Short time ahead wind power production forecast.

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Introduction

- new model to forecast wind power production of the park 5- to 30-minutes ahead
- the model is based on machine learning techniques and uses historical wind and power production time series

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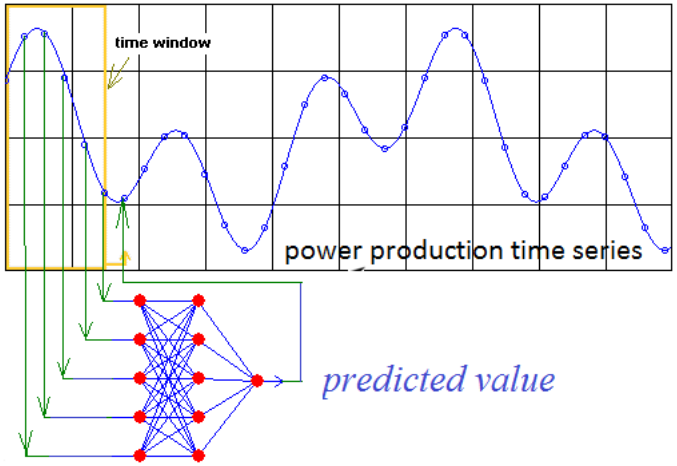
Model description

- 6 month historical data from several on-shore wind parks from Sweden and Norway
- time series analysis of historical park production and NWP data
  - ANN uses the historical power production values as inputs
  - ANN uses wind speed and direction time-series and hourly NWP data, in addition to historical power production
- length of a time window is two times longer than the prediction horizon



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Validation of the model (RMSPE on predicted power production)

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}$$

Prediction time-window	Hourly weather forecast and historical power production time series	Historical power production time series
5 minutes ahead prediction	12.2	8.2
15 minutes ahead prediction	14.9	9.7
30 minutes ahead prediction	15.1	9.5

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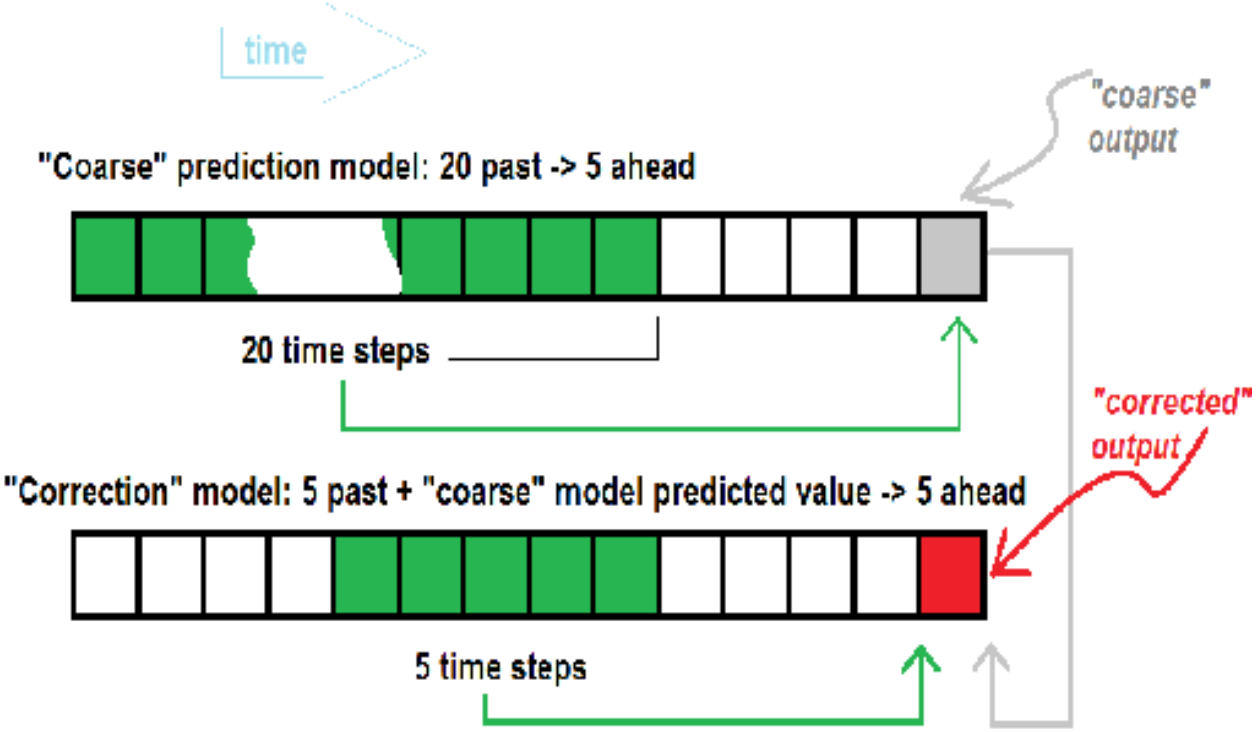
Model's modification: double-module architecture



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Validation of the new model

Prediction horizon	5 minutes			10 minutes			20 minutes			30 minutes		
Time-series window interval, minutes	10	20	30	20	30	40	30	40	60	40	60	90
Number of hidden neurons	10 to 30	20 to 60	30 to 90	20 to 60	30 to 90	40 to 100	30 to 90	40 to 100	60 to 100	40 to 100	60 to 100	90 to 100
Validation error (RMSPE)	14.9	9.7	7.9	15.1	12.2	8.1	18.1	12.4	8.6	16.2	8.9	8.9

