

Assignment 1: The Perceptron

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Abstract

1. Introduction

In 2021, it was estimated that 537 million people worldwide had diabetes, and this number was projected to increase to 643 million by 2030 and 783 million by 2045. It was also approximated that 45% of people with diabetes, predominantly those with type 2 diabetes, were undiagnosed, highlighting an urgent need to improve diagnosis and provide timely care (IDF and cgmpt).

Predicting diabetes is a binary classification problem. A binary classification is the process of categorising data into 2 classes.

We will use the Pima Indians Diabetes dataset which has been used in many other papers to measure the performance of different algorithms

Before machine learning, the most common approach to binary classification problems was to use statistical methods.

We will be measuring the performance of the perceptron model. The perceptron model is a supervised machine learning algorithm for learning a linear classifier.

The previous approaches have been to use statistical methods, which require a lot of computational power. LDA and logistic regression are examples of these methods.

What are some other downsides? hidden relationships. Bad with small datasets. underlying relationships not known. Complex interactions and intercorrelations among many features.

Limitations of perceptron. Linearly separable data. No probabilistic output.

There are many better ways to do this now. The purpose of this paper is to analyse the performance of the perceptron algorithm on the Pima Indians Diabetes dataset.

2. Method

2.1. Prediction

We have implemented a very simple version of the Single Layer Perceptron (SLP) algorithm.

A SLP is a binary classifier which is a supervised machine learning algorithm. It is a binary classifier that takes in a vector of input features \mathbf{x} and outputs a single value y of 1 or 0 indicating which class the features belong to.

$$\mathbf{x} = [x_1, x_2, \dots, x_n] \quad (1)$$

There is a weight vector \mathbf{w} which is the same length as the input vector \mathbf{x} , and is learned during the training phase.

$$\mathbf{w} = [w_1, w_2, \dots, w_n] \quad (2)$$

The output y is determined by the decision function. The decision function is used to classify the input features into one of the classes. We initially use a basic binary classification decision function which takes the dot product of the inputs \mathbf{x} and the weights \mathbf{w} then passes this through an activation function. We use the sign function as the activation function.

$$y = \text{sign}(\mathbf{x} \cdot \mathbf{w}) \quad (3)$$

2.2. Training

Our initial implementation of the SLP training algorithm uses a feedforward method.

We need a way to update the weights.

Given a training set of n samples $\{(\mathbf{x}_i, y_i)\}_{i=1}^n$

First the weights are initialised to small random values. This is important because of the indicator function in the decision function will stop a weight from updating if it is 0. This is because

Now for each sample in the training set we make a prediction $y^* = \text{sign}(\mathbf{x}_i \cdot \mathbf{w})$. We then use the prediction and the correct value to calculate the loss. The loss for each sample is given by

$$l_i = \max\{0, -y_i \langle \mathbf{x}_i, \mathbf{w} \rangle\} \quad (4)$$

The loss gives us a metric to tell us how far away the prediction is from the correct output. Or at least it shows the "direction" we need to move the weights to get closer to the correct output.

We need to choose how much we want to update the weights(why?). To do this we use a hyperparameter called the learning rate η . The learning rate is a small positive number that we use to increase or decrease how much the weights are updated. [10]

Now that we have the loss we can update the weights. Each weight can be updated using the following equation.

$$w_i^* = w_i - \eta \cdot l_i \cdot x_i \quad (5)$$

This process is rep

We are given a training set of features with corresponding labels. For each sample in the training set we use the features to predict/calculate y . We then compare the prediction with the correct label. We use an error/loss function to compute the loss/error which will help us update the weights. The loss is a metric to tell us how far away the prediction is from the correct output. Or at least it shows the "direction" we need to move the weights to get closer to the correct output.

Initially we split the dataset into a training set and a test set with a 80/20 split. The samples for each set are chosen randomly.

2.3. Evaluation

We evaluate all variations of the model using the accuracy metric and the F1 score. Where TP is the number of true positives, TN is the number of true negatives, FP is the number of false positives and FN is the number of false negatives. [10]

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN} \quad (6)$$

$$F_1 = 2 \cdot \frac{\text{Precision} \cdot \text{Recall}}{\text{Precision} + \text{Recall}} \quad (7)$$

Where

$$\text{Precision} = \frac{TP}{TP + FP} \quad (8)$$

$$\text{Recall} = \frac{TP}{TP + FN} \quad (9)$$

We will also use the ROC curve to compare model variations between each other. It will also show us how well the models are performing compared to a random classifier.

