Electric Energy Consumption Forecast based on Spatial Information

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Context

- Power companies need to predict monthly of their consumers' energy consumption;
- In practice, each company defines its criteria for checking for inconsistencies in reading data;
- Forecast based on average consumption;
- Fixed percentages for defining a minimum and maximum consumption range;

Motivation

- Predicting consumption:
  - It is relatively simple when its consumers' consumption history exists.
  - It is difficult or impractical for consumers with no consumption history.
    - Example: New consumer installation or a short history of power consumption.

Purpose

➜ Prediction proposed method using neighborhood energy consumption information to prediction of consumers without consumption history.

Proposed Method

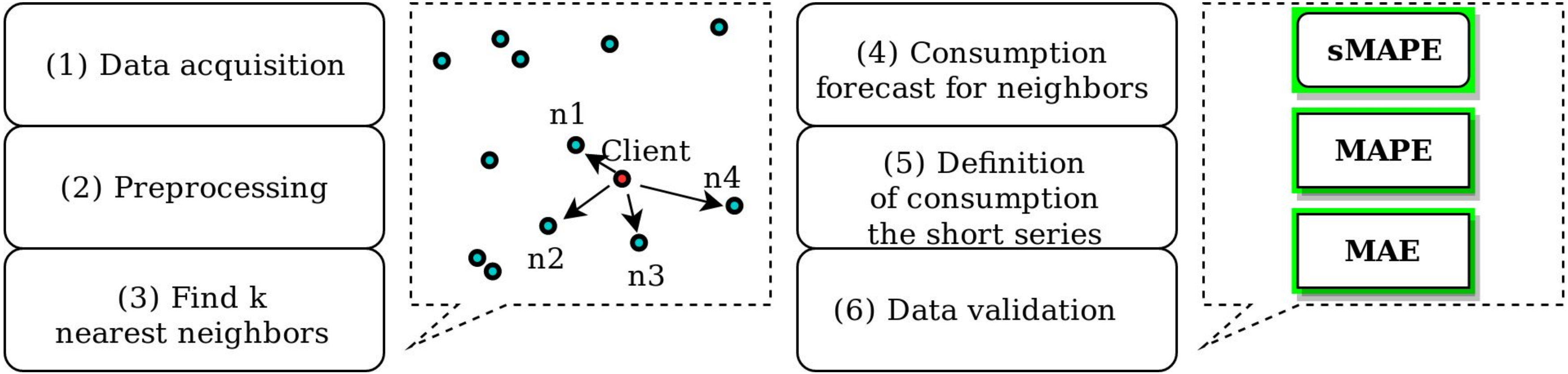


Fig. 1. Steps of the proposed method

(1) Data Acquisition

- Power consumption data from 2,316,760 active customers
  - monthly consumption history
  - from January 2017 to April 2019
  - Clients are organized into classes and subclasses, according to ANEEL Normative Resolution.

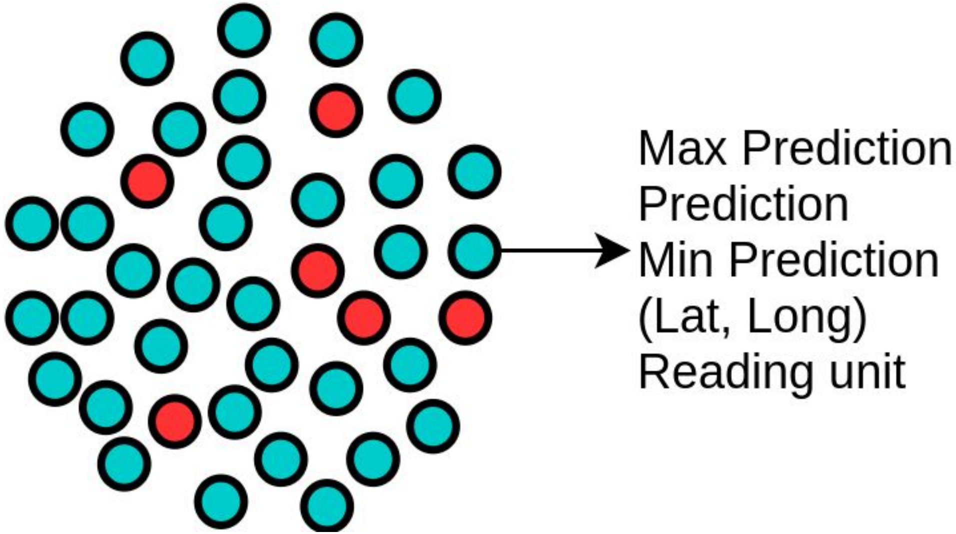
- Clientes classes:
  - Residential, Industrial, Commercial, Public service, Self-Consumption, Rural, Government and Lighting public

