Forensic examination of computer-manipulated documents using image processing techniques

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Abstract The recent exponential growth in the use of image processing software applications has been accompanied by a parallel increase in their use in criminal activities. Image processing tools have been associated with a variety of crimes, including counterfeiting of currency notes, cheques, as well as manipulation of important government documents, wills, financial deeds or educational certificates. Thus, it is important for the Document Examiner to keep up to date with latest technological and scientific advances in the field. The present research focuses on the use of image processing tools for the examination of computer-manipulated documents. The altered documents were examined using a suite of currently available image processing tools. The results demonstrate that a number of tools are capable of detecting computer-based manipulations of written documents.

1. Introduction

The development of digital technology has drastically changed the concept of written document and, along with it, the nature and perpetration of white-collar crimes. Owing to revolutionary changes made possible by new technology, forgers are becoming tech-savvy and are capable of fabricating documents with or without signatures using the skills and tools these modern technologies afford. Forgery of documents, e.g., important government documents, wills and educational certificates have become easy to perfect. As a result of these advances in science and technology, it is becoming increasingly difficult to determine the authenticity of a file transferred through a network. Therefore, it is essential for the Forensic Document Examiners to keep abreast of the latest technological and scientific advances in the field.

In most cases, forgers apply cut and paste techniques to manipulate figures, letters, or words that consequently alter the meaning of the document. Workers have reported the use of image processing techniques in forensic document examinations. The present study aims to explore the uses of image processing techniques for the examination of computer-manipulated documents. The primary goal of this research is to study and characterize the various forms of alterations that have been found in a written document.

2. Materials and methods

To study the image processing techniques in forensic document examinations, this research was divided into two phases. In

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phase-I, documents (in particular, those typically used by forgers) were selected. The original documents were first scanned (Figs. A1–H1) and then, alterations were made using image processing software (Figs. A2–G2). In phase-II, image processing software was used to detect alterations in the manipulated documents.

2.1. Collection of samples

The documents collected for the study, included detail mark sheets, identity cards, bank cheques and documents consisting text on plain paper. Original samples were scanned using a colour digital scanner.

2.2. Manipulation of scanned samples

Forty manipulated samples were created out of four scanned copies of original samples. The manipulations included both addition and deletion of text from the original documents. The details of which can be found in Tables 1 and 2, respectively. The manipulations were done in multiple ways, as described below.

2.2.1. Deleting text using Paint software

A scanned copy of the document was opened in the standard Paint software application. A portion of the text was erased using the Erasure tool. To make the erased surface appear consistent with the rest of the surface, the Color Picker tool was used. The manipulated file was saved in JPEG format from the Paint software application.

2.2.2. Adding text using Paint and Adobe Photoshop software

A scanned copy of the document was opened in the Paint software application. The Rectangular Selection tool was selected. Next, the Text Tool was selected in order to add new text. A Rectangular Selection appeared on the document where the desired figure or text was inserted and in the final step, the altered document was saved in JPEG format.

Alternatively, text could be added to the document using Adobe Photoshop software. The document was edited using the copy and paste tool. Various words and letters in the document were copied and pasted at new locations within the same document. The Rectangular Marquee tool was selected from the editing window. The portion of the document to be copied was selected using Rectangular Marquee tool. Next, ‘layer via copy was selected and the Move tool was used to place the copied portion of the document at the desired location. After all additions were made, the document was saved in JPEG format.

Using these procedures, various alterations were made on a number of samples at different locations in the document. Then manipulations were carefully made so that they were difficult to detect by the naked eye. All of the altered documents were saved in both PSD and JPEG format and then examined. The layers of the documents were merged using Merge Visible command from the layer option in the main panel. As the result of this process the background surfaces were typically disturbed. This was verified by converting all of the documents with printed backgrounds into Negative Image using Picasa editing software.

3. Examination of the altered documents

The documents were thoroughly examined to check whether there were any irregularities such as:

(a) Irregular spacing between letters and words.
(b) Discrepancies in font and design of inserted words and letters.
(c) Discrepancies in size of inserted letters or words.
(d) Crowding of various letters and words.
(e) Non-uniformities in the background.

Figure A  
The documents were examined for these irregularities using image processing tools, described below.

3.1. Use of Picasa photo editing software

A scanned document was opened in the Picasa application. The resolution was increased using the Cropping tool to magnify the image approximately 100x. The Highlighting tool was applied twice in order to highlight the background and make it more prominent and visible. By doing so, the disturbance in the background could be observed. The background surfaces were examined carefully; in general, no matter how digital document manipulations are made, the background surfaces always get disturbed.