We will construct the curve by using the results from stratified 8-fold cross-validation. Each point of the curve represents one cross-validation run. $k = 8$ was chosen since it divides the dataset equally. With 768 samples we get

96 samples in each fold. Since the dataset is not balanced we use select each fold randomly but while maintaining the class distribution between folds [5–7].

2.4. Dataset

There are 9 samples in the dataset that only have 8 features instead of 9. Since there is only a small number of samples with missing features we removed them from our dataset.

3. Experiments

Experiments.

4. Conclusion

Conclusion.

5. Introduction

Please follow the steps outlined below when submitting your manuscript to the IEEE Computer Society Press. This style guide now has several important modifications (for example, you are no longer warned against the use of sticky tape to attach your artwork to the paper), so all authors should read this new version.

5.1. Language

All manuscripts must be in English.

5.2. Dual submission

Please refer to the author guidelines on the CVPR 2025 web page for a discussion of the policy on dual submissions.

5.3. Paper length

Papers, excluding the references section, must be no longer than eight pages in length. The references section will not be included in the page count, and there is no limit on the length of the references section. For example, a paper of eight pages with two pages of references would have a total length of 10 pages. **There will be no extra page charges for CVPR 2025.**

Overlength papers will simply not be reviewed. This includes papers where the margins and formatting are deemed to have been significantly altered from those laid down by this style guide. Note that this L^AT_EX guide already sets figure captions and references in a smaller font. The reason such papers will not be reviewed is that there is no provision for supervised revisions of manuscripts. The reviewing process cannot determine the suitability of the paper for presentation in eight pages if it is reviewed in eleven.

5.4. The ruler

The L^AT_EX style defines a printed ruler which should be present in the version submitted for review. The ruler is provided in order that reviewers may comment on particular lines in the paper without circumlocution. If you are preparing a document using a non-L^AT_EX document preparation system, please arrange for an equivalent ruler to appear on the final output pages. The presence or absence of the ruler should not change the appearance of any other content on the page. The camera-ready copy should not contain a ruler. (L^AT_EX users may use options of `cvpr.sty` to switch between different versions.)

Reviewers: note that the ruler measurements do not align well with lines in the paper — this turns out to be very difficult to do well when the paper contains many figures and equations, and, when done, looks ugly. Just use fractional references (*e.g.*, this line is 087.5), although in most cases one would expect that the approximate location will be adequate.

5.5. Paper ID

Make sure that the Paper ID from the submission system is visible in the version submitted for review (replacing the “*****” you see in this document). If you are using the L^AT_EX template, **make sure to update paper ID in the appropriate place in the tex file.**

5.6. Mathematics

Please number all of your sections and displayed equations as in these examples:

$$E = m \cdot c^2 \tag{10}$$

and

$$v = a \cdot t. \tag{11}$$

It is important for readers to be able to refer to any particular equation. Just because you did not refer to it in the text does not mean some future reader might not need to refer to it. It is cumbersome to have to use circumlocutions like “the equation second from the top of page 3 column 1”. (Note that the ruler will not be present in the final copy, so is not an alternative to equation numbers). All authors will benefit from reading Mermin’s description of how to write mathematics: <http://www.pamitc.org/documents/mermin.pdf>.

5.7. Blind review

Many authors misunderstand the concept of anonymizing for blind review. Blind review does not mean that one must remove citations to one’s own work—in fact it is often impossible to review a paper unless the previous citations are known and available.

Blind review means that you do not use the words “my” or “our” when citing previous work. That is all. (But see below for tech reports.)

Saying “this builds on the work of Lucy Smith [1]” does not say that you are Lucy Smith; it says that you are building on her work. If you are Smith and Jones, do not say “as we show in [7]”, say “as Smith and Jones show in [7]” and at the end of the paper, include reference 7 as you would any other cited work.

An example of a bad paper just asking to be rejected:

An analysis of the frobnicatable foo filter.

