Evaluation of Spell Correction on Noisy OCR Data

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Agenda

Motivation

Problem Description

Related Work

Solution Framework

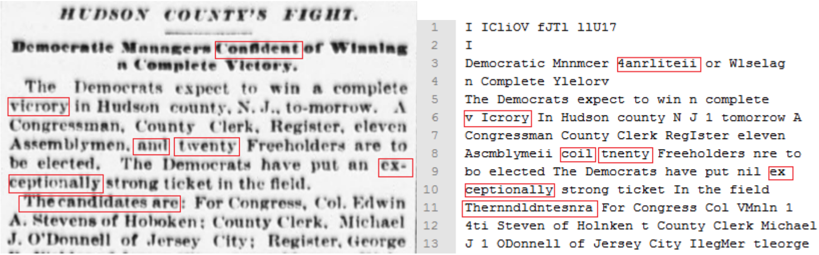
- Data Gathering
- Data Preprocessing
- Spelling Correction Evaluation

Discussion

Conclusion and Future Work

Motivation

- OCR is the electronic translation of handwritten, typewritten or printed text into machine translated images
- It has wide applications in the fields of banking, healthcare, digital libraries, handwriting recognition,etc.[7]
- Spell correction becomes necessary while using OCR for digital libraries when dealing with historic newspapers as the OCR process generates a lot of noisy text
- A major problem that surfaces when evaluating the spell correction process is that the text has to be verified against the original text (ground truth) to estimate its performance.
- This one-to-one verification may lead to word alignment problems, since the corrected and original text can be of different lengths.



HUDSON COUNTY'S FIGHT.

Democratic Managers Confident of Winning a Complete Victory.

The Democrats expect to win a complete vicrory in Hudson county, N. J., to-morrow. A Congressman, County Clerk, Register, eleven Assemblymen, and twenty Freeholders are to be elected. The Democrats have put an exceptionally strong ticket in the field.

The candidates are: For Congress, Col. Edwin A. Stevens of Hoboken; County Clerk, Michael J. O'Donnell of Jersey City; Register, George

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Figure : Scanned newspaper image and its corresponding noisy OCR text

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Aim: To develop an algorithm that can automatically evaluate a spell correction algorithm so as to align three parallel corpora - the noisy OCR, corrected and original/ manually cleaned text.

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Related Work

- Kukich [5] comprehensively discusses various spelling correction techniques based on non word, isolated word and real word spelling errors
- N-gram analysis, dictionary lookup and probabilistic techniques ([1],[3]) are used for correcting isolated and nonword errors while context-dependent techniques([4],[2]) are used mostly for correcting real word errors including the correction of word split and join errors
- All of the above algorithms are evaluated based on the percentage of spelling errors corrected or reduction in the word error rate[6]and do not consider the word alignment problem arising due to word split and join errors in the OCR text

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Solution Framework

- Apply spell correction on the OCR text dataset
- Decide parameters for evaluation of spell correction
- Design an algorithm for spell correction evaluation

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Data Gathering

- **Data Source** : Chronicling America - provides scanned OCR newspaper pages of American newspapers published between 1836 and 1922
- **Data Statistics** : 50 news articles of “The Sun” newspaper published between November-December 1894 consisting of tokens
- **Data Characteristics** : News articles consist of one or more OCR errors of the types- Real word, Non-real word, Non-word, Word Split and Join and New line errors, They also do not have any punctuation

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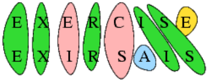
Data Preprocessing

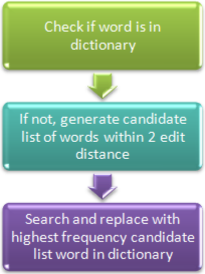
- Required to deal with OCR errors in the news articles
- Edit distance algorithm is used for spelling correction of non-real and non-word OCR errors using precompiled dictionary for look-up
- The dictionary used for look-up is a concatenation of several public domain books from Project Gutenberg and lists of most frequent words from Wiktionary and the British National Corpus augmented with a large people names list extracted from ClueWeb12 dataset

Spelling Correction Algorithm

- "Edit distance" corresponds to the minimum number of insertion, deletion and substitution required to transform one string into another



- String Edit distance algorithm for spelling correction:


Check if word is in dictionary

If not, generate candidate list of words within 2 edit distance

Search and replace with highest frequency candidate list word in dictionary

- The choice of 2 is governed by the trade off between algorithm runtime and quality of spelling correction.

