COMP 551 Kaggle Competition: Classification of Modified MNIST*

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***Abstract*— This paper provides the report for the Kaggle Competition (assignment 4) of COMP 551 using the provided Modified MNIST dataset. The dataset includes a set of 8-bit grayscale images that include 2 or 3 digits of different sizes that are rotated and scaled from the classic MNIST dataset. The goal is to design Machine Learning algorithms that identify the biggest digit in each image. Several algorithms have been used in the report. First, the logistic regression and linear SVM are used which lead to relatively lower precisions. Second, a forward neural network completely developed by the team was implemented. Finally, a convoluted neural network was trained and tested on the preprocessed dataset which showed the best performance.**

I. INTRODUCTION

The MNIST database [1] is a set of handwritten images that is popular for training and testing of Machine Learning algorithms [2].

II. PREPROCESSING

The provided images in the Modified MNIST include 3 numbers that are rotated and scaled from the MNIST dataset and are written on random backgrounds. Some samples of the train dataset with their associated outputs are shown in Figure 1 The format for the images is 8-bit grayscale image, thus each pixel has 256 shades of gray represented by numbers 0 (black) to 255 (white) as shown in Figure 2.

Before, the data are used for training, the following preprocessing steps are used.

A. Thresholding

Since the numbers in the dataset match the 255 shade, a simple idea for preprocessing is to use *image thresholding*. The idea of thresholding is to compare the pixel values of the input image f with some threshold T and make a binary decision for the output binary image g as below

$$g(i,j) = \begin{cases} 1 & f(i,j) \geq T \\ 0 & f(i,j) \leq T \end{cases} \tag{1}$$

for all i, j where i, j represent the coordinates of the ij^{th} pixel [3].

The output of this filter is shown in Figure 3

B. Median Filter

The output of this filter on thresholded images are shown in Figure 4.

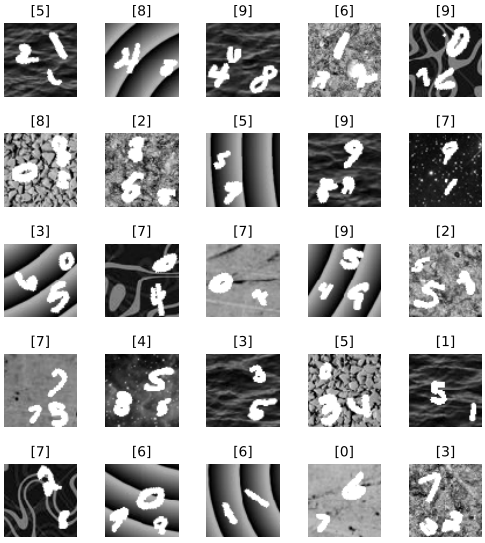

Fig. 1. 25 Random Samples of the original train dataset

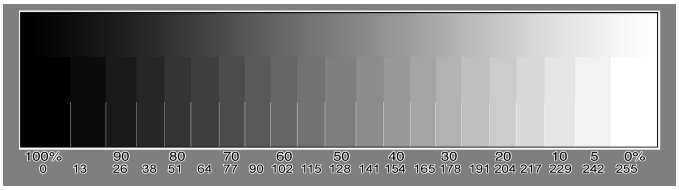

Fig. 2. 8-bit Grayscale Shades of Gray

C. Biggest Number

The output of this filter on thresholded images are shown in Figure 5.

III. MATH

Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

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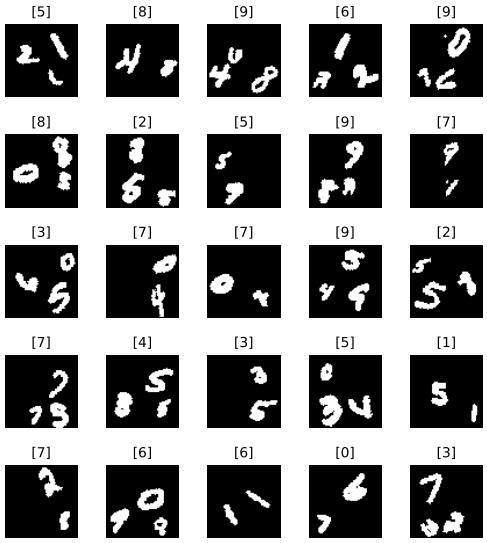

Fig. 3. Output of thresholding on images from Figure 1

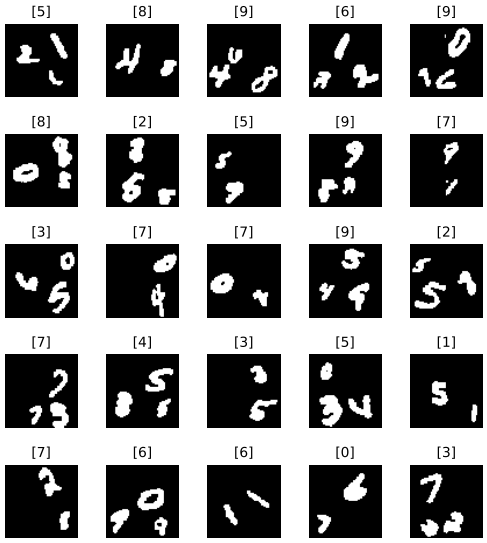

Fig. 4. Output of median filter on thresholded images from Figure 3

A. Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

B. Units

- Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as 3.5-inch disk drive.