In this paper we present a performance analysis of our previous paper [1], and show it to be inferior to all previously known methods. Why the previous paper was accepted without this analysis is beyond me.

[1] Removed for blind review

An example of an acceptable paper:

An analysis of the frobnicatable foo filter.

In this paper we present a performance analysis of the paper of Smith *et al.* [1], and show it to be inferior to all previously known methods. Why the previous paper was accepted without this analysis is beyond me.

[1] Smith, L and Jones, C. “The frobnicatable foo filter, a fundamental contribution to human knowledge”. Nature 381(12), 1-213.

If you are making a submission to another conference at the same time, which covers similar or overlapping material, you may need to refer to that submission in order to explain the differences, just as you would if you had previously published related work. In such cases, include the anonymized parallel submission [8] as supplemental material and cite it as

[1] Authors. “The frobnicatable foo filter”, F&G 2014 Submission ID 324, Supplied as supplemental material fg324.pdf.

Finally, you may feel you need to tell the reader that more details can be found elsewhere, and refer them to a technical report. For conference submissions, the paper must stand on its own, and not *require* the reviewer to go to a tech report for further details. Thus, you may say in the body of the paper “further details may be found in [9]”. Then submit the tech report as supplemental material. Again, you may not assume the reviewers will read this material.

Sometimes your paper is about a problem which you tested using a tool that is widely known to be restricted to a single institution. For example, let’s say it’s 1969, you have solved a key problem on the Apollo lander, and you believe that the 1970 audience would like to hear about your solution. The work is a development of your celebrated 1968 paper entitled “Zero-g frobnication: How being the only people in the world with access to the Apollo lander source code makes us a wow at parties”, by Zeus *et al.*

You can handle this paper like any other. Do not write “We show how to improve our previous work [Anonymous, 1968]. This time we tested the algorithm on a lunar lander [name of lander removed for blind review]”. That would be silly, and would immediately identify the authors. Instead write the following:

We describe a system for zero-g frobnication. This system is new because it handles the following cases: A, B. Previous systems [Zeus et al. 1968] did not handle case B properly. Ours handles it by including a foo term in the bar integral.

...

The proposed system was integrated with the Apollo lunar lander, and went all the way to the

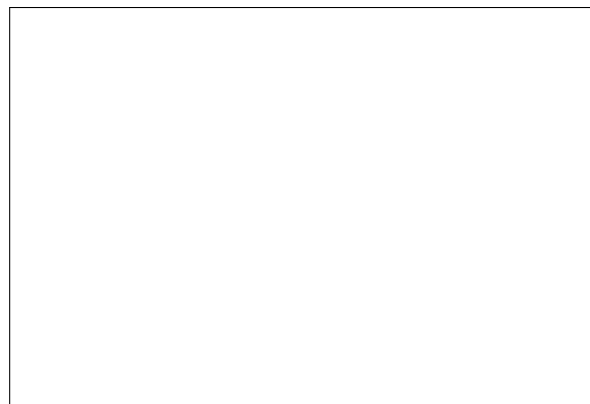


Figure 1. Example of caption. It is set in Roman so that mathematics (always set in Roman: $B \sin A = A \sin B$) may be included without an ugly clash.

moon, don’t you know. It displayed the following behaviours, which show how well we solved cases A and B: ...

As you can see, the above text follows standard scientific convention, reads better than the first version, and does not explicitly name you as the authors. A reviewer might think it likely that the new paper was written by Zeus *et al.*, but cannot make any decision based on that guess. He or she would have to be sure that no other authors could have been contracted to solve problem B.

FAQ

Q: Are acknowledgements OK?

A: No. Leave them for the final copy.

Q: How do I cite my results reported in open challenges?

A: To conform with the double-blind review policy, you can report results of other challenge participants together with your results in your paper. For your results, however, you should not identify yourself and should not mention your participation in the challenge. Instead present your results referring to the method proposed in your paper and draw conclusions based on the experimental comparison to other results.

5.8. Miscellaneous

Compare the following:

$\text{\$conf_a\$}$ conf_a
 $\text{\$}\mathit{\text{conf}}\text{\$}$ conf_a

See The \TeX book, p165.

