back-to-front interference noise problem of text document images (Tian, Wang, & Zhang, 2011).

Likforman-Sulem, Darbon & Smith et al., have proposed historical document enhancement techniques using non-local means. They compared their technique of text enhancement with median and wiener filters (Likforman-Sulem et al., 2011). In 2013, Hedjam & Cheriet worked on historical document image restoration and they adopted the Grid-based Sauvola (GBS) method for historical document image restoration, they claimed that their algorithm is very fast (Hedjam & Cheriet, 2013).

Gaofeng Menget et al., have removed circular noise from scanned documents using bi-linear blending Coon's surface technique. They used 70 scanned documents of A4 size with missing data of 3.23%. They also compared their results with two state-of-the-art methods mask matching and Hough transformation. But still, computational cost is high in the proposed method (Meng et al., 2013).

Alessandro Vinciarelli has worked on scanned documents for noisy text categorization; he experimented on a set of 200 documents. He created noisy documents from clean text documents and used Optical Character Recognition (OCR) for handwriting recognition-based methods (Saher et al., 2024). The results have shown the performance loss for recall values is up to 60 or 70 percent. The result table reports the noise level of the documents in terms of word error rate which is 49.4% for handwriting and term error rate for OCR 54.9% (Vinciarelli, 2005).

Moghaddamet et al. used a variational approach to enhance text from degraded scanned documents and their proposed model also uses the reverse diffusion process for the enhancement of double-sided document images. They have applied the standard spatial transform provided in MATLAB programming. They experimented on noisy input images as recto and verso sides of a degraded double-sided document image, restored the version of the document using the double-sided wavelet method, restored the version of the document using the ICA method, and finally restored the version of the document using Niblack's method. The impact of each model in terms of the PSNR, the OCR recognition rate, and the percentage of incorrectly introduced characters is 0.36 (Moghaddam & Cheriet, 2010).

Oleg Okunet et al. have presented a method for text detection in binary document images. They have performed experimentation on 27 color images from magazines, captured by an HP ScanJet 5370C scanner, and 15 binary images from the UW-I database. Their method attained an accuracy of 95% (Okun, Yan, & Pietikäinen, 2002). Yiming Yang et al. have proposed the Linear Least Squares Fit (LLSF) mapping noise and redundancy reduction from scanned documents. They used the Word Removal technique for the Removal of non-informative words in document indexing and retrieval to improve the accuracy of the results and to reduce the redundancy of the computation (Yang, 1995).

Refaey et al., have proposed an algorithm that consists of two computational stages. During the first stage, which is the DETECTION stage: they performed detection of ruled lines from degraded tex documents. In the second step, is the REMOVAL stage: the ruled lines removal (text isolation) in grey-level handwritten image documents has been performed. It has been observed that the algorithm is only helpful for skew or rotations of the ruled lines but not for text enhancement (Refaey, 2015).

In 2015, Saluja, S et al., proposed a model for segmentation as well as the elimination of non-textual content from degraded document images by using morphological operations such as dilation and erosion. They have tried to solve the problem by creating bounding boxes around the textual content and finally eliminating the non-textual region, whereas only the textual region is enhanced (Nazir et al., 2023). The proposed model has been tested on 200 images as a dataset where the texts are degraded

and merged with the background which becomes impossible for detection and noise eradication (Saluja, Bedwal, Rana, & Tayal, 2015).

In 2014, a different approach was suggested by Simon and his co-researchers by correcting photometric distortion for more pattern noise and specular highlight in smart phone recaptured document images (Khera et al., 2023), but when the proposed applied moir´e pattern and specular highlight still appeared on the images (Simon, Choe, Yun, & Park, 2014).

Olaniyi Kayode has proposed an algorithm that consists of three basic steps and an additional original step based on Fuzzy Inference Systems (FIS) for the detection and removal of small statistical and structural noise particles from binarized degraded historical handwritten document images. In this research, he estimated the average stroke width (ASW) of the binarized handwritten image and extracted the features set for the detection of dots and other noise particles. The proposed technique heavily depends on the accuracy of the features extracted for de-noising documents (Olaniyi Kayode, 2013).

RachidHedjam and his co-authors proposed a unique image restoration model for visual quality enhancement using a multispectral imaging system (MSI). They have used BAnQ Dataset; multispectral historical document images with different types of degradation such as ink fading, folding, and tears. Each of these multispectral images contains eight bands. They evaluate the results by visually checking the restored output against its noise-affected input (Hedjam & Cheriet, 2013).

Rafi Cohenet et al. have suggested a technique to segment historical document images into text elements from non-text elements (Gilanie, 2013). They examined the segmentation quality on 252 pages of degraded textual images. Their suggested technique convolved the image with different filters like Laplacian of Gaussian (LoG) and achieves an accuracy about 92% for drawings and 90% for text elements segmentation (Cohen, Asi, Kedem, El-Sana, & Dinstein, 2013).

