

Handwritten Character and Digit Recognition Using Convolutional Neural Network

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Abstract: *The necessity for quick and precise content section on little handheld PCs has prompted a resurgence of interest in on-line word recognition utilizing counterfeit neural Networks. Old style strategies are consolidated and improved to give strong recognition of hand-printed English content. The focal idea of a neural net as a character classifier gives a legitimate base to are cognition framework; long-standing issues comparative with preparing, speculation, division, probabilistic formalisms, and so forth, need to settled, notwithstanding, to instigate astounding execution. assortment of developments in a manner to utilize a neural net as a classifier in a very word recognizer are introduced: negative preparing, stroke twisting, adjusting, standardized yield blunder, mistake accentuation, numerous portrayals, quantized loads, and incorporated word division all add to effective and hearty execution.*

Keywords: Handwritten Character Recognition (HCR), Neural Network, Characters, Digits, Segmentation.

I. INTRODUCTION

The new presentation of minimal effort compact pen-based PCs, (for example the "Personal Digital Assistant" or PDA classification) has concentrated on viable enhancements in Handwritten Character Recognition (HRS). This moves towards computerized pointer for composing gives more data, similar to pen stroke, pressing factor and speed of composing. HRS has been read for almost forty years and there are numerous unprecedented proposed approaches. In coming days, character recognition framework may work a vital factor to make a paperless climate by digitizing and handling existing paper records. Along these lines, for example, you might be prepared to take advantage of a book field with the pointer, hand compose a message to somebody or compose records, have it naturally changed over to an all the more effectively decipherable typewritten text, thus send it. the trouble is very complex, and surprisingly as of now there's no single approach that disentangles it both successfully and absolutely on the whole settings. In Handwritten Character, a picture containing text should be fittingly given and pre-processed. Then, the substance ought to be by the indistinguishable symbolic bear division or feature extraction. Minimal took care of pieces of the substance will be the outcome, and these should go through recognition by the system [1]. Finally, pertinent information ought to be applied to the apparent pictures to confirm the outcome. Convolutional Neural Networks (CNN), applied in Handwritten Character, mull over high hypothesis limit and don't require significant establishment data and formalization to possess the decision to require care of the created language Character issue.

The basic objective of this paper is to make up a gainful physically composed character and digits Character system for English characters dependent on CNN. The physically composed characters may contain mix case (capital and little letter sets) of English characters so 52 cases (26 for capital and 26 for little) are associated with this examination for the portrayal. To zero in our work on a subproblem that is adequately manageable to guide to usable undertaking in an entirely sensible time, we've chosen to restrict the space to hand-printing, so character-level division is normally prompted by a pen lift. The CNN gives an incredibly decent exactness of more than 95%. rest of the paper is composed as given in layout beneath.

II. PROBLEM STATEMENT

One thing which separates the people from different creatures is its inconceivable pace of advancing in order to be told and discover new ways and philosophies. we have come reserved from our base precursors at this point one thing hasn't changed bounty, our method of taking note of down data on an actual medium. On the off chance that we continue to utilize this crude strategy of pen and paper, we will not have the option to progress into the since quite a while ago run with our maximum capacity. With the forthcoming computerized upset, why not additionally change our methods of taking note of data with the help of cutting-edge ideas like Convolutional Neural Network.

This undertaking proposes to frame a Convolutional Neural Network which can have the adaptability to peruse Manually written Characters and Digits as an info picture. When info picture of character is given to proposed framework, at that point it'll perceive input character or digit which is given in picture. Character and grouping of characters are finished by a variety of Neural layers. the most point of this undertaking is to successfully perceive a chosen character or digit of type design utilizing the Convolutional Neural Network approach and show it in light of the fact that the yield [2].