The space after *e.g.*, meaning “for example”, should not be a sentence-ending space. So *e.g.* is correct, *e.g.* is not. The provided \eg macro takes care of this.

When citing a multi-author paper, you may save space by using “et alia”, shortened to “*et al.*” (not “*et. al.*” as “*et*” is a complete word). If you use the `\etal` macro provided, then you need not worry about double periods when used at the end of a sentence as in Alpher *et al.* However, use it only when there are three or more authors. Thus, the following is correct: “Frobnication has been trendy lately. It was introduced by Alpher [1], and subsequently developed by Alpher and Fotheringham-Smythe [2], and Alpher *et al.* [4].”

This is incorrect: “... subsequently developed by Alpher *et al.* [2] ...” because reference [2] has just two authors.

6. Formatting your paper

All text must be in a two-column format. The total allowable size of the text area is $6\frac{7}{8}$ inches (17.46 cm) wide by $8\frac{7}{8}$ inches (22.54 cm) high. Columns are to be $3\frac{1}{4}$ inches (8.25 cm) wide, with a $\frac{5}{16}$ inch (0.8 cm) space between them. The main title (on the first page) should begin 1 inch (2.54 cm) from the top edge of the page. The second and following pages should begin 1 inch (2.54 cm) from the top edge. On all pages, the bottom margin should be $1\frac{1}{8}$ inches (2.86 cm) from the bottom edge of the page for 8.5×11 -inch paper; for A4 paper, approximately $1\frac{5}{8}$ inches (4.13 cm) from the bottom edge of the page.

6.1. Margins and page numbering

All printed material, including text, illustrations, and charts, must be kept within a print area $6\frac{7}{8}$ inches (17.46 cm) wide by $8\frac{7}{8}$ inches (22.54 cm) high. Page numbers should be in the footer, centered and $\frac{3}{4}$ inches from the bottom of the page. The review version should have page numbers, yet the final version submitted as camera ready should not show any page numbers. The \LaTeX template takes care of this when used properly.

6.2. Type style and fonts

Wherever Times is specified, Times Roman may also be used. If neither is available on your word processor, please use the font closest in appearance to Times to which you have access.

MAIN TITLE. Center the title $1\frac{3}{8}$ inches (3.49 cm) from the top edge of the first page. The title should be in Times 14-point, boldface type. Capitalize the first letter of nouns, pronouns, verbs, adjectives, and adverbs; do not capitalize articles, coordinate conjunctions, or prepositions (unless the title begins with such a word). Leave two blank lines after the title.

AUTHOR NAME(s) and **AFFILIATION(s)** are to be centered beneath the title and printed in Times 12-point, non-boldface type. This information is to be followed by two blank lines.

The **ABSTRACT** and **MAIN TEXT** are to be in a two-column format.

MAIN TEXT. Type main text in 10-point Times, single-spaced. Do NOT use double-spacing. All paragraphs should be indented 1 pica (approx. $\frac{1}{6}$ inch or 0.422 cm). Make sure your text is fully justified—that is, flush left and flush right. Please do not place any additional blank lines between paragraphs.

Figure and table captions should be 9-point Roman type as in Figs. 1 and 2. Short captions should be centred. Callouts should be 9-point Helvetica, non-boldface type. Initially capitalize only the first word of section titles and first-, second-, and third-order headings.

FIRST-ORDER HEADINGS. (For example, **1. Introduction**) should be Times 12-point boldface, initially capitalized, flush left, with one blank line before, and one blank line after.

SECOND-ORDER HEADINGS. (For example, **1.1. Database elements**) should be Times 11-point boldface, initially capitalized, flush left, with one blank line before, and one after. If you require a third-order heading (we discourage it), use 10-point Times, boldface, initially capitalized, flush left, preceded by one blank line, followed by a period and your text on the same line.

6.3. Footnotes

Please use footnotes¹ sparingly. Indeed, try to avoid footnotes altogether and include necessary peripheral observations in the text (within parentheses, if you prefer, as in this sentence). If you wish to use a footnote, place it at the bottom of the column on the page on which it is referenced. Use Times 8-point type, single-spaced.

