
What If Without the Conformal Prediction

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Abstract

The abstract paragraph should be indented ½ inch (3 picas) on both the left- and right-hand margins. Use 10 point type, with a vertical spacing (leading) of 11 points. The word **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

What if the world had no conformal prediction? This paper attempts to answer that question. But before addressing this question, we must first introduce the unique nature of the conformal prediction topic itself. Compared to algorithms like gradient boosting that have been around for some time, conformal prediction—proposed in the 2000s and gaining prominence only recently—is a very young research direction. Therefore, beyond merely discussing what the present would be like without conformal prediction, we should also reflect on the algorithm’s future impact by examining the insights it offers. If this research direction had never been proposed, how might related theories and applications evolve in the future?

Translated with DeepL.com (free version)

2 Need

Discuss the problem or need that the XXX method addresses. Why was this method developed? What gaps in knowledge or practice does it fill? State the background issues of Conformal Prediction.

3 Introduction to Conformal Prediction

A simple introduction to the conformal prediction algorithm

1. Core insight: a revolutionary abstraction of the “score” definition Your observation that “the definition of the score removes the dependence on the model’s internal structure” captures the essence of conformal prediction.

(1) The key step: the nonconformity score • Traditional view: model outputs (such as softmax probabilities or SVM decision values) are used directly as proxies for confidence. These are tightly coupled to the model’s internal structure. A neural network probability and a random forest probability do not have the same meaning and cannot be compared directly. • CP’s abstraction: it introduces a nonconformity score $A(x, y)$. The only requirement is that for a data point (x, y) , a higher score means the pair looks more “strange” or “nonconforming” relative to the model or data distribution. • Structure removed: this score A can be anything—prediction error $|y - f(x)|$, negative log-likelihood, distance to a decision boundary, or variance across an ensemble. CP does not care how A is constructed; it only uses the ranking of these scores. It compresses any model into a scalar score generator.

(2) Significance: this abstraction achieves model-agnosticism. Whether using a ResNet, a transformer, or logistic regression, as long as a “strangeness score” can be computed for each candidate label, CP can provide coverage guarantees. This decouples uncertainty quantification from model design.

2. Theoretical foundation: trading “exchangeability” for mathematical guarantees Your point that CP “uses exchangeability to obtain mathematical guarantees” touches its statistical core.

(1) Mild assumption: CP does not require the data to be i.i.d.; it only needs exchangeability—the joint distribution remains unchanged under index permutations. This is weaker than i.i.d. and closer to practical settings (e.g., time series can often be made approximately exchangeable after proper preprocessing). (2) Strong guarantee: under this mild assumption, CP yields its key validity guarantee: for any new test point, the probability that the true label falls outside the prediction set is at most α , the preset error rate. This is a finite-sample, distribution-free guarantee independent of model complexity or data distribution. (3) Insight: CP demonstrates a path where strong, practical statistical guarantees arise not from assuming a specific data-generating distribution, but from exploiting symmetry properties of data order. This is foundational for statistical inference in modern high-dimensional, complex data settings.

4 Benefits

Highlight the advantages of using the XXX method. What are its strengths compared to other methods? How has it contributed to advancements in statistical machine learning?

4.1 Existing Applications

Could you elaborate on the current application scenarios for conformal prediction? It’s used in drug development and even crop discovery—the benefits are numerous!

4.2 idea insight

Therefore, the true insight of conformal prediction is that it offers a meta-methodology:

1. Decoupling: It separates model performance (implicitly reflected through the score function A) from output guarantees (derived from rank-based calibration and exchangeability). 2. Guarantee-first design: It reverses the traditional approach. Instead of trying to make model outputs “look like” probabilities and then hoping for guarantees, CP first builds a framework that inherently provides guarantees (via calibration and set-valued prediction), and then embeds any model inside it. 3. Infrastructure-friendly: It provides a simple, unified, and theoretically sound reliability layer for the diverse and ever-changing machine-learning ecosystem. This is not only an algorithmic innovation but also an elevation in system-level engineering thinking.