David Rivest-Hénault and his co-authors introduced a binarization algorithm as local linear models to estimate both the expected stroke and the background pixel intensities in old degraded textual images. The level set method is used in erosion mode to remove less likely stroke pixels from degraded historical handwritten documents. They analyzed printed documents from the DIBCO'09 test dataset using commercial OCR Fine Reader software. Binarized images are produced using the proposed method, and Otsu's and Sauvola's methods. The results obtained showed with the recognition error rate for Otsu's are 0.392, Sauvola's 0.575, the multi-scale grid-based Sauvola 0.337, and finally for the proposed method it is 0.357. The computational time for the proposed method is high due to too much steps and complexity involved in proposed method (Rivest-Hénault, Moghaddam, & Cheriet, 2012).

Mehdi Haji et al. have proposed an unsupervised learning method for the removal of noise patterns in handwritten images using expectation maximization (EM) and fuzzy inference systems (FIS). The primary objective of the proposed algorithm is to enhance the recognition performance of document processing systems, albeit at the expense of increased computational complexity. A subset of 250 degraded images was utilized for noise reduction. For training, 60% of the database was randomly selected, while the remaining 40% was used for testing. The top 1 and top 2 recognition rates across the entire test database were 80.1% and 85.4%, respectively, whereas their approach achieved improved rates of 88.9% and 92.7%. The algorithm employs multiple iterations of the Expectation-Maximization (EM) method to distinguish noise from text (Haji et al., 2012).

Zhixin Shi et al., have developed techniques for the enhancement of degraded binary document images. Problems that are targeted by the methods described include large blobs or irregular clutter noise, salt-and-pepper noise, and removal of non-text objects such as rule-lines. The methods have tested 204 images from the challenge set of the DARPA MADCAT Arabic handwritten document. The algorithm described is designed to remove the salt-and-pepper noise, while not removing the small components that are part of the strokes. The proposed method is not effective for improving the quality of the text by fixing broken strokes (Shi, Setlur, & Govindaraju, 2011).

Faisal Shafait and Thomas M. Breuel have used Projection Based Page Segmentation Methods in the

analysis of bi-tonal document images. The proposed method has been developed for skew correction and removal of border noise while retaining the actual content of the document images. The noise artifacts remains in document image by applying the described algorithm on degraded scanned document and further research is needed for better cleanup of documents without loss of textual data (Shafait & Breuel, 2011).

Ednardo Mariano et al., have proposed to eliminate specular noise from photographed documents under varying illumination conditions. The captured images are true-color RGB with 24-bit depth and are separated into their individual RGB components, each represented as an 8-bit grayscale image. The core concept of the algorithm involves comparing the intensity levels of pixels within the document images. The proposed method only works for removal of simple specular noise in grayscale images other noise particle remains in the documents (Mariano et al., 2011).

Laurence Likforman-Sulem and his co-workers have proposed a method for document enhancement of various historical periods to improve OCR recognition which combines two recent noise reduction steps. The first step consists of the Total Variation (TV) framework while the second step consists of a filter based on Non-local Mean (NL means). TV approach is used at the character level for the restoration of degraded character contours while NL means is a non-local filter which can smooth character parts from neighboring data. The TV β parameter has to be set within a range of values according to character size and noise level (Likforman-Sulem et al., 2011).

Nikos Nikolaou et al. proposed Adaptive Run Length Smoothing Algorithm (ARLSA) for segmenting historical machine-printed documents. These documents often present challenges such as low quality, local skew, degradation from aging printing matrices, ink diffusion, and dense layouts. The proposed methodology consists of five sequential stages, including noise and punctuation mark removal. The algorithm was tested on a variety of historical and degraded machine-printed documents in languages such as Greek, English, French, and Roman. The Fine Reader technique struggles with noisy documents, achieving F-measure scores of 59.7%, 60.8%, and 44.0% for line, word, and character segmentation, respectively. In contrast, the proposed technique demonstrates improved performance, achieving F-measure scores ranging from 70% to 83% across all segmentation levels (Nikolaou, Makridis, Gatos, Stamatopoulos, & Papamarkos, 2010).

Samir Malakar et al. have proposed noise-removal techniques for text document images. They have developed a new filtering technique, called Middle of Modal Class (MMC), for smoothing the input images. They have collected 50 text document images of each type and have chosen the size of the window as 3x3 pixels, 5x5 pixels and 7x7 pixels for their experimental procedure. Visual observation of these input images results shows that performance is giving better results for only smaller window size. They compared the obtained results by visual inspection procedure (Malakar et al., 2011).

Hamed Behin et al., introduced preprocessing and physical layout analysis of binary documents, utilizing bottom-up approaches for text documents. The technique involves key steps such as preprocessing, segmentation, feature extraction, classification, and reconstruction. In the proposed algorithm, the binary document image is processed to distinguish and separate lines, noise, textual content, and graphical elements. The algorithm has been tested on a database comprising magazines, newspapers, and official letters. The final results indicate a recognition accuracy of 98% for textual regions, 83% for graphical regions, and 93% for noisy regions (Behin et al., 2010).