Prediction time-window	ANN module	SVM module
5 minutes ahead prediction	7.9	6.4
30 minutes ahead prediction	8.9	7.9

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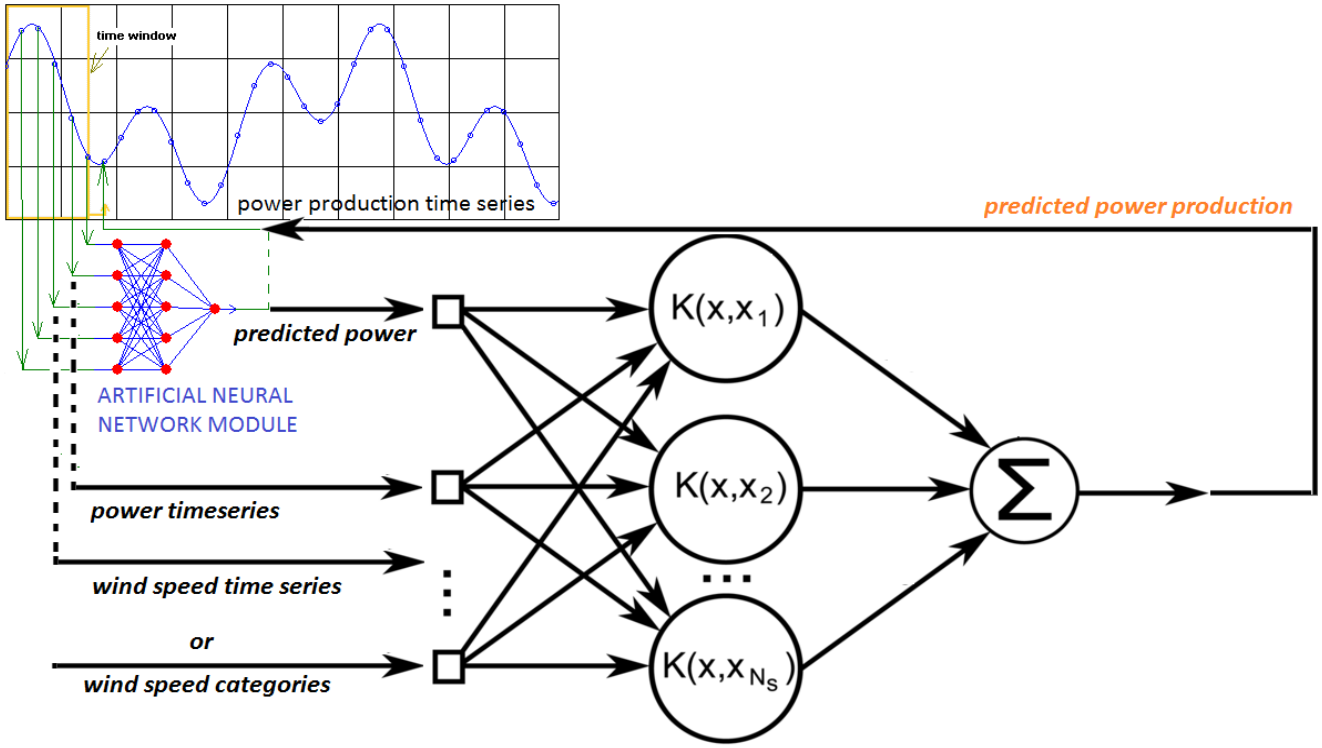
Model's modification: selection of the second layer



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Validation of ANN/SVM model (RMSPE on predicted power production)

SVM modules' architectures and root-mean-square percentage error of wind power production forecast performed by corresponding modules.

Prediction horizon	5 minutes				10 minutes				30 minutes					
Power production time-series length, minutes	5	5	10	10	5	5	10	10	5	5	10	10	20	20
NWP data used	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Wind speed and direction time-series, minutes	5	5	5	5	5	5	5	5	10	10	10	10	10	10
Validation error (RMSPE)	6.6	6.7	5.9	5.9	6.9	6.8	6.1	6.2	9.1	9.4	8.6	9.2	8.2	8.5

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Categorization approach

Wind speed ranges and corresponding numerical attributes used for categorization.

Wind speed range, m/s	<0.5	0.5-1	1-3	3-7	7-10	10-15	15-20	20-25	>25
Category	Failed record	Wind calm	Light breeze	Gentle breeze	Fresh breeze	Strong wind	Near gale	Gale	Cut off
Numerical attribute	1	2	3	4	5	6	7	8	9

Prediction horizon	5 minutes		10 minutes		30 minutes		
Power production time-series length, minutes	5	10	5	10	5	10	20
Wind speed and direction time-series, minutes	5	5	5	5	10	10	10
RMSPE for model without categorization approach	6.7	5.9	6.8	6.1	9.1	8.6	8.2
RMSPE for model with categorization approach	4.5	4.6	5.1	5.1	6.5	6.2	6.2

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Conclusions

- model uses NWP, historical wind speed and power production data and employs machine learning methods and categorization approach.
- best performance is shown for combination of ANN and kernel method for double-module model
- model shows that use of NWP data is not significantly improve the accuracy for very short time ahead forecast (5-10 minutes ahead), yet is valuable for 30 (and longer) minutes ahead forecasts.
- if categorization of an input variable is used, the better accuracy of the forecast can be achieved even with smaller number input variables.

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Thank you!

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