Lecture Notes in Networks and Systems 517

Simon Fong
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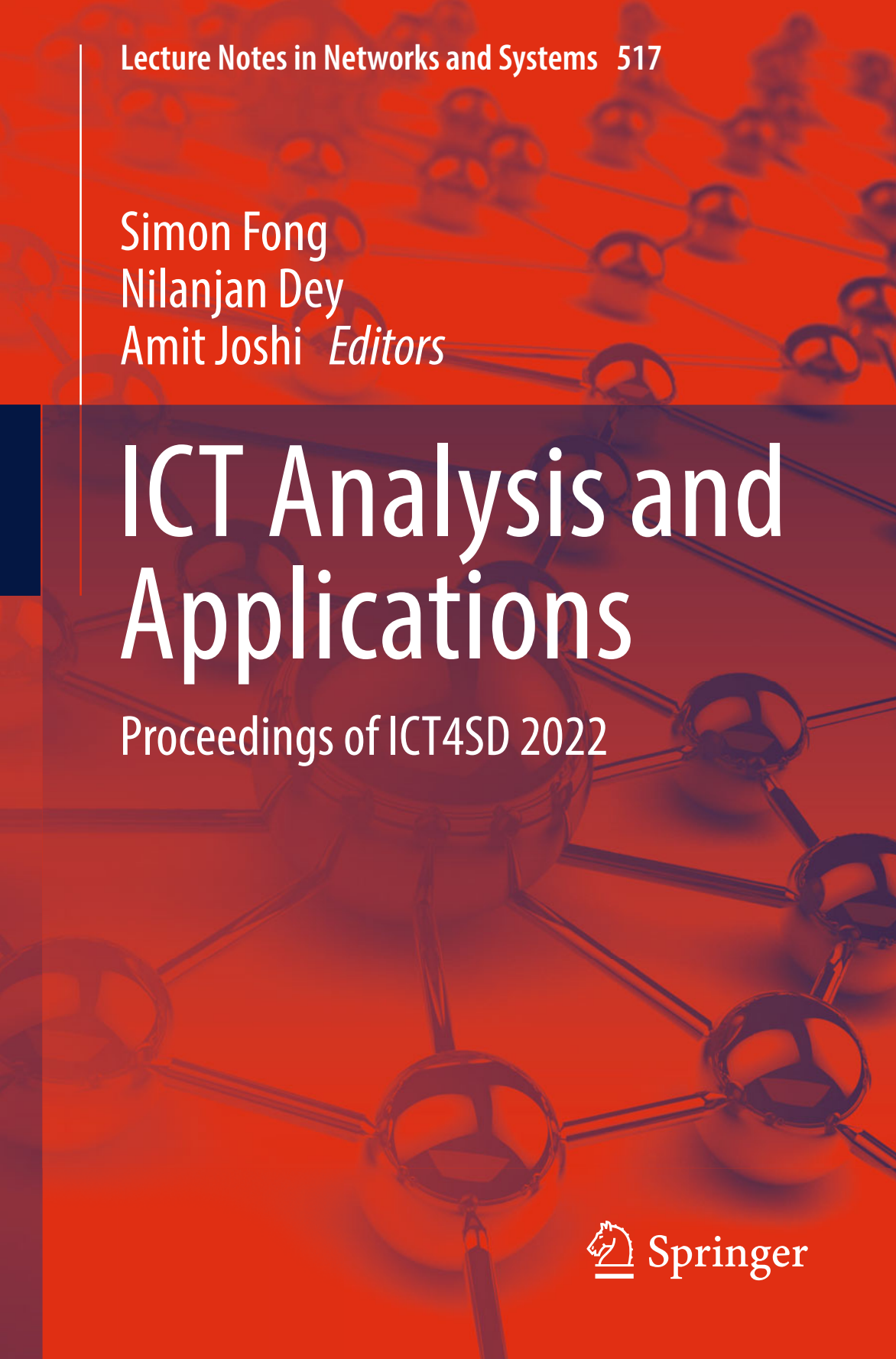
ICT Analysis and Applications

