Comparative implementation of Handwritten and Machine written Gurmukhi text utilizing appropriate parameters

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Abstract. Optical character recognition is concerned with the recognition of optically processed characters. The recognition is done offline after the writing or printing has been completed, unlike online recognition where the computer has to recognize the characters instantly as they are drawn. The performance of character recognition depends upon the quality of scanned documents. The preprocessing steps are used for removing low-frequency background noise and normalizing the intensity of individual scanned documents. Several filters are used for reducing certain image details and enabling an easier or faster evaluation. The primary aim of the research work is to recognize handwritten and machine written characters and differentiate them. The language opted for the research work is Punjabi Gurmukhi and tool utilized is Matlab.

1. Introduction
Optical Character Recognition is the procedure via which text within an image is converted into the text itself. It has always been a dream that human functions are replicated by a machine. However, during last four decades, this dream has grown to reality. Optical character recognition is considered among prominent applications of pattern recognition. Several commercial systems based on OCR are available in the market today, but still, human reading capabilities cannot be matched [1]. In simple terms, OCR is processing via which input in the form of text characters is provided to a computer through an image. OCR has empowered scanned documents to be much more than image files, converting into searchable documents with text content that is computer recognizable. OCR allows people to convert important documents into electronic documents without any need to retype them manually. The accuracy level obtained is good and information processing is done in minimum time [3], [11]. The OCR algorithm is primarily based on the set of learned characters. The characters in the learned set are compared with the scanned image file. The learned set can be generated easily. The focus of the research work in the paper is on differentiating printed and handwritten Gurmukhi text. Deciding someone’s scribbled handwriting is much more difficult as compared to recognizing the characters that constitute a neat laser-printed computer text. This is where human brains beat smart computers hands-down. OCR simplifies the process where computers are supposed to recognize text written in image.[3].

2. Gurmukhi script
Gurmukhi characters come into use for writing the Punjabi language. The second Sikh Guru, Shri Guru Angad Dev Ji harmonized Gurmukhi. Gurmukhi literally means “from the mouth of Guru” [17].
2.1. Structure of Gurmukhi Character
Gurmukhi script is written from top to bottom and left to right. Gurmukhi script is free from case sensitivity [13]. Gurmukhi words are partitioned into three zones; upper, middle and lower. The header line is responsible for separating the upper zone from the middle zone and the base line takes care of untying middle zone from the lower zone as shown in Fig. 1. The bottom strip comprises of lower modifiers [17].

![Figure 1](image1.png)

**Figure 1.** The Figure depicts three zones of a word in Gurmukhi script.

Gurmukhī has thirty-eight consonants (akhar), 10 vowel symbols (lāgamātrā), two symbols for nasal sounds (pair bindi and jippī), and one symbol which duplicates the sound of any consonant (addak) [15].

2.2. Machine written text (MWT) Vs. Handwritten text (HWT) in Gurmukhi
The differences between machine written text (MWT) and handwritten text (HWT) are summarized below [7], [8], [14].
- The number of strokes in machine written language is comparatively less than handwritten text.
- MWT preciseness makes it more readable as compared to HWT.
- The size and dimensions of HWT face variation where MWT does not.
- The available formats and fonts are much more in the case of MWT as compared to HWT.
- MWT does not face the spacing problem as in the case of HWT.

Fig. 2 depicts similar words written in MWT and HWT.

![Figure 2](image2.png)

**Figure 2.** Displays MWT (left) against HWT (right)

3. Contribution and Implementation of research work
The motive of research work is to perform the comparison of HWT and MWT via designing appropriate program using simulation tool (MATLABR2013) on three different parameters; MSE (mean square error), PSNR (peak signal to Noise ratio), and IMV(intensity mean value).

(i) **SSIM (Structural Similarity Index Measure):** SSIM is responsible for calculating the similarity index between two images. The initial uncompressed image is used as a reference to decide the quality of images under study [4], [5].
(ii) **MSE (Mean Square Error):** It is a method used to check errors. The calculation is performed on two MSEs and compared to find the level of accuracy of an image. The quantitative score obtained helps to measure the degree of homogeneity or the level of error or distortion between them.

(iii) **PSNR (Peak Signal Noise Ratio):** PSNR is commonly used as a measure of the quality of reconstruction of loss compression codecs. The original data acts as a signal and the noise behaves as an error caused by compression. A higher PSNR would normally indicate that the reconstruction is of higher quality [4], [5].