3.2. Use of Adobe Photoshop

The number of layers in the document was easy to determine if PSD, as opposed to JPEG, files were opened in Adobe Photoshop. On the other hand, if the altered file was saved as a JPEG from Adobe Photoshop, information about the number of layers applied was lost and no layer detection could be performed.

4. Results

The altered documents were examined using both Picasa and Adobe Photoshop software.

Following observations have been made:

The following observations were made:

(a) In the case of text additions, disturbances in the background surface of the document were observed for documents with printed backgrounds such as detailed mark sheets, cheques, and identity cards (Figs. A-3, A-4, B-3). Moreover, discrepancies in the text and font of altered words were observed (Fig. C-3).

(b) Irregular spacing between letters and words was observed both in the case of additions and deletions of text in the scanned document’s body (Fig. C-3).

(c) In the case of text additions, discrepancies in the size of various words and letters were observed in the newly added text (Fig. C-3).

(d) Disturbances in the form of small dots on the background surface of the document were additionally observed (Fig. D-3). For example, using the copy and paste technique in Adobe Photoshop to add text resulted in disturbances on the background surface.
in disturbances in the patterns of the joined text and the background surface. These disturbances arose because the background surface was copied and pasted along with the added text. This feature, in particular, proved to be very useful as forgers are possibly not familiar with it. These observations were made on both types of documents, having either printed or plain backgrounds (Fig. E-3).

(e) In the case of certificates, the watermarks present in the background of the certificate can be changed or forged; however, it was observed that text written on the watermark cannot be removed. Thus, when the document-bearing text on the watermark was examined in Adobe Photoshop, it always showed a single layer. The forger cannot paste new text onto the background of the watermark. When such an alteration was made, some loss in background color was observed. Moreover, disturbances in the sequence of pixels were observed around the edges of the alterations (Figs. F-3, G-3, G-4).

(f) In altered documents, copied letters exhibited different pixel colors as compared to other letter forms of the same document when examined at 100× magnification.

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**Figure E**  
(E-1): The original scanned document of plain paper. (E-2): The addition of words in scanned document of plain paper. (E-3): The circle with the arrow shows the unique pattern of dots which do not join with the above line when copied.

**Figure F**  
(F-1): The original scanned document of identity card. (F-2): The removal of text done on scanned copies of identity cards. (F-3): Removal of some part of the background surface in white colour of altered documents of identity cards.
If an altered document was printed out and rescanned, it was observed that all letters (both original and altered) had the same pixel color.

(g) Plain or white backgrounds exhibited pale colors following deletion. (Figs. F-3, G-3, G-4). Furthermore, it was observed that pasting text resulted in irregularities in the background.

(h) If the forger saves the altered file in PSD format, without first merging the layers then the layers are visible when the file is reopened in Adobe Photoshop. Manipulated
documents that have printed backgrounds can be changed from positive to negative form in Adobe Photoshop. The area containing additions or deletions typically appears highlighted and is easily visible. On the other hand, when a file is altered in Adobe Photoshop and saved in any format other than PSD, or as a PSD file after merging the layers, then the layer information is lost and it would not be possible to detect manipulations by examining layers.

5. Discussion

Here, it was shown that there is utility in using image processing software to analyze digitally manipulated documents to detect manipulations. The results demonstrate that many features were associated with manipulations in digital documents, such as disturbances of the surface of the document, size and spacing discrepancies of words and letters, the presence of dots, irregularities in the pixel arrangements, changes in pixel colors of altered letters and words, as well as the presence of unique sequence of dots around each inserted letter or word. Earlier studies\textsuperscript{3,5} reported the use of image processing tools for the analysis of questionable documents. In the present study, the results obtained after examination of all of the documents were encouraging and suggest ways to help document examiners in detecting manipulations of digital documents.

6. Conclusion

In this era of cybercrime, computers are used most frequently to commit certain crimes, such as altering documents to change their meaning. In this paper, we studied alternations in system-generated documents, including documents with printed backgrounds as well as plain backgrounds. The manipulation of the documents was done with the help of image processing software applications including Adobe Photoshop and Paint. After manipulating the documents, they were examined for alterations; encouraging results were obtained. The results demonstrated that a number of features were associated with image manipulation and could easily be detected using standard image processing applications.

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Conflict of interest

None declared.

Ethical approval

Necessary ethical approval was obtained from the institute ethics committee.

References