Proceedings of ICT4SD 2022



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Editors

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ISSN 2367-3370 ISSN 2367-3389 (electronic)
Lecture Notes in Networks and Systems
ISBN 978-981-19-5223-4 ISBN 978-981-19-5224-1 (eBook)
https://doi.org/10.1007/978-981-19-5224-1

Preface

The Seventh International Conference on ICT for Sustainable Development (ICT4SD 2022) targets theory, development, applications, experiences and evaluation of interaction sciences with fellow students, researchers, and practitioners.

The conference is devoted to increasing the understanding role of technology issues and how engineering has day by day evolved to prepare human friendly technology. The conference will provide a platform for bringing forth significant research and literature across the field of ICT for sustainable development and provide an overview of the technologies awaiting unveiling. This interaction will be the focal point for leading experts to share their insights and provide guidance and address participant's questions and concerns.

The conference will be held on July 29–30, 2022, at Hotel Vivanta by TAJ, Panaji, Goa. The conference is organized by Global Knowledge Research Foundation, Supporting Partner InterYIT, International Federation for Information Processing, State Chamber Partner Goa Chamber of Commerce and Industry, and National Chamber Partner Knowledge Chamber of Commerce and Industry.

Research submissions in various advanced technology areas were received and after a rigorous peer review process with the help of program committee members and 193 external reviewers for 1200+ papers from 25 different countries including Algeria, United States, United Arab Emirates, Serbia, Qatar, Mauritius, Egypt, Saudi Arabia, Ethiopia, Oman, out of which 225 were accepted with an acceptance ratio of 0.19. These will be presented in 30 parallel sessions in two days organized physically and virtually including 1 inaugural and 1 keynote session.

Technology is the driving force of progress in this era of globalization. Information and communication technology (ICT) has become a functional requirement for the socio-economic growth and sustained development of any country. The influence of information communications technology (ICT) in shaping the process of globalization, particularly in productivity, commercial, and financial spheres, is widely recognized. The ICT sector is undergoing a revolution that has momentous implications for the current and future social and economic situation of all the countries in the world. ICT plays a pivotal role in empowering people for self-efficacy and how it can facilitate this mission to reach out to grassroots level. Finally, it is concluded

that ICT is a significant contributor to the success of the ongoing initiative of Startup India.

In order to recognize and reward the extraordinary performance and achievements by ICT and allied sectors and promote universities, researchers and students through their research work adapting new scientific technologies and innovations. The two days conference had presentations from the researchers, scientists, academia, and students on the research work carried out by them in different sectors.

The conference has invited eminent dignitaries including Shri. Nitin Kunkolienker, President, MAIT, Prof. Mike Hinchey, President, IFIP, Dr. Milan Tuba, Vice Rector for International Relations, Singidunum University, Serbia, Prof. Jagdish Bansal, India, Mr. Aninda Bose, Springer Nature, and Dr. Amit Joshi, Director, G R Foundation.

Taipa, Macao — Simon Fong
Kolkata, India — Nilanjan Dey
Ahmedabad, India — Amit Joshi

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Recognition of Struck Out Words Using a Deep Learning Approach

Varsha Naik, Ahbaz Memon, Abhishek Chebolu, Prajakta Chaudhari, and Snehalraj Chugh

Abstract Handwritten document contains a lot of unreadable texts or elements which have no meaning such as struck out words or characters. If such words are fed into a handwriting recognition system, there can be a drop in the accuracy of the system, and it may result into predicting false words. In this paper, we propose an approach to detect these struck out words. With the help of CNN model, we train the model to recognize and differentiate the normal words from the struck out words. For this purpose, some common types of struck out strokes were handled. In order to obtain a handwritten text free of these words, this method may identify strike-through text, locate the word/character, and erase these words. The model was trained on a set of English words and characters that we generated, and it was then put to the test on a range of texts that contained words that had been struck out. The experimental results demonstrate the accuracy of the proposed approach, where the models achieved accuracy levels of 100%.

