Robust Power System State Estimator using Projection Statistics for IEEE systems

K. Sathish Kumar, Basavaraja Banakara, B. V. Sanker Ram

Abstract: In Real-time applications like measurement noise in distributed power system. From model of Gaussian frequently deviates or unknown are obtained and estimated in terms of impulse pulse of noise. Under such situations, the efficiency behavior changes. State estimation (SE) methods which are conventional which have both measured and estimated values with the noise consideration is greatly depleted. In this paper, state estimation methods are used in power systems to reduce the error and noise either in two stages of operation. To achieve a linear property of the estimated output by using adjustment of weights and its measurements. The estimator considers the limits and statistical data with a good efficiency even with and without noise effects and disturbances. To understand the behavior of SE methods, IEEE test bench of 14-bus and 30- buses are considered. the results are simulated in MTALAB-SIMULINK environment. Index Terms: Load flow study, IEEE 14 and 30 Bus systems, Statistics, GM-estimator, MATLAB, M file.

I. INTRODUCTION

Robust estimation for input and output state of power systems, which has a major role in monitoring applications and control. Based on our experience, it is found that the (GM)-estimator of robust in nature and generalized like maximum-likelihood using statistics projection with one of the best method in the literature. To multiple interacting and conforming bad data as well as some types of cyber attacks are also done earlier. In addition, its computing efficiency is high [1]. All the estimation and observation algorithms are used for estimation methods like conventional and latest to reduce the bad measurements and Gaussian noise and also the error and to get the statistical analysis of the error in terms of mean and standard deviation.

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The error may be too high or low and the variation is estimated time-to-time in estimation methods. The type of programming in terms of objective function for minimizing the error is of several types like convex and non-convex programming, liner and non-linear programming, stochastic and deterministic and etc. [5]-[7]. One of them is considered in powers system analysis like AC power or DC power flow analysis with different loads. Formulation of statistical analysis by using least square and Newton methods. [11]-[15]. In particular, one step utilizes information of system and state topology historically which changes. Next bad or not useful data is removed by accurate measurements. While simulation results are used to estimate state or output for instant to instant with time consuming and high measurement of power. The new method faces all previous data with comparison with present data and computed with large computations, especially in a large electric power grid. Considering offline simulation when compared to online estimation process. [13].

II. ESTIMATION OF STATES IN POWER SYSTEM

The problem in power systems by estimating state with several problems like linear, nonlinear, static and dynamic conditions and state estimation is a nonlinear to be solved. In general several optimization and repetitive algorithms are used in present real-time scenarios, which Static is usually assumed in static estimation for AC power model [8]:

\[ z = h(x) + w, \]  

(1)

\[ x = (v_1 e^{j\delta_1}, v_2 e^{j\delta_2}, \ldots, v_n e^{j\delta_n})^T \]  

(2)

Where \( w \) is an \( m \times 1 \) matrix which consists of vector plus additive and bad noises of measurement. Variables of random in nature with zero statistical mean values which are Gaussian, i.e., \( u \sim h (.) \) is a vector with nonlinearity of functions, which indicates the present and past states of \( x \) to the measurements \( z \).
N (0, Σ), where 0 is the initial value and Σ is a diagonal matrix. With z is an vector with m×1 indicating the set of accurate measurements.

1) WLS State Estimation
2) Problem setup

The proposed Robust Data Mathematically, driven estimation algorithm which is of two parts:

- An Approach with nearest and closest Neighbors statistically, which includes with nearest network with good and bad measurements.
- Data; Minimization problem with data sets of unbiased in nature, where a set of many small distance data points are estimated.

Data Initialization: MATLAB environment tool boxes, which are adopted for calculating and understanding the actual behavior of the IEEE power systems. To understand the power flow in the power systems, to simulate and understand the behavior and analysis of the power system for offline and online load profiles, state estimation methods are used with respect to the load data and profile. To generate power system true states by estimating sets of true measurement with Gaussian noises (parameters measured are mean and standard deviations) [9]. The IEEE bus systems include bad and good measurements like: 1) power injection 2) line power flows 3) magnitudes of the voltage; 4) some measurements in terms of phase angle.

Data consideration: the data estimated from the estimation methods are robust and used to detect the bad measurements and remove the errors in power systems in terms of voltage and angle error. Depending upon the measurement parameters the adjustment of the generated data is considered:

- Bad Data of estimation
- Attack in terms of Malicious
- Training Period
- Validation Period
- Testing Period

To obtain the error minimum, different estimation methods are used like Mean square error, standard deviation and etc.

\[
MSE = \frac{1}{m} \sum_{i=1}^{m} \left( \frac{z_i - h_i(x_{current})}{\sigma_i} \right)^2.
\] (3)

Here, the MATLAB code of the GM-estimator to all researchers. The code attached is to implement the GM-estimator. The test systems include IEEE 14-bus, 30-bus and extended to 118-bus systems.
### III. M-FILE Programming

IEEE 14 Bus System

\[
nbus = 14
\]

<table>
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<tr>
<th>No</th>
<th>pu</th>
<th>Degree</th>
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</thead>
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<tr>
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<td>0.0000</td>
</tr>
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<td>-9.8000</td>
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<tr>
<td>3</td>
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<td>-14.8000</td>
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<td>-15.0800</td>
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<td>14</td>
<td>1.0356</td>
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</table>

Max_voltage_estimation_error = 4.1307e-004
Max_angle_estimation_error = 6.7613e-004
Voltage_error_mean_estimation = 1.4550e-004
Angle_error_mean_estimation = 7.8571e-004

![Voltage Angle Comparison Result](image1)

**Fig 4:** Voltage magnitude Versus Bus number for IEEE 14 Bus system

IEEE test system for 30 bus:

\[
nbus = 30
\]

<table>
<thead>
<tr>
<th>Bus No</th>
<th>Voltage (Per unit)</th>
<th>Angle (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>-0.0000</td>
</tr>
<tr>
<td>2</td>
<td>1.0431</td>
<td>-5.3500</td>
</tr>
<tr>
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<tr>
<td>14</td>
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<td>-15.8400</td>
</tr>
</tbody>
</table>

![Voltage Angle Comparison Result](image2)

**Fig 5:** Voltage angle Versus Bus number for IEEE test system of 14 bus

![Measurement Estimation Comparison Result](image3)

**Fig 6:** Measurement estimation Versus Measurement number for IEEE 14 Bus system
Robust Power System State Estimator using Projection Statistics for IEEE systems

Max\_voltage\_estimation\_error = 4.3244e-004
Max\_angle\_estimation\_error = 0.0094
Voltage\_error\_mean\_estimation=2.0624e-004
Angle\_error\_mean\_estimation = 0.0060

Analysis: By comparing test benches of test bus systems like 14 and 30, maximum voltage estimation error and estimating error of the mean values of voltages when estimated are low in IEEE 14 bus system. Error estimation for maximum angle and mean angle error estimation are low in IEEE 30 bus system.
IV. CONCLUSIONS

To obtain the data as per the state estimation in power system requires several methods are adapted to the robust data by estimating all the possible states in power system. To estimate initial State Estimate and considering as a search problem by using minimum distance and for regression Bayesian is used. In some cases, reduction of dimension in terms of size and indexing in an efficient way the simulated results are compared with conventional estimation methods within a less time as mentioned in IEEE benchmark systems.

REFERENCES


AUTHORS BIBLIOGRAPHY

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