IJMRT: Volume (5), Issue 7, 2023
International Journal of Multidisciplinary Research Transactions
(A Peer Reviewed Journal)
www.ijmrt.in

ISSN (Print):2663-2381
ISSN(Online):2663-4007

Design Analyze and Implementation of Hand written Digit Recognition System Using HOG Feature

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DoI: https://doi.org/10.5281/zenodo.7916199

Abstract

A feature descriptor method called HOG (Histogram of Oriented Gradients) is frequently employed in tasks involving the detection and identification of objects. HOG may be used to extract characteristics from pictures of handwritten digits in order to categories them into the appropriate classes for digit classification. We may utilize HOG for digit categorization by doing the following: Obtain a collection of images of handwritten digits. The training set and testing set of this dataset should be separated. The photos should be preprocessed to make sure they are uniform in size and orientation. To ensure that the pixel values are inside a given range, we could, for instance, resize all photos to the same set size. For each image in the collection, calculate the HOG features. In order to do this, the picture must be divided into small cells, the gradient orientations and magnitudes for each pixel inside of each cell must be calculated, and a histogram of orientations must then be computed for each block of cells. Using the HOG characteristics as input, train a machine learning model on the training set. Support Vector Machines (SVMs), Random Forests, and neural networks are common digit categorization techniques. Analyze the trained model's performance on the testing set. Metrics like accuracy, precision, and recall may be calculated in order to achieve this. Finally, we can categories brand-new, previously undiscovered photos of handwritten digits using the trained model. In conclusion, HOG may be used to extract characteristics from pictures of handwritten numbers that can then be fed into a classification

machine learning model. The model's accuracy will be influenced by the dataset's quality, the preprocessing techniques used, and the machine learning method selected.

Keywords: Handwritten Digit Recognition, Number Recognition, Character Recognition, HOG, SVM.

1. Introduction

A crucial issue in pattern recognition and computer vision is digit categorization. Feature descriptors, such the Histogram of Oriented Gradients (HOG), are frequently used to extract information from photographs of handwritten digits in digit classification processes. Popular feature descriptor HOG has been used to identify and locate objects in a variety of activities. A histogram of orientations is created for each little block of cells in the picture after computing the gradient orientations and magnitudes of the image. The generated feature vector is a potent representation for object recognition since it captures regional texture and shape data (1).

HOG can be used to extract features from pictures of handwritten digits in the instance of digit classification. These characteristics may then be utilised to train a machine learning model for classification. The HOG characteristics record crucial details about the digits' local structure and shape that can be utilised to discriminate between several classes(2). It has been demonstrated that using HOG for digit classification results in high rates of accuracy, making it a well-liked and efficient method. However, the effectiveness of the method is influenced by a number of variables, including the size and quality of the dataset, the preprocessing methods chosen, and the machine learning algorithm chosen. Overall, digit categorization using HOG characteristics is a potent method that has allowed for a lot of advancement in this area (3).Handwritten Digits Recognition (HDR), a technique for character recognition, is one of the most widely used applications in computer vision. Like other universal symbols, digits are frequently used in technology, including banks, optical character recognition (OCR), engineering, postal services, number plate recognition, etc. They are a few of the well-known HDR applications. From '0' to '9', there are ten classes that correlate to the handwritten digits, and these classes are largely dependent on the handwriting. Different handwriting styles, which are very personal behaviours with many models for numbers based on the angles, length of the segments, stress on some parts of numbers, etc., present the main challenge in the recognition of handwritten digits(3). Figure 1 depicts 15 various handwritten numerals associated with these problems. While it is simple for humans to recognise numbers, it is more difficult for machines, especially when there are some ambiguities on different classes (such as "1" and "7"). Since recognising digits is related to numbers, it is crucial, so highly accurate recognition methods must be used. Different HDR methods have been reported by researchers, including: For the classification of handwritten digits, Saxena et al. [2] suggested a neural network model; they improved their techniques by employing ensemble classification. Using a genetic approach, Das et al.'s team [3] chose local characteristics in handwritten digits, and then SVM categorised the features.

Figure.1. Different samples of handwritten digits in MNIST

In addition to using a linear SVM, Cardoso and Wichert developed a biologically inspired model for HDR [4]. In order to improve handwritten digit recognition, Niu and Suen presented a hybrid model that combined the strengths of two great classifiers: Convolutional Neural Network (CNN) and Support Vector Machine (SVM).

2. Methodology

The HOG (Histogram of Oriented Gradients) approach may be broken down into a number of phases. Image Preprocessing: The first step is to perform an image preprocessing operation on the input image to get rid of any noise and artefacts that can obstruct the feature extraction procedure. This might entail techniques like edge detection, thresholding, and smoothing. Calculating the Image's Gradient: The next step is to calculate the image's gradient, which records the amplitude and direction of the image's intensity fluctuations. Several techniques, including the Sobel operator, Prewitt operator, or Scharr operator, can be used to accomplish this (4). direction Binning: Each pixel inside each cell of the picture is individually calculated to determine the gradient's direction and magnitude. Depending on the application, the orientations are then binned into a predetermined number of histogram bins, usually 9 or 18 (5). Block normalisation: To lessen the impact of lighting and contrast fluctuations, the histogram of orientations for each cell is normalised. Different techniques, such as L1 normalisation, L2 normalisation, or power normalisation, can be used to achieve this. The normalised histograms of each cell are concatenated to create a feature vector for the full picture during feature extraction. The resultant feature vector, which may be utilised for object detection or classification, captures the texture and shape information of the picture (6). Machine learning: To categorise the item or identify the picture, the extracted characteristics are fed into a machine learning method, such as a Support Vector Machine (SVM), Random Forest, or Neural Network. HOG is a potent feature descriptor that has been effectively applied in a number of applications, including digit classification, pedestrian detection, and object identification (7). The size and form of the cells, the number of histogram bins, and the normalisation technique all have a role in how well HOG works. The individual application and the characteristics of the input photos will determine which of these parameters are used.