3.1. **Procedure**

Primarily the image is scanned for preprocessing. Thereafter after removing noise from it, a suitable classifier rule is set up for HWT and MWT [9], [10]. The detailed steps are mentioned as under.

- Image is given as input from the external source.
- Image is converted into matrix comprised of rows and columns.
- RGB image is converted into gray scale image.
- Apply OTSU technique to identify threshold value of the concerned image.
- Labels of threshold image are identified.
- Perform extraction of text characters based on image labels.
- Segment text characters from the image.
- Apply three parameters (SSIM, PSNR, and MSE) for identifying MWT and HWT.
- Finally, the comparison is made.

3.2. **Implementation using MATLAB R2013**

The detailed implementation of the research work is mentioned as under [2]. Firstly, an image is scanned for providing input to the system. The scanned image can be of HWT or MWT in Gurmukhi script [6].

**Case 1: HWT**

Let the input image be a handwritten image of the first letter of Gurmukhi script (Oorra) as shown in Fig. 3 [12].

![Figure 3. Representation of first Gurmukhi HWC (Oorra)](image_url)

Fig. 4 shows the screen of the developed program consisting two panels, left (HWT) and right (MWT). Each panel consists of three segments; Loading image, preprocessing and finally processing image. Fig. 4, shows the image been uploaded on the designed program on MATLAB R2013 on HWT panel.
Figure 4. The figure depicts the first character (Oorra) of Gurmukhi script been uploaded on HWT panel.

After uploading the image, inversion of an image is performed followed by indexing and boxing as shown in Fig. 5.

Figure 5. The figure depicts the image obtained after preprocessing in HWT panel.

Thereafter the image is processed which involves cropping, reshaping and resizing of the concerned image as shown in Fig. 6.

Figure 6. The figure displays the final processed image along with calculated parameters on HWT panel.
Finally, values are obtained for three different parameters under study as shown in Fig. 7.

![Figure 7](image)

**Figure 7.** The figure highlights the three different parameters values obtained on HWT panel.

3.3. *Case 2: MWT*

Firstly, provide input image to the system consisting machine written character (Fig. 8).

![Figure 8](image)

**Figure 8.** The figure depicts the first character (*Oorra*) of Gurmukhi script been uploaded on MWT panel.

Thereafter preprocessing of an image is conducted which comprises indexing, boxing, and cropping as shown in Fig. 9.

![Figure 9](image)

**Figure 9.** The figure depicts the image obtained after preprocessing in MWT panel.

Finally, the obtained image is cropped, reshaped and resized as shown in Fig. 10 followed by segmentation.
Finally, values are obtained for three different parameters under study as shown in Fig. 11 in the case of MWT.

3.4. Comparing parameters – HWT Vs. MWT
The values of the parameters obtained after running the designed code are compared in tabular form as shown in Fig. 12 and in graphical form in Fig. 13.
As SSIM values face no change in value, the emphasis is laid on calculating MSE and PSNR values. Fig. 14 shows the MSE results of HWC and MWC obtained for next nine letters of Gurmukhi script followed by Fig. 15 in graphical form.

| Gurmukhi Handwritten Character | MSE (HWC) | Gurmukhi Machine written Character | MSE (MWC) |
|-------------------------------|-----------|-----------------------------------|-----------|
| ਗ                            | 133.14286 | ਪ                   | 94.777778 |
| ਘ                            | 132.14286 | ਰ                   | 109.03175 |
| ਙ                            | 140.62698 | ਙ                   | 107.69648 |
| ਚ                            | 146.21429 | ਚ                   | 123.84127 |
| ਛ                            | 141.9032  | ਛ                   | 132.92857 |
| ਜ                            | 85.198413 | ਜ                   | 84.253908 |
| ਕ                            | 109.47619 | ਕ                   | 110.35714 |
| ਝ                            | 116.3254  | ਝ                   | 93.68254  |
| ਞ                            | 110.71429 | ਞ                   | 77.15873  |

**Figure 14.** MSE values of HWC and MWC for next nine letters in Gurmukhi script

**Figure 15.** The figure displays a comparison of MSE values of HWT and MWT in graphical form.

Fig. 16, shows the PSNR results of HWC and MWC obtained for next nine letters of Gurmukhi script followed by Fig. 17 in graphical form.
4. Conclusion
The results obtained from the research work performed is summarized as under:
- The MSE in the case of HWT is more than MWT.
- The value of PSNR is greater in the case of MWT as compared to HWT which indicates that reconstruction in MWT is of higher quality.
- SSIM value obtained in both the cases is same.

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