On the Uncertainty of Wind Power Forecasts

(AMCS Optimization course final project submission)

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Abstract

Reliable wind power generation forecasting is crucial to meet energy demand, to trade and invest. We propose a model to simulate and quantify uncertainties in such forecasts. This model is based on Stochastic Differential Equations whose time-dependent parameters are inferred using continuous optimization of an approximate Likelihood function. The result is a skew stochastic process that simulates uncertainty of wind power forecasts accounting for maximum power production limit and other temporal effects. We apply the model to historical Uruguayan data and forecasts.

1. Introduction

We propose a model to simulate and quantify uncertainties in wind power generation forecasts. This model is based on Stochastic Differential Equations (SDEs) whose time-dependent parameters are inferred using optimization techniques of an associated approximate Likelihood function. Through continuous optimization, we find the optimal parameters of an unbounded convex problem with convex constraints.

We are able to simulate and quantify uncertainties in a variety of wind power generation forecasts while taking into account the skewness of the errors. This method is non-intrusive and is independent of forecasting technology or future developments. Through optimization, we update and tune the parameters of our SDE as we receive new sets of observations and their associated forecasts. Additionally, we are able to compare in a quantitative manner the different forecast technologies and how they behave in different real-world scenarios. This model is to be extended to the uncertainty quantification of other power generation sources such as the uncertainties in the power generation of solar power plants. This introduces new challenges in terms of optimization and modeling. Finally, we apply our model to synthetic and real wind power generation data for bench-

marking. We apply the model to Uruguayan wind power production as determined by historical data and corresponding numerical forecasts for the period of March 1 to May 31, 2016.

1.1. Model

We propose the following parameterized stochastic differential equation (SDE),

$$dV_t = -\theta V_t dt + \sqrt{2\theta \alpha p_t (1 - p_t)(V_t + p_t)(1 - V_t - p_t)} dW_t$$

$$V_0 = v_0$$
(1)

where $\theta > 0$ and $\alpha > 0$ are parameters to be inferred.

1.2. Dual submission

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1.3. 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 2019.

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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.

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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.

1968] didn't 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 moon, don't you know. It displayed the following behaviours which show how well we solved cases A and B: ...

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Compare the following:

 $\begin{array}{ll} & & conf_a \\ & & \\ &$

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 $\setminus eg$ 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.) 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 [?], and subsequently developed by Alpher and Fotheringham-Smythe [?], and Alpher et al. [?]."

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

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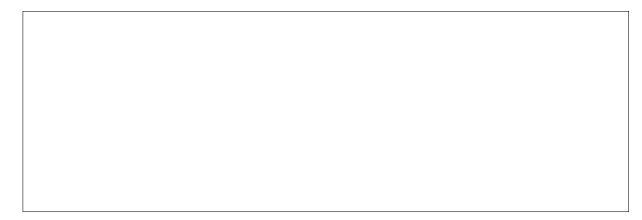


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Method	Frobnability
Theirs	Frumpy
Yours	Frobbly
Ours	Makes one's heart Frob

Table 1. Results. Ours is better.

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 $^{^{\}rm 1}{\rm This}$ is what a footnote looks like. It often distracts the reader from the main flow of the argument.

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