Hajime Imura and Yuzuru Tanaka proposed for full-text search in image-scanned documents. This method effectively handles variations in language and font by utilizing a novel pseudo-coding scheme. It relies on the statistical features of character structures and their shapes to enhance search accuracy (Imura & Tanaka, 2010). Deivalakshmi, S., along with fellow researchers, proposed a methodology for distinguishing text and non-text regions in document images. The algorithm is divided into three key steps: block segmentation, feature extraction, and classification. The technique was tested on multiple scanned article images from the MediaTeam Document Database, demonstrating improved performance compared to existing

methods (Deivalakshmi, Palanisamy, & Vishwanathan, 2013).

Hossein Ziaei Nafchi and his co-researchers proposed a novel approach for denoising binarized historical document images. Their research introduces an unsupervised post-processing method based on a phase-preserved denoised image. The approach was tested on multiple state-of-the-art binarization methods using the DIBCO'09, '10', '11', and H-DIBCO'12' datasets. It employs non-orthogonal, complex-valued log-Gabor wavelets. Performance evaluation metrics, including recall and F-measure (F-M), yielded scores of 89.82, 86.49, and 88.91, respectively. The method effectively removes severely degraded portions of document images (Nafchi, Moghaddam, & Cheriet, 2013).

Amit Vijay Nandedkar and his co-authors employed a spectral approach-based technique for text-graphics separation in color document images. The algorithm was evaluated using a publicly available document dataset containing graphics, including stamps and logos. The primary goal of their technique is to enhance the efficiency of optical character recognition (OCR) systems. Their experimental dataset comprised 400 document images featuring stamps in various colors and multicolor logos, available in both 200 dpi and 300 dpi resolutions. The results obtained on the 200-dpi dataset were nearly identical to those on the 300-dpi dataset. The proposed algorithm achieved a recall of 89.1% and a precision of 96.9% (Nandedkar, Mukhopadhyay, & Sural, 2015).

From the reviewed literature, it has been established that there is a need to identify and eliminate artifacts and noise in scanned document images that obstruct text readability. These distortions create difficulties in reading, making the text unclear or unpleasant for human interpretation. Enhancing these images through appropriate pre-processing and post-processing techniques can improve their clarity, ensuring a more readable and visually appealing document.

3. Research Methodology

A noise-influenced historical text document and old manuscript restoration technique involves various steps for the betterment of the textual data in handwritten and printed documents. First of all, our proposed system has to read a noisy scanned document image source as input data then we apply preprocessing on it to set the document format by transforming it into the desired format such as RGB to gray scale image as well as perform binarization to convert the image text and noise into black or white pixel values, brightness correction, without any loss of text data. In this process, textual data with unwanted noise properties is enhanced, whereas noise particle data is also enhanced. We have also applied useful approaches like image de-blurring, to produce a better view of the textual data that should be easily readable, and to enhance the text from the document dilation, eroding has also been performed. The Gaussian mixture model allied with Expectation Maximization (EM) methods to restore document image until desired, noise-free output image with improved visual observation has been achieved. In the desired image phase if some part of the noise exists in the image, then we must apply other techniques of image restoration for its noise elimination till the desired image is achieved. The proposed top-down approach is shown in Figure 3.

