UTK HTB WECC System State Estimation Using Optimization Methods

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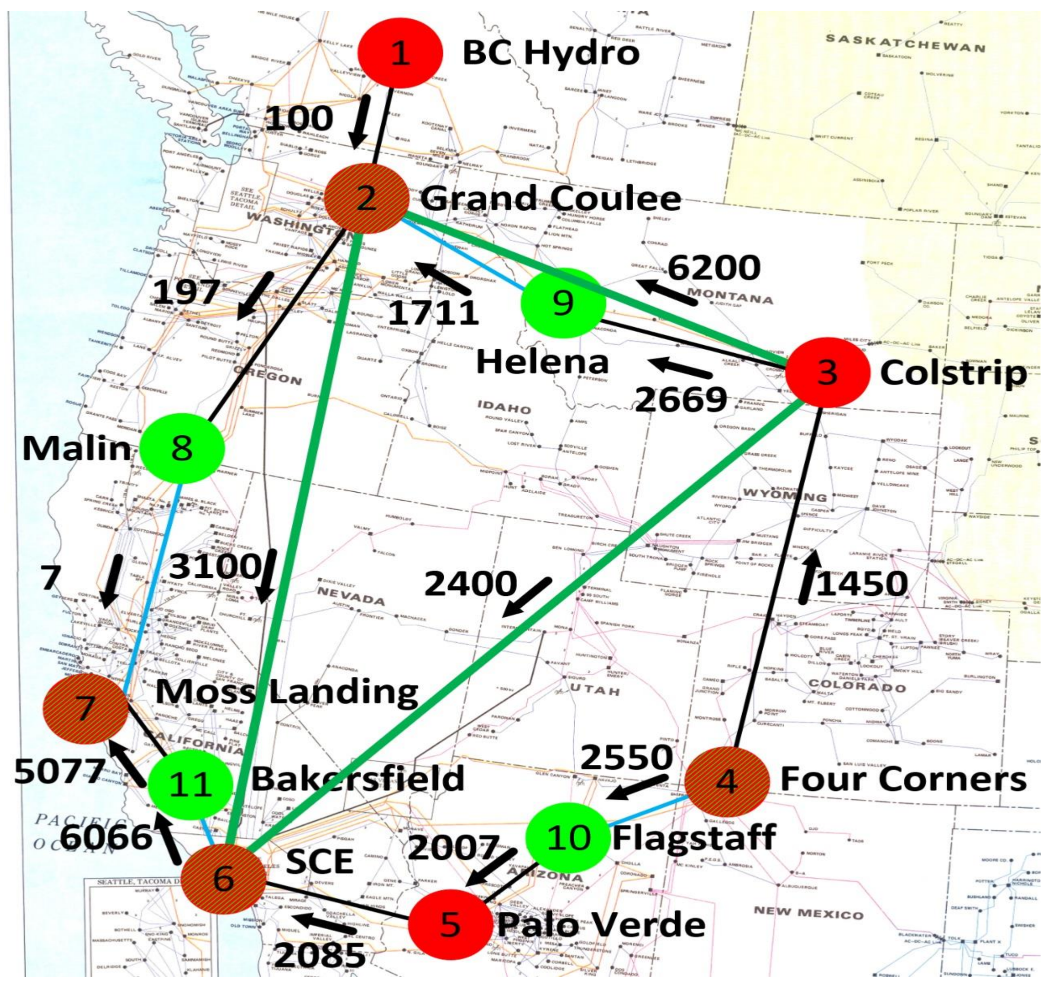
MOTIVATION

- Necessary module for monitoring and control
- To enhance stability and improve operation
- The use of real time measurement to predict current and future state
- Desire to quickly restore the system to normal state in case of emergency
- Prevention of blackout due to inaccurate estimate of the system



WLS METHOD

Minimize $\sum_{k=1}^{n} W_{kk} r_k^2$

Subject to $z_k = h_k(x) + r_k$

$$J(x) = \sum_{k=1}^{n} \frac{(z_k - h_k(x))^2}{R_{kk}}$$

where $R_{kk} = \frac{1}{W_{kk}}$

$$G(x^k) = \frac{\partial g(x^k)}{\partial x} = H^T(x^k) R^{-1} H(x^k)$$

$$\Delta \hat{x} = G^{-1} H^T R^{-1} \Delta z$$

LEAST ABSOLUTE VALUE

$$min \quad c^T |\bar{r}|$$

$$s.t. \quad H\hat{x} - \bar{r} = \bar{z}$$

$$c^T = [1, 1, \dots, 1]$$

Define:

