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| CSE 474: Project 2 |

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### Abstract

The Abstract paragraph should be indented ½ inch (3 picas) on both left and right-hand margins. Use 10 point type, with a vertical spacing of 11 points. Abstract must be centered, bold and in point size 12. Two line spaces precede the Abstract. The Abstract must be limited to one paragraph.

# 1 Introduction

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# 2 Dataset

For this exercise the MNIST Fashion dataset was used for all training and validation. The dataset is comprised of 70,000 28x28 pixel grayscale images of 10 different types of clothing. Each picture has a corresponding integer label from 0-9 which correspond to image descriptions as listed in Table 1.

Table : MNIST Fashion Labels

|  |  |
| --- | --- |
| **Label** | **Description** |
| 0 | T-shirt/top |
| 1 | Trouser |
| 2 | Pullover |
| 3 | Dress |
| 4 | Coat |
| 5 | Sandal |
| 6 | Shirt |
| 7 | Sneaker |
| 8 | Bag |
| 9 | Ankle boot |

As the images are 28x28 greyscale pixels there is only one channel in the image with pixel intensities ranging from 0-255, Therefore there are features per image.

# 2 Preprocessing

## 2.1 Part 1

In part on the MNIST dataset is loaded using the “util\_mnist\_reader.load\_mnist()” function provided by the instructor. This function returns a pair of arrays, the first being an array of images represented as matrix and the second being an array of integers which represent the correct labels for the corresponding images. Calling this function twice with different specifiers allows us to obtain 60,000 training samples with labels as well as 10,000 testing samples with labels.

As all image pixel values range from [0,255] we divide both the training samples and testing samples by 255 to normalize these values to [0,1]. Then an extra feature of constant 1 is appended to the end of each sample to represent the bias term

Next the labels are converted into one hot encoding. In this encoding each label is represented by an array of size 10 holding all zeroes except for at the location of the correct label where a one is placed. This is done by creating a zeros array of the appropriate size and then iterating over the labels array and setting the corresponding locations to one

## 2.2 Part 2

In this section data preprocessing is done essentially the same way as in part 1. The training and testing datasets are loaded, normalized to one. In this case the one-hot matrices are created using the keras utility function to\_categorical which produces the same labels matrix as described above.

## 2.3 Part 3

In this section data is preprocessed differently than in parts one and two. In this case we would like to use 2D convolutional layers in our CNN, these require two-dimensional layers to work properly. To achieve this the function “k.datasets.fashion\_mnist.load\_data()” is called. This returns a pair of pairs. The first pair is the training images and labels and the second is the testing images and labels.

In this case the images are stored as two-dimensional arrays of 28x28 values, one per sample, and the labels are again stored as a one-dimensional array of integers. The load data function returns 60,000 training samples and 10,000 testing samples.

As in parts 1 and 2 the values range from [0,255] and so are normalized to [0,1] and the labels are converted to one-hot encoding as in part 2.

# 3 Architecture

## 3.1 Part 1

For part one a simple three-layer neural network is implemented. The layers of this network are as described

* Input layer – takes the 1x784 input features from an image as its activations
* Hidden layer – full connected layer with nodes. This takes the 784 activations from the previous layer and computes its activations as
* Output layer – fully connected softmax layer with 10 nodes. This takes the previous activations and generates 10 outputs which correspond to the 10 possible classes using the equation

This architecture was chosen as it is the smallest possible network with one hidden layer. This makes it simpler to create by hand. This network is shown in Figure 1. The softmax function is used in the output layer to ensure that the sum of all output activations is one, and therefore can be treated as a probability distribution.

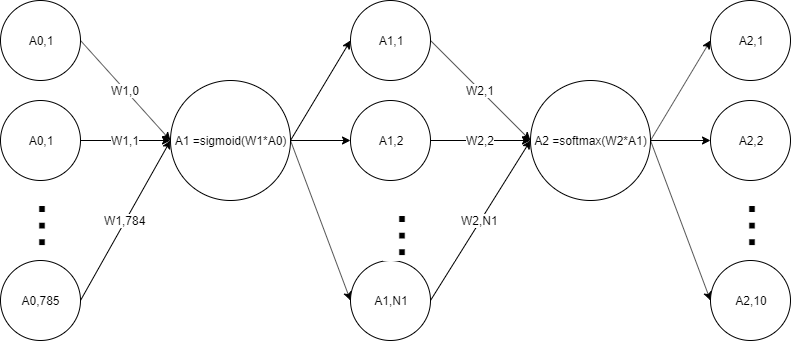


Figure : Part 1 Network Diagram

## 3.2 Part 2

For part 2 a deeper neural network is implemented consisting of the following layers

* Input layer – takes the 1x784 input pixels as activations
* Hidden layer – fully connected, computes activations using the ReLu function
* Hidden layer – fully connected, computes activations using the ReLu function
* Hidden layer – fully connected, computes activations using the ReLu function
* Output layer – fully connected, computes activations using the softmax function to produce 10 outputs corresponding to the 10 possible classes

This architecture was selected as it provides the network a great deal of flexibility while maintaining a relatively simple structure. The ReLu activation function is used in hidden layers to avoid gradient vanishing. Softmax was used for the output layer so that the sum of all output activations is one, and therefore can be treated as a probability distribution.