5 Competitors

1. nonparametric estimates of prediction loss (cross-validation and the bootstrap “632 rule”) as well as Breiman’s out-of-bag error estimates for random forests

2. Covariance penalties, including Mallows’ C_p and the Akaike Information Criterion, are parametric methods discussed in Section 4 along with the related concept of degrees of freedom.

5.1 Style

Papers to be submitted to NeurIPS 2019 must be prepared according to the instructions presented here. Papers may only be up to eight pages long, including figures. Additional pages *containing only acknowledgments and/or cited references* are allowed. Papers that exceed eight pages of content (ignoring references) will not be reviewed, or in any other way considered for presentation at the conference.

The margins in 2019 are the same as since 2007, which allow for $\sim 15\%$ more words in the paper compared to earlier years.

Authors are required to use the NeurIPS L^AT_EX style files obtainable at the NeurIPS website as indicated below. Please make sure you use the current files and not previous versions. Tweaking the style files may be grounds for rejection.

5.2 Retrieval of style files

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

<http://www.neurips.cc/>

The file `neurips_2019.pdf` contains these instructions and illustrates the various formatting requirements your NeurIPS paper must satisfy.

The only supported style file for NeurIPS 2019 is `neurips_2019.sty`, rewritten for L^AT_EX 2_ε. **Previous style files for L^AT_EX 2.09, Microsoft Word, and RTF are no longer supported!**

The L^AT_EX style file contains three optional arguments: `final`, which creates a camera-ready copy, `preprint`, which creates a preprint for submission to, e.g., arXiv, and `nonatbib`, which will not load the `natbib` package for you in case of package clash.

Preprint option If you wish to post a preprint of your work online, e.g., on arXiv, using the NeurIPS style, please use the `preprint` option. This will create a nonanonymized version of your work with the text “Preprint. Work in progress.” in the footer. This version may be distributed as you see fit. Please **do not** use the `final` option, which should **only** be used for papers accepted to NeurIPS.

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The file `neurips_2019.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 formatting instructions contained in these style files are summarized in Sections 6, 7, and 8 below.

6 General formatting instructions

The text must be confined within a rectangle 5.5 inches (33 picas) wide and 9 inches (54 picas) long. The left margin is 1.5 inch (9 picas). Use 10 point type with a vertical spacing (leading) of 11 points. Times New Roman is the preferred typeface throughout, and will be selected for you by default. Paragraphs are separated by 1/2 line space (5.5 points), with no indentation.

The paper title should be 17 point, initial caps/lower case, bold, centered between two horizontal rules. The top rule should be 4 points thick and the bottom rule should be 1 point thick. Allow 1/4 inch space above and below the title to rules. All pages should start at 1 inch (6 picas) from the top of the page.

For the final version, authors’ names are set in boldface, and each name is centered above the corresponding address. The lead author’s name is to be listed first (left-most), and the co-authors’ names (if different address) are set to follow. If there is only one co-author, list both author and co-author side by side.

Please pay special attention to the instructions in Section 8 regarding figures, tables, acknowledgments, and references.

7 Headings: first level

All headings should be lower case (except for first word and proper nouns), flush left, and bold.

First-level headings should be in 12-point type.

7.1 Headings: second level

Second-level headings should be in 10-point type.

7.1.1 Headings: third level

Third-level headings should be in 10-point type.

Paragraphs There is also a `\paragraph` command available, which sets the heading in bold, flush left, and inline with the text, with the heading followed by 1 em of space.

8 Citations, figures, tables, references

These instructions apply to everyone.

8.1 Citations within the text

The `natbib` package will be loaded for you by default. Citations may be author/year or numeric, as long as you maintain internal consistency. As to the format of the references themselves, any style is acceptable as long as it is used consistently.

