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Automatic Handwritten Digits Recognition

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Abstract – *Usually, a handwritten digit recognition is a methodology that perform the recognition of handwritten digits. There are many training images are used for this identification. The images of MNIST dataset and proprietary dataset composed of 3.415 images are used. This work, had suffer some image processing before feature extraction and classification in order to be as similar as possible to the MNIST dataset samples. The dataset is divided into train, test and validation sets and the performance of the three different classifiers is compared and evaluated. This designed system could successfully reduce the time of creating and accessing the digital storage of students examinations, as well as allow the automatic indexing of student grades towards a full digital evaluation system.*

Key Words: Android, Handwritten digit recognition, Image processing, Smart Phone, Computing

1. INTRODUCTION

The field of research of automated text reading is known as Optical Character Recognition (OCR) that include Handwritten Character Recognition (HCR) and Handwritten Numeral Recognition (HNR). The process of HCR consist on performing image acquisition (picture, document, touch screen devices or others) where a region of interest containing the text to be recognized will be selected and proceeds.

A popular approach for segmentation of touching pairs was proposed by Fujisawa et al. [5], based on the length of connected components (CC) and its contour information. The algorithm was tested on a proprietary dataset composed of 46 most frequent touching pairs and a correct segmentation rate of 95% was reported by the authors. This algorithm had a performance of 94,9% reported by the authors on 450 images of ZIP Codes. A search algorithm is triggered to identify the most suitable one according to a predefined fitness function. The authors reported a correct rate of 96% on some samples of the NIST SD19 database.

It combine different types of features extracted from different representations of the same character instead of using a feature vector based on a single representation of a character. A feature descriptor that has proved to be suited to the HCR problem is the Histogram of Oriented Gradients (HOG) descriptors. The HOG descriptors have shown a better performance for the MNIST database when compared to other well-known techniques like PCA (Principal Component Analysis) and DCT (Discrete Cousine Transform) applied on SVM (Support Vector Machine) classifiers.

Convolutional Neural Networks (CNN) for image classification has become one of the most appealing classification methods and has been the key to solve a lot of the most challenging machine learning problems.

1.1: METHODS

The main goal of this work is to develop a full HCR methodology that performs the recognition of the handwritten characters. The algorithm was tailored for this problem, from the preprocessing to the final classification. It was not found in the literature any solution for this specific problem (recognition of handwritten numbers in classroom maps). In classification, a convolutional neural network was fine tuned for data that comes directly from the segmentation module. In a attempt to improve the classification results, an alternative approach that combines the features from the fully connected layer of the CNN with HOG features and give it to a SVM classifier was tested, leading to the highest classification accuracy. Although the algorithm was designed for this problem, all the modules developed can be easily adapted to other HCR applications. This database can be used to introduce variety to other existent databases.

A. Segmentation : Connected Components Analysis

In this a string of characters can be read and segmented into isolated characters. Segmentation means it is the partition of images into set of regions. In HNR, the aim of segmentation is to divide a numeral string into individual numerals to perform the recognition. One of the segmentation technique is the Connected Component Analysis (CCA). It is defined as a set of connected pixels.

B. Feature Extraction: Histogram of Oriented Gradients

It is the transformation of input data into set of features. It can be also characterized as the reduction of initial set of raw data into manageable groups. It is mainly used for reduction purpose. In some cases, due to memory issues and computation power the input data may be too large to be processed by an algorithm, feature extraction transform the data into reduced set of features. HOG is used as the major extraction method for handwritten digit recognition. HOG is mainly used in computer vision and image processing.

C. Classification: SVM and CNN

Classification is the mapping of input data and its corresponding output class. It is one of the major step where the data will be recognized, differentiated and understood, making it possible to find a solution by applying classification algorithm.

1) Support Vector Machines: It is one of the most powerful classifier, also known as hyperplane classifier. SVM combines multiple binary SVM classifier into N binary problems, where each one separating a class from others.