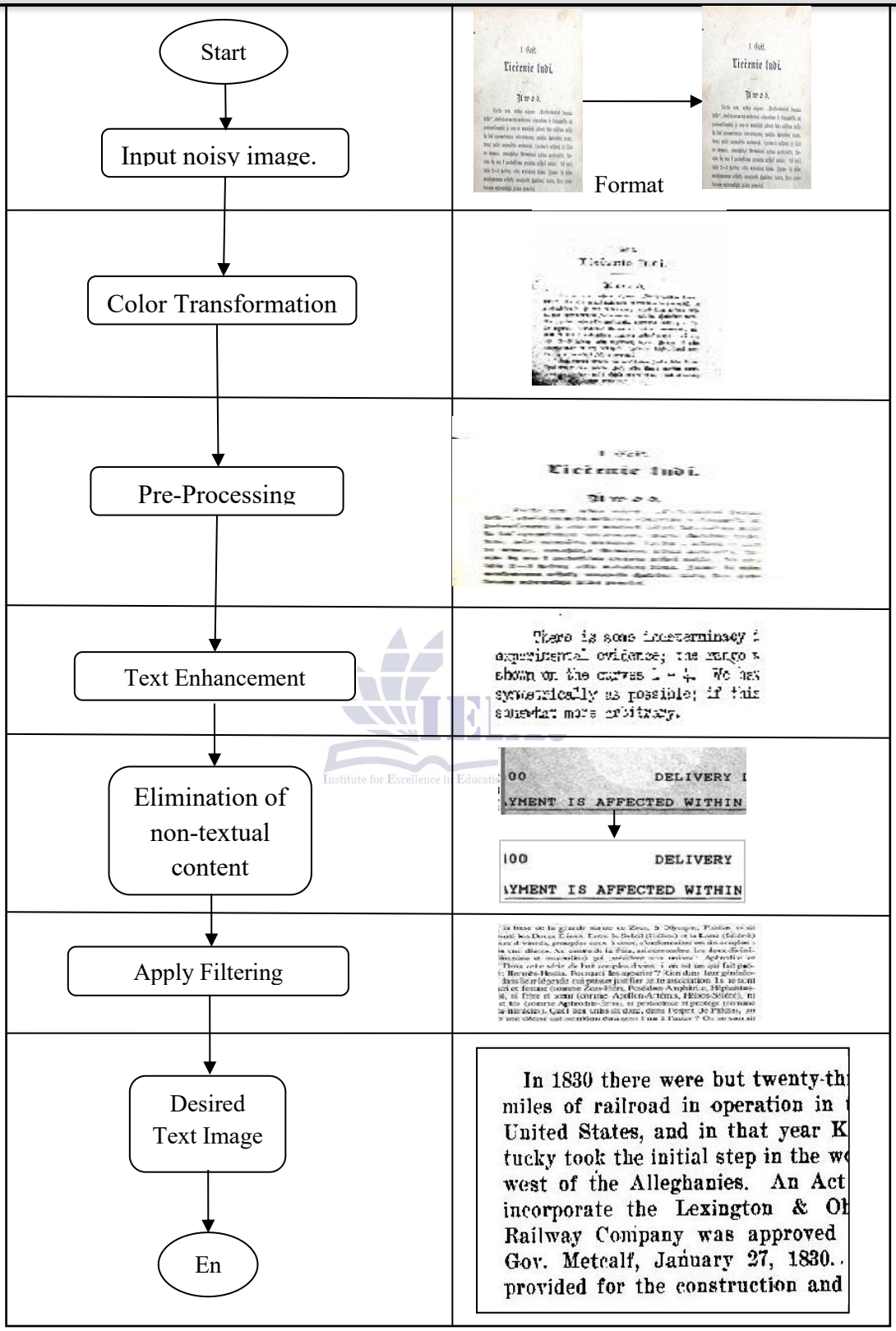


Fig. 3. The top-down approach of proposed methodology

3.1 The Proposed Methodology

The proposed methodology is divided into succeeding stages and explained in detail. The foremost steps for this task which are involved in our approach are discussed in the following.

3.1.1 Original / Noisy Image

There are so many sources of text documents with noised particles available in different scanned formats which need to be de-noised. The major experimental work of the proposed methodology includes scanned document material from the MediaTeam Document Database. The documents are scanned in 300 dpi by using "Hewlett Packard ScanJet" scanning device (Gilanie, Bajwa, et al., 2018; Sauvola & Rautiainen, 2016). Some degraded documents images are taken for experiments from the Library of Congress (LOC). In this database there is large collection of different scanned documents with different languages. In the preferred database, the scanned document images are influenced by different types of noise and most of the documents are unable to read properly due to degradation of text.

3.1.2 Preprocessing

Some preprocessing steps needed to be performed before noise removal. The selection of good pre-processing techniques is very significant in image processing (Gilanie, Ullah, Mahmood, Bajwa, & Habib, 2018). So, in this context, the first step we took was to remove background noise from text documents. For this step, we used quite a simple thresholding method. To achieve high accuracy with scanned data, this data should be preprocessed so that further potential errors caused by noise and skew can be avoided and it must increase the overall speed of proposed work. Document image pre-processing suppresses undesirable distortions or enhances some image features to improve the quality of the textual data of the image for further processing (Khera et al.). So, we use Matlab programming to convert scanned color text images or RGB images into binary images with intensity (on a [0, 1]). If the intensity of a considered pixel is less than or equal to the defined value, then it is defined as a black pixel, otherwise defined as a white pixel.

3.1.3 Noise reduction

Noise reduction is the method of removing noise from a textual document to reshape text to an easily readable view as it looks fresh and appears just like the original one. When a noisy scanned document is processed to de-noise then there are always missing values in the data. The Expectation Maximization (EM) algorithm is a simple technique used in point estimation of unknown parameters (theta) in dynamic systems and it can deal with general missing data (latent variables). In this study, noise has been reduced using EM which is described in equations of E-step and M-step m mentioned in Equation (1) and (2).

$$\boldsymbol{E-Step}: q^{(t+1)} = arg_q maxF(q, \emptyset^{(t)}) \quad (1)$$

$$\boldsymbol{M-step}: \emptyset^{(t+1)} = arg_0 maxF\left(q^{(t+1)}, \emptyset\right) \quad (2)$$

3.1.4 Text Enhancement

After eliminating some portion of noise, the resulting text document may appear as airbrushed, spray-painted, and in semi-dotted form. So, we made one more step to lessen this effect by using 3x3 and 5x5 structuring elements with all entries are ones in a dilation process for the remaining foreground pixels to fill the possibly made gaps in the text. This helps us improve the various aspects of a textual image to make it visually better.

