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| **PA1 Report: Implementation and Evaluation of Logistic and Softmax Regression Classifier on various Human Facial Expressions** |

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**Abstract**

This document is the report of the first programming assignment (PA1) in CSE 253 Neural Networks/Pattern Recognition at UC San Diego in Winter 2020 by Huimin Zeng and Zhenrui Yue. The report is based on the requirements of the problems in the assignment and contains four sections for the three programming problems and the individual contributions of each team member in this group.

In this report, we first described the provided dataset and its preprocessing: Extended Cohn-Kanade Dataset (CK+) [1], which consists of various pictures of human faces with different emotions. With preprocessed data, we implemented the cross-validation procedure to avoid overfitting, then, Principal Components Analysis (PCA) was applied to the dataset to reduce the dimensions of input data. In the following sections, we first developed a logistic regression classifier with Batch Gradient Descent and Stochastic Gradient Descent, the classifier was trained with the processed facial expressions and its performance on the dataset was evaluated and visualized in the report. A softmax regression classifier was also implemented to classify all given emotions: anger, disgust, fear, happiness, sadness and surprise, the section also evaluates the softmax classifier and represents its performances visually. Finally, the last section addresses the individual contributions to this programming assignment.

**The abstract should summarize briefly what you did, and the best percent correct you got on each problem !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!**

**1 Data Preprocessing, Cross-Validation and PCA**

The first section contains three subsections: the dataset preprocessing and two basic methods adopted in this assignment: Cross-Validation and Principal Component Analysis.

**1.1 Data Preprocessing**

The Extended Cohn-Kanade Dataset (CK+) was introduced in the first assignment to train and evaluate our regression model, CK+ was released by various researchers from Disney Research in 2010 based on Cohn-Kanade (CK) database in 2010. The dataset contains pictures of human facial expressions that represent visual information of seven emotions: angry, disgust, fear, happy, sadness, surprise and contempt. CK+ was tested and validated for the purpose of detecting different emotions, it also provides two baseline models and their performances using respectively Active Appearance Model and linear support vector machine [1].

The image data from CL+ was provided in both resized and aligned form from the assignment files and should be first preprocessed by the data loader given in the assignment code. The aligned data are processed images of aligned human faces in all seven emotions whereas the resized folder has resized images only available in two emotions: happiness and anger. The assignment code provides a few functions that automatically loads images from either aligned or resized folder and returns a dictionary with the emotions as keys and a list of images as values, the code also provides function that creates a balanced image set for the specified emotions and function that help to display an image based on matrix values.

**1.2 Cross-Validation**

Before the data could be trained as input of a machine learning model, we first implemented cross validation, a widely adopted validation technique that splits data into different folds, so that some of the folds could be used to train a mathematical model and the rest folds to test and validate the model. Different combinations of training and testing folds could give a better overall estimation of the model behavior in predicting unknown data and its generalization ability [2].

In our implementation, we first wrote a function that split the emotions and returns a list with each facial emotion and their images in multiple folds according to the given dictionary data input and fold number as arguments. Followingly, a second function was created, where the preprocessed folded image list would be divided into training, testing and validation data. Afterwards, the training data would be processed using Principal Component Analysis (PCA, which will be introduced in the next subsection), the dimensions of the image data would be reduced by projecting them to the principal components in order to simplify the image data and reduce training time. Then, three data loaders would be returned for training, testing and validation sets, each data loader consists of the given emotion classes and corresponding image data in reduced dimension.

So you should also have some limit on the number of training steps, say 100 passes through the complete training data. One pass through all of the training data is called an epoch.

**1.3 Principal Component Analysis (PCA)**

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

http://www.nips.cc/

The file **nips2015.pdf** contains these instructions and illustrates the various formatting requirements that your NIPS paper must satisfy. LaTeX users can choose between two style files: **nips11submit\_09.sty** (to be used with LaTeX version 2.09) and **nips11submit\_e.sty** (to be used with LaTeX2e). The file **nips2015.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 file **nips2015.rtf** is provided as a shell for MS Word users.