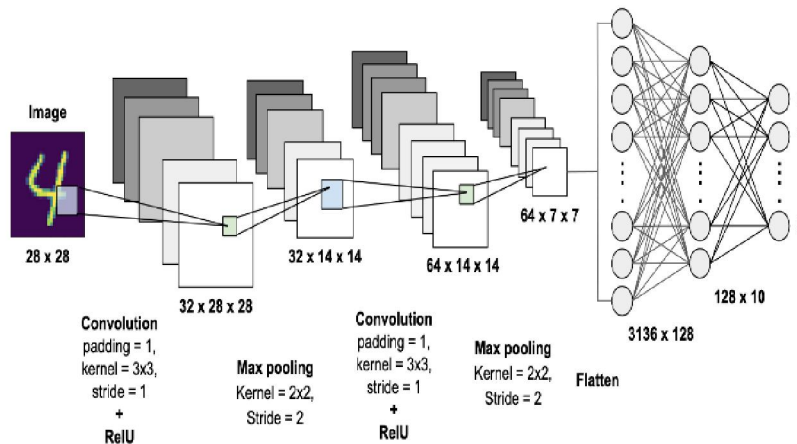


Figure 1: General overview of implementation of CNN

III. LITERATURE SURVEY

We propose another Written by hand Character method that utilizes numerical features of letters. The paper figures out how to perceive isolated interpreted characters using a Cognitive neural association. The characters are formed on a standard piece of paper using a pen, and thereafter they're gotten optically by a scanner and prepared to an equal picture which is taken apart by a PC. during this paper we present that new technique for HCR and also depict our investigation and tests performed on the neural Network.

Handwritten substance stays an open investigation inside the space of Optical Character Recognition (OCR). This paper proposes a capable system towards the advancement of translated content recognition structures. 3-layer Covolutional Neural Network (CNN) is utilized during this paper using directed learning approach. 55 examples of each English letter set are used as a CNN getting ready measure to ensure the overall relevance of structure towards new information sources. Two different learning estimations are used in this paper. Hand-composing Character ecognition (CR) has been broadly concentrated inside the second 50 years and favorable to gressed to A level adequate to give innovation driven applications. Presently, the quickly developing computational force empowers the execution of the current CR strategies and encourages an expanding interest on many arising application spaces, which require further developed procedures. In this paper writer has proposed framework is to effectively perceive the disconnected written by hand digits with the following precision than past works done. Additionally past written by hand number recognition frameworks are upheld just perceiving single digits and that they don't appear to be equipped for perceiving numerous numbers at just once. So the writer has zeroed in on effectively performing division for disengaging the digits.

In this paper writer has proposed framework is to proficiently perceive the disconnected manually written digits with the following precision than past works done. Likewise past Handwritten number recognition frameworks are upheld just perceiving single digits and that they don't appear to be fit for perceiving different numbers at only one occasion. So the creator has zeroed in on effectively performing division for disengaging the digits.

The paper will depict the best way to deal with ask very 90% precision inside the field of Handwritten Character Recognition (HCR). There are many examination depleted the area of HCR yet at the same time it's an open issue as we are as yet ailing in getting the best precision. during this paper, the disconnected written by hand character recognition are finished utilizing Convolutional neural Network and Tensorflow. a procedure called Delicate Max Relapse is utilized for appointing the prospects to manually written characters being one among the few characters since it gives the qualities somewhere in the range of 0 and 1 summary to 1. the point is to build up the product with a terribly high exactness rate and with negligible existence intricacy and furthermore ideal.

IV. HARDWARE AND SOFTWARE REQUIREMENT

4.1 Programming Languages

- a. Python is a deciphered, significant level and broadly useful programing language. Python's plan reasoning stresses code meaningfulness with its eminent utilization of incredible whitespace. Its language builds and item situated methodology mean to help software engineers compose clear, intelligent code for nearly nothing and enormous scope projects. Python is progressively composed and trash gathered. It upholds numerous programming standards, including organized (especially, procedural), object-situated, and practical programming. Python is normally portrayed as a "batteries included" language due to its extensive standard library.
- b. C++ might be a broadly useful programing language made by Bjarne Stroustrup as an expansion of the C fake language, or "C with Classes". The language has extended altogether after some time, and current C++ presently has object-situated, conventional, and utilitarian highlights furthermore to offices for low-level memory control. it's almost consistently carried out as an arranged language, and bunches of sellers give C++ compilers, including the Free Programming Establishment, LLVM, Microsoft, Intel, Prophet, and IBM, so it's accessible on numerous stages.