2) Convolutional Neural Networks: I t is a type of artificial neural network used for image recognition and processing, that process pixel data. It also use deep learning and feed-forward artificial neural network in machine learning. CNN architecture have mainly three layers: convolutional layer, subsampling layer and a fully connected layer. The CNN architecture starts with input layer that hold pixel values of the image and pass it to the convolutional layer. The subsampling layer perform a down sampling operation along eith the height and weight of input. In the fully connected layer each neurons is connected to the preceding one.

2. IMPLEMENTATION

A. Image and Data Acquisition

In this phrase the user select the image from the file that will submitted to recognition.

B. Pre- processing

The aim is to identify the region of interest (ROI) in the input image. ROI are the cells of map grid and is able to identify the grids and its cells.

C. Segmentation

It required a sub-module, that perform segmentation into five individual numerals. Segmentation algorithm starts by performing a Bounding Box Analysis (BBA) to identify the ROIs and verify each of the cells contains a number.

D. Feature Extraction

In this HOG descriptor is used for the computation, where the cell size and block size were set as 8*8 and 16*16 respectively.

E. Classification

It is the reasoning part of the system. The CNN+SVM model receives the raw image as input on CNN structure. The feature in the fully- connected layer are given to the SVM classifier. The feature from the CNN fully-connected layer are obtained through a very different process than HOG descriptor. It led the SVM classifier, resulting HOG+CNN+SVM model. These models produce an output vector, that will sent to a multi-stage matching system. If there is any no matching output of the more accurate model, one is set into a list of no-matching numbers that will proceed to the next most accurate model and attempt to perform the match producing another no-matching list. This process continues for the next models or until there are no no-matching number or the output vector has passed through the four models.

2.1: System Requirements

A) Software Requirements

Environment: Android studio 8.0

Operating System: Windows 8.1

Language: JAVA

Application: Android Application

Front End: Android studio 8.0

B) Hardware Requirements

Processor: Intel Core i3

RAM: 4 GB

Hard Disk Drive: 1 TB

2.2: Development Tools

A) Android Studio

It is one of the integrated development environment (IDE) for Android application development. Android studio help to develop Android app and games. With the support for Google Cloud Platform and Google app integration, Android Studio offers developers a well-stocked toolkit for creating Android apps. Andriod studio is a platform that have mainly three layers such as OS, Middle layer, Application keys. Gradle helps in the configuration of the application with ease. It also check that there are no bugs in the code.

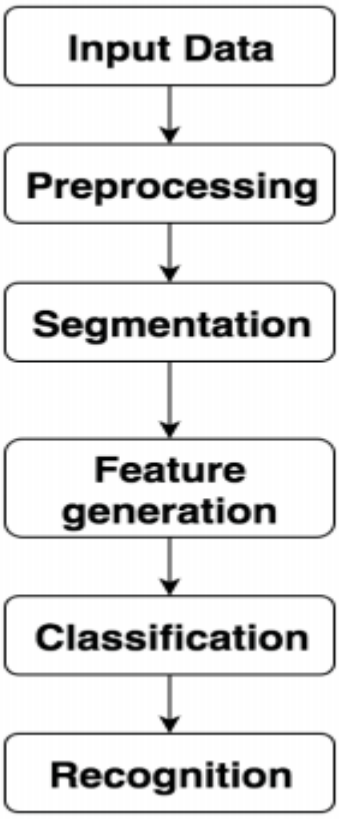

Fig -1: Recognition

3. CONCLUSIONS

Handwritten character recognition is not a trivial task. Many factors such as calligraphy between writers, Strictness of writing and raw image resolution. Sloppiness on the writing of some numerals, the placement of the numbers on unexpected regions and the image resolution are the main issues. After analysing the results of each model, it is remarkable that their accuracy depends not only of the sloppiness of the writing but also of the classes of numerals. As a conclusion from the performance of the classifiers receiving HOG features and/or features from the fully-connected layer of the CNN, CNN provides a better diversity of features than the features extracted by HOG. This fact lead us to the assumption that the process of feature extraction of the CNNs, maps more details from the raw image producing robust features that can provide more accurate results for sloppy cases, than the HOG features.

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