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

**2 Logistic Regression**

First level headings are lower case (except for first word and proper nouns), flush left, bold and in point size 12. One line space before the first level heading and ½ line space after the first level heading.

**2.1 Happiness vs Anger using the resized dataset**

5b Training Accuracy: 0.6805555555555556

Testing Accuracy: 0.6666666666666666

Validation Accuracy: 0.6666666666666666

5c Training Accuracy: 1.0 Testing Accuracy: 1.0 Validation Accuracy: 0.8888888888888888 Training Accuracy: 1.0 Testing Accuracy: 0.8888888888888888 Validation Accuracy: 1.0 Training Accuracy: 1.0 Testing Accuracy: 1.0 Validation Accuracy: 1.0 Training Accuracy: 1.0 Testing Accuracy: 1.0 Validation Accuracy: 1.0 Training Accuracy: 1.0 Testing Accuracy: 1.0 Validation Accuracy: 1.0 Training Accuracy: 0.9722222222222222 Testing Accuracy: 0.8888888888888888 Validation Accuracy: 1.0 Training Accuracy: 1.0 Testing Accuracy: 1.0 Validation Accuracy: 1.0 Training Accuracy: 0.9861111111111112 Testing Accuracy: 1.0 Validation Accuracy: 1.0 Training Accuracy: 1.0 Testing Accuracy: 1.0 Validation Accuracy: 1.0 Training Accuracy: 1.0 Testing Accuracy: 1.0 Validation Accuracy: 1.0

5d Training Accuracy: 0.925 Testing Accuracy: 0.8 Validation Accuracy: 0.8 Training Accuracy: 1.0 Testing Accuracy: 0.8 Validation Accuracy: 0.6 Training Accuracy: 1.0 Testing Accuracy: 0.8 Validation Accuracy: 1.0 Training Accuracy: 1.0 Testing Accuracy: 0.8 Validation Accuracy: 0.8 Training Accuracy: 0.925 Testing Accuracy: 0.8 Validation Accuracy: 0.8 Training Accuracy: 0.975 Testing Accuracy: 1.0 Validation Accuracy: 0.8 Training Accuracy: 1.0 Testing Accuracy: 0.8 Validation Accuracy: 1.0 Training Accuracy: 0.975 Testing Accuracy: 0.8 Validation Accuracy: 0.8 Training Accuracy: 0.925 Testing Accuracy: 1.0 Validation Accuracy: 1.0 Training Accuracy: 0.975 Testing Accuracy: 1.0 Validation Accuracy: 0.8

**3 Softmax Regression**

First level headings are lower case (except for first word and proper nouns), flush left, bold and in point size 12. One-line space before the first level heading and ½ line space after the first level heading.

**3.1 Headings: second level**

Training Accuracy: 0.8416666666666667 Testing Accuracy: 0.6666666666666666 Validation Accuracy: 0.7333333333333333 Training Accuracy: 0.8666666666666667 Testing Accuracy: 0.5333333333333333 Validation Accuracy: 0.4666666666666667 Training Accuracy: 0.8416666666666667 Testing Accuracy: 0.5333333333333333 Validation Accuracy: 0.4666666666666667 Training Accuracy: 0.8333333333333334 Testing Accuracy: 0.6666666666666666 Validation Accuracy: 0.6666666666666666 Training Accuracy: 0.85 Testing Accuracy: 0.7333333333333333 Validation Accuracy: 0.9333333333333333 Training Accuracy: 0.85 Testing Accuracy: 0.5333333333333333 Validation Accuracy: 0.8 Training Accuracy: 0.8166666666666667 Testing Accuracy: 0.6666666666666666 Validation Accuracy: 0.7333333333333333 Training Accuracy: 0.8333333333333334 Testing Accuracy: 0.9333333333333333 Validation Accuracy: 0.6 Training Accuracy: 0.875 Testing Accuracy: 0.6 Validation Accuracy: 0.8 Training Accuracy: 0.85 Testing Accuracy: 0.6666666666666666 Validation Accuracy: 0.6666666666666666

**3.1.1 Headings: third level**

Third 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 third level heading and ½ line space after the third level heading.

**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.