(2) Preprocessing

- The Database has customers with short series
  - 1 to 4 months (95,052).
- Disregarded series that:
  - (1) have less than threes neighbor installations;
  - (2) cases where clients do not have valid coordinates, which makes it impossible to identify their location and distance to their neighbors;
  - (3) cases in which the series do not have consumption registered in the reference month of this study;

(3) Finding K-Nearest Neighbor

➜ k-nearest neighbors are defined based on the customer's geographic coordinates.



(4) Consumption forecast for neighbors

➜ Minimum and maximum prediction intervals were performed for the reference month of June 2018;

➜ Consumption was estimated using statistical methods:

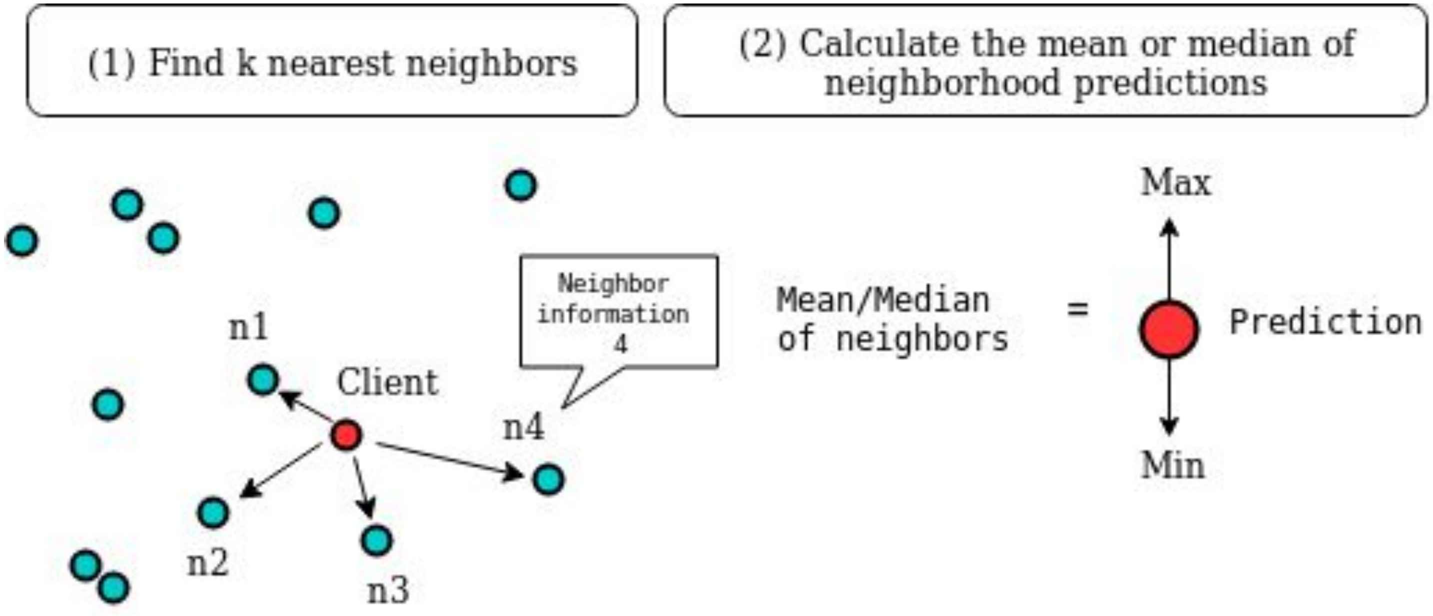
- STL → Better in the Industrial and Self-consumption class;
- ARIMA →Better in the Public Lighting and Public Power class
- BAQR → Better in the: Residential, Rural, Public Service, and Commercial classes.