## 3.3 Part 3

In part 3 a simple convolutional neural network is implemented with the following layers

* Input layer – takes 28x28x1 input pixels as activations
* Convolutional layer – 32 3x3 filters with ReLu activations
* Convolutional layer – 32 3x3 filters with ReLu activations
* Maxpool layer – 2x2 filter
* Dropout layer – rate = 0.25
* Fully connected – ReLu activation with 392 nodes
* Fully connected – softmax activation with 392 nodes

# 4 Citations, figures, tables, references

These instructions apply to everyone, regardless of the formatter being used.

## 4.1 Citations within the text

Citations within the text should be numbered consecutively. The corresponding number is to appear enclosed in square brackets, such as [1] or [2]-[5]. The corresponding references are to be listed in the same order at the end of the paper, in the **References** section. (Note: the standard BibTeX style unsrt produces this.) As to the format of the references themselves, any standard reference style is acceptable, as long as it is used consistently.

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

Indicate footnotes with a number 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).

## 4.3 Figures

All artwork must be neat, clean, and legible. Lines should be dark enough for purposes of reproduction; artwork should not be hand drawn. 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 is lower case (except for first word and proper nouns); figures are numbered consecutively.

Make sure the figure caption does not get separated from the figure. Leave sufficient space to avoid splitting the figure and figure caption.

You may use color figures. However, it is best for the figure captions and the paper body to make sense if the paper is printed either in black/white or in color.

|  |
| --- |
|  |

Figure 1: Sample Figure Caption

## 4.4 Tables

All tables must be centered, neat, clean and legible. Do not use hand drawn tables. The table number and title always appear before the table. See Table 1.

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.

Table 1: Sample table title

|  |  |
| --- | --- |
| Part  Description |  |
| Dendrite | Input terminal |
| Axon | Output terminal |
| Soma | Cell Body (contains cell nucleus) |

# 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 that 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 PostScript or PDF files

Please prepare PostScript or PDF files with paper size “US Letter,” and not, for example, “A4.” The -t letter option on dvips will produce US Letter files.

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 can check which fonts a PDF files uses. In Acrobat Reader, select 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
* LaTeX users:
  + Consider directly generating PDF files using pdflatex (especially if you are a MiKTeX user). PDF figures must be substituted for EPS figures, however.
  + Otherwise, please generate your PostScript and PDF files with the following commands:
  + dvips mypaper.dvi -t letter -Ppdf -G0 -o mypaper.ps
  + ps2pdf mypaper.ps mypaper.pdf
  + Check that the PDF files only contains Type 1 fonts.
* xfig “patterned” shapes are implemented with bitmap fonts. Use “solid” shapes instead.
* The \bbold package almost always uses bitmap fonts. You can try the equivalent AMS Fonts with command
  + \usepackage[psamsfonts]{amssymb}
  + or 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
* Sometimes the problematic fonts are used in figures included in LaTeX files. The ghostscript program eps2eps is the simplest way to clean such figures. For black and white figures, slightly better results can be achieved with program potrace.
* MSWord 2007 and Windows users (via PDF file):
  + Install the Microsoft Save as PDF Office 2007 Add-in from
  + http://www.microsoft.com/downloads/details.aspx?displaylang=en&familyid=4d951911-3e7e-4ae6-b059-a2e79ed87041
  + Select "Save or Publish to PDF" from the Office or File menu
* MSWord and Mac OS X users (via PDF file):
  + From the print menu, click the PDF drop-down box, and select "Save as PDF…"
* MSWord and Windows users (via PS file):
  + To create a new printer on your computer, install the AdobePS printer driver and the Adobe PostScript Printer Description (PPD) file from
  + <http://www.adobe.com/support/downloads/detail.jsp?ftpID=204>
  + *Note:* You must reboot your PC after installing the AdobePS driver for it to take effect.
  + To produce the ps file, select "Print" from the MS app, choose the installed AdobePS printer, click on "Properties", click on "Advanced."
  + Set “TrueType Font” to be “Download as Softfont”
  + Open the “PostScript Options” folder
  + Select “PostScript Output Option” to be “Optimize for Portability”
  + Select “TrueType Font Download Option” to be “Outline”
  + Select “Send PostScript Error Handler” to be “No”
  + Click “OK” three times, print your file.
  + Now, use Adobe Acrobat Distiller or ps2pdf to create a PDF file from the PS file. In Acrobat, check the option “Embed all fonts” if applicable.

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[dvips]{graphicx} ...

\includegraphics[width=0.8\linewidth]{myfile.eps}

or

\usepackage[pdftex]{graphicx} ...

\includegraphics[width=0.8\linewidth]{myfile.pdf}

for .pdf graphics. See section 4.4 in the graphics bundle documentation (http://www.ctan.org/texarchive/macros/latex/required/graphics/grfguide.ps)

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

## Acknowledgments

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

## References

References follow the acknowledgments. Use unnumbered third 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 this year you can use a ninth page as long as it contains *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 hiippocampal region CA3. *Journal of Neuroscience* **15**(7):5249-5262.