4.2 Libraries

- a. OpenCV (Open Source PC Vision Library) is an open source PC vision and AI programming library. The library has very 2500 advanced calculations, which has an extensive arrangement of both class and cutting edge PC vision and AI calculations. These calculations might be wont to distinguish and perceive faces, recognize objects, group human activities in recordings, track camera developments, track moving articles, extricate 3D models of items, produce 3D point mists from sound system cameras, join pictures together to supply a high-goal picture of a total scene. It has C++, Python, Java and MATLAB interfaces and supports Windows, Linux, Android and Macintosh operating system. OpenCV is composed locally in C++ and envelops a templated interface that works consistently with STL holders.
- b. NumPy is Quick and flexible, the NumPy vectorization, ordering, and broadcasting ideas are the true guidelines of cluster figuring today. NumPy offers complete numerical capacities, arbitrary number generators, polynomial math schedules, Fourier changes, and the sky is the limit from there. NumPy upholds a huge scope of equipment and processing stages, and plays well with disseminated, GPU, and inadequate cluster libraries.
- c. Shark is a quick, measured, highlight rich open-source C++ AI library. It gives strategies to straight and nonlinear improvement, part based learning calculations, neural Networks, and different other AI procedures. It is a vigorous tool stash for world applications furthermore with respect to investigate. Shark chips away at Windows, MacOS X, and Linux. It accompanies broad documentation. Shark is authorized under the GNU Lesser Overall population Permit.
- d. MLPack is a AI programming library for C++, based on top of the Armadillo library. MLPack has a weight on adaptability, speed, and usability. Its point is to frame AI feasible for amateur clients through a clear, reliable Programming interface, while at the same time abusing C++ language highlights to deliver greatest execution and most extreme adaptability for master clients. Its proposed target clients are researchers and specialists. it's open-source programming conveyed under the BSD permit, making it valuable for creating both open source and restrictive

programming. Deliveries 1.0.11 and before were delivered under the LGPL permit. The task is upheld by the Georgia Foundation of Innovation and commitments from round the world.

- e. TensorFlow is an free and open-source programming library for AI. It is utilized across an assortment of errands however includes a specific focus on preparing and derivation of profound neural Networks. TensorFlow offers various degrees of deliberation so you'll pick the right one for your necessities. On the off chance that you wish greater adaptability, anxious execution takes into account quick cycle and natural troubleshooting. for goliath ML preparing undertakings, utilize the Appropriation Methodology Programming interface for conveyed preparing on various equipment arrangements without changing the model definition.
- f. Pandas is a product library composed for the Python fake language for information control and examination. especially, it offers information constructions and tasks for controlling mathematical tables and measurement. it's free programming delivered under the three-condition BSD permit. The name comes from the expression "board information", an econometrics term for informational indexes that incorporate perceptions throughout various time spans for the indistinguishable people. Its name might be a play on the expression "Python information examination" itself. Wes McKinney began building what might become pandas at AQR Capital while he was a specialist there from 2007 to 2010.
- g. Matplotlib is a plotting library for the Python programing language and its mathematical science expansion NumPy. It gives an item situated Programming interface to installing plots into applications utilizing broadly useful GUI tool compartments like Tkinter, wxPython, Qt, or GTK+. there's additionally a procedural "pylab" interface upheld a state machine (like OpenGL), intended to intently take after that of MATLAB, however its utilization is debilitate. SciPy utilizes Matplotlib. Matplotlib was initially composed by John D. Tracker, from that point forward it's an enthusiastic advancement local area, and is appropriated under a BSD-style permit. Michael Droettboom was assigned as matplotlib's lead designer quickly before John Tracker's demise in August 2012, and further joined by Thomas Caswell.
- h. Pillow is a free and open-source extra library for the Python programing language that adds support for opening, controlling, and saving numerous elective picture document designs. it's accessible for Windows, Macintosh operating system X and Linux. the most current adaptation of PIL is 1.1.7, was delivered in September 2009 and upholds Python 1.5.2–2.7, with Python 3 help to be delivered "later". Improvement seems, by all accounts, to be suspended, with the last endeavor to the PIL archive coming in 2011. Therefore, a replacement project called Pad has forked the PIL store and added Python 3.x help. This fork has been received as a swap for the underlying PIL in Linux disseminations including Debian and Ubuntu (since 13.04).