Keywords Optical character recognition (OCR) · Image classification · Convolution neural network · Struck out words · Handwritten document

1 Introduction

Handwriting recognition has caught the interest of researchers for quite some time. The development of innovative handwriting recognition systems has been made possible by technological advancements in computer architecture, as well as other scientific research developments. Optical character recognition (OCR) is a technique for identifying and recognizing text in images [1]. This process converts the textual data contained in the image into a machine-readable format. It converts the pixel representation of a letter into the character representation that corresponds to that letter. It is a machine that simulates the act of reading. Because of this, OCR of printed text is considered to be a less difficult hurdle to overcome than OCR of handwritten

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S. Fong et al. (eds.), *ICT Analysis and Applications*, Lecture Notes in Networks and Systems 517, https://doi.org/10.1007/978-981-19-5224-1_59

text [2] because of the fact that the process can encounter a range of challenges in order to achieve the desired results. The handwritten texts are bound to contain errors or unnecessary elements that can hinder the model's outcomes [3]. The most common of these errors in handwriting is the part of the text that has been struck out or scratched out of the text. When we humans write a word or some content on a page by mistake, we normally scratch or strike-through it to delete it from the page. Due to the fact that it is dependent on the person who wrote the text, every person can strike out in a different ways, such as using crossed-out lines, wavy lines, completely blacked out words, single lines, multiple lines, slanted lines, zig-zag lines, and so on [4]. According to the researchers, the accurate detection of struck out words will aid in a better understanding of handwritten documents [5]. Other types of errors can be reduced by using an image processing techniques. In order to avoid erroneous output, it is essential that the struck out words are handled with care. The paper is divided into five major sections, starting with the literature survey section where we have studied various papers with the implementation of processing of struck out words. Then, in the methodology section, we describe our process and model for the recognition of the struck out words. The numerous applications of the detected words have been described in the applications section of the paper. In the results section, we have noted down the results we obtained from our classification model. The paper concludes with the discussion of the future scope of our study in our conclusion section.

2 Literature Survey

Numerous papers on struck out text processing have been published in recent years [6] has proposed a graph-based model for the representation of a textually connected component in the form of a graph. If the shortest path exists which is almost as long as the text component's width and maintains a reasonable degree of straightness, it is designated as the strike-through line. The accuracy obtained is 98.2% when determining whether a component is strike through. This model dealt with documents written in English, Bengali, and Devanagari scripts.

In the paper [7], the author proposed the use of a two-class HMM-based classifier to distinguish between the words that were struck out and the rest of the words. They examined common properties and characteristics of noisy writing in this paper, using Bangla online handwritten words. Adak and Chaudhuri [6] reports an overall F-measure of 82.02% for identifying strike-through strokes. However, that work detects only strike-through straight lines, whereas [6] considers all types of overwriting, crossing out, and repetition detection, obtaining an F-measure of 71.48%.

The paper [5] has analyzed the effects of strike-through text on writer identification. Writer identification can be viewed as a classification problem in which the objective is to identify a writer from a set of n writers given a sample of handwriting. The paper demonstrates that the presence of struck out texts impairs the ability to identify the writer. For detection, a CNN-SVM hybrid model is used. The results

indicate that they achieved a 98.85% (98.54%) F-Measure for struck out text detection on English (Bengali) handwriting while testing on their generated database. It was observed that the F-measure dropped in the presence of struck out words by 5.43% (4.92%).

In his proposal [8], Alex Shonenkov mentions one of the applications that can be used to strike-through words on handwritten pages. They have proposed a model that generates a person's handwriting from character images that are present in the training dataset. They have attempted to improve the accuracy of handwritten text recognition models by data augmentation. Their proposed system not only generates handwritten text but also stimulates the strike-through characters to the greatest extent possible, making them as close to the originals as possible. In terms of drawing lines that strike out the characters, it has the ability to alter their inclination, size, and transparency.