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Spelling Correction Evaluation

- Required to measure the performance of spelling correction

- Evaluation Parameters:

1. Accuracy : measures the percentage of actual errors that get corrected in the OCR text after spelling correction and defined as follows:

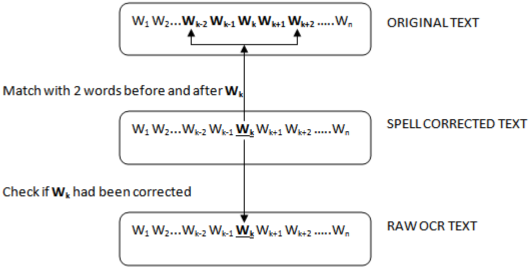
   $$Accuracy = \frac{TP + TN}{TP + FP + TN + FN}$$

   where,
   TP=Number of True Positives,
   TN=Number of True Negatives,
   FP=Number of False Positives,
   FN=Number of False Negatives.

2. Time taken to run Spelling Correction Algorithm

Spelling Correction Evaluation (SCE) Algorithm

- Word by word correspondence between corrected and original dataset not possible because of Word Split and Join errors in OCR dataset
- SCE algorithm performs word by word automatic evaluation on post spell corrected OCR dataset using an n-word grams approach



W_1 W_2...$\mathbf{W_{k-2}}$ $\mathbf{W_{k-1}}$ $\mathbf{W_k}$ $\mathbf{W_{k+1}}$ $\mathbf{W_{k+2}}$ .....W_n
ORIGINAL TEXT
Match with 2 words before and after $\mathbf{W_k}$
W_1 W_2...W_{k-2} W_{k-1} $\underline{\mathbf{W_k}}$ W_{k+1} W_{k+2} .....W_n
SPELL CORRECTED TEXT
Check if $\mathbf{W_k}$ had been corrected
W_1 W_2...W_{k-2} W_{k-1} $\underline{\mathbf{W_k}}$ W_{k+1} W_{k+2} .....W_n
RAW OCR TEXT

Match Found	Spell Corrected	Outcome
Y	Y	TP
Y	N	TN
N	Y	FP
N	N	FN

Figure : Schematic diagram for alignment of spell corrected article text with original article text for a word W_k

Example

Line text from 3 versions of a news article:

OcrLine= *Irnniluttry iiownllllnu at tilchmond*
CorrectedLine= *Irnniluttry iiownllllnu at Richmond*
OriginalLine= *Grand jury now sitting at Richmond*

Word in Corrected Line	**Corresponding Word Window in Original Line**	**Result**
Irnniluttry	Grand jury now	FN
iiownllllnu	Grand jury now sitting	FN
at	Grand jury now sitting at	TN
Richmond	sitting at Richmond	TP

Spelling Correction Evaluation Results

- SCE algorithm tested on 50 spell corrected articles using 3 versions of each article: Original text, Raw OCR text and Spell Corrected text

Accuracy : 73.1%
Time taken : 9 seconds on average per article

- We believe that the results are less accurate due to the presence of a large number of non-word, new line, word split and join errors in the OCR data which can not be corrected by the edit distance spelling corrector used for this research.

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Discussion I

- Spelling Correction accuracy can be improved by correcting other OCR errors like New Line and Word Split and Join errors
- Choice of a dictionary for the edit distance algorithm affects the results of spelling correction
- The choice of window size N=2 in SCE algorithm is based on the Word Split and Join errors in the dataset. This value can be set appropriately by considering the maximum difference of lengths in each line of OCR and original text in the dataset.
- A limitation of the SCE algorithm is that it requires all 3 versions of a newspaper article (Original, Corrected and OCR) to have the same number of lines as alignment of line texts is performed. In case of difference in the number of lines of text due to some Word Split and Join errors, the words window needs to be extended so as to cover previous and next line texts also for alignment.