4.3 Other Software

- a. Keras might be a Straightforward, Adaptable and Amazing Programming interface intended for friends and relatives, not machines. Keras follows best practices for lessening intellectual burden: it offers steady and straightforward APIs. It limits the measure of client activities needed for normal use cases, and it gives clear and significant blunder messages. Pip could be a bundle the executives framework written in Python wont to introduce and oversee programming bundles. It interfaces with a web storehouse of public and paid-for private bundles, called the Python Bundle Record. Most appropriations of Python incorporate pip preinstalled. Python 2.7.9 and later (on the python2 arrangement), and Python 3.4 and later incorporate pip (pip3 for Python 3) as a matter of course.
- b. Project Jupyter might be a philanthropic association made to "create open-source programming, open-principles, and administrations for intelligent processing across many programming dialects". Venture Jupyter's name might be a respect to the three center programming dialects upheld by Jupyter, which are Julia, Python and R, and furthermore a praise to Galileo's journals recording the creation of the moons of Jupiter. Undertaking Jupyter has created and upheld the intelligent processing items Jupyter Journal, JupyterHub, and JupyterLab.

4.4 Data Sets

Modified National Institute of Standards and Technology (MNIST) is a enormous arrangement of PC vision dataset which is broadly utilized for preparing and testing various frameworks. it totally was made from the 2 exceptional

datasets of Public Organization of Norms and Innovation (NIST) which holds double pictures of handwritten digits. The preparation set contains written by hand digits from 250 individuals, among them half preparing dataset was workers from the position and furthermore the rest of it totally was from highschool understudies. Be that as it may, it's regularly ascribed in light of the fact that the first datasets among other datasets to demonstrate the viability of the neural Networks

The information base contains 60,000 pictures utilized for preparing further as not many of them is utilized for cross-approval purposes and 10,000 pictures utilized for testing. Every one of the digits are grayscale and situated during a fixed size where the power lies at the center of the picture with 28×28 pixels. Since every one of the photos are 28×28 pixels, it frames an exhibit which might be smoothed into $28 \times 28 = 784$ -dimensional vector. Every part of the vector could be a double worth which portrays the force of the pixel.

