

# Numerical Methods for Estimation Problems

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## I. INTRODUCTION

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## II. LINEAR BASIS FUNCTION REGRESSION

We will now examine regression models that use a linear combination of arbitrary basis functions. The closed form solution is actually available for such model classes (Bishop equation 3.15). For this section, our training data was generated using the function  $y(x) = \cos(\pi x) + \cos(2\pi x)$  with added noise.

### A. Polynomial basis functions

We first try linear regression with a simple polynomial basis  $\phi_0(x) = 1$ ,  $\phi_1(x) = x$ ,  $\dots$ ,  $\phi_M(x) = x^M$ . Note that for a given  $M$  there are  $M + 1$  basis functions.

For  $M = 0$ , the result is a constant function. We can simplify the closed-form solution above to see that this is simply the mean of all the observations. As  $M$  increases, sum of squares error decreases and our estimate function comes closer to the points (Figure x). However, if  $M$  becomes too high, we see a tendency to overfit. The estimate curve goes through all the training points, resulting in zero error, but it would fare poorly if tested on more data from the underlying distribution.

This demonstrates the need to restrict the complexity of our possible model to the amount of training data at our disposal.

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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.

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- 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.
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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

$$\alpha + \beta = \chi \quad (1)$$

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  $\mu_0$ , 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*.

## IV. USING THE TEMPLATE

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### A. Headings, etc

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.

TABLE I  
AN EXAMPLE OF A TABLE

One	Two
Three	Four

We suggest that you use a text box to insert a graphic (which is ideally a 300 dpi TIFF or EPS file, with all fonts embedded) because, in an document, this method is somewhat more stable than directly inserting a picture.

Fig. 1. Inductance of oscillation winding on amorphous magnetic core versus DC bias magnetic field

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.

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