Detecting Credit Card Fraud in a Skewed Data Set Using Deep Learning

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Abstract

1   [PUT THE ABSTRACT HERE WHEN YOU'RE DONE]

1   Introduction

3 Credit card fraud is a problem for many people across the United States, with 45,428 cases of credit
4 card fraud reported to the Federal Trade Commission in 2017. With datasets available today, neural
5 networks can be trained to identify trends in fraudulent and non-fraudulent transactions.

6 The output of these networks can be used to notify consumers of suspicious activity on their accounts
7 and prevent further losses.

1.1   The Dataset

9   For this case study, the dataset consists of over 280,000 credit card transaction data points accumulated
10 over 2 days in European countries. Each data point holds basic information about the transaction as
11 well as obfuscated data resulting from a PCA transformation, which can be seen in Table 1 . The data
12 prefixed with a "V" is the transformed data.

Table 1: Sample Transaction Data Points

Time	V1	V2	...	V27	V28	Amount	Class
0	-1.359807134	-0.072781173	...	0.133558377	-0.021053053	149.62	0
70071	-0.440095203	1.137238976	...	0.768290751	0.459623328	227.3	1
132086	-0.361427839	1.133471917	...	-0.001249817	-0.182750897	480.72	1
150426	-0.269118964	-0.063708356	...	0.385434237	0.21311729	7.33	0
172792	-0.533412522	-0.189733337	...	-0.002415309	0.013648914	217	0

13 One of the interesting metrics of the dataset is the ratio of fraudulent to non-fraudulent transactions.
14 With fraudulent transactions only making up 0.172% of the 280,000+ transactions, this poses a
15 challenge for a neural to make accurate identifications for fraudulent cases.

16 The fraudulent cases are also the most interesting result from the network, as simply identifying the
17 99.82800% of non-fraudulent cases is trivial. The skewed distribution of data points is illustrated in
18 Figure 1

1.2   Retrieval of style files

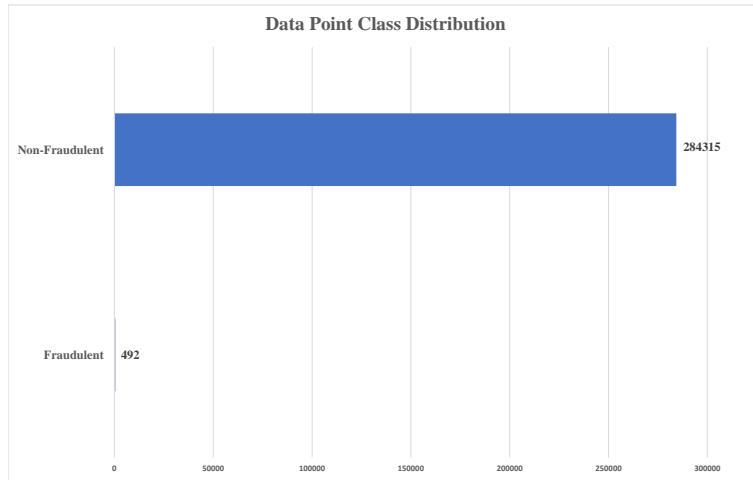20 The style files for NIPS and other conference information are available on the World Wide Web at

Figure 1: Distribution between fraudulent and non-fraudulent data points.

The file `nips_2017.pdf` contains these instructions and illustrates the various formatting requirements your NIPS paper must satisfy.

The only supported style file for NIPS 2017 is `nips_2017.sty`, rewritten for LaTeX 2$_\varepsilon$. **Previous style files for LaTeX 2.09, Microsoft Word, and RTF are no longer supported!**

The new LaTeX style file contains two optional arguments: `final`, which creates a camera-ready copy, and `nonatbib`, which will not load the `natbib` package for you in case of package clash.

At submission time, please omit the `final` option. This will anonymize your submission and add line numbers to aid review. Please do *not* refer to these line numbers in your paper as they will be removed during generation of camera-ready copies.