V. BLOCK DIAGRAM

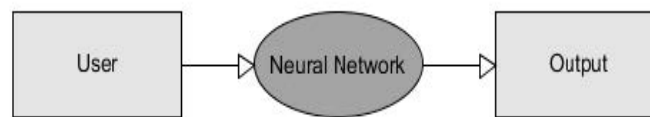


Figure 2: Block Diagram 1

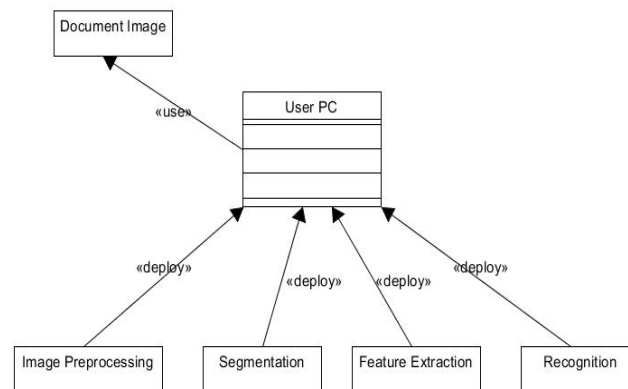


Figure 3: Block Diagram 2

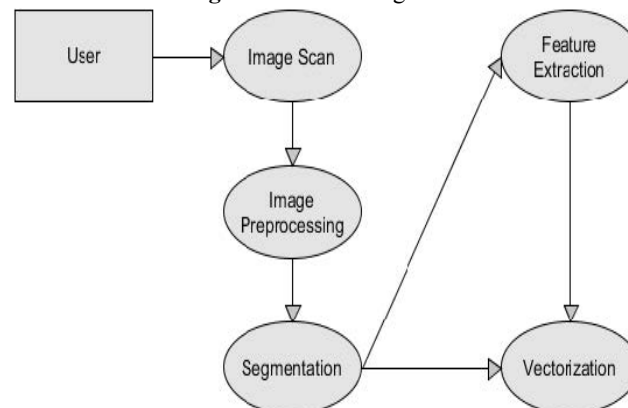


Figure 4: Block Diagram 3

VI. IMPLEMENTATION

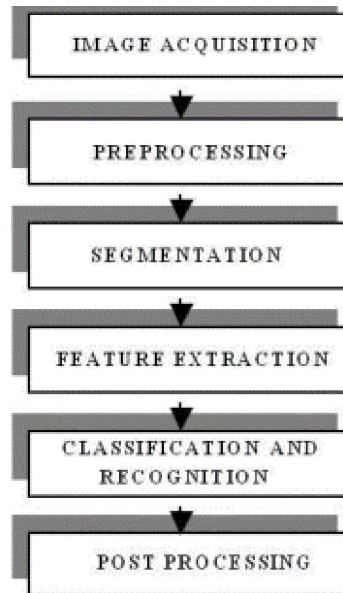


Figure 5: Implementation flow

5.1 Image Acquisition

In Image acquisition, the prominence framework secures an examined picture as an information picture. The picture ought to have a specific organization like JPEG, BMT and so forth This picture is procured through a scanner, camera or the other appropriate advanced information input gadget [3].

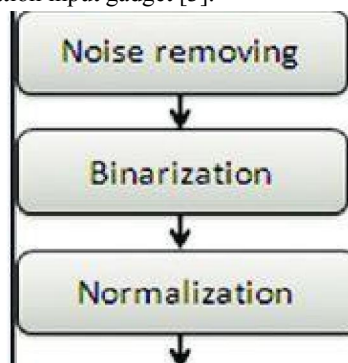


Figure 6: Image Acquisition inner processes

5.2 Pre-processing

A. Gray Scale

A picture is an exhibit, or a lattice, of square pixels (picture components) organized in segments and lines. In an (8 digit) dim scale picture every pel has a doled-out force that goes from 0 to 255. A dim scale picture is the thing that individuals ordinarily call a highly contrasting picture, however the name accentuates that such an image will in-enlightened numerous shades of dark. a standard dim scale picture has 8-digit shading profundity 256 dark scales. A "real nature pictures 24-bit shading profundity $8 * 8 * 8$ pieces $256 * 256 * 256$ tones = 16 million tones. Some dark scale pictures have more dim scales, for instance 16 cycle = 65536 dim scales. There are two general gatherings of pictures: vector illustrations (or line craftsmanship) and bitmaps (pixel based or pictures) [3].

B. Thinning

Thinning calculation could be a Morphological activity that is acclimated eliminate chosen front ground pixels from paired pictures. It protects the geography (degree and availability) of the underlying area while relinquishment the greater part of the primary closer view pixels.

5.3 Segmentation

The segmentation is that the most fundamental a piece of the preprocessing technique. It makes us conceivable to extricate every last detail of each different character. Line is extricated trailed by character extraction. The double picture is filtered start to finish and amount of column pixels is determined. In the event that entirety is 0, line is removed. Also, for character is extricated if amount of segment pixels is 0. The picture is filtered from left to appropriate for character extraction [6].

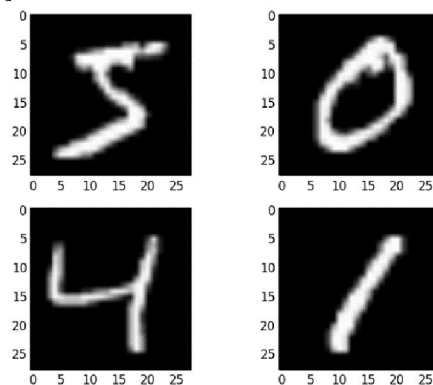


Figure 7: Segmentation on Handwritten digits

5.4 Feature Extraction

In pattern recognition in image processing, Feature extraction might be an extraordinary sort of dimensionality decrease. At the point when the information document to a calculation is simply too huge to possibly be handled and it's suspected to be famously excess (much information, however very little data) at that point the information record will be changed into decreased portrayal set of highlights (additionally named include vector). Changing the information record into the arrangement of highlights is named highlights extraction [5].