3 Methodology

3.1 Dataset

In order to carry out the experiment, we required a database of handwritten documents that contained text that had been struck out [9]. As an alternative to using a publicly available dataset, we decided to go ahead and generate our own dataset because we needed a sufficient number of handwritten samples from writers for both training and testing purposes for this research. Consequently, it was necessary to create a new database containing various types of struck-through text in order to deal with the situation. It was requested of the writer that he or she strikes out some words in their running handwriting styles.

There was a total of 500 words collected for each of the two classes, struck out words and normal words, where the struck out words can be seen in Fig. 1. We also increased the dataset size by augmenting the data. When data are augmented, it is advantageous because it improves the performance and outcomes of models by generating new and different examples for train datasets. For each class, a total of 200 images were augmented. The total number of struck out words and the total number of normal words were 700 and 700, respectively.

3.2 Convolutional Neural Network [CNN]

Convolutional neural networks (CNNs), abbreviated as ConvNets, have a deep feed-forward architecture and a remarkable ability to generalize more than networks with fully connected layers [10]. An important distinction between CNNs and ANNs is that CNNs have been extensively used in the field of image recognition, whereas

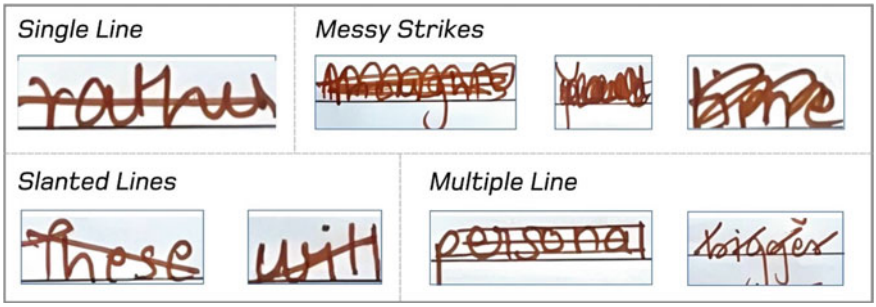

Fig. 1 Different types of struck out words handled in our dataset

ANNs have been used in the field of textual data [11]. The ability to encode image-specific features into the architecture makes the CNN more suited for image focused tasks while also further reducing the number of parameters required to set up the model is a significant advantage.

CNNs are fundamentally based on the presumption that the input will be composed of images. In general, there are three types of layers in CNN's architecture. Convolutional, pooling, and fully connected layers are the types of layers used in CNN Fig. 2. The convolution layers are a collection of convolutional filters or kernels that are used to create the final output [10]. These filters are applied to the input image, which is expressed as N-dimensional metrics, in order to generate the output feature map. The goal of the pooling layer is to reduce the dimensionality of the feature map as it is built up. Each CNN architecture has a fully connected layer at the end of it. Each neuron in this layer is connected to every neuron in the layer before it, forming a network. It is used as the CNN classifier, among other things. Following flattening, this input is in the form of a vector, which is generated from the feature maps that were used to create it. The output of the FC layer corresponds to the final CNN output, which is in the form of a vector created from the feature maps after flattening. The output of the FC layer represents the final CNN output.