3.1.5 Image Restoration Techniques

This can be very useful for subsequent processing of the image, like layout analysis and OCR. A manuscript and historical document restoration technique involves various stages. First, we create a database of damaged manuscripts or degraded documents. Each page of the document is subjected to noise removal and enhancement techniques. In this phase of text to be in readable form, some missing areas and the gap in between the text were recovered using textual image restoration methods. In this research work the main purpose is to reduce noise from scanned documents and indicate that the restoration of the text document images has been performed by using the Gaussian mixture model (GMM) a kernel density estimator. Therefore, we

have used GMM for restoration of the texture which is described in the following Equation (3).

$$p(x|y) = \sum_{i=1}^{M} w_i g(x|\mu_i, \sum i \quad \ldots\ldots (3)$$

3.1.6 Elimination of non-textual content

This processing step comprises of detection and removal of non-textual objects from degraded historical documents such as noise in the form of spots or lines and improving the quality of the text by fixing broken strokes. The artifacts and non-textual content due to over-thresholding of documents where the contrast between the foreground and background is poor or uneven will be eliminated from textual data. Our purpose is to extract readable text from degraded documents by separating the background from the foreground. Such that the obtained image document has a better text appearance further that it must be made clear in the texture and foreground compared with the background area.

3.1.7 Output image

It has been observed that the processed output images have better readable text and document views than input images with noisy artifacts. The processed output textual image has characteristics of a visually clear and pleasant text document. The statistical results provide sufficient evidence in this way to bring about the desired task. The proposed algorithm performs well and can improve the appearance of the original documents greatly. Our proposed method is best for processing noisy document images into noise-free text, and it is also best for enhancing the textual data. The desired output document image after its restoration appears just like the original and fresh textual document. To read such types of images in the finest view and without any difficulty is our goal.

Experimental results show that the proposed algorithm is very fast and robust. The above-selected image shown in Figure 4 is noise-influenced and has so many artifacts. The image is processed to retrieve the textual data by using the proposed methodology and is shown in Figure 5. It can be observed from the resulting document that the noise is eliminated, and the text is in an easily readable form.

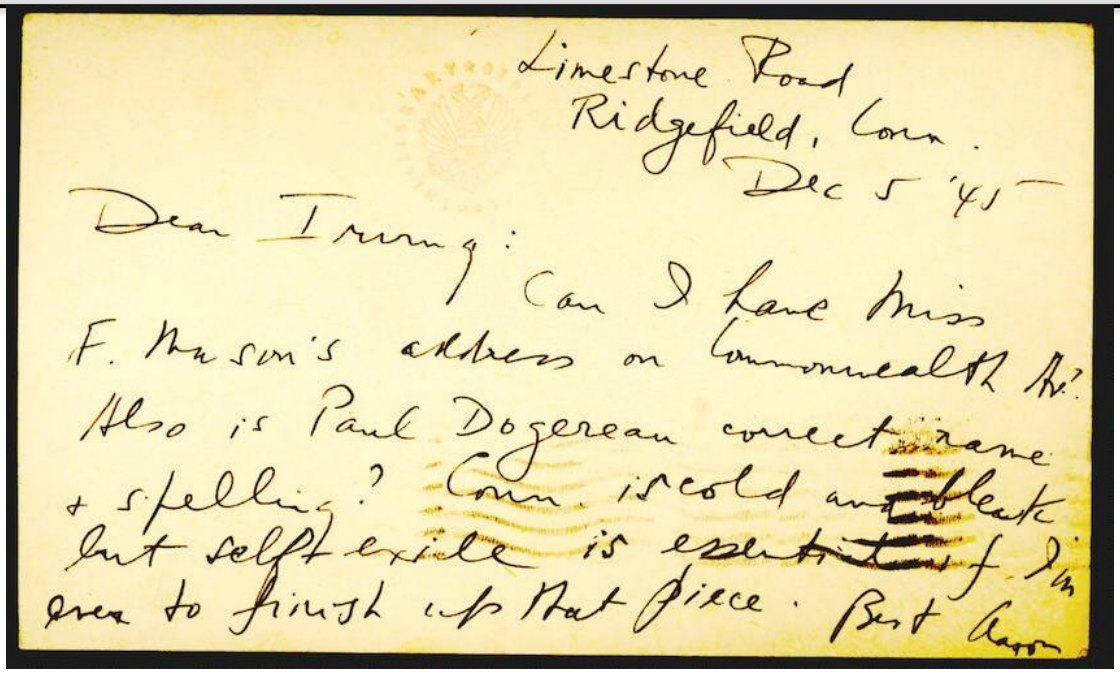


Fig. 4. A noise-influenced image document picked from Library of Congress (LOC) database