The file `nips_2017.tex` may be used as a "shell" for writing your paper. All you have to do is replace the author, title, abstract, and text of the paper with your own.

The formatting instructions contained in these style files are summarized in Sections 2, 3, and 4 below.

2   General formatting instructions

The text must be confined within a rectangle 5.5 inches (33 picas) wide and 9 inches (54 picas) long. The left margin is 1.5 inch (9 picas). Use 10 point type with a vertical spacing (leading) of 11 points. Times New Roman is the preferred typeface throughout, and will be selected for you by default. Paragraphs are separated by ½ line space (5.5 points), with no indentation.

The paper title should be 17 point, initial caps/lower case, bold, centered between two horizontal rules. The top rule should be 4 points thick and the bottom rule should be 1 point thick. Allow ¼ inch space above and below the title to rules. All pages should start at 1 inch (6 picas) from the top of the page.

For the final version, authors' names are set in boldface, and each name is centered above the corresponding address. The lead author's name is to be listed first (left-most), and the co-authors' names (if different address) are set to follow. If there is only one co-author, list both author and co-author side by side.

Please pay special attention to the instructions in Section 4 regarding figures, tables, acknowledgments, and references.

3 Headings: first level

All headings should be lower case (except for first word and proper nouns), flush left, and bold.

First-level headings should be in 12-point type.

3.1 Headings: second level

Second-level headings should be in 10-point type.

3.1.1 Headings: third level

Third-level headings should be in 10-point type.

Paragraphs There is also a \paragraph command available, which sets the heading in bold, flush left, and inline with the text, with the heading followed by 1 em of space.

4 Citations, figures, tables, references

These instructions apply to everyone.

4.1 Citations within the text

The natbib package will be loaded for you by default. Citations may be author/year or numeric, as long as you maintain internal consistency. As to the format of the references themselves, any style is acceptable as long as it is used consistently.

The documentation for natbib may be found at

> http://mirrors.ctan.org/macros/latex/contrib/natbib/natnotes.pdf

Of note is the command \citet, which produces citations appropriate for use in inline text. For example,

> \citet{hasselmo} investigated\dots

produces

> Hasselmo, et al. (1995) investigated...

If you wish to load the natbib package with options, you may add the following before loading the nips_2017 package:

> \PassOptionsToPackage{options}{natbib}

If natbib clashes with another package you load, you can add the optional argument nonatbib when loading the style file:

> \usepackage[nonatbib]{nips_2017}

As submission is double blind, refer to your own published work in the third person. That is, use "In the previous work of Jones et al. [4]," not "In our previous work [4]." If you cite your other papers that are not widely available (e.g., a journal paper under review), use anonymous author names in the citation, e.g., an author of the form "A. Anonymous."

4.2 Footnotes

Footnotes should be used sparingly. If you do require a footnote, indicate footnotes with a number[1] in the text. Place the footnotes at the bottom of the page on which they appear. Precede the footnote with a horizontal rule of 2 inches (12 picas).

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[1]Sample of the first footnote.

Note that footnotes are properly typeset *after* punctuation marks.[2]

4.3 Figures

All artwork must be neat, clean, and legible. Lines should be dark enough for purposes of reproduction. The figure number and caption always appear after the figure. Place one line space before the figure caption and one line space after the figure. The figure caption should be lower case (except for first word and proper nouns); figures are numbered consecutively.

You may use color figures. However, it is best for the figure captions and the paper body to be legible if the paper is printed in either black/white or in color.
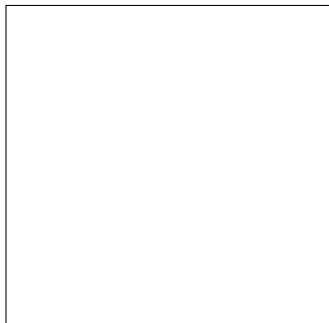
Figure 2: Sample figure caption.

4.4 Tables

All tables must be centered, neat, clean and legible. The table number and title always appear before the table. See Table **??**.

Place one line space before the table title, one line space after the table title, and one line space after the table. The table title must be lower case (except for first word and proper nouns); tables are numbered consecutively.