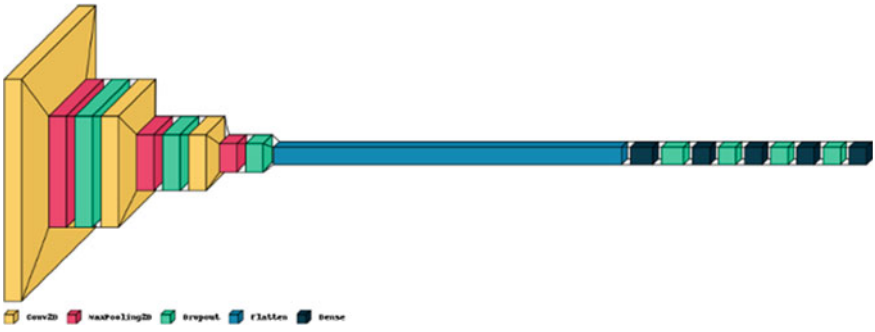

Fig. 2 CNN model architecture

Our dataset consists of images with words and characters, so it was essential to choose a model that would help in handling the data and provide better results. As we discussed, CNNs provide us with an advantage when the dataset comprises of images. We experimented and narrowed down our model for efficient training with the help of CNN architecture. For the training phase, words are extracted from the pages of various writers and label them as normal or struck out. These samples were provided as input to our CNN-based binary classification model [3]. The model is saved so that it can be tested in the future and used for real-time applications. During the testing phase, the extracted words are provided as input to the saved model, which is then used to predict and distinguish the normal words from the crossed-out words. The words that have been crossed-out can either be deleted or used in other applications in the future. This will be discussed extensively in the application section.

4 Applications

Even though the struck out words appear to be meaningless, they can help us achieve a variety of results [12]. In addition to removing the struck out words, our model improves the accuracy of our primary task, handwritten character recognition. After addressing the primary issue of accuracy loss, we can now discuss the potential applications of these struck-through words and how they can help us in various ways.

These words can be used in many ways such as

- They can be used to investigate the patterns and types of strokes used by the writer in order to gain a better understanding of his or her behavior. These cancelled out words or different types of strokes [13] essentially convey the thought process that a writer went through while writing the page in question.
- Using these words, we can figure out which word the author removed or deleted from his or her work. Obtaining this can be accomplished by unmasking the struck out lines from the word and recognizing the characters concealed behind the strike line [14]. A lot of questions, such as which words were misspelled and was the author writing something completely different from the context of his previous words, can be answered.
- Automatically generating handwritten text images is a currently prevalent discussion. The models used for this purpose attempt to replicate human handwriting [15] in order to make it appear more human-like rather than computer generated. It makes use of a dataset that contains the characters and words of an existing author. Because it is important for the generated text to appear genuine and not machine simulated, it is also possible to generate the strike-through words to make it appear more realistic.

Table 1 Classification report

	Precision	Recall	F1-Score
Struck out words	1.00	1.00	1.00
Non-struck out words	1.00	1.00	1.00
Accuracy			1.00
Macro average	1.00	1.00	1.00
Weighted sverage	1.00	1.00	1.00

5 Results

This paper examines the classification of words that have been struck out using a deep learning approach. The CNN architecture is being used as a deep learning model in this study. In order to achieve this accuracy, we trained the CNN architecture from scratch on the dataset we generated. We performed resizing on all of the images to the same height and width because CNN accepts images of the same size. We used 80% of our generated database for training purposes and 20% for testing purposes Table 1. The Adam optimizer was used to train the CNN, and sparse categorical cross-entropy was used as the loss function. Accuracy, recall, the f1-score, and precision are some of the commonly used performance measures that we took into consideration when evaluating the performance of our approach. The previously mentioned model and dataset were used to obtain the results of the above measures. The figure shows that we were successful in achieving a precision and recall of 100% Table 1.

6 Conclusion and Future Scope

In this paper, we discussed the automatic detection of struck out words from English handwriting. These words present a challenge for handwritten text recognition, especially when dealing with complex texts we discussed above, this approach can identify strike-through texts and delete the strike to produce a text that is free of errors. We have tested our model on the English language. Using our CNN model, we were able to achieve an excellent accuracy of 1.0.

In the future, we want to focus on putting the applications into practical methods. If we understand why the writer has crossed-out the word and how the writer has crossed-out the word, the applications listed can provide us with valuable insight into the writer of the document. We can deduce the person's state of mind, while they are writing the page by examining these characteristics. Aside from that, we want to broaden the scope of our model by allowing it to learn on a variety of different languages since each language has its own set of characteristics.

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