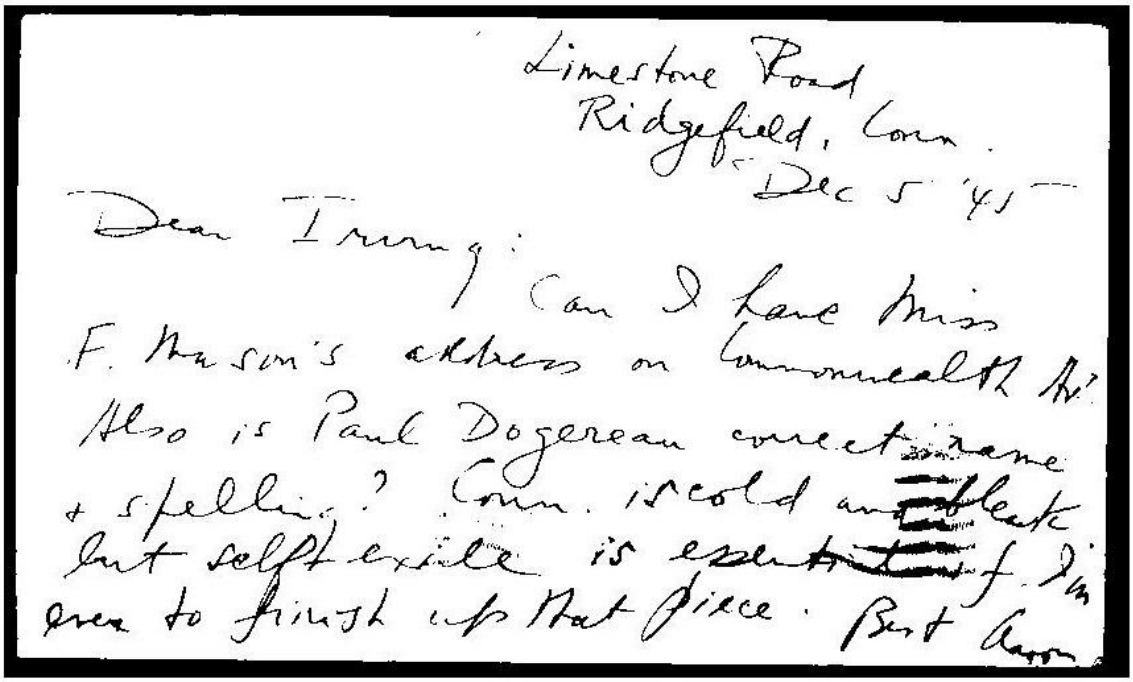


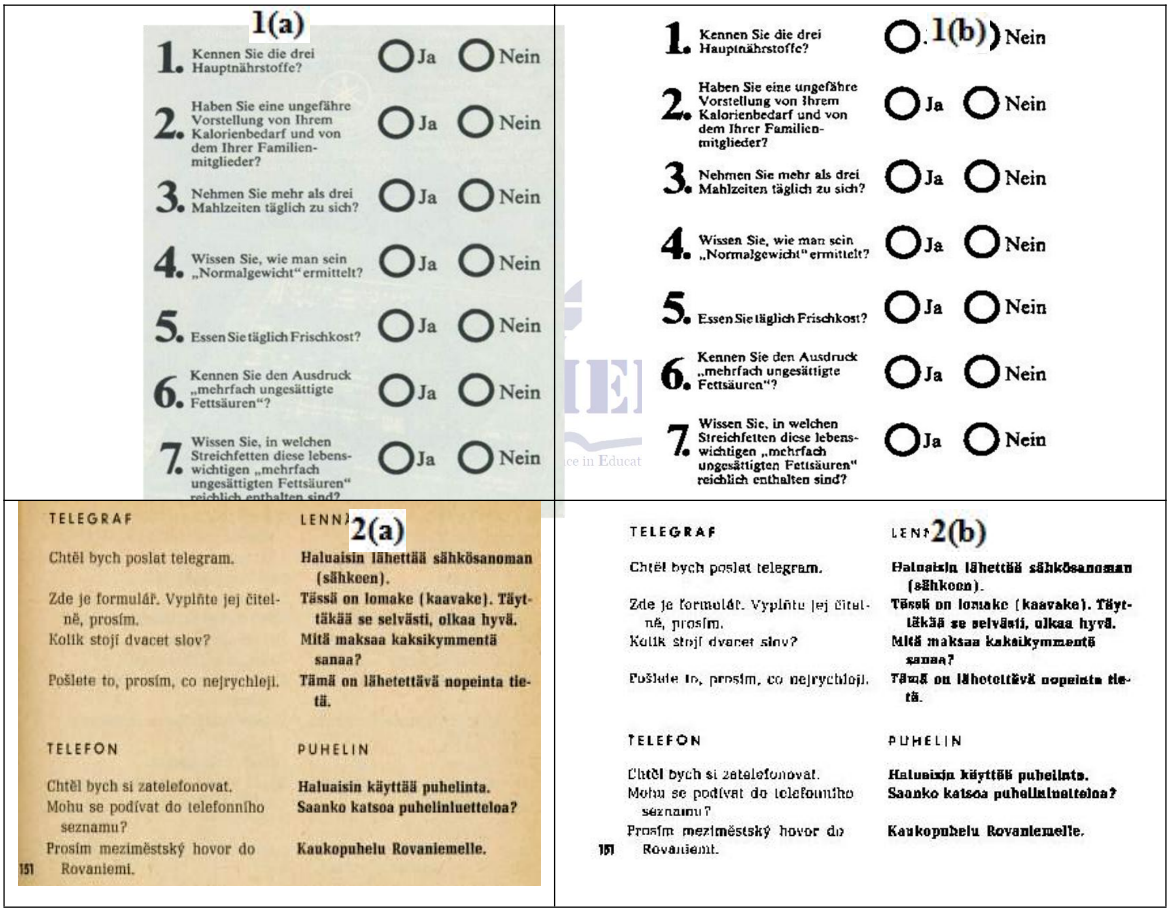
Fig. 5. Processed document from proposed methodology

