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| **10601B Midway Report** |
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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**

**1.1 Motivation**

Based on what we have learned from class, considering the amount of data and our understanding on each classifier, we chose K-nearest neighbor, logistic regression and neural network as our first classifiers. All these classifiers are basic and easy to implement so that in the future, our current experience can help us try more advanced classifiers, such as boosting, support vector machine and deep learning.

**1.2 Background and Related Work**

The database CIFAR-10 is a famous sample template for image classification, which consists of 60000 32X32 color images in 10 classes, with 6000 images per class. Each individual image sample consists of RGB color model parameters and is vectorized to 3072 parameters with value from 0 to 255. From the original database, we randomly select 5000 images as our training sample.

1. **Methods**

**2.1 Distance-Weighted K-Nearest Neighbors**

K-nearest neighbors classifier is a very intuitive algorithm and easy to implement. In training phase, we save both features *xTrain* and labels *yTrain* of the entire training set as our model. In classification phase, we assign the label by looking the most frequent class of the top *k* closest neighbors. Sometimes the frequencies of different classes could be tied, and one way to resolve this issue is to use the summation of “voting power” in replace of direct counting. Here, we use the Euclidean distance as our distance measure.

Consider the *k* nearest neighbors of test data **x**:

We define the “voting power” of each class *j* on test data **x** as the summation of the distance inverse of *k* nearest neighbors that have label *j*:

The class that possesses the highest voting power is chosen to be the label of the test data.

**2.2 Multinomial Logistic Regression**

In multinomial logistic regression, we want to classify the data into *k* classes with discrete label . For the case of CIFAR-10 *k* equals 10, and the likelihood of the particular class given specific weight is determined by:

In our implementation, we prepend the training and test data matrix with an “ones” column so that we can simplify

The conditional log likelihood can be expressed as

To maximize the conditional log likelihood of the weight vector **w**, we take partial derivative on each dimension *j* and each class c:

where

By gradient ascent, we can approximate the optimal solution by iteration:

* 1. **Artificial Neural Network**

Artificial Neural Network is popular classifier that is used to estimate the class of data,  which depends on a large number of [inputs](https://en.wikipedia.org/wiki/Argument_of_a_function) and known output label to train the data sets. It is generally described as interconnected [neurons](https://en.wikipedia.org/wiki/Artificial_neuron) which can exchange data and messages between each node. The connections of nodes from different layers have numeric weights value that can be tuned based on previous experience, making neural network capable of learning.

There are several equations that often used in neural network classifier.

Hidden layer input function:

Hidden layer output function, sigmoid unit function:

Output layer function:

Gradient descent method is generally used to update node weight value. Here are the functions of this algorithm.

For each output unit m:

For each hidden unit h:

For each network weight :

where

And for those functions, X means input data, t(k) means target output data of training example k, o(h) means observed unit output of training example h, means the weight from i to j and means learning rate in this neural network classifier.

**3 Experiments and Results**

**Feature extraction**. Before we train the classifier, all 5000 image samples are preprocessed using VLFeat toolbox to extract HOG (Histogram of Oriented Gradient) with cell size equals 8 as new sample feature.

**Cross Validation**. In order to verify the performance of our classifiers, we partitioned the 5000 image samples into 5 batches, and used the first 4 batches as training set and the last batch as test set.

**Normalization**. In both training set and test set, each HOG features are normalized column-wise to real number in [0, 1], where the maximum feature becomes 1 and the minimum feature becomes 0.

**3.1 Headings: second level**

Second level headings are lower case (except for first word and proper nouns), flush left, bold and in point size 10. One line space before the second level heading and ½ line space after the second level heading.

**3.2 LR**

**3.3 Artificial Neural Network**

**Label conversion.** In order to extend the range of original data labels, which is a 4000\*1 matrix, we converted it to a 4000\*10 matrix. For each row, if the original label value is four, the fifth element of this row will be 1 and all others are 0. As a result, we got a 4000\*10 matrix with all elements are 0 or 1 as new label set.

**Neural network structure.** The neural network has 3 layers, input layer, hidden layer and output layer. The input is a 4000\*496 matrix, so the input nodes n should be 496, the hidden layer nodes h has n + 1 nodes, which is 497. Because we converted the labels data to a 4000\*10 matrix, the output nodes m has 10 nodes.

**Function and parameters.** We used sigmoid function as driving function and gradient descent algorithm to update nodes and weights. The learning rate equals to 0.1.

**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.

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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

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| **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.