Discussion II

- We compared our N-gram based SCE algorithm with the LCS (Longest Common Subsequence) algorithm The LCS of corrected and original text gives a list of matching corrected words found in the original text.
- Following the similar evaluation procedure of calculating accuracy as in the N-word gram approach, it was found that there is no statistically significant difference in accuracy when using either of the two algorithms.
- We posit that LCS is a special case of the N-word gram algorithm when the window size N is set to the complete text in a line.

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Conclusion and Future Work

- Proposed a novel approach and highlighted challenges for evaluating a spell correction algorithm on noisy OCR dataset through N-word grams alignment of the OCR, corrected and manually cleaned text.
- Preliminary results of application of our algorithm on an Edit distance based spell corrector evaluate its accuracy to be 73.1
- SCE algorithm can be used to compare among multiple spell correction algorithms and decide which one suits the dataset better and gives best accuracy
- In future, we plan to use other spelling correction algorithms like context dependent spelling correction to correct the OCR text and measure the accuracy using our SCE algorithm

Thank You!

Questions??

References

[1] Agarwal, S.
Utilizing big data in identification and correction of ocr errors.

[2] Bassil, Y., and Alwani, M.
Ocr context-sensitive error correction based on google web 1t 5-gram data set.
arXiv preprint arXiv:1204.0188 (2012).

[3] Chattopadhyaya, I., Sirchabesan, K., and Seal, K.
A fast generative spell corrector based on edit distance.
In *Advances in Information Retrieval*. Springer, 2013, pp. 404–410.

[4] Elmi, M. A., and Evens, M.
Spelling correction using context.
In *Proceedings of the 36th Annual Meeting of the Association for Computational Linguistics and 17th International Conference on Computational Linguistics-Volume 1* (1998), Association for Computational Linguistics, pp. 360–364.

[5] Kukich, K.
Techniques for automatically correcting words in text.
ACM Computing Surveys (CSUR) 24, 4 (1992), 377–439.

[6] Rice, S. V.
Measuring the accuracy of page-reading systems.
PhD thesis, University of Nevada, 1996.

[7] Singh, A., Bacchuwar, K., and Bhasin, A.
A survey of ocr applications.

Table : Different cases for word alignment in SCE algorithm

Token index of OriginalLine Token index of CorrectedLine(i)	Starting index (j)	Ending index (j)
Length[CorrectedLine] <4 or Length[OriginalLine]<4	0	Length[OriginalLine]
i=0	0	3
i=1	0	4
i=Length[CorrectedLine]-2	i-2	Length[OriginalLine]
i=Length[CorrectedLine]-1	i-2	Length[OriginalLine]
i=Length[CorrectedLine]	i-2	Length[OriginalLine]
i=Length[CorrectedLine+1]	i-2	Length[OriginalLine]
i>=Length[CorrectedLine]+2	Length[OriginalLine]-3	Length[OriginalLine]
Any other value of i	i-2	i+3

Algorithm 1 MatchWordGrams function of SCE Algorithm for measuring accuracy

```
function MatchWordGrams(OcrLine, CorrectedLine, OriginalLine, jstart, jend, i)
    for (int j=jstart; j<jend; j++) do
        if ((CorrectedLine[i].equals(OriginalLine[j]))&&(!(OcrLine[i].equals(CorrectedLine[i])))) then
            $tp = tp + 1$  flag0=false  return tp
        end
        else if ((CorrectedLine[i].equals(OriginalLine[j]))&&(OcrLine[i].equals(CorrectedLine[i]))) then
            $tn = tn + 1$  flag1=false  return tn
        end
    end
    if (!(OcrLine[i].equals(CorrectedLine[i]))&&flag0==true) then
        $fp = fp + 1$  return fp
    end
    else if ((OcrLine[i].equals(CorrectedLine[i])) && flag1==true) then
        $fn = fn + 1$  return fn
    end
```