4. Results and Discussions

4.1. Results

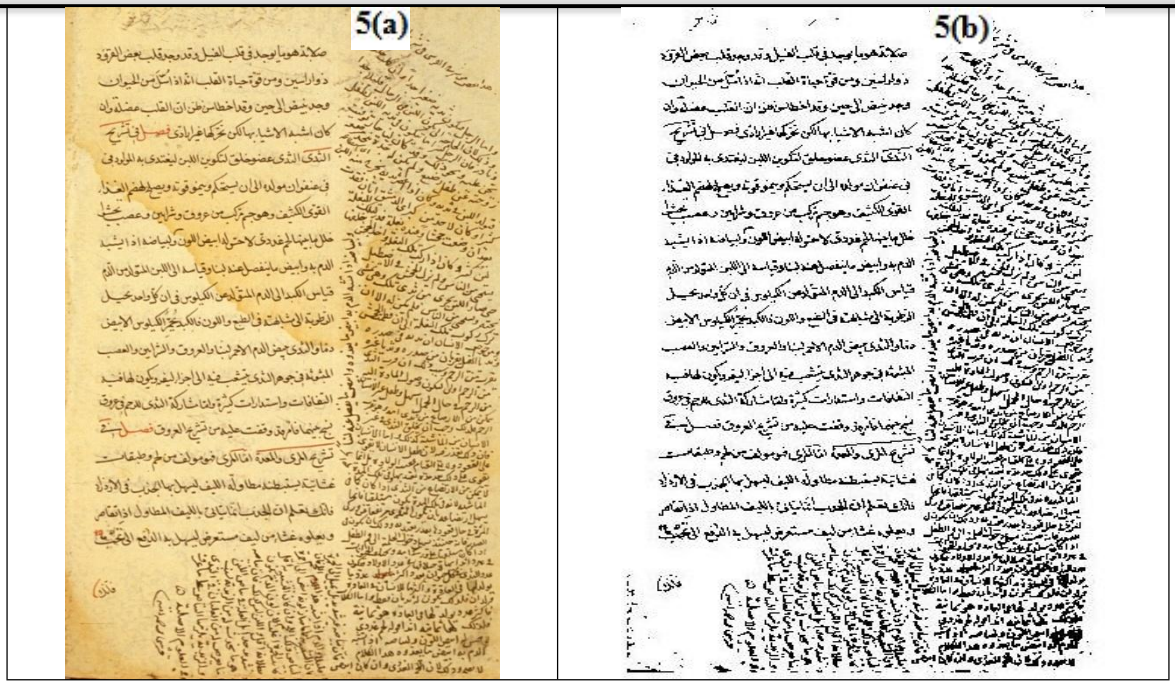
It has proved to be an excellent noise reduction model for studying unreadable text in the best look and view. Many experiments have been carried out to assess the performance of the proposed algorithm. These tests are conducted on different datasets including MediaTeam Document and Library of Congress (LOC) image document databases, which are available on the websites. The chosen document for denoising noisy documents and processed image documents. The obtained numerical and statistical

results of different textual image analysis parameters like image dimension, SNR (Ullah, Andleeb, Aftab, Hussain, & Gilanie, 2017), PSNR (Janjua, Jahangir, & Gilanie, 2018), contrast, and energy value of each textual image before. We have processed noise-influenced scanned text images that are degraded due to paper aging and other artifacts with our proposed method, which is shown in Figure 6 (a), and obtained the resulting image which is shown in Figure 6 (b). The statistical results are presented in Table 1. So, visual, and quantitative results of these images show that the output image is perceivable and easily readable than the original noisy one.



	
I trust that all 4(a) are gathered within and about this old house today, already feel the welcome that goes out to each one of you from the hearts of the Lockhaunders. If we can make you as glad you came - as you have made us, by coming, we shall surely rejoice together.	I trust that all 4(b) are gathered within and about this old house today, already feel the welcome that goes out to each one of you from the hearts of the Lockhaunders. If we can make you as glad you came - as you have made us by coming, we shall surely rejoice together.

Fig. 6.



Showing the images from MediaTeam Document and Library of Congress (LOC) Databases X (a) Original noisy scanned document X (b) Enhanced text document.

Table 1: Presents the values of quantitative parameters of Figure 6 (1(a) and 1(b))

Name of image	Dimensions	Format	SNR	MSE	PSNR	Contrast	Energy
Figure a (Input Image)	505X400	JPEG	2.6930	0.652	90.654	1.3135e+009	42594000
Figure b (Output Image)			4.3445			3.6316e+008	79401584

The original Scanned image has 505X400 dimensions and its format is JPEG, initially the SNR value for the original image is 2.6930, MSE is 0.652, PSNR is 90.654, its contrast is 1.3135e+009 and energy is 42594000.After applying the proposed methodology to enhance the document, the SNR value is 4.3445, contrast is 3.6316e+008 and energy is 79401584.