(5) Definition of consumption of the short series

- The proposed method considers four scenarios for consumption estimation and prediction interval.
  - Scenario 1: for customers without history
  - Scenario 2: Customers who have one consumption months
  - Scenario 3: Customers who have two consumption months
  - Scenario 4: Customers who have three ou four consumption months

(5) Definition of consumption of the short series

➜ Scenario 1: for customers without history



(5) Definition of consumption of the short series

- Scenario 2: Customers who have one consumption months
  - Repeats the previous month's consumption for the prediction consumption.
- Scenario 3: Customers who have two consumption months
  - Calculates the mean consumption of previous months to predict consumption.
- Scenario 4: Customers who have three ou four consumption months
  - Calculates median consumption of previews months to predict consumption.

Validation of Results

$$MAPE = \frac{1}{n}\sum_{i}^{n}\left|\frac{y_i - \hat{y}_i}{y_i}\right|$$

$$sMAPE = \frac{100\%}{n}\sum_{t=1}^{n}\frac{|\hat{y}_t - y_t|}{|\hat{y}_t| + |y_t|}$$

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|\hat{y}_i - y_i|$$

Results and Discussion

- Tests were performed based on a mildly populated municipality in Maranhão, Brazil.
- In total, 86,874 customers remained after the preprocessing.
- Distance from Manhattan was used as a metric of the proximity of the points.

Results and Discussion

Table 1. Results by class of the three best methods chosen to predict neighborhood consumption.

	Methods		
Classes	BAQR	STL	ARIMA
Residential	**36.20%**	47.00%	57.10%
Industrial	41.80%	**32.90%**	62.10%
Commercial	**32.60%**	61.90%	157.00%
Rural	**38.90%**	48.70%	203.70%
Government	129.40%	77.50%	**57.90%**
Lighting public	29.50%	32.90%	**25.10%**
Public service	**31.30%**	337.80%	229.70%
Self-Consumption	14.40%	**10.00%**	12.70%

Results and Discussion

Table 2. Results of validation metrics by consumption class.

CLASSES	QTY.	sMAPE (%)	MAPE (%)	MAE	Within range (%)
Residential	79,871	30.92	1,136.56	490.05	96.14%
Industrial	76	26.57	133.29	379.28	94.74%
Commercial	4,032	36.42	301.43	1,292.05	94.10%
Rural	1,475	33.17	614.16	3,472.73	93.42%
Government	577	25.15	91.11	443.54	93.41%
Lighting public	12	22.71	45.12	667.67	91.67%
Public service	98	41.57	200.91	1,548.66	83.67%
Self-Consumption	733	22.69	447.65	86,477.52	89.50%

Results and Discussion

Yocuru (2003)	
MAPE	Accurate
< 10%	Highly
[10% - 20%]	Good
[20% - 50%]	Reasonable
>50%	Inaccurate

Table 3. Customers distribution according to sMAPE and MAPE metric value range

	Percentage of customers by metric	
Range	sMAPE (%)	MAPE (%)
[0 - 10%[	37.39	28.70
[10% - 20%[	16.57	15.16
[20% - 50%[	22.89	23.43
[50% - inf[	23.15	32.70

Conclusion

- ➜ Presented a method to prediction power consumption for consumers with short or no have consumption history.

- ➜ The proposed methodology:
  - Euclidean distance x Manhattan distance;
  - Evaluate Different regressors;

Conclusion

➜ Main contributions:

- Solves a real problem of the energy supply companies, using simple techniques and with reasonable accuracy;
- An alternative method was developed to forecast energy consumption in customers without a history of consumption;
- The proposed method uses spatial data as a step in the forecast flow of energy consumption;
- We determine and compare the most accurate prediction methods for the different consumption classes.

Future Works

- Implementation of the proposed method in the energy company's system;
- Improvement of the method using other network-based serial data estimation techniques:
  - Temporal Convolutional Networks (TCN)
  - Neural basis expansion analysis (N-BEATs)

Questions

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