$\hat{x} = \hat{x}_a - \hat{x}_b, \quad \hat{x}_a, \hat{x}_b \geq 0$

$r = u - v, \quad u, v \geq 0$

The optimization problem becomes

$$\sum_{i=1}^{m} |r_i| = c_i(u_i - v_i)$$

$$s.t. \quad H\hat{x}_a - H\hat{x}_b + u - v = z$$

$$u, v, \hat{x}_a, \hat{x}_b \geq 0$$

QUADRATIC PROGRAMMING

$$\min_x \quad \frac{1}{2} x^T H x + c^T x \qquad s.t. \quad A.x \leq b, \quad Aeq.x = beq, \quad lb \leq x \leq ub$$

$$x = quadprog(H, c, A, b, Aeq, beq)$$

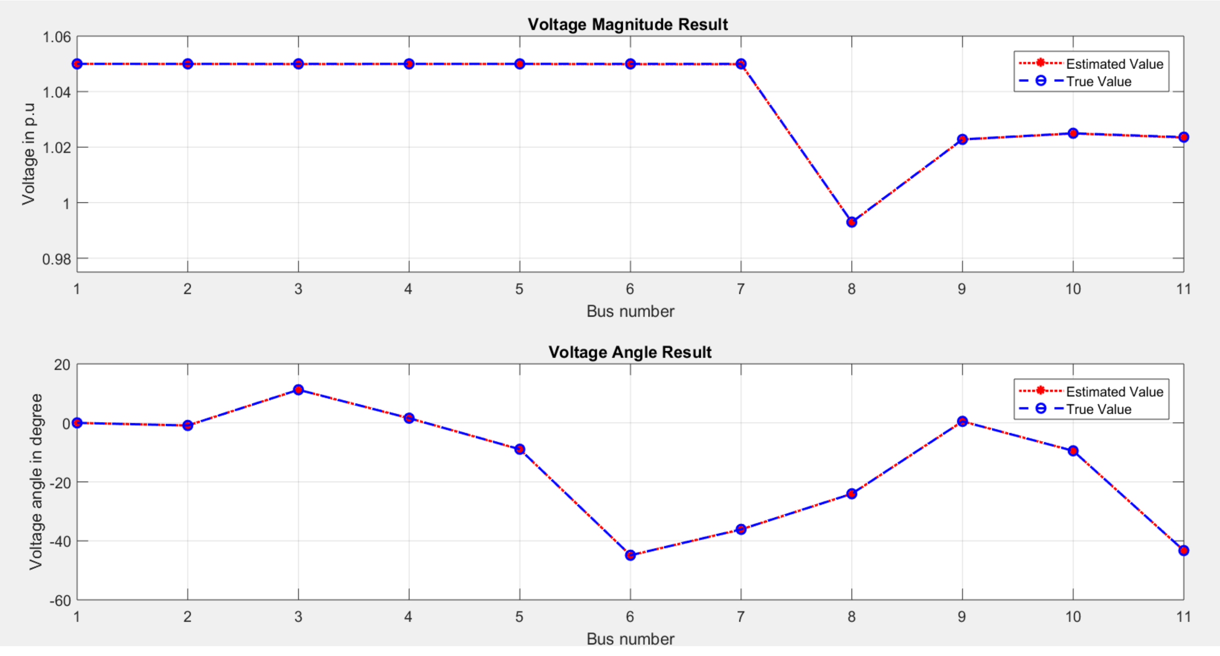
$$\min_x f(x)$$

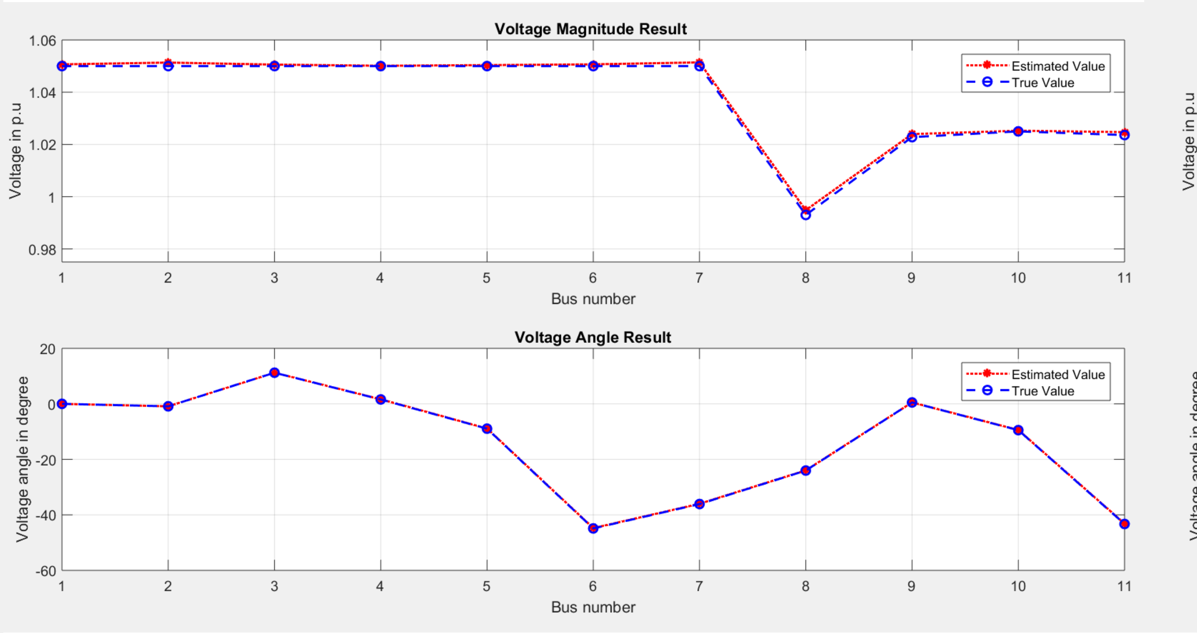
$c(x) \leq 0 \qquad A.x \leq b$

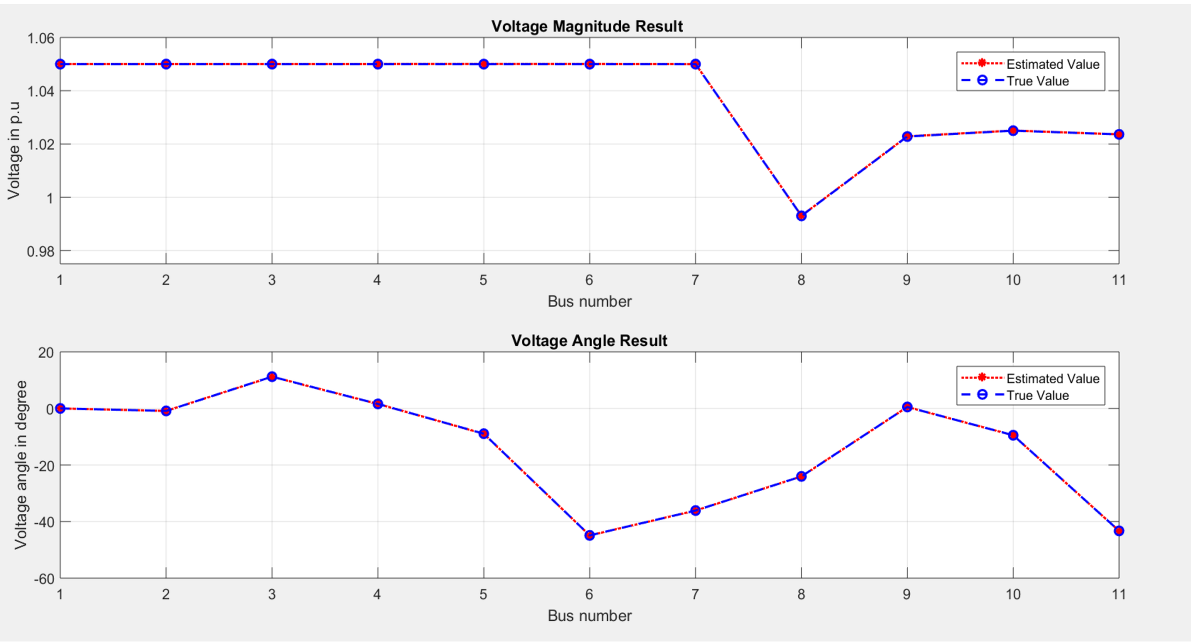