6.4. Cross-references

For the benefit of author(s) and readers, please use the

`\cref{...}`

command for cross-referencing to figures, tables, equations, or sections. This will automatically insert the appropriate label alongside the cross-reference as in this example:

To see how our method outperforms previous work, please see Fig. 1 and Tab. 1. It is also possible to refer to multiple targets as once, *e.g.* to Figs. 1 and 2a. You may also return to Sec. 6 or look at Eq. (11).

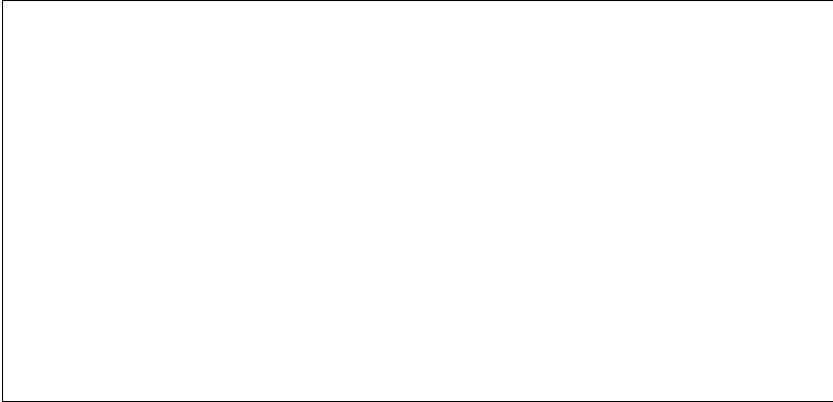
If you do not wish to abbreviate the label, for example at the beginning of the sentence, you can use the

`\Cref{...}`

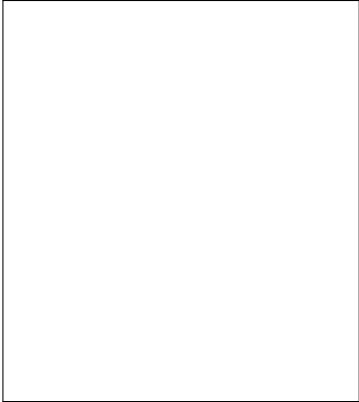
command. Here is an example:

Figure 1 is also quite important.

¹This is what a footnote looks like. It often distracts the reader from the main flow of the argument.



(a) An example of a subfigure.



(b) Another example of a subfigure.

Figure 2. Example of a short caption, which should be centered.

Method	Frobnability
Theirs	Frumpy
Yours	Frobbly
Ours	Makes one’s heart Frob

Table 1. Results. Ours is better.

6.5. References

List and number all bibliographical references in 9-point Times, single-spaced, at the end of your paper. When referenced in the text, enclose the citation number in square brackets, for example [8]. Where appropriate, include page numbers and the name(s) of editors of referenced books. When you cite multiple papers at once, please make sure that you cite them in numerical order like this [1–3, 8, 9]. If you use the template as advised, this will be taken care of automatically.

6.6. Illustrations, graphs, and photographs

All graphics should be centered. In L^AT_EX, avoid using the `center` environment for this purpose, as this adds potentially unwanted whitespace. Instead use

```
\centering
```

at the beginning of your figure. Please ensure that any point you wish to make is resolvable in a printed copy of the paper. Resize fonts in figures to match the font in the body text, and choose line widths that render effectively in print. Readers (and reviewers), even of an electronic copy, may choose to print your paper in order to read it. You cannot insist that they do otherwise, and therefore must not assume that they can zoom in to see tiny details on a graphic.

When placing figures in L^AT_EX, it’s almost always best to use `\includegraphics`, and to specify the figure width as a multiple of the line width as in the example below

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

6.7. Color

Please refer to the author guidelines on the CVPR 2025 web page for a discussion of the use of color in your document.

If you use color in your plots, please keep in mind that a significant subset of reviewers and readers may have a color vision deficiency; red-green blindness is the most frequent kind. Hence avoid relying only on color as the discriminative feature in plots (such as red vs. green lines), but add a second discriminative feature to ease disambiguation.

References

- [1] FirstName Alpher. Frobnication. *IEEE TPAMI*, 12(1):234–778, 2002. 5, 6
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- [10] Stephen Marsland. *MACHINE LEARNING An Algorithmic Perspective Second Edition*. CRC Press, 2015. [2](#)