Note that publication-quality tables *do not contain vertical rules.* We strongly suggest the use of the `booktabs` package, which allows for typesetting high-quality, professional tables:

```
https://www.ctan.org/pkg/booktabs
```

This package was used to typeset Table **??**.

5 Final instructions

Do not change any aspects of the formatting parameters in the style files. In particular, do not modify the width or length of the rectangle the text should fit into, and do not change font sizes (except perhaps in the **References** section; see below). Please note that pages should be numbered.

6 Preparing PDF files

Please prepare submission files with paper size "US Letter," and not, for example, "A4."

Fonts were the main cause of problems in the past years. Your PDF file must only contain Type 1 or Embedded TrueType fonts. Here are a few instructions to achieve this.

- You should directly generate PDF files using `pdflatex`.

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[2]As in this example.

- You can check which fonts a PDF files uses. In Acrobat Reader, select the menu Files>Document Properties>Fonts and select Show All Fonts. You can also use the program `pdffonts` which comes with `xpdf` and is available out-of-the-box on most Linux machines.
- The IEEE has recommendations for generating PDF files whose fonts are also acceptable for NIPS. Please see `http://www.emfield.org/icuwb2010/downloads/IEEE-PDF-SpecV32.pdf`
- `xfig` "patterned" shapes are implemented with bitmap fonts. Use "solid" shapes instead.
- The `\bbold` package almost always uses bitmap fonts. You should use the equivalent AMS Fonts:

    `\usepackage{amsfonts}`

    followed by, e.g., \mathbb{R}, \mathbb{N}, or \mathbb{C} for $\mathbb{R}$, $\mathbb{N}$ or $\mathbb{C}$. You can also use the following workaround for reals, natural and complex:

    ```
    \newcommand{\RR}{I\!\!R} %real numbers
    \newcommand{\Nat}{I\!\!N} %natural numbers
    \newcommand{\CC}{I\!\!\!\!C} %complex numbers
    ```

    Note that `amsfonts` is automatically loaded by the `amssymb` package.

If your file contains type 3 fonts or non embedded TrueType fonts, we will ask you to fix it.

6.1 Margins in LaTeX

Most of the margin problems come from figures positioned by hand using `\special` or other commands. We suggest using the command `\includegraphics` from the `graphicx` package. Always specify the figure width as a multiple of the line width as in the example below:

```
\usepackage[pdftex]{graphicx} ...
\includegraphics[width=0.8\linewidth]{myfile.pdf}
```

See Section 4.4 in the graphics bundle documentation (`http://mirrors.ctan.org/macros/latex/required/graphics/grfguide.pdf`)

A number of width problems arise when LaTeX cannot properly hyphenate a line. Please give LaTeX hyphenation hints using the `\-` command when necessary.

Acknowledgments

Use unnumbered third level headings for the acknowledgments. All acknowledgments go at the end of the paper. Do not include acknowledgments in the anonymized submission, only in the final paper.

References

References follow the acknowledgments. Use unnumbered first-level heading for the references. Any choice of citation style is acceptable as long as you are consistent. It is permissible to reduce the font size to `small` (9 point) when listing the references. **Remember that you can go over 8 pages as long as the subsequent ones contain *only* cited references.**

[1] Alexander, J.A. & Mozer, M.C. (1995) Template-based algorithms for connectionist rule extraction. In G. Tesauro, D.S. Touretzky and T.K. Leen (eds.), *Advances in Neural Information Processing Systems 7*, pp. 609–616. Cambridge, MA: MIT Press.

[2] Bower, J.M. & Beeman, D. (1995) *The Book of GENESIS: Exploring Realistic Neural Models with the GEneral NEural SImulation System.* New York: TELOS/Springer–Verlag.

[3] Hasselmo, M.E., Schnell, E. & Barkai, E. (1995) Dynamics of learning and recall at excitatory recurrent synapses and cholinergic modulation in rat hippocampal region CA3. *Journal of Neuroscience* **15**(7):5249-5262.