$ceq(x) = 0 \qquad Aeq.x = beq$

$lb \leq x \leq ub$

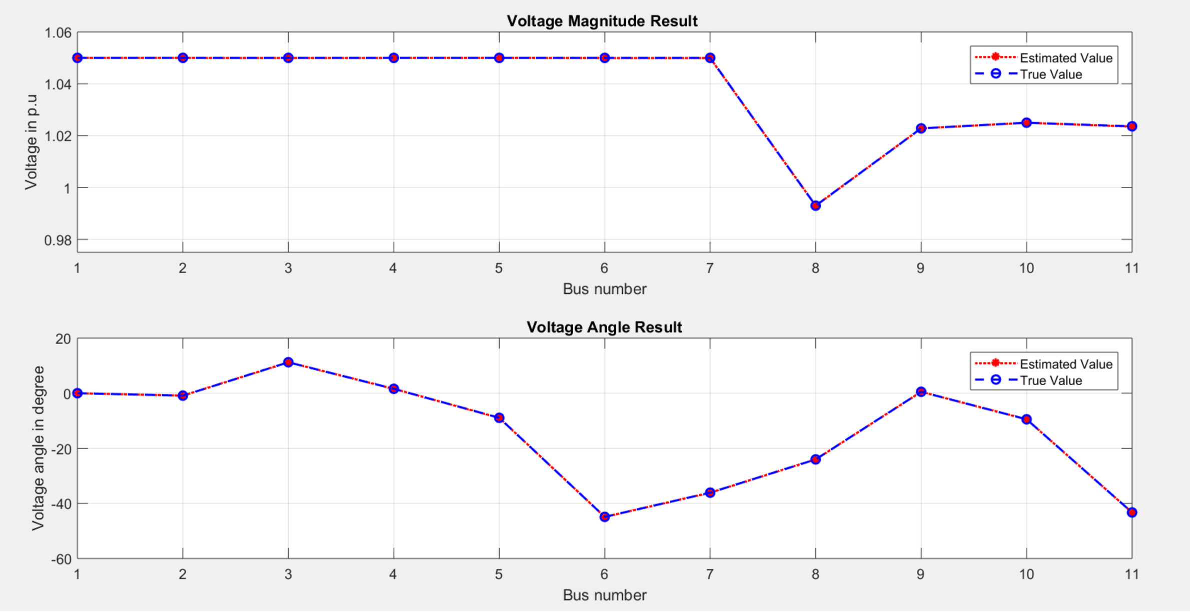
x = $fmincon(fun, x_0, A, b, Aeq, beq, lb, ub, nonlcon)$







QP LINEAR CONSTRAINTS



COMPARISON

	WLS	LAV	Quad(LC)	Quad(NLC)
Bad data	Considers bad data analysis	Does not consider bad data analysis	Does not consider bad data analysis	Does not consider bad data analysis
SCADA implementation (with bad data)	Requires more CPU time and vise versa	Less CPU time and vise versa	Less CPU time and vise versa	Less CPU time and vise versa
PMU implementation (with lev meas)	Does not have any deficiency with scaling	Does not have any deficiency with scaling	Does not have any deficiency with scaling	Does not have any deficiency with scaling
Robustness	Not robust	Robust	Robust	Robust
Computational performance	Poor with bad data	Better with bad data	Better with bad data	Better with bad data

CONCLUSION

The objective of this paper is to analyze various constrained optimization techniques in state estimation for the WECC system network. The initial states was carried out using the weighted least square to estimate the state of the system. Hence, the application of optimization tools for state estimation was successful as shown in the results above. All results consistent with PSAT result.