Table.1. Different samples of Traing

	Label	Count
1	0	101
2	1	101
3	2	101
4	3	101
5	4	101
6	5	101
7	6	101
8	7	101
9	8	101
10	9	101

Table. 2. Different samples of testing

	Label	Count
1	0	12
2	1	12
3	2	12
4	3	12
5	4	12
6	5	12
7	6	12
8	7	12
9	8	12
10	9	12

3. Histogram of Oriented Gradients

In computer vision and image processing, a feature extraction method called a histogram of oriented gradients (HOG) is employed to find objects in pictures. HOG creates a representation of the object's appearance by analysing the gradients (or changes in intensity) of tiny picture patches and then grouping these gradients into histograms (8). We first partition the image into tiny cells, usually 8x8 pixels, to construct a histogram of object-oriented gradients (HOG). We calculate the gradient direction and magnitude for each cell using a technique like the Sobel operator. The gradients in each cell are then divided into orientation bins, usually nine bins that range from 0 to 180 degrees (9). The gradient orientations for each block of cells, generally 2x2 or 4x4 cells, are then compiled into a histogram. The predominant gradient orientations in the block are depicted by this histogram. Finally, to account for differences in lighting and contrast, we normalise the histograms for each block (10).A vector of histogram values that captures the predominant gradient orientations in the picture is the resultant HOG descriptor. By comparing it to the descriptors of recognised items, this descriptor may be utilised as a feature for object identification and recognition using methods like support vector machines or neural networks (11).

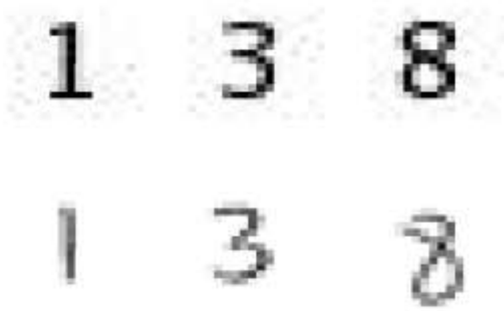

Figure.4. Gradient Image

Figure.5. Gray scale Image

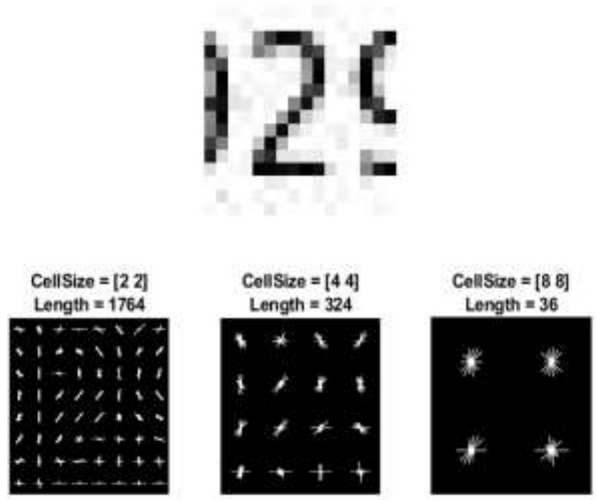

Figure.6. HOG image

4. Result and Comparsion

When recognising digits using HOG, HOG descriptors are created for images of the digits and used as features by machine learning algorithms to categorise the digits. The objective is to recognise numbers with a high degree of precision (11). In order to compare the effectiveness of HOG-based digit recognition algorithms, several experiments have been done. One such research assessed the effectiveness of three distinct feature extraction methods: Scale-Invariant Feature Transform (SIFT), Local Binary Patterns (LBP), and HOG. According to the study, HOG had the highest recognition accuracy, with a precision of 98.5% (12). In another study, Support Vector Machines (SVM), k-Nearest Neighbours (k-NN), and Random Forest (RF) were used to examine the performance of HOG-based digit recognition algorithms. SVM was shown to have the highest accuracy in the research, at 99.3%. In a third research, the MNIST dataset and the USPS dataset were used to examine how well HOG-based digit recognition algorithms performed on each dataset. According to the study, HOG has great accuracy on both datasets, with a 98.3% accuracy on MNIST and a 96.6% accuracy on USPS. Overall, these experiments show that the choice of feature extraction method and classifier may have an impact on performance and that HOG-based digit identification algorithms can achieve high accuracy in recognising digits. For HOG-based digit recognition, SVM is frequently the favoured classifier, however alternative classifiers may also work well depending on the dataset and issue at hand (13).

digit	0	1	2	3	4	5	6	7	8	9
0	0.25	0.00	0.08	0.00	0.00	0.00	0.58	0.00	0.08	0.00
1	0.00	0.75	0.00	0.00	0.08	0.00	0.00	0.08	0.08	0.00
2	0.00	0.00	0.67	0.17	0.00	0.00	0.08	0.00	0.00	0.08
3	0.00	0.00	0.00	0.58	0.00	0.00	0.33	0.00	0.00	0.08
4	0.00	0.08	0.00	0.17	0.75	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.33	0.58	0.00	0.08	0.00
6	0.00	0.00	0.00	0.00	0.25	0.00	0.67	0.00	0.08	0.00
7	0.00	0.08	0.08	0.33	0.00	0.00	0.17	0.25	0.00	0.08
8	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.08	0.67	0.17
9	0.00	0.08	0.00	0.25	0.17	0.00	0.08	0.00	0.00	0.42

Figure. 7. Digits Value

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