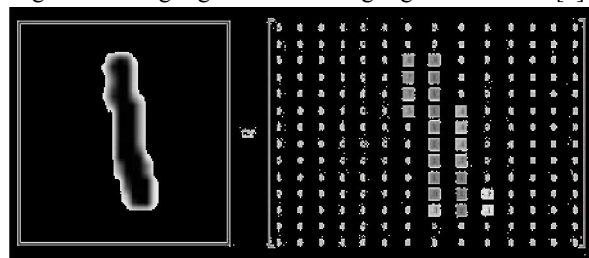


Figure 8: Feature Extraction process

5.5 Classification and Recognition

The decision making is done inside the order stage. For perceiving the characters, the extricated highlights are utilized. Various classifiers like SVM and Neural Networks are utilized. The classifiers sort the given info include withheld example and track down the best coordinating with class for input, that Delicate Max Relapse is utilized [4]. Soft Max regression assigns the probability to each result thus classification becomes easy. It basically first adds up all the evidences it gets by the below formula and then convert that into the possible probabilities.

$$\text{evidence}_i = \sum_j W_{i,j} x_j + b_i$$

Figure 9: Softmax Function

Here, weights and bias are denoted by W_i and b_i respectively for the class i , and j denoted by summing over the reserved pixels in the input image x . We translate the proof of the tallies into the evaluated probabilities 'y' using the "SoftMax" which is an activation or link function, $y = \text{softmax}(\text{evidence})$. Now for converting the probabilities of input being in any of the defined class, $\text{Softmax}(x) = \text{normalize}(\exp(x))$.

5.6 Post-processing

The last and last period of the character recognition is that the Post-processing. it's the methodology for amending the misclassified yield by utilizing semantic correspondence. It measures yield by getting it after the structure are perceived. On the off chance that the structure is perceived absolutely, the exactness will be improved as per the information on language [4]. Shape Recognizers carry on diversely for different Handwritten input. For the trivial few, it prompts an individual characters of string while additionally remembering a few quantities of substitutes for second case, by remembering the proportion of certainty for each other option.

VI. CONCLUSION

As the technology is advancing, the ways of communicating between human beings and computers are also changing. The speech and handwriting recognition are among novel methods of exchanging ideas or information between computers and its users. Handwriting recognition can be both offline and online. We are hopeful for the upcoming future.

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REFERENCES

- [1]. Isha Vat and Shamandeep Singh, "Offline Handwritten English Numerals Recognition using Correlation Method" International Journal of Engineering Research and Technology (IJERT): ISSN: 2278-0181 Vol. 3 Issue 6, June 2014.
- [2]. Rahul Kala, Harsh Vazirani, Anupam Shukla and Ritu Tiwari. "An Overview of Character Recognition Focused on Off-Line Hand-writing", IEEE Transactions on Systems, Man and Cybernetics part application and re-views, Vol. 31, NO. 2, May 2001.
- [3]. Wojciech Kacalak & Maciej Majewski, "Handwriting Recognition Methods using Artificial Neural Networks", pp 27 April 2015.
- [4]. IA Ahmed Mahdi Obaid, IIA Hazem M. El Bakry, IIIM.A. Eldosuky, IVA.I. Shehab, "Handwritten Text Recognition System Based on Neural Network", International Journal of Advanced Research in Computer Science & Technology (IJARST 2016), pp Vol. 4, Issue 1 (Jan. - Mar. 2016).

- [5]. Megha Agarwal, Shalika, VinamTomar, Priyanka Gupta, “Handwritten Character Recognition using Neural Network and Tensor Flow”, International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8, Issue- 6S4, April 2019.
- [6]. J.Pradeep1, E.Srinivasan2 and S.Himavathi3, “Diagonal based Feature Extraction for Handwritten Alphabets recognition system using Neural Network”, International Journal of Computer Science & Information Technology (IJCSIT), Vol 3, No 1, Feb 2011