There is an increase in SNR, contrast, and energy of the processed document image. In this document image, different artifacts are the cause of the degradation of textual data. In our proposed denoising method the noise in the document is eliminated, and the entire resultant document is perceptually better and easily readable. The statistical results are presented in Table 2. So, the visual and quantitative results of these images show that the output image is more easily readable than the original noisy one.

Table 2: Presents the values of quantitative parameters of Figure 6 (2(a) and 2(b))

Name of image	Dimensions	Format	SNR	MSE	PSNR	Contrast	Energy
Figure a (Input Image)	257X400	JPEG	3.5149	0.594	86.962	1.6237e+008	47047752

Figure b (Output Image)			4.5009			5.4409e+008	19879164

We have processed noise-influenced scanned text images that are degraded due to paper aging and other artifacts with our proposed method. The original Scanned image has 257X400 dimensions and its format is JPEG, initially, the SNR value for the original image is 3.5149, MSE is 0.594, PSNR is 86.962, its contrast is 1.6237e+008 and energy is 47047752. After applying the proposed methodology to enhance the document, the SNR value is 4.5009, contrast is 5.4409e+008 and energy is 19879164.
There is an increase in SNR, contrast, and energy of the processed document image. In this document image, different artifacts are the cause of the degradation of textual data. In our proposed denoising method the noise in the document is eliminated, and the entire resultant document is perceptually better and easily readable.

4.2. Discussion

We have processed noise-influenced scanned text images that are degraded due to paper aging and other artifacts with our proposed method. The statistical results are presented in Table 3. So, visual, and quantitative results of these images show that the output image is perceivable and easily readable than the original noisy one. The original Scanned image has 320X480 dimensions and its format is JPEG, initially the SNR value for the original image is 3.2445, MSE is 0.782, PSNR is 90.503, its contrast is 2.1159e+008 and energy is 54936796. After applying the proposed methodology to enhance the document, the SNR value is 7.8201, contrast is 6.9429e+008 and energy is 60545384.
There is an increase in SNR, contrast, and energy of the processed document image. In this document image, different artifacts are the cause of the degradation of textual data. In our proposed denoising method the noise in the document is eliminated, and the entire resultant document is perceptually better and easily readable.

Table 3: Presents the values of quantitative parameters of 6 (4(a) and 4(b))

Name of image	Dimensions	Format	SNR	MSE	PSNR	Contrast	Energy
Figure a (Input Image)	594X653	JPEG	3.7679	0.638	89.593	1.3331e+009	65660140
Figure b (Output Image)			6.2663			3.5228e+008	109015616

Original Scanned image has 594X653 dimensions and its format is JPEG, initially, the SNR value for the original image is 3.7679, MSE is 0.638, PSNR is 89.593, its contrast is 1.3331e+009and energy is 65660140. After applying the proposed methodology to enhance the document, the SNR value is 6.2663, contrast is 3.5228e+008 and energy is 109015616. There is an increase in SNR, contrast, and energy of the processed document image. In this document image, there are different artifacts, which are the cause of the degradation of textual data. In our proposed denoising method the noise in the document is eliminated, and the entire resultant document is perceptually better and easily readable.
We have processed noise influenced by scanned text images that are degraded due to paper aging and other artifacts with our proposed method. So, the visual and quantitative results of these images show that the output image is more easily readable than the original noisy one.
The original Scanned image has 613X1061 dimensions and its format is JPEG, initially the SNR value for the original image is 2.2223, MSE is 0.376, PSNR is 88.305, its contrast is 1.4016e+009 and energy is 36427920. After applying the proposed

methodology to enhance the document, the SNR value is 5.5238, contrast is 8.7071e+008 and energy is 128955536.

There is an increase in SNR, contrast, and energy of the processed document image. In this document image, different artifacts are the cause of the degradation of textual data. In our proposed denoising method the noise in the document is eliminated, and the entire resultant document is perceptually better and easily readable.

5. Conclusions and Future Work

With the digitized images, we have proposed a reliable algorithm for unreadable text retrieval from scanned document images. We have developed and validated a standardized quantification system for the enhancement of textual images. The experimental results indicate that the planned framework is rigorous in noise reduction and enhancement of textual data. It is difficult to prove if a given denoising algorithm will be equally useful in the general case. Our experiments show that for some simple cases, the developed technique for denoising may be iterated successfully. When the noise is very high compared to the contrast between pixels, leakage unfortunately occurs, and multiple iterations could produce a homogeneous document image.

In future, it is required to develop a denoising technique. This may be equally useful for every type of document, language, and text. Generally, applicable in each environment of denoising a document. As it has been discussed in conclusion that this methodology of denoising of document image is only helpful for a simple noise in the text document and it is also difficult to decide an algorithm which is equally useful for general case.

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