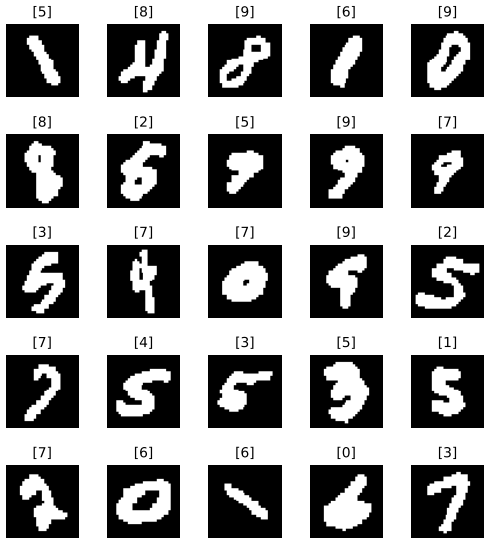

Fig. 5. Output of biggest number filter on thresholded images from Figure 3

- Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.
- Do not mix complete spellings and abbreviations of units: Wb/m2 or webers per square meter, not webers/m2. Spell out units when they appear in text: . . . a few henries, not . . . a few H.
- Use a zero before decimal points: 0.25, not .25. Use cm3, not cc. (bullet list)

C. Equations

The equations are an exception to the prescribed specifications of this template. You will need to determine whether or not your equation should be typed using either the Times New Roman or the Symbol font (please no other font). To create multileveled equations, it may be necessary to treat the equation as a graphic and insert it into the text after your paper is styled. Number equations consecutively. Equation numbers, within parentheses, are to position flush right, as in (1), using a right tab stop. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in

$$\alpha + \beta = \chi \tag{1}$$

Note that the equation is centered using a center tab stop. Be sure that the symbols in your equation have been defined before or immediately following the equation. Use (1), not

Eq. (1) or equation (1), except at the beginning of a sentence: Equation (1) is . . .

D. Some Common Mistakes

- The word data is plural, not singular.
- The subscript for the permeability of vacuum ?0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter o.
- In American English, commas, semi-/colons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
- A graph within a graph is an inset, not an insert. The word alternatively is preferred to the word alternately (unless you really mean something that alternates).
- Do not use the word essentially to mean approximately or effectively.
- In your paper title, if the words that uses can accurately replace the word using, capitalize the u; if not, keep using lower-cased.
- Be aware of the different meanings of the homophones affect and effect, complement and compliment, discreet and discrete, principal and principle.
- Do not confuse imply and infer.
- The prefix non is not a word; it should be joined to the word it modifies, usually without a hyphen.
- There is no period after the et in the Latin abbreviation et al..
- The abbreviation i.e. means that is, and the abbreviation e.g. means for example.

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Use this sample document as your LaTeX source file to create your document. Save this file as **root.tex**. You have to make sure to use the cls file that came with this distribution. If you use a different style file, you cannot expect to get required margins. Note also that when you are creating your out PDF file, the source file is only part of the equation. *Your TEX → PDF filter determines the output file size. Even if you make all the specifications to output a letter file in the source - if your filter is set to produce A4, you will only get A4 output.*

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Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced. Styles named Heading 1, Heading 2, Heading 3, and Heading 4 are prescribed.

B. Figures and Tables

Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation Fig. 1, even at the beginning of a sentence.

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity Magnetization, or Magnetization, M, not just M. If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write Magnetization (A/m) or Magnetization A[m(1)], not just A/m. Do not label axes with a ratio of quantities and units. For example, write Temperature (K), not Temperature/K.

V. CONCLUSIONS

A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

APPENDIX

Appendixes should appear before the acknowledgment.

ACKNOWLEDGMENT

The preferred spelling of the word acknowledgment in America is without an e after the g. Avoid the stilted expression, One of us (R. B. G.) thanks . . . Instead, try R. B. G. thanks. Put sponsor acknowledgments in the unnumbered footnote on the first page.

References are important to the reader; therefore, each citation must be complete and correct. If at all possible, references should be commonly available publications.

REFERENCES

[1] Y. LeCun, C. Cortes, and C. J. Burges. Mnist handwritten digit database, yann lecun, corinna cortes and chris burges. [Online]. Available: http://yann.lecun.com/exdb/mnist/

[2] W. contributors, "Mnist database — wikipedia, the free encyclopedia," 2018, [Online; accessed 16-March-2018]. [Online]. Available: https://en.wikipedia.org/w/index.php?title=MNIST_database&oldid=829836442

[3] A. C. Bovik, *The essential guide to image processing*. Academic Press, 2009.