The documentation for `natbib` may be found at

<http://mirrors.ctan.org/macros/latex/contrib/natbib/natnotes.pdf>

Of note is the command `\citet`, which produces citations appropriate for use in inline text. For example,

```
\citet{hasselmo} investigated\dots
```

produces

Hasselmo, et al. (1995) investigated...

If you wish to load the `natbib` package with options, you may add the following before loading the `neurips_2019` package:

```
\PassOptionsToPackage{options}{natbib}
```

If `natbib` clashes with another package you load, you can add the optional argument `nonatbib` when loading the style file:

```
\usepackage[nonatbib]{neurips_2019}
```

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.”

8.2 Footnotes

Footnotes should be used sparingly. If you do require a footnote, indicate footnotes with a number¹ 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).

Note that footnotes are properly typeset *after* punctuation marks.²

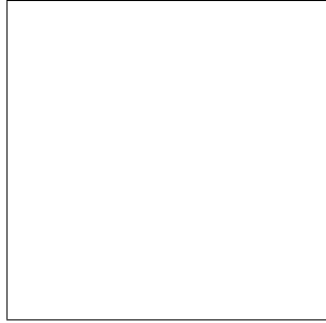


Figure 1: Sample figure caption.

Table 1: Sample table title

Part		
Name	Description	Size (μm)
Dendrite	Input terminal	~ 100
Axon	Output terminal	~ 10
Soma	Cell body	up to 10^6

8.3 Figures

All artwork must be neat, clean, and legible. Lines should be dark enough for purposes of reproduction. 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 should be lower case (except for first word and proper nouns); figures are numbered consecutively.

You may use color figures. However, it is best for the figure captions and the paper body to be legible if the paper is printed in either black/white or in color.

8.4 Tables

All tables must be centered, neat, clean and legible. 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.

Note that publication-quality tables *do not contain vertical rules*. We strongly suggest the use of the `booktabs` package, which allows for typesetting high-quality, professional tables:

<https://www.ctan.org/pkg/booktabs>

This package was used to typeset Table 1.

9 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 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.

¹Sample of the first footnote.

²As in this example.

10 Preparing PDF files

Please prepare submission files with paper size “US Letter,” and not, for example, “A4.”

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 should directly generate PDF files using `pdflatex`.
- You can check which fonts a PDF file uses. In Acrobat Reader, select the 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 NeurIPS. Please see <http://www.emfield.org/icuwb2010/downloads/IEEE-PDF-SpecV32.pdf>
- `xfig` “patterned” shapes are implemented with bitmap fonts. Use “solid” shapes instead.
- The `\bbold` package almost always uses bitmap fonts. You should use the equivalent AMS Fonts:

```
\usepackage{amsfonts}
```

followed by, e.g., `\mathbb{R}`, `\mathbb{N}`, or `\mathbb{C}` for \mathbb{R} , \mathbb{N} or \mathbb{C} . You can also use the following workaround for reals, natural and complex:

```
\newcommand{\RR}{\mathbb{R}} %real numbers
\newcommand{\Nat}{\mathbb{N}} %natural numbers
\newcommand{\CC}{\mathbb{C}} %complex numbers
```

Note that `amsfonts` is automatically loaded by the `amssymb` package.

If your file contains type 3 fonts or non embedded TrueType fonts, we will ask you to fix it.

10.1 Margins in L^AT_EX

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

See Section 4.4 in the graphics bundle documentation (<http://mirrors.ctan.org/macros/latex/required/graphics/grfguide.pdf>)

A number of width problems arise when L^AT_EX cannot properly hyphenate a line. Please give LaTeX hyphenation hints using the `\-` command when necessary.

Acknowledgments

Use unnumbered third level headings for the acknowledgments. All acknowledgments go at the end of the paper. Do not include acknowledgments in the anonymized submission, only in the final paper.

References

References follow the acknowledgments. Use unnumbered first-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 you can use more than eight pages as long as the additional pages contain *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 hippocampal region CA3. *Journal of Neuroscience* **15**(7):5249-5262.