ISSN (O) 2321-2004, ISSN (P) 2321-5526

IJIREEICE

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Vol. 9, Issue 11, November 2021

DOI: 10.17148/IJIREEICE.2021.91108

Comparative Analysis of Spline Based ML Methods for Power Consumption Estimation

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Abstract: Machine learning based estimation of power consumption has been established as a method of generating exact demand estimates for mutual economic benefit of providers and consumers. The current work compares multiple implementations of a low-complexity spline-based ML technique in terms of mean error and RMSE performance to propose an accurate model for generation of power consumption estimates.

Keywords: Machine learning, demand forecasting, spline, RMSE.

I. INTRODUCTION

The estimation of consumption of electricity has emerged as a relevant topic in recent years, due to the linkage of national economies with the demand and supply of electricity. As a consequence, a number of novel techniques have been proposed in recent times to generate accurate electricity demand estimates for local and extended geographies. Among the more popular methods, machine learning based estimation techniques have been preferred by researchers for their various benefits, ranging from reduction in cost and ease of use to vastly improved accuracy. As a consequence, the present work seeks to explore a specific low-complexity machine learning technique for annual power consumption estimation. The spline-based technique is varied with respect to the number of point estimations used to generate the final estimates and the comparative results are presented.

II. LITERATURE SURVEY

In the recent past, many researchers have worked on the problem of accurate electricity demand forecasting considering different durations of time. A polynomial regression model has been presented in [1], which gives accurate results for the specific geographical location. A comparative study has been made among regression-based techniques, Artificial Neural Network based methods, and Kalman Filter based estimation, for demand prediction in [2], with the Kalman Filter based method showing greatest accuracy. Radial basis Function based methods have been explored in conjunction with Genetic Algorithm technique, in [3], with results achieved being superior to backpropagation-based methods. Grey forecasting has been explored in [4] in order to improve the performance of standard neural network-based methods.

One major challenge plaguing most techniques is the increased complexity of the methods, incurred to achieve acceptable accuracy. Thus, low-complexity methods such as the one outlined in [5] allows for achievement of desirable accuracy without proposing a highly complex technique which requires significant resources to implement. A similar technique based on second-order regression splines is outlined in [6] which allows achievement of appreciable accuracy with moderately low complexity. The present work therefore seeks to compare multiple adaptive regression-based models on the basis of mean error and RMSE, based on the dataset presented in [6].

III. MODEL

The model employed for the work presented in the paper is a regression model where present year's demand *Y* is dependent on previous year's consumption *X*, and two constants *M* and *C*. The corresponding equation 1 is shown below.

$$Y=MX+C \quad (1)$$

The autoregression function *f* is applied to calculate *N*-step autoregression as shown in equation 2 below.

$$Y_{N+1}=f(\sum_1^N M_i X_i + C_i) \quad (2)$$

The simulation results for 2, 3 and 4 step versions of the technique are presented in the following section.

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Electrical, Electronics, Instrumentation and Control Engineering

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IV. RESULTS AND DISCUSSIONS

The results obtained for mean errors and RMSE are shown for the techniques, in Table 1 and Table 2 respectively.

TABLE I MEAN ERRORS FOR 2, 3 AND 4 STEP SPLINE_BASED ESTIMATION

YEAR	4-STEP ERROR	3-STEP ERROR	2-STEP ERROR
	%	%	%
2000-01	-1.173	-1.074	0
2001-02	0.905	1.03	0
2002-03	0.424	0.042	-0.001
2003-04	-0.155	-0.059	-0.001
2004-05	0.768	0.108	0.001
2005-06	-0.628	-0.048	0.001
2006-07	-0.647	0.034	-0.001
2007-08	0.528	-0.055	-0.001
2008-09	0.136	0.025	0
2009-10	-0.221	-0.001	0
2010-11	0.082	-0.001	-0.001

TABLE III COMPARATIVE RMSE FOR 4, 3 AND 2 STEP TECHNIQUES

TECHNIQUE	RMSE
4 STEP ADAPTIVE SPLINE	0.6146
3 STEP ADAPTIVE SPLINE	0.4511
2 STEP ADAPTIVE SPLINE	0.0008

The corresponding graphical results are presented in Figure 1 and Figure 2 respectively, which follow.

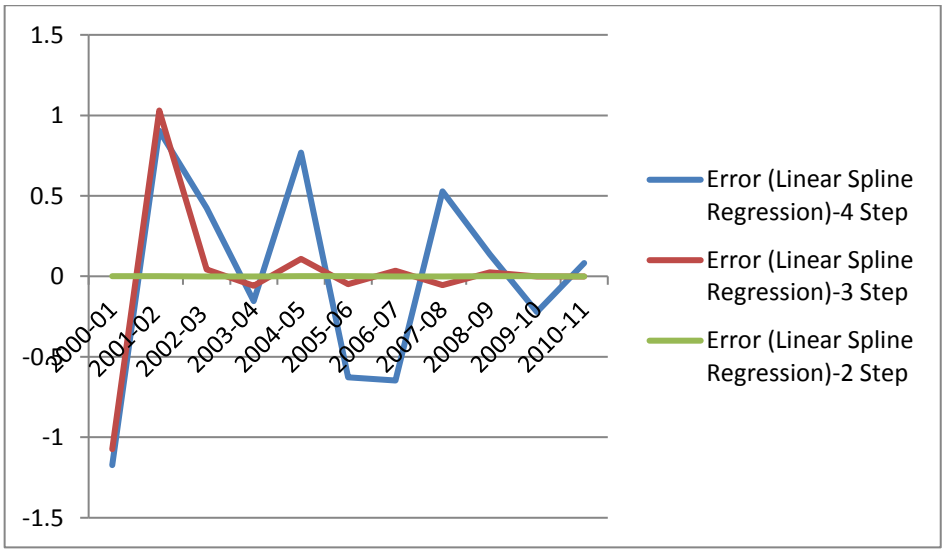

Fig. 1 Comparison of Errors for 4, 3 and 2 step Spline-Based Estimation

ISSN (O) 2321-2004, ISSN (P) 2321-5526

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Electrical, Electronics, Instrumentation and Control Engineering

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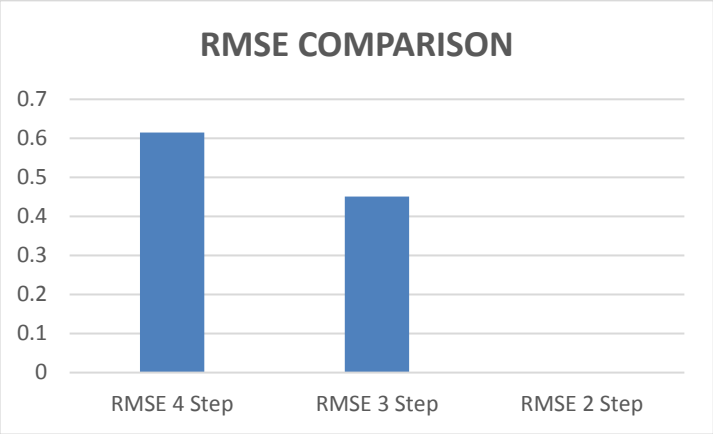

Fig. 2 Comparison of RMSE for 4, 3 and 2 step Spline-Based Estimation

The results obtained clearly show the advantage of using two-step adaptive spline method for estimation of power consumption, since lowest estimation error and RMSE are achieved through application of this technique.

V. CONCLUSION

The present work clearly demonstrates the effectiveness of the two-step adaptive spline estimation technique. Further research in this domain may focus on investigation of techniques for hourly demand forecast using similar or other low-complexity techniques.

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